THE STUDY OF LAND USE CHANGES IN URBAN FRINGES OF KENYA USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM: A CASE STUDY OF NORTH KAPUTEI, KAJIADO DISTRICT

BY

OKONG'O AKOTH EMILY

B. ENVS (PLANNING AND MANAGEMENT)
(HONS) 2000

KENYATTA UNIVERSITY

A THESIS SUBMITTED IN PART FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN PLANNING

UNIVERSITY OF NAIROBI

AUGUST 2006

DECLARATION

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

Signed ..... 9th August 2006

Emily Akoth Okong'o

(Candidate)

This thesis has been submitted for examination with my approval as the Principal University Supervisor.

Signed .....

Dr. Samuel Obiero

(Supervisor)

DEDICATION

Special appreciation to my family, my daughters (Michelle and Megan) for because of you I got the zeal to complete this study, my mother (Tabitha), and most importantly to my father (late Philip Okong'o) for the inspiration and support.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the assistance of several institutions and individuals who have helped me in one way or another to successfully complete this study.

First my great gratitude to Dr. Samuel Obiero in DURP whose supervision, critical appraisal of the manuscript and general guidance, inspiration and support made this work into thesis; and to all members of staff of University of Nairobi particularly the Department of Urban and Regional Planning for the necessary support and facilities that prepared me for this masters program.

Special thanks go to Gandhi Nithi Smarak Fund for the scholarship that enabled me to complete this course. Many thanks to the Regional Centre for Remote sensing, Kasarani and Kenya Institute of Survey and Mapping for the relevant data and technical support accorded; Olkejuado county council, Kajiado District Physical Planning Department and Isinya Land Control Board.

I would wish to acknowledge the help I have received from Mr. Dismas Anduru for the support he accorded during and outside this study. Special thanks go to Mrs Margret Ogolla for her dedicated support and persistence; Mr. Ken Oguya for his invaluable assistance that enabled me produce the maps and complete the study.

Not forgetting my family for laying a solid foundation for my schooling and inspiration. Special thanks to my children and husband for bearing with my absence during this study. Lastly to the Almighty God for his blessings and guidance, and whose word has kept me going.

ABSTRACT

North Kaputei is a rapidly changing area in Kitengela location of Kajiado district. Located about 30kms southeast of Nairobi city, the area has experienced a lot of physical growth, which can be attributed to its close proximity to the capital city of Nairobi. Its land use development is characterized by the extensive residential and commercial activities in contrast to the rural characteristic which it had exhibited. The land use activities have taken place in a comparatively high rate over the last twenty years thus overshadowing the administrative and planning efforts of the area.

This study was set out to examine the nature and trend of land use changes in North Kaputei focusing on the socio-economic factors influencing land use changes such as rampant subdivision, cheap housing, low land values and other factors with their subsequent impacts were also examined.

The study's objectives were therefore to: examine the nature and trend of land use changes in North Kaputei over the past twenty years; Examine the range of data needed to monitor land use changes; examine the current methods and technologies for geo-data gathering, analysis and information management and assess their deficiencies in the study area; and finally to investigate the potential role of applying GIS and RS techniques in geo-data acquisition, processing, analysis and information management for effective land use management as compared to the existing conventional methods in the area.

The study hypothesized that lack of up-to-date, reliable and readily available land related data and information management contribute to haphazard land use development with the current methods of gathering and analyzing land use changes being inefficient and inadequate for monitoring and managing land use changes in North Kaputei.

The methodology adopted involved the visual digital interpretation of land use according to the land use classification from satellite images for the year 1987, 1995 and 2000. Subsequently land use maps were crossed with each other to identify and quantify the pattern of land use changes using GIS tool. The study also employed primary and secondary methods of data collection for qualitative and quantitative data.

The study revealed that an area that was typically rural countryside has gradually evolved into an urban environment such that past settlement patterns in North Kaputei had developed without much land use planning and management. The land use management in the study area was therefore admittedly out of step with the speed of land use development.

The effectiveness and deficiencies of the land use management institutions in the implementation of development control provisions has been examined based on the premises that effective land use management takes place within an institutional, policy and legal framework and this requires a well-organized land information system for monitoring, capturing and managing land use changes. It was also found that the relevant institutions do not have adequate resources to monitor and control development in North Kaputei.

Management of land use changes requires spatially accurate and timely information on land use and changing pattern. Monitoring provides the land use administrators, planners and policy-makers with required information about the current state of development and the nature of changes that have occurred. The study concluded that remote sensing and Geographical Information system (GIS) provides vital tools which can be applied in the analysis at the district and as well as at the city level. Remote sensing becomes useful because it provides synoptic view and multi- temporal land uses/land cover data that are often required.

The problem concerning the optimal use of land resources and improved land management is increasingly being magnified by the rapid urbanization. This intensifies the pressure on land and related resources. Therefore, there is need for continuous monitoring of land use changes as a basis for planning development and control of land resources. The study recommended an integrated land information management system that is equipped with various factors such as institutional setup, organizational procedures, legal framework, human and financial resources, and implementation plan for its suitability. The study thus weighted the use of GIS to build automated land information system for efficient management.

TABLE OF CONTENTS

CHAPTER FOUR: BACKGROUND OF STUDY AREA

CHAPTER SIX: TOWARDS EFFECTIVE LAND USE CHANGE MANAGEMENT IN NORTH KAPUTEI

LIST OF MAPS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

LIST OF BOXES

LIST OF ABBREVIATION

GIS	Geographic Information Systems
RS	Remote Sensing
OCC	Olkejuado County Council
NK	North Kaputei
SARDEP	Semi Arid Development Programme
EPZ	Export Processing Zone
LCB	Land Control Board

CHAPTER ONE: INTRODUCTION

1.0 Overview

Rapid population growth, increased demand for land and changing land uses have the potential to create adverse effects on local and global environmental resources and human settlements. In many developing countries, the expanding human settlements and waste emanating from rapid urbanization are greatly threatening and conspiring to destroy the land resource which is invaluable for the present and future generations (Kohler, 1987). Consequently, monitoring land use changes is becoming an increasing important issue in the world today as conflicting land uses occasioned by the soaring population growth and rapid development increase. There is urgent need to prevent over exploitation and poor management of land resources on which many lives in the present and future generation depend on.

One of the major issues in land use management facing the developing world today is the development of effective modern monitoring systems that can be used to manage the equilibrium between population, environment and land development (NEAP, 1998). Most developed countries have recognized the need for managing their land resource hence, have developed necessary interventions and land use information management systems particularly for urban and rural areas. But in developing countries, including Kenya, the situation is particularly serious since the available land use management information systems are not applied at all or in few cases, are used in inconsistent manner, which has little positive impact. This situation occurs in systems where there is unchecked rural-urban population influx, and urban sprawl leading to uncontrolled and unplanned human settlement and land use development with poor strategies in resource management and conflicting land uses which lead to modification or depletion of the resources.

Rapidly changing areas like North Kaputei need up-to-date planning data on land use in form of inventories in order to keep pace with the rapidly increasing changes in land use pattern. Unfortunately, many rapidly changing areas in developing countries like Kenya,

lack sufficient, accurate and timely records on land use that are essential for land use planning and management. Without reliable and relevant land use related data, decisions are liable to be made without full awareness of land use development concerns that need to be addressed. Furthermore, without up-to-date and reliable records, it is difficult to identify the trends in land use changes and evaluate the significance of change observed (Bastein, 1993).

As rapid changes in land use take place, the need for pertinent information becomes critical. In Kenya, both government and planners recognize the non-existence or lack of spatial-temporal data/record on different land use patterns that can be used to monitor and control land use matters in the country (Gitau et al, 1998). However, as concerns data collection, other pressing concerns like HIV/AIDS pandemic, poverty reduction, food security, and other socio-economic issues aimed at achieving the Millennium Development Goals are often given more priority than the need for land use information and management. Further, the authorities concerned with land use management continue to use inefficient and inadequate methods and technologies for land use data collection and analysis (Gitau and Syagga, 1998).

North Kaputei in Kajiado district, bordering Nairobi city has experienced tremendous land use changes over the past fifteen years occasioned by increasing migration of various groups of people from other surrounding areas and from farther away in the country. This trend has resulted to a strain on the limited and fragile resources in the region accentuating to frequent land ownership/usage conflicts. This in turn has been a threat to sustainable use of land and its management.

Hence, there is need to examine the extent to which the use of modern technologies such as remote and geographic information systems can provide relevant data/information for sustainable land use planning, development and management and ensure that land use activities are compatible in the rapidly changing areas of major urban fringe.

1.1 Problem Statement

For many decades, the principle land use system in the semi-arid region of North Kaputei in Kajiado District has been extensive livestock grazing (pastoral-nomadism or footloose) interspersed with wildlife habitation. However, the scenario has changed dramatically in that land use patterns have undergone drastic changes in the last twenty years. Population pressure and increased demand for land have resulted in uncontrolled and random subdivision and sale of former large group ranches for high-density or nucleated human settlement.

Various parts of North Kaputei, particularly the areas around Noonkopir Township are urbanizing rapidly. The population projection for the year 2020 indicates that the population of the area will be more than double. This increase in population is expected to be accompanied with increased demand for land for development and settlement. However, these human settlements if left to occur haphazardly and randomly will result to adverse impacts on the capacity of infrastructure in the area.

Government offices on the ground acknowledge that the techniques and technologies available for land use data acquisition and analysis are inadequate in meeting the management needs of the current complexities of urban land use patterns (as a result of urban sprawl) and the changing human settlement patterns in the rapidly urbanizing areas like North Kaputei (Van Lier, 1994). In addition, continued uses of analogue as opposed to digital methods of data capture and presentation is inadequate and ineffective in monitoring the land use changes within an urban fringe like North Kaputei.

In Kenya, we are faced with the challenge of monitoring the status and trends of land uses and providing timely information necessary for planning and management of these land uses. There is an alarming rate of encroachment of development and settlement in North Kaputei caused by immigrants from overpopulated high potential areas as well as the densely populated City of Nairobi resulting to constant land use changes and conflicts among different users. This necessitates the need for constant monitoring of land cover

using remote sensing techniques and analysis of the same using GIS tool integrated with other existing methods and techniques.

This study therefore, aims to examine the potential applicability of remote sensing and geographic information systems techniques in capturing, analyzing and monitoring the trend in land use patterns and changes in North Kaputei.

1.2 Research Questions

The study seeks to answer the following questions:

1. What is the nature and trend of land use changes in North Kaputei and how have they occurred over the past twenty years?
2. What are the existing methods and technologies for geographic data gathering, analysis and information management? How effective are they for land use monitoring and management?
3. What range of data is needed to monitor these land use changes?
4. Is there a role GIS and RS techniques would play in the collection and analysis of geographic data for efficient land use planning, management and monitoring in North Kaputei?
5. What can be done to establish a more effective land use control, planning and management system in North Kaputei?

1.3 Research Objectives

The study focuses on the data needed to monitor land use changes and the potential role GIS and RS can play in geo-data acquisition and analysis for land use monitoring with the overall objective to examine the nature and trends of land use changes in North Kaputei and their underlying factors. The following specific objectives are used to facilitate the research: -

1 Examine the nature and trend of land use changes in North Kaputei over the past twenty years.

2 Examine the range of data needed to monitor land use changes in North Kaputei.

3 Evaluate the current methods and technologies used for geo-data gathering, analysis and information management and assess their deficiencies in the study area.

4 Investigate the potential role of applying GIS and RS techniques in geo-data acquisition, analysis, and processing and information management for effective land use management as compared to existing conventional methods in the area.

5 To recommend a more effective land use change management system for North Kaputei.

1.4 Research Premises

This study is based on the following research premises:

1. That there have been drastic changes in the land use pattern over the past twenty years in North Kaputei, and the trend will continue to expand and intensify in the medium term.
2. That there is need for adopting modern geo-information system for effective monitoring and management of land use changes in North Kaputei and other areas in Kenya.
3. That GIS and RS techniques are better and effective tools for geo-data acquisition, monitoring and analyzing rapid land use changes and their trends as compared to traditional conventional methods.

1.5 Study Hypotheses

1. Lack of reliable and readily available land related data and information management contribute to haphazard land use development, planning and monitoring which lead to land use conflicts in the area.
2. That current methods and technologies for gathering and analyzing land use changes in North Kaputei are inefficient and inadequate for monitoring rapid land use changes.
3. That GIS and RS technique provide effective, reliable and timely geo-data and analysis for land use planning and management.

1.6 Justification and Significance of the Study

Research on land use changes in rapidly changing areas is justified on the basis that land plays important role in providing main source of livelihoods to over eighty percent of the world population (Bernstein, J. D. 1994).

North Kaputei, being a dry land environment is dynamic and fluctuations and changes are expected as a consequence of either natural and/or human activities. Thus experiences rapid land use changes caused by rapid population influx and resulting urbanization phenomenon. As the population keeps expanding, more demand is placed on the land, which in turn is converted into diverse users. In an area of fragile ecological balance, like North Kaputei, these land use dynamics ought to be closely monitored and the resultant conflicts resolved.

North Kaputei is not the only rapidly urbanizing area neighbouring Nairobi City, the study chose it due to its unique characteristics and fragile ecosystem. It is more of rural urban character unlike the other urban fringes like Thika, Kiambu, Ngong and Ruiru which are equally rapidly urbanizing due to the influence and influx from Nairobi city but have exhibited exclusive urban character. However, North Kaputei being an ASAL the predominant land use systems had been ranching, wildlife conservation and footloose system. But this has in the recent past changed with the rapid and uncontrolled subdivision of the former large group ranches into individual property which in turn allow the owner sole right of making decision on the use of that land resulting to rapid subdivision and dynamic marketing of land and agro-products.

The current trend of deterioration will lead to a gloomy future for the populace if the status quo is maintained, thus a rational land use management is needed as an intervention. Striking a balance between satisfying human livelihood needs and wise usage of resources especially land to ensure sustainability of natural resource base is the biggest challenge the study intends to address.

Relevant and reliable data on such changes is necessary in order to reflect the magnitude of change and the likely impacts on a continuous temporal basis. Spatial temporal

analysis of such land use changes assists in predicting the future direction of change and hence the necessary intervention measures implemented.

In principle and in general terms, then the rational for monitoring land use changes is to detect change as early warning to any further deterioration of the environment; identifying affected and vulnerable spots for the purpose of formulating strategies for combating land use conflict and land degradation.

Farther, while various studies have been carried out in the North Kaputei, most of them are on the range management and human-wildlife conflicts, which have failed to give the necessary regard to planning implications of increasing human settlement and the resultant land use changes, (Kohler, 1987). Most of the studies have also concentrated on other urban fringes such as Ngong, Kiambu which have been established and are more urbanized without giving much concern to North Kaputei which has mainly been a wildlife conservation corridor and grazing ground for several years as part of a Nairobi fringe.

The study therefore, aims at appreciating the importance of applying RS and GIS techniques in monitoring land use changes in rapidly changing areas. It also gives broad guidance for institutional and methodological framework in undertaking detailed land use studies in North Kaputei.

1.7 Scope of the study

The study deals with monitoring of land use changes within North Kaputei covering an area of 128.6 square kilometers. Socio-economic and demographic factors contributing to land use changes are also examined. Sample areas are chosen for detailed study and analysis of socio-economic factors relevant to land use changes. The aim of the study is to monitor land use changes over the past twenty years and their resulting development, planning and management implications. The study also examines the existing methods for geo-data gathering and analysis and investigating the potential role of GIS and RS techniques in geo-data acquisition, analysis and information management for effective land use management as compared to the conventional techniques in the area.

Since land use management should start with investigations on the current land use and the previous land use dynamics, it is felt that a time-series analysis of land use changes would be the most important starting point in the study. In this way, the study gives a picture of the nature of land use changes, their effects and conflicts in a multi temporal period. Satellite images of 1987, 1995 and 2003 are used. The study also examines the efficiency of current methods and technologies for geo-data acquisition, analysis and information management in the area and their resulting deficiencies in planning and management of land use changes.

This study uses existing satellite image and photographic scenes of the area and GIS tools to capture, analyze and monitor changes. The study area is limited to North Kaputei of Kitengela location in Isinya division falling within the coordinates of (62, 40), (76, 40), (76, 20), (62, 20) ***(Give map references/coordinates)***

1.8 Definition of Key Terms and Concepts

Attribute data: refers to the descriptive data about spatial data and their metadata.

Geo-spatial: relates to geographic space and or location that can be graphically identified and described using maps and or coordinate systems (spatial data).

Geographic information systems: is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their spatial locations. Practitioners also regard the total GIS as including operating personnel and the data that go into the system.

Land: an area of earth's surface, the characteristics of which embrace all reasonably stable or predictably cyclic attributes of the biosphere vertically or above the soil.

Land development: all the activities leading to a durable modification o land conditions with a view of deriving higher benefits of land.

Land Information system: a system of capturing, storing, checking, integrating, manipulating, analyzing and displaying data about land and its use. This includes the techniques such as remote sensing and geographic information systems.

Land use: the accommodation in spatial terms of all human activities on land and the management of land to meet human needs and it is the functions of land determined by natural conditions and human interventions.

Land use management: this refers to the process whereby the resources of land are put into practically planned and in good effects, which are guided by national laws, policies and regulations.

Land use conflicts: those development activities, which are incompatible with each other.

Small scale Holdings: individual residential plots that are not within the town centre. These are sparsely distributed mainly in a leapfrog manner.

Urban Land use: Township boundary; development with urban character of mixed land use in nucleated manner. The urban area as population centres inhabited by 2000 or more people which has increased within North Kaputei. The characteristic of urban land use are analysed by studying the population and employment changes. There is a tendency for human activities to agglomerate to take advantage of economies of scale. The causes of this trend are mainly economical and historical.

Large farms: these are big parcels of land that are non-subdivided farms mainly for the indigenous residents of North Kaputei and the corporate land buying companies which are mainly ready for farther subdivisions. Such as Flower farms, grazing grounds etc.

Ecotourism: this is a conservation strategy which ensures that the wild animals are not interfered with but the owners of the farms where they are but turn them into economic gain such as the ostrich farms such as Maasai Ostrich Farms, Camp sites etc.

1.9 Study Methodology

1.9.1 Study Area and Population

This study was carried out in North Kaputei of Kitengela location in Isinya division of Kajiado district. It lies between longitudes $36^0 5'$ and $37^0 55'$ east and between $1^0 10'$ south. It covers a total area of 201.82 square kilometers with a total population of 17347 people **(Map 4.1)**. The Maasai community dominantly occupies the area although within the Noonkopir urban center, there are other ethnic groups residing in the area particularly Kikuyu, Kamba, Luo, Kisii, Luhya and many other ethnic groups within the country. The main socio-economic activities are livestock production and mining as well as game ranching, although with the mixture in ethnic composition, there are various economic activities that have been introduced by the new immigrants such as trade, commercial and crop farming.

The target population included different landowners, developers, business operators and various authorities that deal with land use control, planning and management in North Kaputei. Households were interviewed to collect information on their socioeconomic issues, migration trends, and their contribution to the land use changes in the area.

The study dealt with the Physical Planning Department and Olkejuado County Council as land use planning authorities to identify methods they apply to capture and manage land use development, and the problems they face in this exercise.

1.9.2 Methods of Data Collection

The study utilized various methods including primary and secondary, and qualitative and quantitative methods as described below.

1.9.2.1 Secondary Data

The study made use of existing and available information, including raw and unpublished data on the types of land use pattern, existing methods of geo-data acquisition and management both in the country and the study area. This kind of data was obtained from

land registry records and maps, development plans and existing institutions. Land use development and subdivision approvals records were obtained from records in the physical planning offices in Kajiado district. Data on the trends in growth of urban center was obtained from census report on population and housing of 1969 to 1999. Already available data from various books, magazines, booklets, government documents, private records and studies carried out by other scholars on land use planning in urban fringe and the applicability of GIS and RS were collected from various libraries. The main sources of secondary data included libraries like UN libraries, and World Bank Library. The university libraries including The University of Nairobi libraries such as the Jomo Kenyatta Memorial Library, IDS library, ADD library and Kenyatta University library were also visited.

Information on the physical background of North Kaputei, population size, employment and business types were obtained from Central Bureau of Statistics and census reports. Relevant satellite images and topo-sheets covering the past and present land use patterns in the study area were also acquired. Some were purchased and used to analyze the trend of land use changes with the aid of GIS tool.

1.9.2.2 Primary Data

Data on types of land use patterns and trends in land use changes over the past fifteen years and the socioeconomic factors that influenced them were obtained from the following sources:

1.9.2.2.1 Sample Size

The study population falls under two sub-locations namely Kitengela and Sholinke consisting of four zones. North Kaputei had a population of 17347 (Population and Housing Census, 1999) with 5,005 households. However, it was not possible to interview the 5005 households but a sample size of 65 households was interviewed.

The sample of the study population to whom the household survey was carried out was drawn from the whole of North Kaputei of Kajiado district. The study area was clustered

into five blocks, which have different land uses and household characteristics as shown in maps below.

Block 1: Noonkopir Central Business District, and Miriam's Area; Jua Kali (Nyamacharata);

Block 2: T-Shopping center road; Ndatani Estate; Ndivo/Ikawa residence

Block 3: Quarry; K.A.G. Children's Home; Pinto Dream Club; New Valley Estate; Jitan

Block 4: Area around Masaai Ostrich and Flower farms toward the Oloosirikon and park

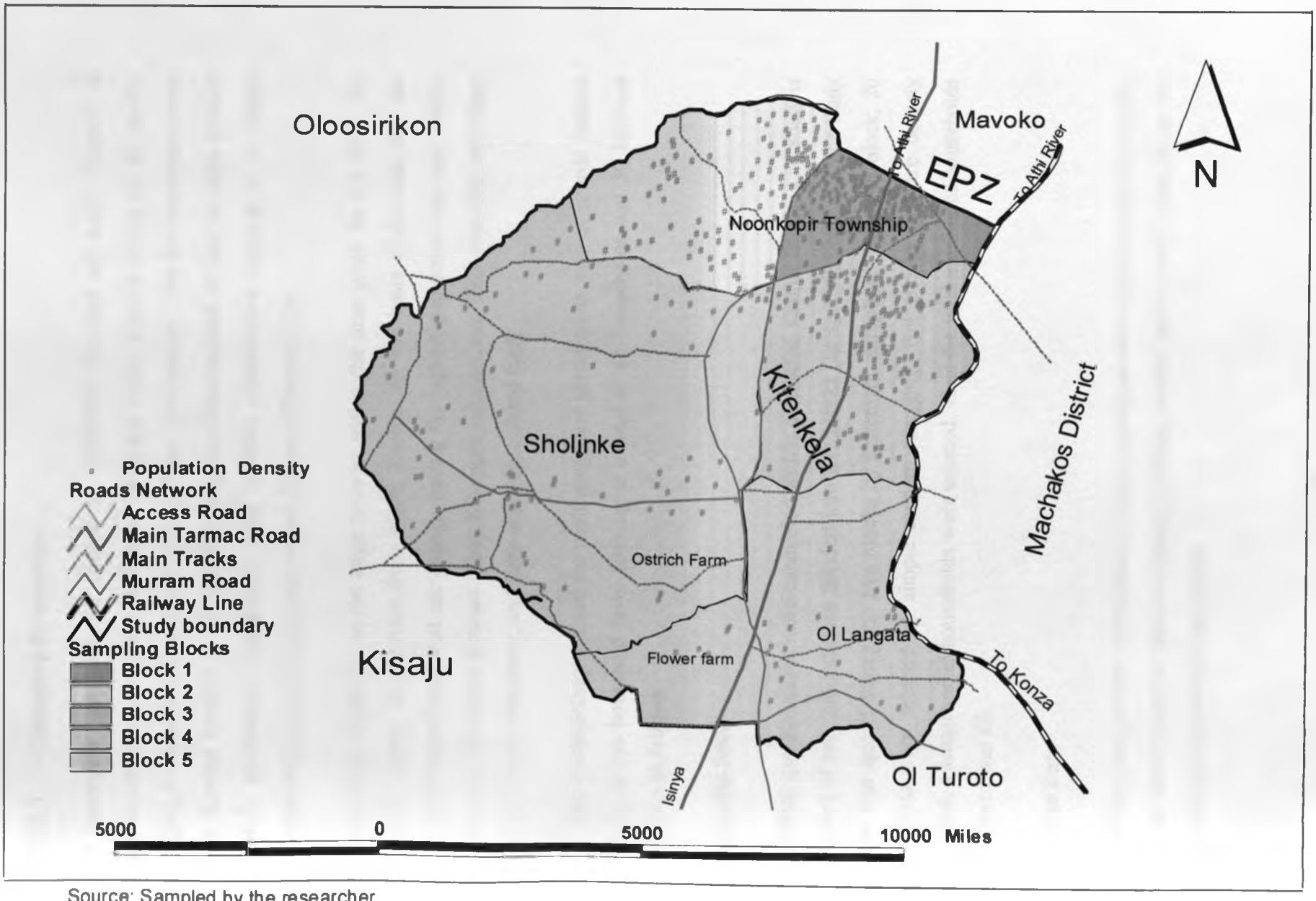
Block 5: Area towards the railway line up to Konza and Ol Langata.

Noonkopir town has the highest density and intense land use development (Block 1), but the development is random guided with a mix of residential groups of different income earners. A sample size of 30 households was taken.

The area around river Kitengela towards the park (Block 2) is densely populated and has experienced rapid changes in land use development. It is a high-density area in terms of small-scale settlements and has a mix of urban and rural character. Based on this, a sample size of 15 households was taken.

Block 3 toward the railway line to Konza has experienced a sparse development and is not nucleated. It has both urban and rural character and a sample size of 10 households was taken. The areas towards Isinya and ol turoto locations (Blocks 4 and 5) are sparsely populated in terms of settlement and a total 10 households was taken.

Map 1.2: Sampling Blocks of the Study Area



Source: Sampled by the researcher

1.9.2.2.2 Sampling Procedure

The researcher used rational criteria to determine the area of study. Nairobi is neighboured by Ngong, Kiambu, Ruiru, Thika and North Kaputei which are all rapidly changing in terms of urbanization and land use development. But the researcher chose North Kaputei because of its unique ecological characteristics in that the area exhibits livestock production interspersed with wildlife conservation making it a fragile ecosystem which is lacking in other urban fringes of Nairobi City.

Because North Kaputei was too large to cover within the time given for the study, the researcher chose one location from North Kaputei on the basis of the one that has experienced most rapid land use change, having the highest population size and density and this was Kitengela location. Thus Kitengela location was then stratified into urban land, small-scale settlement, and large-scale agricultural land.

The study methodology utilized the multi-stage and stratified as well as simple random sampling at the household level arriving at a total of 65 households and 30 land-use developers as follows:

Households Data

Household questionnaires were conducted within a selected sample frame. The study is composed of two sub-locations divided into five blocks (as specified earlier). The study sample was spread among the five blocks by systematic sampling. For each block, 20 households were selected by simple random sampling. But Blocks that are densely populated, a sample of 25 households were selected. Thus the total number of households interviewed was 65.

Land Use Data

Various land use patterns were captured from remotely sensed satellite images in a multi-temporal survey together with the ground truthing carried out to verify what is on the image and the current land use pattern.

In carrying out ground truthing, the study employed cluster and multistage sampling by first dividing the study area into blocks (zones) forming the basis for analysis of land use trend or direction of urbanization. After dividing the area into zones, a multi stage sampling was applied whereby after selecting the blocks as in household, the respondents were chosen randomly in each block. The technique was used to study the particular business operator or land uses chosen at random within the zones.

The study also used non-probability sampling particularly to identify the industrial activities and other unique land uses such as game ranching. This involved accidental quota and purposing sampling such that where any different land use came across was interviewed.

In mapping land use, the study employed stratified and multi-stage sampling, as it was necessary to first classify the various categories of use within the study area. The study stratified land uses into different types and since land use classification is of different hierarchy where a certain class can be disaggregated to different classes of higher orders. In this regard, systematic identification, recording and analysis of different land uses in North Kaputei were carried out. The study involved multi-level classification of land use.

Satellite imagery was used in level 1 of land cover and land uses with the capability of being disaggregated into specific categories into level 2. At this stage, with the use of cadastral maps, land uses were identified and classified into the following classes:

- Vegetation/agriculture
- Built up
- Infrastructure

Built up areas were jointly classified under urban land and small farm holdings but this was further broken down using ground truthing into level three of industrial, residential and commercial uses and each of these could further be broken down. Agriculture was categorized into large-scale farms and small-scale farms with the former further

categorized into rangeland and game ranching. Each of these land-uses has significant planning implications.

Cluster and multistage sampling were used in the field by first dividing the study area into blocks (zones) forming the basis for analysis of land use trend or direction of urbanization. After dividing the area into zones, a multi stage sampling was applied whereby after selecting the blocks, the respondents were chosen randomly in each block. The technique was used to study the particular business operator or land uses chosen at random within the zones.

Table 1.1: Multi-level Classification of Land Uses in North Kaputei

Level 1	Level 2	Level 3	Level 4
Vegetation/ Rangeland	▪ Woodland ▪ Open grassland		
Built-up Areas	▪ Urban land ▪ Scattered settlements	• Industrial • Commercial • Residential ▪ Game ranching • Industrial mining • Individual homes plots	
Drainage	▪ Perennial river ▪ Seasonal river		
Infrastructure	▪ Transport networks	• Road networks • Pipeline • Railway line	o Major roads o Arterial roads o Tracks

Source: Conceptualized by researcher, 2003

1.9.2.2.3 Sources of Primary Data

a) Household Questionnaire

This was administered in carrying out household survey, which is an important tool to obtain the socio-economic and demographic information, availability of infrastructure services. Information on land tenure, family structures – sizes, composition, educational levels, occupations and incomes, farm holdings sizes, grazing methods, other land use activities and the attitudes of land owners on their land.

Questionnaires on the various institutions directly or indirectly involved with the land use planning and management were administered to determine the level of interventions and the methods these institutions use to capture, manage and monitor land use changes in North Kaputei and the effectiveness of these methods used.

b) Field Observation

This involved the researcher visiting the area and systematically selecting, observing and recording as well as taking photographs of what was of relevance to the study such as nature of land use conflicts, type of land uses, level of subdivision and size of plots.

c) Unstructured Interview

This method was applied where necessary. Some questions arose during interviews with the landowners, land use authorities and other officials that deal with land use development. Responses from such questions were recorded in a separate form, which were relevant in supplementing the scheduled questionnaire. Government officials concerned with land use development, planning and management such as Kajiado district physical planner, district lands officers and secretary of the SARDEP programme were interviewed to identify problems and challenges they face in controlling land use development in the study area.

Interview schedules were also done with government officials concerned with land use control and management like members of the DDC, members of the land control boards, local authority operating in the area, district physical planner, district lands officer and members of the SARDEP programme to determine whether they have any control on the subdivision and sale of land in the area.

d) Mapping

Mapping of the physical locations of the study area and other infrastructure was used as a tool for research where different types of land uses activities was mapped to show the spatial location of land use pattern and proportions in the study area. This was done by

first interpreting the broad classes of land uses from the assorted satellite images of 1987, 1995 and 2003, which were then demarcated and then digitized into GIS to come up with maps of land use pattern.

1.9.3 Data Analysis

Land use change analysis is a systematic way of analyzing land use change. It requires first having the total area for the different land use classes for the different duration and compares the two maps. Accuracy in interpretation and measurement of these changes is important. Using a computer program, areas of different land uses are compared cell by cell by overlaying the two maps. This provides the basic quantitative information about the land use change that has occurred. A cross table showing the changes from and to another class are then produced. A map of these changes are also obtained using GIS tool.

Data analysis was through qualitative and quantitative methods. Household questionnaires were coded and data entered into the Statistical Package for Social Sciences for quantitative analysis. Descriptive analysis was used to summarize data to enable the researcher to meaningfully describe the distribution of score of various variables using a few indices. Measures of central tendency, measures of variability, frequency distribution and relationships were applied as well as inferential statistics were utilized in data analysis to infer various sample variables to the total area population.

Table 1.2: Analytical Framework

Objective	Data Needs	Source	Analysis
To examine the nature and trend of land use changes in North Kaputei over the past 15 years	• Mapping of land uses in the years 1987, 1995 and 2000 from the satellite image scenes of respective years • Main types of land use to observe: - Urban settlement - Small scale settlement - Vegetation cover - Large-scale farms/ranching - New land uses • Change in growth of each type of land use - Size in hectares of each land use - Percentage change in size in hectares from 1987 – 2000 • Nature of land use conflicts arising as a result of land use change - Court cases - Land Board cases - Caveats	• Landsat images from Regional Centre for Mapping for Resource Development, Kasarani. • Topographical maps from Survey of Kenya. • Cadastral maps for Kitengela Township (Block 1) from Ministry of Lands, Boundary section.	• Analyze the trend in change of each type of land use and the trend over the years: - Percentage change - Coverage - Density • Make projections of future time to assess necessary measures of interventions needed • Analyze the nature of land use conflicts arising from the change in land use in North Kaputei and their planning consequences
Evaluate the current methods and techniques	• Manual land use information (Cadastral, population census)	• Department of Resource Surveys and Remote	• Compare the importance of each method and techniques and their

for geo-data gathering, analysis and information management and assess their deficiencies in North Kaputei	• - Digital land use information	Sensing • Kenya Wildlife Society	effectiveness in monitoring land use changes in North Kaputei
Examine the range of data needed to monitor land use changes in North Kaputei	• Demographic characteristics e.g. population size, density and distribution, migration trend, population quality and commuting patterns • Land values in North Kaputei (rural) • Land values in Noonkopir township • Land values in Nairobi, Athi River and Kajiado corridor	• Central Bureau of Statistics • Ministry of Lands, Kajiado District office • Olkejuado County Council, Noonkopir township	• Identify what is pushing population towards North Kaputei • Project population size for future time • Compare land values between North Kaputei (rural), Noonkopir township and Nairobi as well as in Athi River
	• Land ownership pattern/system in North Kaputei • Registration, subdivision, change in use • Settlement data – housing, market, towns	• Lands office, Kajiado District	• How has the land ownership/system changed over the years and what are the resultant impacts – dichotomy of planned and unplanned settlements • Analysis of registration, subdivision, and change of use in study area
	• Typical plot layout of planned and unplanned settlements • Legal administrative background of North Kaputei (Concept of	• Subdivision plans from Kajiado District Lands office	• How has the legal administrative background impacted on the land ownership pattern and the pattern

	group ranching) • Land use policy • Number of subdivisions per year		of development • How comprehensive is the land policy in terms of controlling development? • What is causing the high rate of subdivision/development in North Kaputei • In which part of North Kaputei is land use planning standards are being followed?
Investigate the potential role of GIS and RS techniques in geo-data acquisition, analysis and processing and information management for effective land use management as compared to existing conventional methods	• Components of GIS • Importance of GIS and its applications in Kenya, and other parts of the world • Importance of RS and its applications in Kenya and other parts of the world • Conventional methods used in geo-data acquisition, processing and analysis	• Various publications and from the internet • Seminar and conferences publications	• Assess the role RS can play in geo-data acquisition and processing • Assess the role GIS can play in geo-data analysis and processing and information management • Compare the roles of RS, GIS techniques and conventional methods of geo-data acquisition, processing and analysis as well as land information management

CHAPTER TWO: LITERATURE REVIEW

CONCEPTS OF LAND AND LANDUSE MANAGEMENT

2.0 Introduction

This chapter involves reviewing and analyzing studies previously done on the subject of the study (both on empirical and theoretical). To understand land use changes well, theories on urban land use pattern are discussed, types of land uses as in urban area, factors affecting the location of the identified land uses and finally the forms of land use conflicts.

2.1 Concept of Land as a Resource

Land occupies a central place in human activities, as it is the physical base – one cannot easily conceive of any human occupation that would not leave prints on land, from agriculture to construction. Land is the ultimate actor in the development and progress of human races (Bureza, 2002).

To many people, land still remains the core of their existence. Consequently, land becomes a basic need as a source of livelihood – whereas landlessness invokes feelings of insecurity and helplessness. Indeed land has been one resource for which a lot of blood has been shed either in form of territorial expansion or in form of asserting ones rights to land as depicted in the various struggles for independence in many African states. Indeed, most governments today are land-based units. Zimbabwe's conflicts between white farmers and black peasants today reflect how sour land issues can get.

The amount of habitable land is finite and fixed while the intensity of using it increases with population growth. Land can be used for different purposes such as urban development, agricultural/rangeland production, transportation and other developments resulting from human settlements. Hence it is important to ensure that land use activities are in harmony with each other and the natural condition of the land as well as the environment as a whole (Habitat, 2000).

This is particularly important in urbanizing areas where expansion of population and industrial activities have generated rapid growth in urban land use activities and other small-scale settlements (Drakakis-Smith, 1986).

This process of urban development has led to the evolution of land use pattern such that land gradually became less important as a resource for food production and rangeland and it is increasingly used for other purposes that have high investment returns such as industrial production, housing, infrastructure and recreation. These emanate from increasing population pressure and changing human needs and aspirations creating competition between land-uses resulting in conflicts (Bernstein, 1993).

Land degradation and environmental problems associated with land use conflicts continue due to the failure to include adequate land information in the development planning stage. Land is the foundation of most human activities and its viable use is critical for economic, social and environmental well being of the present and future generations (Habitat, 2000).

Information on land use pattern and monitoring the evolving pattern using remotely sensed data and geographic information systems could help minimize these conflicts by assisting decision-makers and land use control contributes to enhance their information base.

2.1.1 Land Rights and Land use

Mather, (1986) outlines two enduring concepts of land that influence the views of land users; He states that

" On 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 uses as not just a matter of 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 wider sense that the community has an interest in it."

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

Caldwell (1974) cites several reasons for the necessity of change in outlook toward 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.

The attitudes to land and the power relations, which underlie the use and development of land and the resultant conflicts, are emphasized because any discussion of planning peri-urban land that is often ripe with constant change requires a focus around which to weave its analysis. The issue of how land is conceptualized may be seen to be at the root of wider issues of how and why landowners can or should be controlled in the use of their own property. No government can be efficient without having absolute control over the manner in which land is to be used.

2.1.2 Land as Power and identity

Traditionally, the right of occupation and use has often conferred great economic and political power. Land especially in urban areas has retained its allure as a source of wealth, power and status.

The value of land to the Kenyan social economic and political life is best described by Kenyatta 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 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.

Kohler (1987) identifies four functions that land fulfils to the African. These are: land as a home, contributor to income, reduction in the cost of living and as a forma of investment. The crucial points 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-actualization. These are summarized in the figure 2.1.

Muriuki, 1984), notes that home is a concept that improves the position of the household and his family. Since the land is theirs, they are free to make decision and in this connection, land ownership provides identity. Land also provides security, especially due to the formal security in ownership, symbolized by registration and the issue of title deeds.

2.1.3 Land Values and Land Markets

Land values are measures of intensity of demand and competition for urban land (Malombe, 1992). Land values vary with quality and access to employment, commercial and social services centers in a given area. Consequently land values decline with distance from city center, since most employment, commercial and social services will be located at the city center. They also vary with demand for particular zones so that most businesses would want to locate in the central business district, a location that affords them better market for their goods and services.

High land values in the city center are pushing investors and investments to the periphery where land values are lower hence are cheaper. It is also pushing low and middle-income residents to the fringe areas. The demand for housing, and other land use development in the fringe areas is in turn increasing due to influx of migrants from city center. This increasing in demand plus improved infrastructure has made land values in the urban fringe of Nairobi to appreciate significantly (NCC, 1973).

The land values however are low relative to those in city center. This influx of migrants from city center is therefore likely to continue, owing to the existing differences in the value of land.

Table 2.1: A Comparison of Land Values

Area	Area (Acres)	Land Values (Ksh)
		1989
North Kaputei		
Noonkopir Township	0.25	10,000 – 15,000
North Kaputei (rural)	0.125	6,000 – 10,000
Nairobi City center and environ		
Duruma Road	2.372	3,000,000
Mombasa Road	0.0633	3,560,055
Hospital Hill 209/9627	0.4489	1,050,000
Kajiado town	0.125	15,000– 30,000
		(1990 – 2002)
Noonkopir Township	0.125 (50 x 80)	250,000 – 500,000 (depending on land use – residential or commercial)
North Kaputei rural	0.125 (50 x 100)	100,000 – 150,000
Nairobi City center and environ		
Upper hill .209/1270	1.4689	64,000,000
Kajiado town	0.125	200,000 – 300,000

Source: Ministry of Lands and Settlement (1989/2002)

Table 2.1 shows a comparison of land values in Nairobi, Kajiado and North Kaputei (rural). It indicates that land values are higher in the Nairobi relative to North Kaputei and Noonkopir Township.

Figure 2.1: Cross Section of Land Values

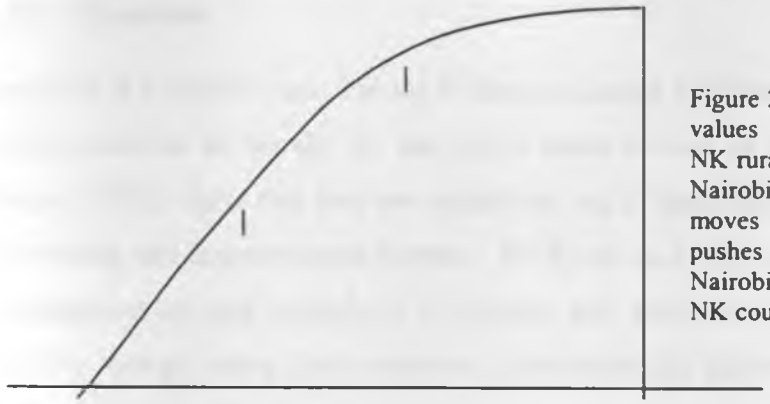
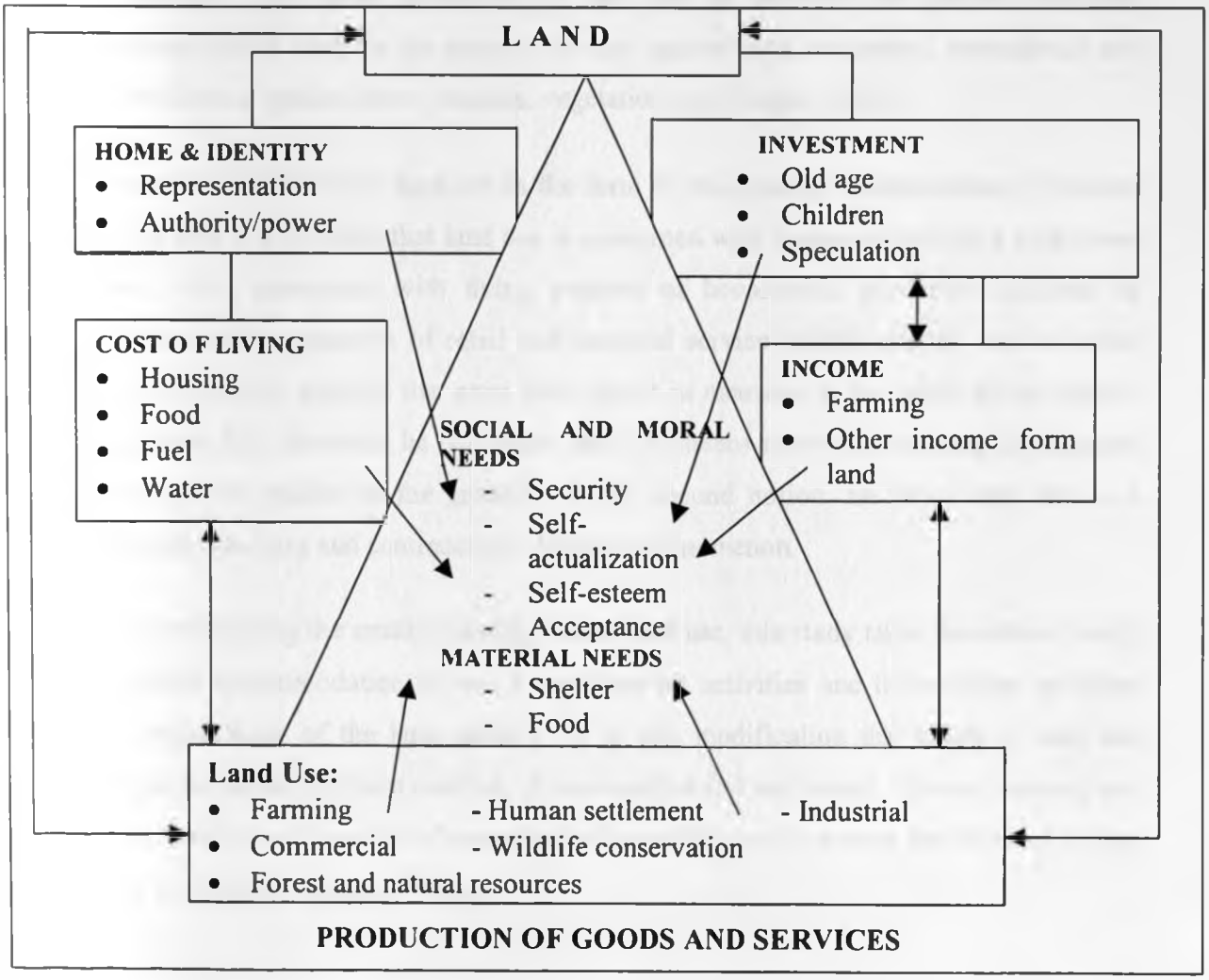


Figure 2.1 shows a cross-section of land values taken from city center through NK rural. It indicates that land values in Nairobi are higher and declining as one moves towards NK rural. This thus pushes those who cannot afford land in Nairobi and Noonkopir Township to NK countryside where land is cheaper.

NK (Rural) Noonkopir Nairobi City center and environ

Source: Constructed by researcher, 2003

Figure 2.2: Functions of Land



Source: Adapted and modified by researcher from Yahya, S. S. (1976)

2.2 Concept of Land use

2.2.1 Overview

Land use is a relative term having different meaning to different people. Stamp (1961) defines land use as literally the use that is made by man on the surface of land. While Hugue (1987), states that land use signify the use of land, territorial water bodies as well as building and improvements thereon. De Bie et al., (1995) defines land use as a series of operations on land, carried out by humans, with the intention to obtain products and or benefits through using land resources. Describing the purpose (s) and the operations sequence captures Land use.

Therefore, land use refers to how land and its improvements are used and distributed over the locality. The above definitions of land use fall between two distinct concepts: functional use of land for the purpose of man (agricultural, residential, recreational etc) and the form of ground cover - houses, vegetation etc (Chapin, 1984).

Blumenfeld, (1971) views land use in the form of two guiding considerations. He states that the first is the notion that land use is concerned with human activity in a very broad sense. It is concerned with living patterns of households, productive patterns of industries, selling patterns of retail and personal service establishments, and the other classes of activity patterns that exist and interact as elements in the urban social system. Thus, from this viewpoint he concludes land use means more than existing or proposed improvements visible on the ground. In the second notion, he views land use as a constantly evolving and continuously changing phenomenon.

While recognizing the multiple definitions of land use, this study takes the term to imply the spatial accommodation of man's development activities and the resultant adoption and modification of the land surface. It is this modification that result to land use changes and to some extent conflicts if uncontrolled and unplanned. Remote sensing and GIS techniques are capable of capturing and recording such changes and conflict arising either in digital or analogue forms.

Increasing human population and the ever-changing human needs and aspirations have attributed to the ever-increasing competition between land uses. The situation is further compounded by the finite land resource and the intensity of their use, which is increasing with population growth resulting to conflicts among land uses. Hence, this calls for adequate land use information system to minimize conflicts most of which lead to unviable land uses and environmental degradation (UNECA, 1986).

2.2.2: Land Use Management Concerns in Kenya

Soon After Kenya attained independence in 1964, the first president, Mzee Jomo Kenyatta, had this to say in regards to land development in Kenya;

> " *our greatest asset in Kenya is our land. This is the heritage we received from our forefathers. In land lies our salvation and survival. It was in this knowledge that we fought for the freedom of our country. Our plans for the future must spring from a resolve to put to maximum production our land, however small the acreage we may possess." (Kenyatta, 1964).*

Maximum production of land cannot be realized without efficient management of the various land uses. Successful implementation of land policies requires reliable spatial data and efficient land information management systems that are currently lacking in the country (Habitat, 2001).

Blumenfeld, (1971)) notes that Various experts and other stakeholders in land matters have constantly argued that land use management concerns in the third world countries constitute one of the most crucial constraint to sustainable economic development of any country.

Okoth-Ogendo, (1976) indicated that this view is not far from the truth as the existing land policies, institutional and technical capacities in third world countries are not only inefficient but also inadequate in addressing most land use development problems. Attempts made in the past to reform these systems in Kenya, for example, have not been successful.

Despite various land management and administration reforms carried out in Kenya since the turn of the century as a government policy, still much is needed to be done to streamline land use management and developments in both urban and rural areas of the country (Habitat, 1999).

The Seventh *Development Plan (1994-1996),* for instance, while stressing the need for proper land use management and utilization for maximum productivity the document outlines the following policy frameworks and strategies:

- Effective land use management and administration through efficient land tenure systems of leasehold, freehold and recognition of the various customary and other land rights existing in the country.
- Accurate land planning, surveys and registration of land.
- Provision of the necessary infrastructure services.
- Efficient and adequate land records and land information management.
- Regular review of planning and survey data standards.
- Minimization of conflicts of competing land uses in both urban and rural areas among other policy strategies.

These official pronouncements unfortunately are toothless bulldogs as they are only in paper and not in practice. The problems are worsening day by day especially due to the demands posed by the high rate of population growth (of about 3.5 %), which has resulted into mass exodus to urban centers and their fringes. This influx has led to other diverse land use related problems in Kenya's urban fringes among other undesirable consequences, hence over-stretching the existing urban infrastructure services and shelter needs in most of Kenya's urban centers. For planners to cope with the above dilemma reliable land related data is urgently needed and on a continuous basis, especially in a rapidly changing area like North Kaputei being on the fringe of a big city like Nairobi City.

The need to induce a balanced and sustainable human settlements patterns for both urban and rural communities in the third world countries today can never be over emphasized.

These countries can borrow a leaf from the experiences of the developed countries such Canada, Australia, Japan and Europe on the benefits of embracing the new technologies for land use developments planning and management activities.

However some developing countries of Asia and Africa, such as Malaysia, Thailand, Tanzania and Nigeria, have started aggressively developing and implementing modern GIS database modules for their urban land use management activities using modern geo-informatics of RS and GPS as data acquisition methods (Ezigbalike, C. et al, 1988 & 2001). The City of Dar-es-Salaam, Tanzania for instance, is a typical success case where comprehensive development and integration of geo-information technologies into land use planning and management involving institutional structural re-organization of the local authority has successfully worked, (Kyariga T., 2001).

2.3 Urbanization and Urban Sprawl

Urbanization is the process in which the number of people living in the city increases compared with the number of people living in rural areas. A country is considered to be urbanized when over 50% of its population lives in urban areas (Nigam, 2000).

Urban areas in the third world countries are growing at unprecedented rates. Since 1950s, the urban populations in these countries have risen from 300 million to 1.3 billion persons. By the year 2030, developing cities are expected to grow by 160% (World Bank, 1999).

Urbanization process changes the regional social and economic activities and generates the urban impact on the natural environment. As such some political economists believe that urbanization is in and of itself inevitable force of nature with positive and negative impacts in all development and has always been regarded as a prerequisite for modernization and hence leading to national development. However, what is not clear is the actual relationship between levels of urbanization, economic development and the resultant land use changes (Obudho, 1976).

To detect the dynamic land use/land cover changes, analysis of the social and cultural impacts and evaluation of the influence of those changes to natural environment increase our knowledge of understanding of human-environment interactions (Nigam R. K. 2000).

However, urbanization implies a social change that is usually transforming rural settlement into urban settlement as urban land features change in both central urban area and in urban-rural fringe. In most of large metropolises of the world, the spreading of built up areas have led to rural metropolis accompanied by change in land use patterns that render the public administration inadequate and inefficient in controlling this rapid land use change (Syagga et al, 1985).

Although the urbanization process often means accelerated economic performance for a country, the accompanying increases in urban land use changes as well as the conversion of land – whether that land lies within or outside the existing urbanized area – may have negative implications. As demands for limited supplies of urban land lies, such that lower income groups may be found to occupy illegal and unserviced subdivisions often on the periphery of cities, where land tends to be most vulnerable to both natural and anthropogenic hazards.

The rapid urbanization of recent years has posed huge challenges to public authorities. Growth has mostly occurred in areas whose governmental arrangements were established or much smaller populations. Moreover, the growth in population has often taken place at the periphery of large cities beyond the boundaries of local government units, with the result that a large number of people has no access to urban services and infrastructure (Stren, 1996).

Further, urbanization process also exerts pressure on sensitive ecosystems as in the case of the arid and semi-arid areas being vulnerable environments. Within an existing built up areas of cities, uncontrolled growth and inadequate infrastructure cause irreversible losses of cultural resources and open space (UNECA, 1986).

Poorly managed development activities also attribute to excessive urban sprawl, which result to the conversion of agricultural land and rangeland to urban use and small-scale settlements (UNECA, 1986).

Uncontrolled urban settlement is manifestation of normal urban expansion or growth process under the exceptional conditions of rapid urbanization. This is in the view that the existence of urban settlements is not considered as a problem, but the fact that they are not guided in their implementation means that they result to a higher distorted physical form (Muriithi, 1990).

The rapid urbanization needs to be guided in order to achieve sustainable land use change monitoring and management. Cloke (1989), notes that if landowners are left to make land use decisions solely, then there would be a potentially random intermixture of land use and/or with no control mechanism against wholesale changes to land use patterns as in the case of the study area.

The operation of the profit motive is the normal determinant of urban sprawl. Nevertheless, there are democratic societies, which manage to arrange their urban growth more effectively like Chicago, New York and Toronto etc. It is not essentially a fact of democratic life that the outskirts of a city should consist of mishmash of ticktack boxes of land uses (Brant, 1972).

2.3.1 Characteristics of Urban Fringe

The term "rural-urban fringe " may from an operational point of view, be defined as an area of transition between well recognized urban land uses and the area devoted to agricultural [Kurtz & Eicher 1958]. In other words, it is the area of mixed urban and rural land uses between the points where the entire range of the city services ceases to be available and the point where agricultural land uses began to predominate. There is absence of a clear break between rural and urban condition measured both in terms of land use and of the social organization (Johnson 1972).

Land use in regions adjacent to large urban centers tend to change due to urban pressure such that farming units tend to be smaller and more intensive and agriculture becomes market gardening. Further, farmers tend to leave the land to obtain non-agricultural employment in the city thus the 'farmer-worker' or 'part-time farmer' arise (Best, 1981).

The process of urbanization and growth of metropolises in western countries are usually accompanied by the transformation of rural settlement into urban settlements. In most of the large metropolises of the world, the spreading of built up areas have led to rural metropolis accompanied by change in land use pattern (Institute of British Geographers, 1968).

Urban land uses, urban population and various functions of the metropolis are then passed along the nearby villages and towns, which are quickly transformed into a part of the metropolitan system until they cannot be distinguished from the central city (Institute of British Geographers, 1968).

The factors spurring this process are usually high-density housing, crowded transport and especially the price of land within the city. Further, a similar process of spreading of the metropolis (such as Nairobi) is by its penetration into the rural areas (Gavish, 1976).

The penetration takes place in certain direction such that the settlement that became part of the metropolis was rural settlements or rangeland in this case (Nairobi Metropolitan Strategy of 1973).

The concept of Metropolitan relates a region to a system of magnetic fields, each surrounding a city and its fringe areas, according to its relative economic strength, variable in its power to attract growth. The fringe while being dependent on the larger center for specialized services and wholesale outlets, is a sub-service and sub-wholesaling center for hinterland areas with a more limited pulling power in attracting new industry. In order to survive, subdominant centers must specialize in the direction indicated by the dominant center, particularly.

Richardson Harries (1996), noted that ambitious immigrants bring vitality to a city as they bring diversity to an area. In any city decentralization of jobs encourage people to settle at the urban fringe in that employees would minimize their daily commuting. Because of a transit system characterized by the Great North road passing through North Kaputei to Namanga and the proximity of Nairobi-Mombasa Highway to North Kaputei has gained more from that outward movement of people and jobs created by the influx of industries towards Mombasa road and the nearby Mavoko Township.

2.3.2 Western Based Concepts of Fringe Characteristics

Much of the present thinking about the urban fringes as rapidly changing areas is rooted in the work of Wehrein published in 1928. He noted that transportation lines were the first decentralizers of urban population and urban land use, and since this means of transport radiated in all directions, it became obvious that the urban fringe appeared like an area perked by fringe-like projections of urbanized land uses. Wehrwein identified some important characteristics of the urban fringe such as rapid residential growth, sporadic subdivisions, speculation, juxtaposed land uses. Cloke (1989), found that he reasons why people move to the urban fringe are an open country environment for raising the children, low rents, nearness to family and friends, healthy place for retirement. However, he pointed out that there exist social problems in the fringe areas such as high transportation costs, transportation congestion, deficient utilities, inadequate government, and quite often, inadequate educational facilities. It is also noted that although people seek certain amenities in the fringe areas in America, even when achieved these amenities are ephemeral.

Some fringe characteristics have also been observed in the city of Sydney in Australia. Golledge (1986), has identified several characteristics of the urban fringe, thus fringe areas are seen as regions with constant changing land uses and occupancy, although farms are small, crop production is intensive, population is mobile, residential expansion is fast, inadequate service provision and public utilities and building and land speculation are common.

In conclusion, the urban fringe areas in developed nations are associated with high standard of living. But this is not the case in developing nations and especially in Kenya where fringe areas are associated with acute deficiencies and disorders in various aspects such as improper housing, crime and delinquencies, inadequate infrastructure, poor sanitation, low incomes, uncontrolled and unplanned land use developments and this is the case in North Kaputei.

2.3.3 The Case for Developing Countries

In his generalized study of urbanization in developing countries, Gerald Breeze (1966) identified two major land use problems in these countries. The first problem was the provision of planned space for new immigrant and swelling population in the city and secondly the failure of these countries to establish effective land use and land value control measures, although these conclusions were based on Indian cities, they are still applicable to African and in particular Kenyan cities over where urbanization and planning experience are less well established.

William Hance (1970) has carried out surveys on selected African cities including Nairobi, and other pre-colonial cities. These surveys have revealed a number of problems that occur such as the high rate of population pressure and uncontrolled developments towards the fringe and the inadequacies of the economic bases for these cities to cope with ever increasing demands of services on them.

Mobagunje (1967) strongly asserts that there is a recurring urban land use patterns in African cities. The ever-increasing rate of in-migration into the city where these new immigrants are unable to afford relatively expensive accommodation within the urban areas drifts to the outer fringe of the city. This peculiar trend of development in African cities contradicts the Western based theories where suburban of cities are generally assumed to be areas for high class and low-density developments.

Yahya (1969) carried out a study into patterns of land use and land use changes in sub-urban Nairobi and noted that the Nairobi fringe area exhibits peculiar characteristics such as:

- Land use contrast in the form of intermixture of agricultural, industrial, recreational, residential and commercial.
- Sectoral differentiation in the city structure with income levels of the residential areas showing a strong relationship with population densities, population growth and household characteristics.
- Generally land values get lower with increasing distance from the city center.

In effect Yahya comes to the conclusion that socio-economic forces are instrumental to the changing pattern of land use and land values in the outer fringes of the city. A consistent theme in most of these studies has been that what goes on in the urban area directly affect the areas adjoining it as a result of interplay between social and economic factors.

Shibira (1978), reviewed detailed studies by Yahya in four selected urban centers, Kakamega, Kisumu, Mumias and Bamburi, and the operating theme was lack of effective urban policies that are necessary for coordinated development of the urban areas. He further noted that there was scarcity of land, infrastructure information, and legal instruments, in the urban centers of Kenya. It is indeed these deficiencies that peri-urban problems find fertile ground on which to spread.

2.4 Theoretical Framework

The trend and structure of land use changes in an urban fringe is quite complex and several theories have been devised in an attempt to generalize about the human interaction and arrangement of land use within an urban fringe. It is hoped that these theories although based on Western studies will put the study into international perspective. It does not necessarily follow that the way cities grow in developed is the same in the developing countries. The study examines the suburban developments in developed countries vis-à-vis the developing countries and lastly an attempt will be made to review local literature on urban development in Kenya.

The multiple nuclei concept of urban growth first suggested by Mackenzie (1933) in Chapin (1972) is built on the assumption that there are often a series of nuclei in the

patterning of urban land uses rather than the single center uses. Harris and Ullman (1962) have expanded this concept and observed that various nuclei were district centers in the origins of metropolitan areas, which persist as nuclei as growth fills in the areas between them. These nuclei appear in various forms for example, sub-urban centers, specialized centers for functions such as industries, wholesaling. Multi nuclei come as a result of certain activities, which are interdependent clustering in the same locality. Segregation of uses, effect of high land values in attracting or repelling uses in the process thus nucleation occur.

Chapin (1972) notes that the economic forces that contribute to shape urban land use extend far beyond the immediate environs of any particular urban area. It involves considerations and functioning of the urban economy as it fits into the larger economy of the region and nation.

Alonzo (1964), in his work on location and land use has introduced two variables that affect the utility of any given parcel of land. First there is the quality of land, which each user will wish to acquire, and secondly, the amount of revenue devoted to land and travel costs and other expenditure. Location theory therefore seeks to explain the question of the most rational location on pattern of land use.

Richard Ratcliff whose major preoccupation in urban land use is mainly based on the interplay of market forces also recognizes that economic activities in each community directly serve its population and are influenced by the nature of that population, and that population tends to influence future land use in urban area and overspill is felt in the peri-urban areas.

Webber in Chapin (1972), utilized interaction as the basic organization concept of his theoretical system on spatial arrangements of land use. He views urban community in two related perspectives – one in which human interaction occurs in a particular metropolitan community and the order in which it extends to widely scattered places. He termed the first interaction as a 'place community' and the second a 'non-place community'.

He explained that with modern transportation and communication developments having the effect of stretching distances, individuals, firms, organizations and institutions more and more have contacts, conduct transactions and maintain communication on a wider basis. Thus, their ties may extend to variety of non-place communities at the same time exist within a particular urban place. He called these non-place communities "urban realms" to distinguish them from urban place.

It is this total concept of urban place, which contributed the urbanization of North Kaputei as an urban fringe or non-place community within metropolis of Nairobi. In monitoring land use changes in rapidly changing area like North Kaputei, it is however not complete and sufficient to examine only the interaction systems within it as an urban realm but to extend to those within the metropolitan area of Nairobi city.

According to Weber's concept, what goes on within the spatial confines of an urban place must be interpreted in the framework of all the ties that the community may have with the surrounding area. These urban places are dynamic in terms of their linkages which Weber defined as dependency ties relating individuals, groups, firms and other entities to one another. These invisible relations bring various interdependent business establishments, households, voluntary groups and personal friends into working associations with each other into operating system.

In the early 20th century, the North American Cities were becoming metropolitan, as they were growing larger as they gained jobs that attracted immigrants. In the process economic and political geography of these cities changed. Growing, they absorbed communities that had been once self-contained as more companies began to create jobs in the suburbs, while improvement in mass transportation enabled more people to move out of the center. Development spilled beyond city limits and annexation failed to keep pace and as a result fringe districts began to incorporate and soon larger cities were surrounded by dozens of suburbs (Blumenfeld, 1971).

Blumenfeld (1971), further notes that the economic and political changes both reflected and helped create social patterns such that most of those who could not be accommodated

within the city moved to those urban fringes. In that sense, annexation was more socially and economically selective than the process of sub-urbanization itself.

2.5 Institutional, Policy and Legal Framework

The problem of rapid land use changes in North Kaputei can be seen as a symptom of another underlying problem of uncontrolled developments and high rate of subdivision. An understanding of institutional, policy and legal framework within which these problems are taking place will be necessary in order to gauge the extent to which frameworks are either facilitating or discouraging the mushrooming of land use activities in North Kaputei. In this way sustainable strategies can be recommended to solve the problems, either within the laid down framework or within a suggested new framework.

2.5.1 Institutional Framework

Institutions are rules of society or of organization that facilitate coordination among people by helping them form expectations which each person can hold in dealing with others (Kihagi 2000). In this case, institutions are seen as how they facilitate or inhibit land use development and supply of housing and the supporting infrastructure.

The Ministry of Lands through the departments of lands, physical planning and Olkejuado County Council manage Land use in North Kaputei. Prior to the enactment of Physical planning Act, development control used to be undertaken by the commissioner of lands, through a section called inspectorate and by the OKCC development control section. These departments have however failed to control land use development resulting in uncoordinated and incompatible developments particularly the urban centers. The Act has now given powers to OKCC to control development (Masinde 2000), but these powers are not adequate to enforce compliance.

The land use changes emanating from urbanization have been too rapid, while the department of physical planning has failed to cope with these changes. The department, which should formulate planning guidelines, does not have the necessary powers to enforce development control. This role has been given to the Olkejuado County Council, which lacks the necessary capability in terms of qualified staff to ensure land use

development control and management. The officer in charge of North Kaputei only deals with issuing of license to developers rather than physical control of development.

2.5.2 Policy and Legal Framework

2.5.2.1 Land Use Policy

Land use policy is the system of laws, rules regulations and practices to govern the rights and obligation of landowners together with appropriate guidelines to ensure maximum utilization of available land in both rural and urban areas.

Land use policy in Kenya is contained in the service centers policy, the growth center policy and the integrated Transport and communications network policy. The first two identified designated centers to become rural trade and production centers and designated settled urban centers to become growth centers. The government intended to intensify investment in infrastructure in these designated centers in order to attract further investment in industry, education and health. These centers were to become alternative focus to Nairobi, Mombasa and other major towns for employment and development in respective regions.

The integrated transport and communication network policy was to link these designated centers to each other and to different parts of the country. These policies were designed to guide urbanization process towards a proper direction. These policies have been successful only in reducing migration to Nairobi and Mombasa as well as trying to balance rural and urban nevertheless rural urban population influx still continues due to the improved road network that the policy has ensured.

However, the land use policy is silent as to the use of scarce land resources and enforcement of regulations and practices that govern rights and obligations of landowners as well as land developers. This has encouraged the mushrooming of conflicting land uses even in well-planned towns. This scenario has made people claim that Kenya does not have land use policy. But rather aspects of land use policy are currently found in various sections of the constitution of Kenya, presidential decrees, administrative circulars, Sessional papers and various National Development Plans. However, there

exist a number of tools, techniques, routines or tactics used in land and land use policy as shown in table 2.2 below.

Table 2.2: Various Techniques used as Land use Policies

Technique/ Routine	Objectives	Legislation	Current Practices
Land use Zoning	Regulate use of land, control urban growth, control travel demand, and regulate supply of housing.	Physical Planning Act Local Government Act	Preparation of Physical development plans delineating land use zones
Development Control	Regulate type and density of development. Aesthetic control. Maintain health and safety standards. Protect environment. Control land values.	Physical Planning Act. Local Government Act. Building By-laws.	Planning permission and approval. Planning inspection by various experts.
Sub-division control	Control densities. Enforce space standards. Enforce servicing standard	Physical Planning Act. Registered Land Act. Street Adoption Act.	Subdivision applications. Survey. Registration and planning
Building control	Ensure safety. Establish space standards. Establish minimum sanitation standards.	Building By-laws grade I and II	
Physical Planning	Provide orderly basis for urban and regional development Improve quality of life. Protect environment	Physical Planning Act. Local Government Act Building By-laws.	Preparation of various development plans.
Land Banking	Create reserves of cheap land. Control land values. Control supply of land for housing.	Local Government Act Land Acquisition Act	Piecemeal accumulation for projects
Development Levy	Raising revenue. Control rate of development	Physical Planning Act	Development applications upon subdivision change of user, etc.
Rating	Raise revenue	Rating Act	Rating based on

			market value of unimproved site.

Source: Modified from various sources

Yahya (1976) observed that these formal measures were far removed from reality and in their place were unorthodox policies, which influence the prevailing practices in Kenya. Thus a concept emerging is that land and land use policies are influenced by non-conventional policies, which are political power-related. This informal processes and attitudes form an important input into policy making. However, this trend has not been spared in North Kaputei, indeed with the growing demand for land, both political and prevailing land use policies are simultaneously being used to allocate land as a resource and control development.

2.5.2.2 Urbanization Policies

Urbanization policies started rudimentarily before 1050s when decisions were made by the colonial government to locate periodic markets, trading centers and urban centers in various parts of the country (Obudho, 1983). During this period, four plans were introduced that altered the cultural and economic landscape of the nation.

The Troupe Report focused on the problems of farming in the white highland, the F.W. Carpenter report of 1954 was primarily concerned with urban wages and proposed policy stabilization of urban wages through collective bargaining (Carpenter, 1954) and the third plan was Swynnerton Plan that dealt with the problems of agriculture in African areas and the Royal East African Commission whose aim was to identify the causes, conditions and trends of overpopulation in the urban areas.

After independence, the first National Development Plan - NDP (1966 – 1970) did not represent any urban planning strategy different from the colonial strategies of the 1950s; instead it focused mainly on land reform in former white settlement. This period emphasized on agriculture and rural activities. The first explicitly national urban policy was seen in the 2nd National Development Plan (1970 – 1974), which emphasized on selective concentration as opposed to the concentrated development strategy. The plan

advocated for continued expansion of largest urban centers and designated seven other centers as growth centers.

The 6th National Development plan (1989 – 1993) was guided by the need for rural-urban balance, having the twin aim of guiding urbanization in bigger urban centers while ensuring such increase occurred in small urban centers. While the 7th and 8th NDPs of 1994 – 1996 and 1997 – 2001 respectively expressed the need for regional equity through development of smaller urban centers with emphasis on industrialization by the year 2020 associating industries with urban centers.

In this contest, the study area emerges as an appendage to the city of Nairobi with no clear balance between the rural and the urbanizing environment. It is apparent that the policies put in place to check the growth of the city has had no expected effect as the development has leapfrogged the National Park the greenbelt separating Nairobi and North Kaputei countryside and is continuing unchecked in the study area.

2.5.2.3 Land Planning Act of 1968

This superceded the Town Planning Act of 1931. The regulation of planning the use and development of land that had been put in place in 1961 were later enacted into the Land Planning Act of 1968. It set out to provide guidelines on the preparation and approval process of plans such as area plans, town plans, subdivision schemes, etc. this act extended to peri-urban areas – 8 km from municipal boundaries. The non-agricultural developments in the rural areas, which had to be approved by the central authority (whose role was to control developments in areas with no interim planning authority) include:

- Subdivision of farms into portions less than 20acres
- Change of use from agricultural to non-agricultural purposes (commercial, residential and industrial)
- Deposits of refuse, scrap and waste material on land.

The major plan carried out under this framework is the Nairobi Metropolitan Growth Strategy of 1973 and structure plans for most of the Municipalities.

The current Land Planning Act also does not have adequate statutory powers to control the haphazard land uses in the country. For example it has no specific provisions to control illegal developments or prosecute developers who contravene land use standards and regulations, hence the need for re-evaluating the existing land policies and institutional structures that govern land utilization in the country.

2.5.2.4 Physical Planning Act (1996)

This is an instrument of land use policy which empowers the director of physical planning to prepare local physical development plans with respect to government land, trust land and private land within an area of authority and city, municipal, town or urban council or with reference to any trading center or market. The purpose of this plan is to guide and coordinate development of infrastructure facilities and services and to control the use of land and for the provision of any land for public purpose.

Section 29 of the Act empowers local authorities to control or prohibit the use or development of land and buildings for proper and orderly development of an area, to control and prohibit subdivision of land or existing plots into smaller unviable sizes, to control development and approve development permissions and formulate by-laws to regulate zoning in respect to use and density of development. However these powers are not adequate to ensure compliance. The Act does not give powers to OKCC to prosecute in cases where development control regulations are flouted. But rather gives powers to the Attorney General, yet this is legal framework for enforcing land use development control. Therefore the act needs to be amended to allow more powers to local authorities for development control.

The Physical Planning Act of 1996 does not recognize other acts like other previous legislations giving rights to individuals such as Registration of Title Act, but rather empowers the Director of Physical Planning to prepare local physical development plans on any land (Kioko, 2001). This thereby results in problems of enforcing compliance.

2.5.2.5 The Land Control Act cap 302

This is an act of Parliament that provides for controlling transactions in agricultural land. It applies to the subdivision of agricultural land without change of user with sizes of subdivision not less than 20 acres. Under section 5 of the Act provides for the provision of Land Control Boards, institutions that are meant to control transactions in agricultural land and through which consent to transact in such land is granted. Any transaction affecting the agricultural land is void for all purposes unless the LCB for the area in which the land is situated has given consent in respect of the transaction. The consent decision is governed by section 9 of the same Act, which states that consent shall be given regarding "the effect it is likely to have on the economic development of the land concerned or on the maintenance of standards of good husbandry within the area". But the consent should be refused if terms and conditions of transaction including price are unfair or where subdivision of the land reduce the productivity of the same.

The Act was complementary to the Land Planning Act when\en the central authority had planning powers over areas 8km outside the town boundaries. The powers of this central authority have since been subsumed by the Physical Planning Act, which places more emphasis on the special planning areas. In the study area if assumes a higher level of importance because it is actively applied to grazing land (agricultural). The Act is applicable in the study area even though subdivisions are far too below 20 acres in some cases.

2.5.2.6 Mining Act Cap 306

This Act vests all unextracted minerals in the government and under section 4 mining without the required authority is prohibited. The Act has failed to address issues of reclamation and rehabilitation of areas that have undergone land dereliction and degradation as a result of mining activities. The Act makes such issues obligatory rather than mandatory. This has applied in area around Noonkopir Township where there are many quarrying activities.

CHAPTER THREE: REVIEW OF METHODS AND TECHNOLOGIES USED FOR MONITORING LAND USE CHANGES

This chapter involves reviewing and analyzing of various publications on the subject of applications of RS and GIS tools in monitoring land uses, existing land use policies and their influence on spatial organization of the area. The contributions of the past studies are studied and their valuable aspects, weaknesses and gaps appraised in relation to the needs of the study objectives. Past studies in Kenya and globally on the various methods and techniques used in monitoring land use changes were also appraised with their potential benefits *vis a vis* the current methods used.

3.0 Land Information System for Land Use Change Monitoring

Monitoring land use changes requires a uniform spatial referencing for the data in the system, which also facilitates the linking of the data within the system with other land related data and can be provided for in the land use information system.

The international Federation of Surveyors defines land use information system as a:

> "Tool for legal, administrative and economic decision-making and an aid for planning and development. It consists of, on one hand, a database containing spatially referenced land related data for a defined area and on the other hand, procedures and techniques for the systematic collection, updating, processing and distribution of the data."

Both rural and urban development operations and management of these areas require land or geographic information which helps to make possible more informed and equitable allocation of resources and assists in the formulation of appropriate projects designs, to conform with the current urban and/or rural conditions, creating circumstances where better informed decisions can be made (Gitau and Syagga, 1996).

Rapid land use development in both rural and urban areas put increasing pressure on the existing land resource. Thus it is here that Dale in Giles (1990:12) stated that "there exist the most urgent needs to improve the basic cadastral and land registration coverage, both to catch up on the growing backlog of work and at the same time address needs of arising settlements."

Within the Kenya government, there is an increasing demand for various types of land information for monitoring land use changes. Land use mapping is very valuable to a wide variety of planning activities (vegetation, land degradation, agricultural forecasting). In addition, information regarding other physical parameters such as geology, hydrology, soils and climate are also important in land use planning. Ultimately, land ownership and property boundaries become critical factors in any type of land use planning (Habitat, 1999).

In both urban and rural areas in Kenya, the inadequacy of land information is the single major constraint in the effective and efficient management of land use, conferment of tenure security and property rights. These cadastral maps and spatial information are essential element in the critical path of development of land.

For Kenya and particularly North Kaputei, land related information is gathered, processed, updated and distributed on manual basis in registers, records, files, maps and plans and these are kept 45 km away in Kajiado (activities which have been computerized and automated in many parts of the world).

3.1 Conventional Methods

Usher (1991) reckons that to have a well-planned and successful land use management, it would have addressed satisfactorily the methods and technologies for geospatial acquisition, analysis and management.

Mapping is one way of recording the extent and status of land use pattern that is useful in monitoring land use changes. Reliability and usefulness of the monitoring data relate to methods applied. Sampling approaches and methods area used to make measurements

and characterize the natural resources of mapped land uses. The accurate initial inventorying and mapping of land use in each map unit (baseline data) is a prerequisite to land use management.

A map enables the land use planners to: appraise the extent of the map unit areas being considered; check the spread and pattern of the various types of land uses or map units of the natural resources being monitored; consider the appropriate sampling strategy and methods; monitor map units (polygons of land use categories) as ecological units which may change differentially due to various unique pressures applied to them; update these maps, which may reveal general trends in changes in cover type and extent.

However, in most cases particularly in Kenya, maps are rarely upgraded and in fact in fact in Kajiado district the cadastral maps of 1986 are what is used today, which do not reflect the actual development on the ground. For instance, the topo-sheet of the study area shows Kitengela Township as a shopping centre. The infrastructure has since changed which is not reflected in the current map. This is so because the map making process has been analogue, thus making it difficult to update and reprint as opposed to digital process which allows easy update and reprints with less time consumption.

Digital DPS-based acquisition, visualization and analysis of field data are increasingly used as standard by a wide range of environmental, engineering and geosciences industries. However, in geospatial fieldwork the methods have not yet been widely adopted due to the high cost associated with installation, maintenance and use of the technologies as well as the lack of qualified expertise responsible for the exercise.

Nevertheless, the digital mapping provides a number of advantages over the traditional mapping methods and techniques: more efficient data gathering, interpretation and analysis; elevation data in digital mapping is inherently 2.5-D or more; real-time or post processed differential GPS data provides very precise geospatial (x,y,z) control on observations, thus reducing locational error and uncertainty.

3.1.1 Development Control

Development Control is the process of managing urban land uses to conform to a desired pattern and /or structure. It aims to achieve through regulation, growth of a town in a planned and orderly manner. It thus can be used to monitor land use changes in an area.

The rationale for development control is to regulate development and use of land to achieve proper physical form. It thus applies the concept of planning standards, zoning, policies, laws and regulations. Development control involves the provision of specifications and regulation of percentage plot coverage and ensures the conformity of land uses. It is this adherence to these planning provisions that are important in monitoring land use changes.

Development control of land use particularly urban expansion as relates to plot size and coverage by physical structures and land subdivision is indispensable in monitoring land use changes. The prevalent monitoring ideology within which development control takes place in any urban development is reflected by the functional efficiency and harmony of the physical form. (Mwangi, 1988)

3.1.2 Remote Sensing Techniques

Howard (1985), suggested that remote sensing is concerned with collection of data by a sensing device not in contact with the object being sensed, and the evaluation of the collected data, which is then termed 'information' and is presented in map form or as statistics.

Edmonds, R. L et al (1998), defines remote sensing as the science and art of acquiring information about objects without coming into physical contact with them. This technique has been used to document resources systematically since the turn of the century using various tools such as airborne camera and satellites.

Patahn (1993) defines remote sensing to mean detecting and measuring some property of an object without coming into contact with it. He noted that remote sensing is able to tell

foresters a great deal about forests – type and extent of trees, and damage being done to them by disease, logging or environmental changes.

Remote sensing is potentially one of the most efficient methods of acquiring data for land use management and environmental information system encompassing all the physical, chemical and biological aspects of the world. It combines sensing, aerospace and communication technologies, automated data processing information theory and system engineering (Paulson, 1992).

Clearly, the concept of remote sensing covers a huge field within science and technology, which encompasses a vast application domain - that is in the sense of inputs of applied science. Therefore, remote sensing is a science or technological system that collects data about an object or phenomenon by devices that are not in contact with the object or phenomenon. The two important aspects of these definitions are data collection (capture) and data analysis (Patahn, 1993).

Remote sensing technology was developed in the early 1890s and mid 1900s in earnest due to improvement and development of platforms such as aircrafts, rockets and spacecrafts. But this time, the technology was meant for military reconnaissance purposes especially during the World Wars. Remote sensing mainly evolved from aerial photographs interpretation and analysis. Between 1960s and 1970s, more sophisticated imaging systems were developed. This tremendously improved the quality of photography and imaging. Remote sensing then found other civilian applications (Agatsiva, 1987).

The term remote sensing as a distinctive field of technology was coined in 1960 in the USA and former USSR. Today, many other nations have developed and launched their own satellite and/or ground data receiving station. Open skies policy also allows for unconditional remotely sensed data accessibility to all nations of the world. Currently, there exist numerous national and international remote sensing data centers concerned with acquisition, processing, storage and dissemination of remote sensing data from

various sources such as Regional Centre for Remote Sensing and Mapping in Kenya and DRSRS (Agatsiva, 1987).

Late 1980s and 1990s saw the advent of medium modern satellites such as Landsat (MSS and TM), SPOT, JERS-1, SPIN-2 with resolution of between 20m – 80m. Landsat and SPOT data are currently used for land cover and land use monitoring, environmental and natural resource monitoring, development planning and management activities. The latest development in remote sensing technology is IKONOS, which has nominal ground resolution of 4m and 1m and it, has brought operational mapping within practical reach of many potential users (Agatsiva, 1987).

The human eye is a remote sensor, and although we capture images, which may be stored in the brain and later retrieved, we can only reproduce them in a subjective sense. The eye can only capture visible radiation, which occupies a very small part of the complete range of radiation (electromagnetic spectrum).

Remote sensing therefore aids in providing a synoptic view of a region, guiding and facilitating fieldworks that allow for the extrapolation and a mapping framework from field observation.

Remote sensing has a number of positive advantages over other sensing systems:

- It allows change to be monitored in a systematic and orderly way
- It is efficient and very cost-effective in terms of per square kilometer
- It overcomes many data collection problems for example in isolated areas, and the facts that normal data collection may terminate as political boundaries
- It can provide for regular updating of information

By using remote sensing and GIS to analyze the nature, growth rate and location of land use changes, the central and local governments can identify cities and towns. They can formulate plans and policies to deal with such uncontrolled growth. The integration of remote sensing and GIS is a powerful tool and decision support system for urban growth management (Halid, 1998).

Remote sensing technique has also been used in mapping slums and squatter areas on the fringes of main urban centers in the world. The situation in these areas (land tenure conflicts with those in core urban centers and planning) is badly hampered by lack of accurate records on population, infrastructure and housing. The traditional ground mapping methods are not possible because of overcrowding. But remote sensing allows for adequate mapping of infrastructure and other activities in urban areas.

3.1.2.1 Applications and Importance of remote sensing Techniques

Bracken (1990), argued that by 2025, 60% of the world's population would be living in towns and cities. "How will we manage this population and the impact it is bound to have on urban planning, infrastructures, the environment, water supply and other vital resources particularly land?" He concluded that satellite imagery is potential solution for urban planners the world over.

Today, nearly half of the world's population lives in cities while in developing countries, people are deserting rural areas for urban settlements and population is rising rapidly. These two factors in less than twenty years will combine to drive over two billion people into urban areas, which in some cases are already overcrowded and the conditions that many new city dwellers find on arrival simply compound the situation (Erickson, 1995)

Most urban growth falls outside formal planning controls, thus increasing economic and social pressures and exacerbating health and hygiene problems. Erickson (1995) further asserts that urban and rural depopulation would be the main issues of the future and their impact would be felt in many areas such as land and water resources management.

Urban development sometimes has scant regard for the environment and is allowed to continue without the assessment of implications of the resultant land use changes (Lagarde, SPOT image's sales manager for Africa, 1995).

Rene-Joly Assoko-Assoko (1997), in his study on Yoaunde the capital city of Cameroon revealed that the city is suffering from anarchic land use and increased risks of flooding, erosion and landslides. To resolve this problem, he suggested, "we must identify and

distinguish zones that can or cannot support urban densification, and we need to keep up with the pace of urban growth".

To keep up with the pace of urban growth and impact on land use changes, there is need for objective data on population influx to assess the impact of growth and to plan development actions. There is also need to analyze urban encroachment on arable and rangeland so that the effects can be evaluated effectively. This requires a spatial view of cities at different dates to enable planning and update land use and land cover maps and much more to upgrade the necessary infrastructures (Assoko-Assoko, 1997).

He further argued that, the rate of urban growth particularly in developing countries in the modern era is making it increasingly difficult to keep track of populations and resulting land use changes, and traditional survey and census methods are proving inadequate as they are time consuming such that information collected become obsolete even before they reach users' desks and thus prove to be of limited use in monitoring populations and the subsidence land use.

The solution: 'Combine satellite imagery with other data sets, says Lagarde (1998). The need for up-to-date data to conduct detailed spatial analysis means that most urban planning department should turn to satellite imagery to give them a broad picture of urban areas untrammeled by boundaries on the ground. Satellite image resolution is currently good enough to produce maps at scales of 1:100 000 up to 1:50 000 and even 1: 25 000 in certain cases (Lagarde, 1995).

Satellite imagery is a vital source of global, frequently updated and reliable information for producing and updating land use maps; satellite data are easily integrated in geographic information systems and are an ideal tool for change detection in rapidly changing areas (Hirschfeld, 1998).

Urban fringes are precisely where uncontrolled settlements of new migrants tend to appear and where planning policy is often not wanting. The utility of satellite imagery is further enhanced when combined with other data. For example, photo interpreters can

analyze Spot image to identify homogeneous habitat zones, and analyze habitat type and density in more detail (Lagarde, 1995).

Satellite imagery is also well suited to detecting change in land use and land cover at various intervals such as five, ten or fifteen years. Keeping track of change over time is vital to provide accurate input for planning guidelines, and here again the remote sensing system has much to offer (*ibid).*

Hirschfeld (1998) explains that clarity of information is key to monitoring change but the question now is: How can satellite images benefit urban planners, who rarely have the required knowledge of remote sensing? Local government agencies need accurate, regularly updated geographic information that they can use immediately. That means it must be pre-interpreted and ready for retrospective analysis and land-use change detection.

Hirschfeld (1998), notes remote sensing is the ideal tool to help planning departments make the right decisions concerning large areas experiencing rapid change, because it lets them compare observed patterns of change at different dates. Various remotely sensed images thus provide a clear picture of urban and agricultural land use.

He further said that with VHR imagery, planners would be able to move inwards from the peri-urban fringes and zoom in on urban centers, where data would have to be refreshed very frequently indeed. Urban planning applications require multi-temporal information, so here complementarity between Spot and other high-resolution data would be an extra asset. And as urban planners and decision-makers know only too well, you have to look at the land from all angles to see the whole picture.

Evaluation aids More Effective Planning in Pretoria

South Africa's Satellite Application Centre (SAC) operates the Spot receiving station and distributes Spot imagery. The SAC has devised a programme to evaluate population growth in a zone to the North of Pretoria. With its gross domestic product outstripping that of all the other sub-Saharan countries put together, South Africa is indeed an

attractive destination for migrants. The SAC conducted a precise evaluation of population influxes and condensed it into a few key figures to guide the government's future planning decision.

Marrakesh: a tale of two cities

For many years Marrakesh in Morocco was hemmed in by its fortified wall, which runs for ten kilometers around the city. But as the city has expanded, the focus of its population has gradually shifted to a new zone that has grown around a concentric scheme, thus making Marrakesh a curious "tale of two cities" (Halid, 1998).

To restore balance to the ensemble, the Moroccan government requested development proposals. One of the projects submitted in 1994 used Spot imagery to evaluate the city's future expansion, based on simulations of how it will look in 2000 and 2020. Population maps and synthesis images of the city illustrated simulation results at different dates. Forecasts for 2020 thus help planners to weigh their options, such as whether to relocate the airport or where to route the corridor for the western by-pass, for example.

Cities Eat into the Countryside in China

70 to 80 % of the population in China still lives in the countryside. But, China's cities are enjoying strong economic growth of around 7 to 10 %, and even as high as 15 % on the southeast coast. Urban expansion acts as a magnet that is draining populations from rural areas, obliging cities to review their infrastructure and land use planning strategies urgently (transportation, highways, residential zoning, etc.).

Spot panchromatic images acquired in 1998 and 1999 highlighted land use changes in China's seventy-two main cities. These images also served to assess the impact of urban growth on agriculture in a country that harbors one fifth of the world's population, but only 7 % of its arable lands.

3.1.2.2 The Case for Kenya

Kenya faces the challenge of monitoring the status and trends on land-based natural resources and providing timely information necessary for planning and management of land uses. Remote sensing has been used to create and update maps; inventory present land uses; assess suitability of different forms of use (e.g. human settlement, economic infrastructure and nature conservation); monitor growth of urban centers and plan recreation areas; identify/monitor critical wildlife habitat; and facilitate land use analysis and planning, leading to sustained land use planning and socio-economic development (Survey of Kenya, 1987)

The current land use practices in Kenya are being undertaken without proper knowledge of changes and the available cover extent. Satellite imagery (particularly Landsat and SPOT) has been used to map land covers in the country. This exercise is crucial since it gives a synoptic picture of the status and trends on land use based on natural resources only.

Box 3.1: Use of remote sensing in land use mapping

Case Study: Kisumu Land use maps and information system
A study carried on Kisumu revealed significance of LIS for the management of the urban areas. The satellite images were interpreted visually for different themes such as housing, communication network, different land use types, and vegetation cover. These were then digitized into a GIS database. A user interface was then created from GIS database using Arc View.

Source: Seminar Presentation Paper, KISM, 1998

Remote sensing has also been used in mapping vegetation by identifying factors responsible in vegetation cover; monitoring and estimating forest degradation in order to plan for rehabilitation/conservation measures; estimating timber volume and its value; and planning efficient timber harvests (Agatsiva, 1998). Remote sensing techniques have also been used in coastal zone management. Radar data is of great use in the exploration of the coastal zone

Timely monitoring of rangelands is vital for their management in Kenya, as these ecosystems have faced increased pressure over the years. NOAA satellite data at 1km spatial resolution has a wide coverage and the spectral channels needed for monitoring

green vegetation dynamics over extensive areas, giving up-to-date information for handling short-term crisis as well as long-term management plans for rangelands.

Box 3.2: Vegetation Mapping

Case Study: Forest Cover Mapping Exercise in Kenya

Forest cover mapping has been undertaken to provide forest management information. The interpretation and subsequent delineation of features of interests for the images were based on their reflectance characteristics. Large expanses of homogeneous areas of forest can clearly be seen on the images and the identifying various classes of vegetation cover on the basis of their shades, texture and shape which correlates to the various vegetation attributes such as phonology, percentage canopy and homogeneity.

Monitoring of forest is carried out to detect changes occurring and subsequently establish their magnitude and trends. Such changes include deforestation, encroachment incisions and degradation by use of multi-temporal images.

Source: Seminar Presentation Paper, KISM, 1998

Recent advances in hardware and software technology mean that powerful multi-attribute mapping and high resolution spatial analysis can now be carried out rapidly in the field. Using satellite-based communication systems, field data may be directly imported to 3-D visualization, analysis and 4-D modeling packages held on powerful computers remote from the field location. These satellite-enabled digital workflows can provide further constraints on the viability of ongoing interpretations giving opportunities to view and analyze data collected in situ and facilitate an interactive approach to be adopted in structural problem solving.

3.1.3 Geographic Information Systems

Geographic information systems (GIS) technology has been used for scientific investigations, resource management, and development planning. Such that, a GIS technology allows emergency planners to easily calculate emergency response times in the event of a natural disaster, or a GIS has been used to find wetlands that need protection from pollution (USGS, 2001).

The important concept in GIS processing that gives it more advantages over the conventional methods is that geographic data includes both spatial and descriptive data. Spatial (or graphic) data is simply data that has a location (a geography) like farm, plot or

street. Descriptive data (or attribute data) is information associated with a particular physical object, or data set; it describes that entity which has some geographical location. For instance, a land parcel that has a particular location might be five acres in area, owned by Kapiti Dairies and is divided into ten plots. These items are descriptive of the parcel hence they are attributes of the parcel. GIS also keeps track of the particular relationships between geographic features that is, a parcel lies within a larger area representing residential zoning (USGS, 2001).

Logsden (1995) notes that GIS deals with geo-referenced spatial data as well as non-spatial data (attributes) and includes operations, which support spatial analysis. GIS allows for the satellite images interpreted to be digitized into a map. New and planned land uses if available are readily mapped and whenever possible monitored so that any changes can quickly be identified. Because GIS can store the data digitally, any new changes can easily be updated with minimum delay and significance making the exercise inexpensive and less time-consuming.

GIS has two components: a method of representing graphics (lines, points and polygons) and a method for processing attribute data. It is the powerful quality of integrating these methods that is one of the many factors distinguishing GIS from other computer processing systems (like CAD). The other primary factor is how the graphics data is mathematically related and represented (topology) which allows for certain GIS operations.

Muasya (2001) gave various reasons why GIS technology is very important to many fields especially in this generation. He said GIS technique is to geodata analysis what the microscope has been to biological sciences. GIS makes it possible to integrate spatial and other kinds of data within a single system and it offers consistent framework for analyzing geographical data. By enabling the operator to put maps, graphic documents and other forms of spatial information (descriptive) into digital form, GIS allows for manipulation and display of geographical information in new and exciting ways that were not possible in the conventional mapping systems.

GIS technique enables one to make connections between activities based on geographic proximity. These connections are often unrecognized without GIS, but can be vital in understanding particular phenomenon and greatly assisting in management of activities and resources (Bracken et al, 1990)

In most developing countries, administrative records of property ownership, tax file records, utility infrastructure are stored in different organizations, institutions and offices. Using appropriate networking, GIS allows access to these records via their geographical positions.

3.1.3.1 Great interests in GIS

Interests in using GIS have been fuelled by the fact that GIS gives a 'high tech' feel to geographic information. Maps had been made conventionally in the past, a process that was tedious and sometimes involving boring and repetitive processes. However, digital mapping that is inherent in GIS technology makes map-making a fascinating experience (Burrough, 1986).

Increasing necessity to continuously monitor the environmental degradation associated with various developments on land has called for the use of GIS which offers an important tool in understanding, analyzing, monitoring and managing complex environmental concerns.

Marble et al (1983) state that operational applications of GIS today include such areas as land and resource management, traffic planning, marketing, military planning as well as a variety of other uses. These statements imply that successful applications of GIS must occur within institutional settings. They also indicate that the operation of such systems must be conducted with a long-term perspective.

One view of this process was espoused by Crain and MacDonald who suggested that a successful GIS must evolve from an inventory tool to an analysis tool, and then ultimately to a management tool. (Crain and MacDonald, 1983)

3.1.3.2 Advantages that can be accrued from GIS

GIS as a Decision support system

Another perspective of a GIS examines its success in the context of a decision support system. Most of the work on GIS design emphasizes this approach. Calkins and others stress that a successful GIS must support the management of some resource or some problem solving process. Furthermore it would appear that a successful GIS must exist within an organizational setting that is capable of providing with proper feeding and nurturing (Calkins and Tomlinson, 1977).

Over the years GIS has various advantages over the conventional techniques of geo-data analysis and management. Walker et al, (1986) has suggested that GIS work in the following ways: Relating information from different sources, Data capture, Data integration, Projection and registration, Data structures and Data modeling

Relating Information From Different Sources

Walker, et al. (1986) notes that *GIS has ability to use information from many different sources in many different forms, which can help with various analyses.* The primary requirement for the source data is that the locations for the variables are known. Location may be annotated by X, Y, and Z coordinates of longitude, latitude, and elevation, or by such systems as ZIP codes or highway mile markers such that any variable that can be located spatially can be fed into a GIS.

Different kinds of data in map form can be entered into a GIS, which can also convert existing digital information (which may not yet be in map form) into forms it can recognize and use. Digital satellite images have been analyzed to produce a map like layer of digital information about vegetative covers and land use. Likewise, census or hydrologic tabular data can be converted to map-like form, serving as layers of thematic information in a GIS.

Data Capture

Data capture - putting the information into the system - is the time-consuming component of GIS work. Identities of the objects on the map must be specified, as well as their spatial relationships. Editing of information that is automatically captured could also be difficult. Many people have wondered how a GIS can use the information in a map? If the data to be used are not already in digital form, that is, in a form the computer can recognize, various techniques can capture the information. Maps can be digitized (as in the case of this study), or hand-traced with a computer mouse, to collect the coordinates of features. Electronic scanning devices also convert map lines and points to digits (Walker, 1986).

A GIS can be used to emphasize the spatial relationships among the objects being mapped. While a computer-aided mapping system may represent a road simply as a line, a GIS may also recognize that road as say, border between a forest and urban development, or as the link between Nairobi and North Kaputei. (USGS, 2001).

Data integration

A GIS makes it possible to link, or integrate, information that is difficult to associate through any other means. Thus, a GIS can use combinations of mapped variables to build and analyze new variables (Logsden, 1995).

Logsden (1995) further illustrated that using GIS technology and Water Company billing information, it is possible to simulate the discharge of materials in the septic systems in a neighborhood upstream from a wetland. The bills show how much water is used at each address. The amount of water a customer uses will roughly predict the amount of material that will be discharged into the septic systems, so that areas of heavy septic discharge can be located using a GIS.

Projection and registration

A property ownership map might be at a different scale from a land use map. Map information in a GIS must be manipulated so that it registers, or fits, with information gathered from other maps. Before the digital data can be analyzed, they may have to undergo other manipulations - projection conversions, for example - that integrate them into a GIS (ESRI White Paper, 1998).

A projection is a mathematical means of transferring information from the Earth's three-dimensional curved surface to a two-dimensional medium - paper or a computer screen. Different projections are used for different types of maps because each projection is particularly appropriate to certain uses.

Since much of the information in a GIS comes from existing maps, GIS uses the 'processing power of the computer' to transform digital information, gathered from various sources with different projections to a common projection (ESRI White Paper, 1998).

Data structures

Can a property ownership map be related to a satellite image, a timely indicator of land uses? Yes, but since digital data are collected and stored in various ways, the two data sources may not be entirely compatible. So a GIS must be able to convert data from one structure to another. Image data from a satellite that has been interpreted by a computer to produce a land use map can be "read into" the GIS in raster format. Raster data files consist of rows of uniform cells coded according to data values. An example would be land cover classification (ESRI White Paper, 1998).

The computer can manipulate raster data files quickly, but they are often less detailed and may be less visually appealing than vector data files, which can approximate the appearance of more traditional hand-drafted maps. Vector digital data have been captured as points, lines (a series of point coordinates), or polygons/areas (shapes bounded by

lines). An example of data typically held in a vector file would be the property boundaries for a housing subdivision.

A GIS can perform data restructuring by converting data into different formats. For example, a GIS may be used to convert a satellite image map to a vector structure by generating lines around all cells with the same classification, while determining the cell spatial relationships, such as adjacency or inclusion. Thus a GIS can be used to analyze land use information in conjunction with property ownership information.

Data Modeling

This is the conceptual organization of a database. It is the style of describing and manipulating the data in the database. Spatial data models specify the sets of components and relationships among the components that must describe both the locational and non-locational aspect of the features of interest. This collection of information forms the heart of a digital cartographic database which provides the capabilities to handle the data in ways that were previously impossible.

For instance, it is difficult to relate wetlands maps to rainfall amounts recorded at different points such as airports, television stations, and institutions. A GIS, however, can be used to depict two and three-dimensional characteristics of the Earth's surface, subsurface, and atmosphere from information points.

For example, a GIS can quickly generate a map with lines that indicate rainfall amounts. Such a map can be thought of as a rainfall contour map. Many sophisticated methods can estimate the characteristics of surfaces from a limited number of point measurements. A two-dimensional contour map created from the surface modeling of rainfall point measurements may be overlain and analyzed with any other map in a GIS covering the same area.

3.1.3.3 What is special about a GIS?

In ESRI White Paper (1998), it is indicated that the way maps and other data have been stored or filed as layers of information in a GIS makes it possible to perform complex analyses in various ways compared to the conventional methods which are outmoded. Such as information retrieval, topological modeling, overlay and data output.

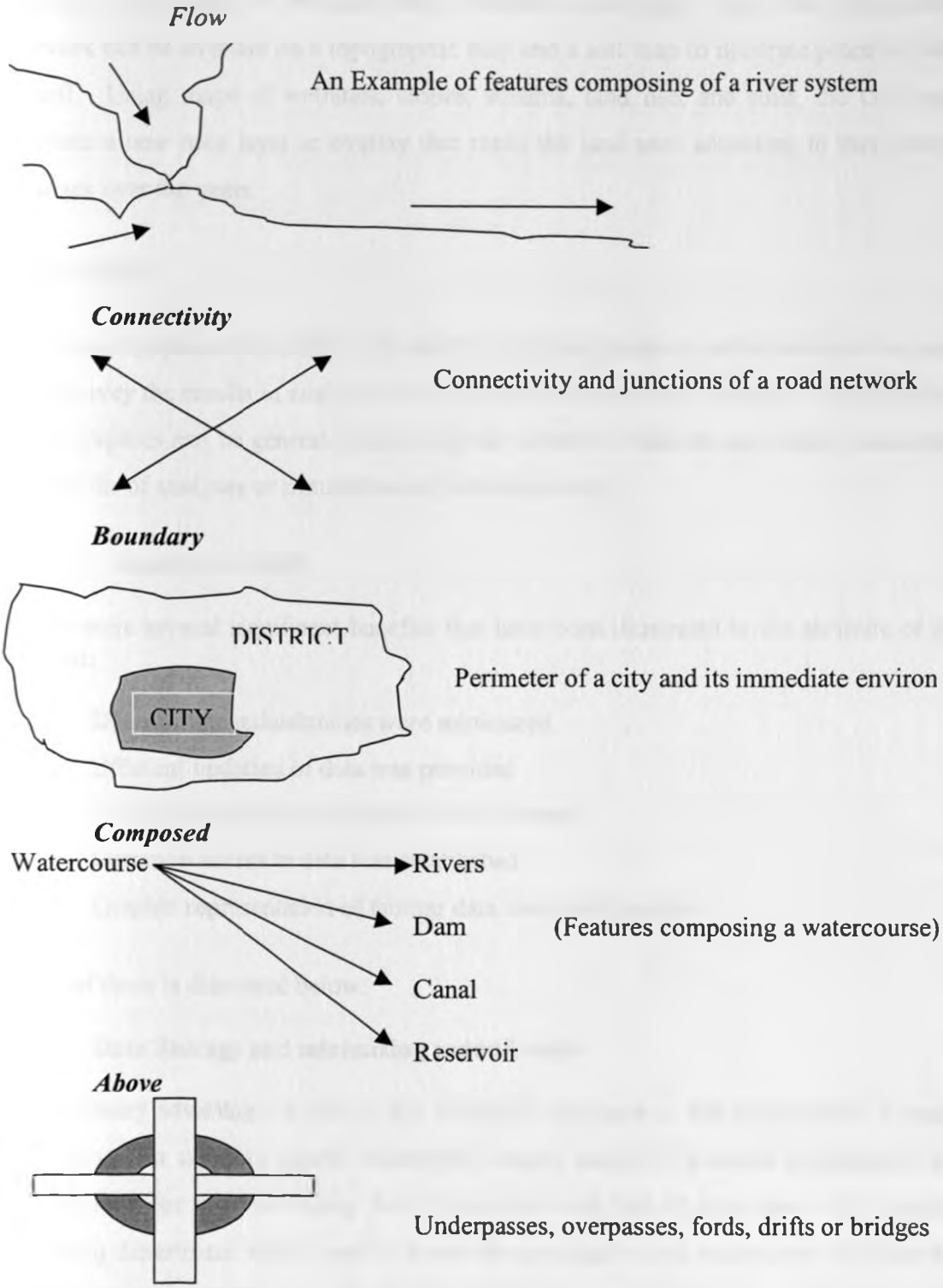
Information retrieval

With a GIS you can "point" at a location, object, or area on the screen and retrieve recorded information about it from off-screen files. Using scanned aerial photographs as a visual guide, you can ask a GIS about the geology or hydrology of the area or even the list of landowners and the level of subdivision. *About how close a mining activity is to the road.* This kind of analytic function allows users to draw conclusions about the swamp's environmental sensitivity.

Topological modeling

A GIS can recognize and analyze the spatial relationships among mapped phenomena. Conditions of adjacency (what is next to what), containment (what is enclosed by what), and proximity (how close something is to something else) can be determined with a GIS. These relationships are used to express interactions that occur between features that are otherwise difficult to represent either with locational data, topological relationships or features descriptions. In modeling relations between features that are difficult to represent should come out clear. Some of these situations can show flows, connectivity, and boundary as shown below:

Figure 3.1: Special Topological Attributes of GIS



Source: Adapted and modified from various sources (Calkins et al 1977, Okoth, 1992 and researcher's constructions, 2003)

Overlay

Overlay is the ability to see data sets combined in one map. Such that infrastructure network can be overlaid on a topographic map and a soil map to illustrate potential water runoff. Using maps of wetlands, slopes, streams, land use, and soils, the GIS might produce a new map layer or overlay that ranks the land uses according to their relative changes over the years.

Data output

A critical component of a GIS is its ability to produce graphics on the screen or on paper that convey the results of analysis to the decision makers about resources. Wall maps and other graphics can be generated, allowing the viewer to visualize and thereby understand the results of analyses or simulations of potential events.

3.1.2.4 Benefits of a GIS

There were several significant benefits that have been illustrated in the attribute of data portion:

1. Data storage redundancies were minimized
2. Efficient updating of data was provided
3. Information retrieval efficiency was increased
4. Common access to data was established
5. Graphic representation of tabular data was made possible

Each of these is discussed below:

1. Data Storage and minimizing redundancies

The primary advantage of GIS or any computer databases is that they provide a central depository for users to access. Municipal, county and town councils departments will always have the need to overlap their information with that of other users – for example, planning department would need to know the topography and water/sewer facilities that existed in an area of a proposed subdivision. Duplication of records, say information that the Land Control Board needs, and data the assessing and planning departments keep, is a

fact of life. But if that data could be stored in one place, one time, and made available to all who need it, the costs (in manpower, man-hours, and space) could be reduced.

In Kenya's case, this can be illustrated in several instances. One particular application show both the sewer and water network information usually in two separate files and map sets combined so that a road repair or construction crew digging up a section of a street could have all the necessary data.

Another issue of redundancy is in duplication of representation: the water department might symbolize and catalogue fire hydrants one-way, and the fire department might do it another way. It might be unclear that 'Device A' and 'Device B' is the same structure. A GIS solves this by having the data common to both departments.

2. Efficiency in updating

The major problem with updating land related data is making it available to others who need it. If the public works department installed a fire hydrant, the changes could be made to their record, and the fire department would have this current data available to them at the same time.

(If a road reserve has been left by the public works of the ministry during a road construction, the changes could be made to their record and the planning departments would have this current data available to them at the same time to ensure that no allocation of the road reserve is made.)

3. Information Retrieval

The ability to have a real time querying capability of the GIS database is probably the single most advantageous benefit realized in an information management system. Retrieval of data is optimized by the fact that the GIS contains all of it, all information in the computer can be accessed by any user, as opposed to chasing down records in different files (and in different buildings, or places) as is usually the case in North Kaputei.

One aspect of a GIS that is difficult to measure is that of the information processing advantages it can offer. This benefit is hard to quantify because the GIS allows the retrieval and analyses that might have otherwise never been considered. In any event, most data queries and statistical operations show large efficiency increase over manual or disparate software methods.

(For example, planning department would be able to visualize this capability by querying GIS for a listing of property whose sizes is less that ¼ acre and/or even those that have been subdivided in the last 10 years. A map would also be generated to highlight these parcels.)

4. Common access

The issue of common access is a vital one in utilizing the GIS to its fullest extent. The primary advantage is in providing each department's data to others who may need it. Of course security measures can be taken to limit access and prevent accidental alterations of the database.

5. Graphic Representation of Tabular Data

Due to the integration of all geographic data via a GIS, data structure information that has existed in the past as records, work orders, invoices, and reports is capable of being represented in a graphical fashion. For instance, map could be generated highlighting those parcels on which families with school-aged children live. By integrating the street network with this data, a school bus routing plan could quickly be established.

3.2 Land use Information Management

In Kenya, land use related information is gathered, processed, updated and distributed manually in registers, records, files, maps, and plans, activities that make monitoring of land use changes and their management difficult and inefficient. The district lands office, the district survey office and the County councils works closely with each other. The table 3.1 summarizes the types of information resulting from the district land related offices.

In North Kaputei or Kajiado district, the government has invested considerable time and money in collecting, managing and disseminating a vast stock of land records as evidenced in table 3.1. However, much of this information is still in the analogue form, often disorganized, outmoded with inefficient methods of collection, management and dissemination. There is also lack of storage space in most departments dealing with land use activities. A major problem results from the land records being independently generated, collected and maintained by different Ministries, departments, sections or offices, and found in variety of forms such as white/green cards, RIM, mutation forms, various files (area, block, correspondence, parcel) registers etc. Consequently it is often difficult to interrelate these records due to their varying levels of analysis and presentation, availability, accessibility and quality. Moreover, in a number of cases, such information lacks copies or backs up in case of misplacements, destruction or corrupt practices resulting in disappearance of files.

Box 3.3: Examples of Land Records

- Different land records exist as property record books, paper files, microfiche, maps, charts etc
- Different land records have been collected at varying levels of detail and accuracy or are mapped at different scales.

Source: Habitat, 2001

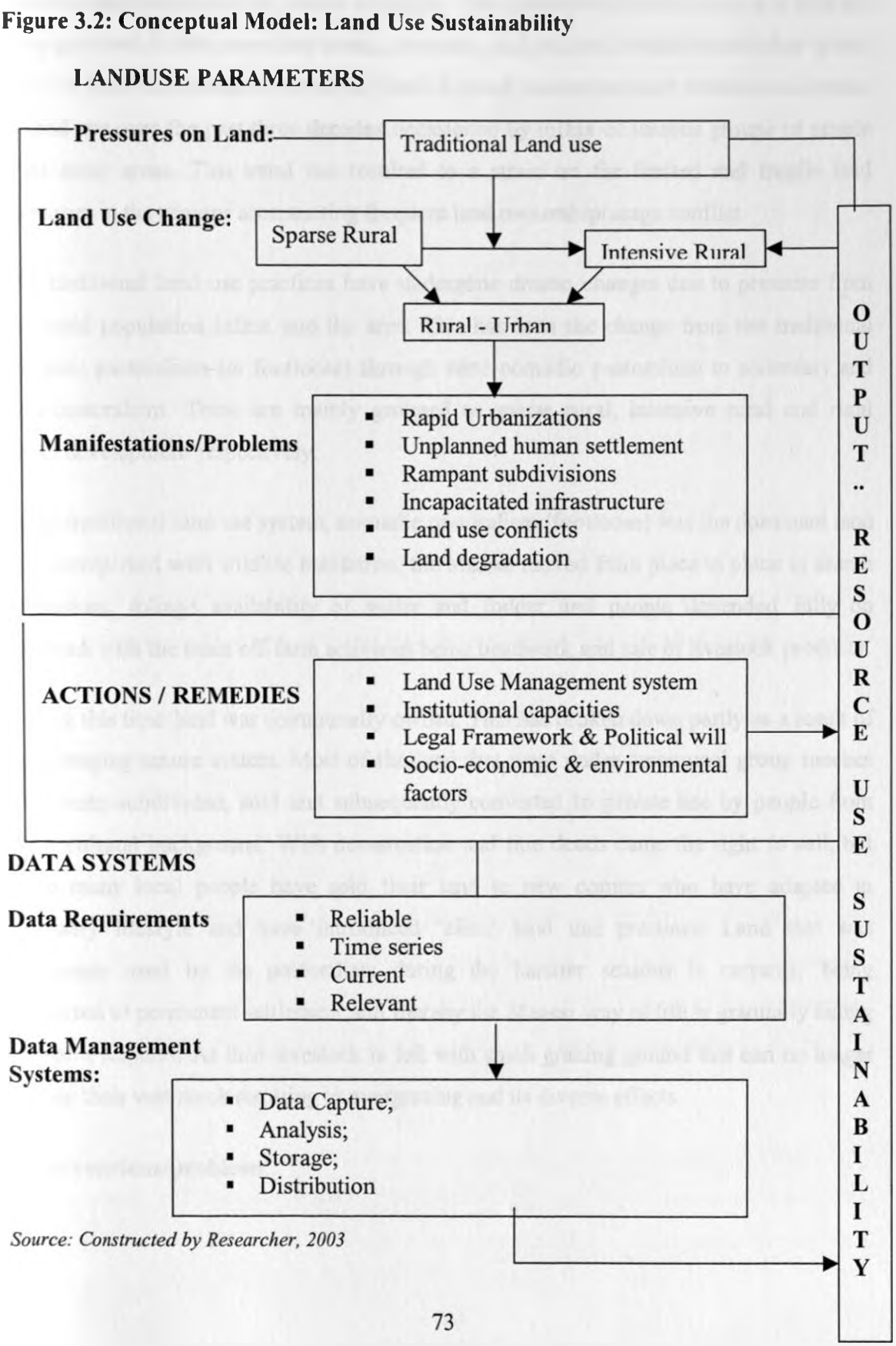
Table 3.1: Land Information Types in North Kaputei

Purpose	Type of information	Form	Storage	Problem/difficulties
Subdivision	Mutation details	Mutations (subdivision form)	Parcel files (record office)	For all types of land information types No storage space
Changes of User	Part development plan, application approval by physical planner	Plans and letters of approval	Parcel file, register (filing cabinets)	No proper arrangement therefore they wear out faster
Land transfers and conveyancing	Letters, application forms, transfer forms application receipts, consent letters	Letters, application forms, transfer forms application receipts, consent letters	Parcels and correspondence forms	No proper arrangement therefore they wear out faster
Adjudication and demarcation	Record on parcel number, size, owner	Forms of transfer of land	Parcel files, cabinets and shelves	No proper arrangement therefore they wear out faster
Registration	Registration of charges Registration of transfer Registration of correction of names and exercise of sale	Letter of consent to transfer, application form receipts, official search from land control board	Parcel and correspondence files	No proper arrangement therefore they wear out faster
Titles	Ownership L.R. No. Size, ground rents	Copy of title for leasehold (white), freehold (green)	Green and white cards in Kalamazoos (archives)	Kalamazoos no longer available
Building plans	Plot sizes, coverage drawings	Approved building plans	Parcel files	Plans put in parcel files are often destroyed

Source: Modified from Habitat, 2001 and field research, 2002

3.3 Conceptual Framework

Figure 3.2: Conceptual Model: Land Use Sustainability



Source: Constructed by Researcher, 2003

Based on the above review, the conceptual model begins by recognizing land as a resource and the basis of all human activities. The interaction between man and land has been governed by the prevailing social, economic and political conditions and this in turn result to land use changes in an area. North Kaputei has experienced tremendous change in land use over the past three decades occasioned by influx of various groups of people from other areas. This trend has resulted to a strain on the limited and fragile land resources in the regions accentuating frequent land ownership/usage conflict.

The traditional land use practices have undergone drastic changes due to pressure from the rapid population influx into the area. This has seen the change from the traditional nomadic pastoralism (or footloose) through semi-nomadic pastoralism to sedentary and agro-pastoralism. These are mainly grouped as sparse rural, intensive rural and rural urban development respectively.

In the traditional land use system, nomadic pastoralism (footloose) was the dominant land use interspersed with wildlife habitation, the Maasai moved from place to place in search of pasture, foliage availability of water and fodder and people depended fully on livestock with the main off-farm activities being beadwork and sale of livestock products.

During this time land was communally owned. This has broken down partly as a result of the changing tenure system. Most of the land that were under communal group ranches have been subdivided, sold and subsequently converted to private use by people from other cultural background. With demarcation and title deeds came the right to sell, but since many local people have sold their land to new comers who have adapted to sedentary lifestyle and have introduced 'alien' land use practices. Land that was previously used by the pastoralists during the harsher seasons is currently being converted to permanent settlement and thereby the Maasai way of life is gradually fading in North Kaputei. As their livestock is left with small grazing ground that can no longer sustain their vast stock resulting to overgrazing and its diverse effects.

Manifestations/problems

With the rapid change in land use as a result of pressure on land and change in land tenure system in North Kaputei come with the problems of urbanization, unplanned settlement arise, rampant subdivisions and resultant land use conflicts. Urbanization and demographic factors are especially important in determining people's interaction with the land resource, which lead to land use changes, causing uncoordinated, uncontrolled and compromising land use, rampant subdivision as well as incapacitated infrastructure if no planning intervention is practiced. Hitherto land cannot accommodate the traditional land use practices.

These effects are then the essence of monitoring land use changes in an area particularly rapidly urbanizing area like North Kaptuei.

Remedy/actions

Addressing the manifestations attributed by the rapid land use changes requires a data system that will address the problems accruing. Notwithstanding the failures of government interventions in urban land markets, some degree of government control must be exerted over urban land use and development. Without effective policies and regulations, it is unlikely that private actors in the land market and development will take into account the cost that their decisions concerning use, density, design, location, and timing of development may impose on sensitive land and cultural resources. This requires political will by those in power, legal backing and institutional capacity to address the manifestation arising from rapid land use change.

In order to properly manage land uses and protect land for prosperity, the changes in uses and their densities need to be efficiently monitored and administered in a sustainable manner. In addition, such techniques lays the groundwork for pulling in the broadcast of actors whose participation is needed for effective land use management strategy to succeed.

Without information on the resources to be managed, it is extremely difficult if not impossible for the relevant authorities to establish effective regulations and policies that affect their areas. Similarly lack of timely and accurate data necessary for land

transactions and development seriously constrain the formulation and implementation of relevant management strategies.

Data System

Undertaking such actions demands various data and information that is reliable, current, and relevant and in time series (at different periods of time) and various methodologies are used to acquire and manage the necessary categories of data/information. Remote sensing provides information on land cover from which land use can be inferred. This is supplemented with conventional methods such as field surveys that provide the necessary household characteristics and land use information and GIS provides the data management and analysis facility.

For data management systems, Remote Sensing and other methods can be used to capture synoptic and panoramic of regions; cost per unit area inexpensive; while GIS tool that allows for integration of various data elements and has a wide scope of data manipulation; has capability to produce and update maps and tabular data would provide analysis and storage facilities.

GIS provides the invaluable tool for planning for development, as it is one of the most recent automated technology advancement in the world used for generating spatial inventory maps and for maintaining tabulated information. It is capable of integrating data from various sources to provide information necessary for effective decision-making.

CHAPTER FOUR

BACKGROUND TO THE STUDY AREA

4.0 Introduction

This Chapter introduces the area of study. It gives an overview of the physical characteristics, the socio-economic characteristics and human settlement of North Kaputei. The physical aspects covered include location and size, topography, geology and soils, climate and agro-climatic zones, as well as drainage and hydrology. The socio-economic set up of the study area includes economic activities since independence, infrastructure and services and population and demographic characteristics. This chapter concludes by looking at the evolution of human settlement in the study area including land use changes in the 1960s, 1970s, 1980s and 1990s.

4.1 Physical Characteristics

North Kaputei exhibits unique physical characteristics, which are based on interplay of physical features with biological and human settlement components of both traditional and modern land uses dichotomy.

4.1.1 Location and Size

North Kaputei lies between longitudes $36^0$5' and $37^0$55' east and between $1^0$10' south. It covers an area of 390.4 square kilometer. It falls within Kajiado district in the rift valley province bordering Machakos to the East, Taita Taveta to the South East, Nairobi, Nakuru and Kiambu to the North, Narok to the West and Republic of Tanzania to the South *(Map 4.1)*.

Until 1995, the study area fell under North Kaputei location within Central division of Kajiado district. Due to rapid population increase, North Kaputei location was upgraded to Isinya division consisting of Isinya, Ol turoto and Kitengela locations. Today the study area is comprised of three sub-locations namely: Kitengela, sholinke and Oloosirikon. It is bound by the Kenya-Uganda Railway line to the East, River Kisaju to the South, the Pipeline road to Kiserian to the West, and to the Northwest borders the Nairobi National

Park, and river Kitengela to the North. Kitengela Township lies in the study area bordering Athi River township/Mavoko to the north and lies about 40 kilometers southeast of City of Nairobi as shown in map 4.2.

4.1.2 Topography

Plains and occasional valleys characterize the general topography of the study area. It falls into two areas: Athi Kapiti plains Central Broken ground which are favorable to the siting of industries and grazing grounds as well as other human settlements.

Athi Kapiti consists of gently rolling and hilly towards Ngong Hills. These Hills are the catchments areas for Kitengela, Athi and Kisaju rivers, which are important sources of water for the livestock, domestic use and small-scale farming as well as other land uses in the area. The altitude range is 1580 – 2460 meters above sea level.

The central broken ground compromises a 20 – 70 km wide stretch from northeast border across the district to southwest. Crisscrossing the area are dry riverbeds, which are important sources of sand for building and construction industry both in the area and in the proximate City of Nairobi. The altitude here ranges from 1220 – 2073 meters above sea level.

4.1.3 Drainage and Water Resources

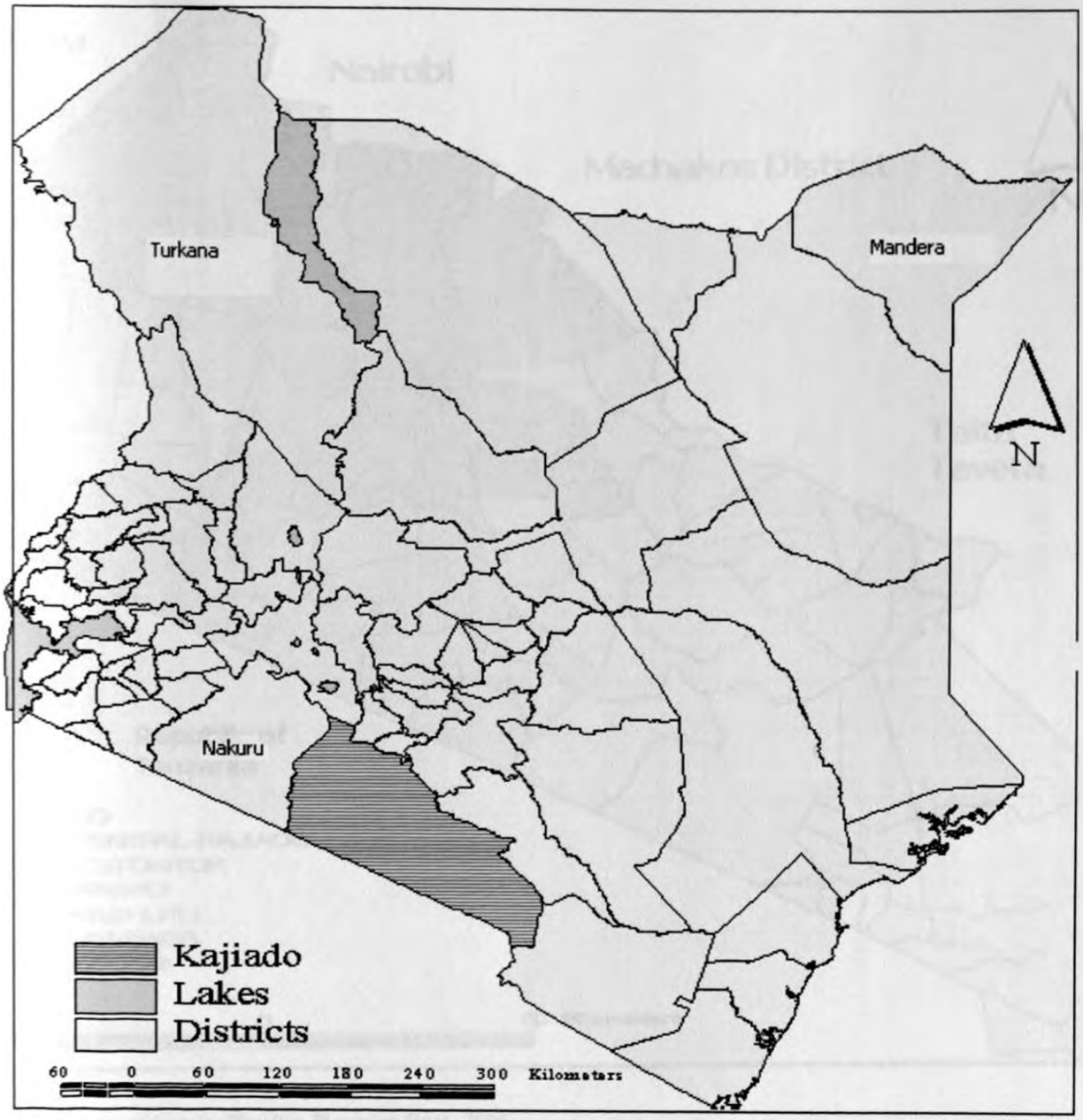
The region does not have adequate surface water for livestock and human consumption. To a greater extent, the area depends on ground water reserves, which is influenced by climate and topography as well as the underlying rock.

The alternative sources of water for domestic and livestock consumption and other land uses are sub-surface sources like water pans, dams and shallow wells. The study area falls under the Upper Athi Catchments whose headwaters are in the Ngong Hills and occupy most parts of the study area. Stony Athi, Empakasi and Kitengela are its major water courses. It is approximately 2,080km^2 (Map 4.5).

Map 4.1: Map of Kajiado District

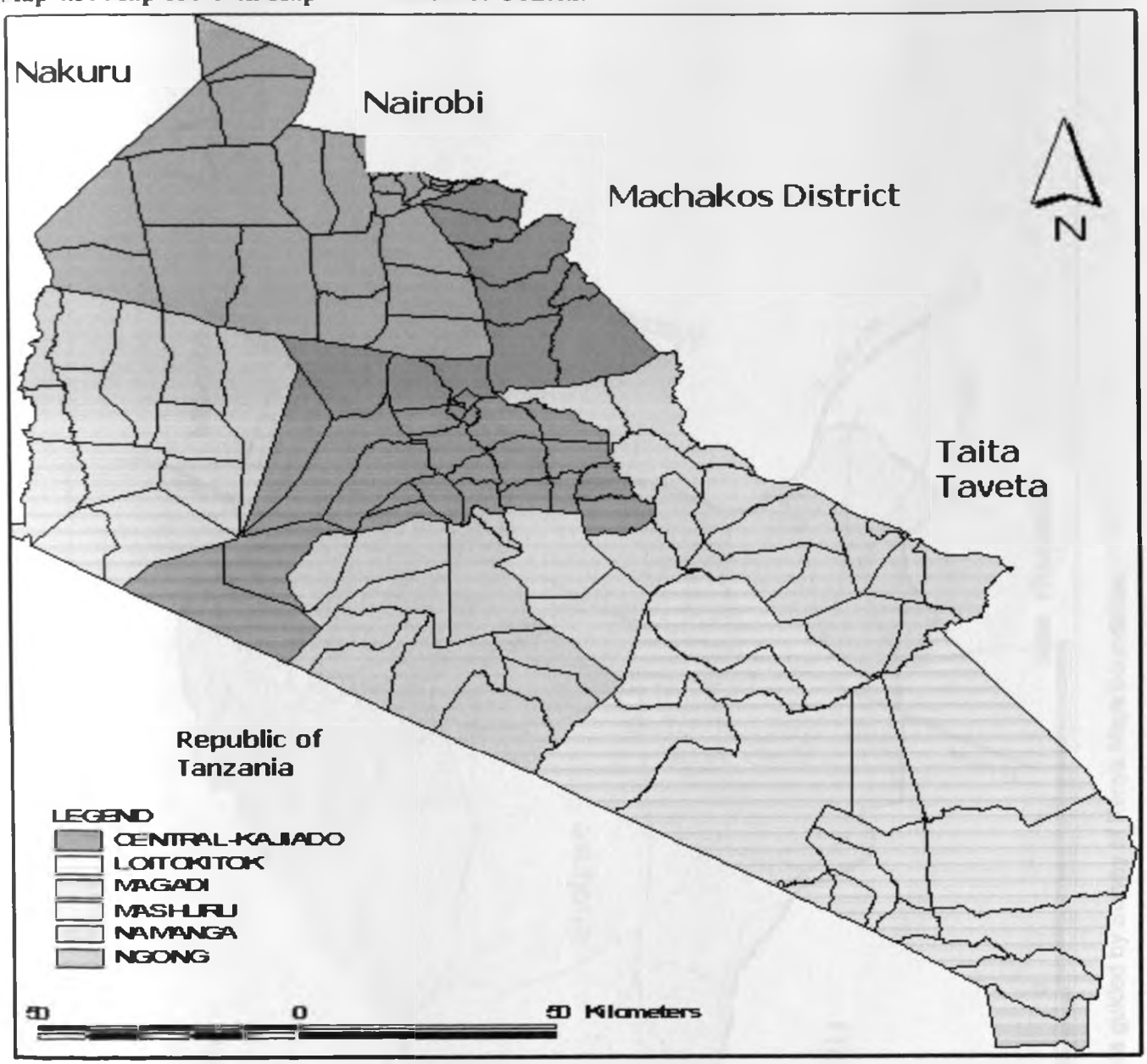
Source: Survey of Kenya, 2002

Map 4.1: Map of Kajiado District in National Context



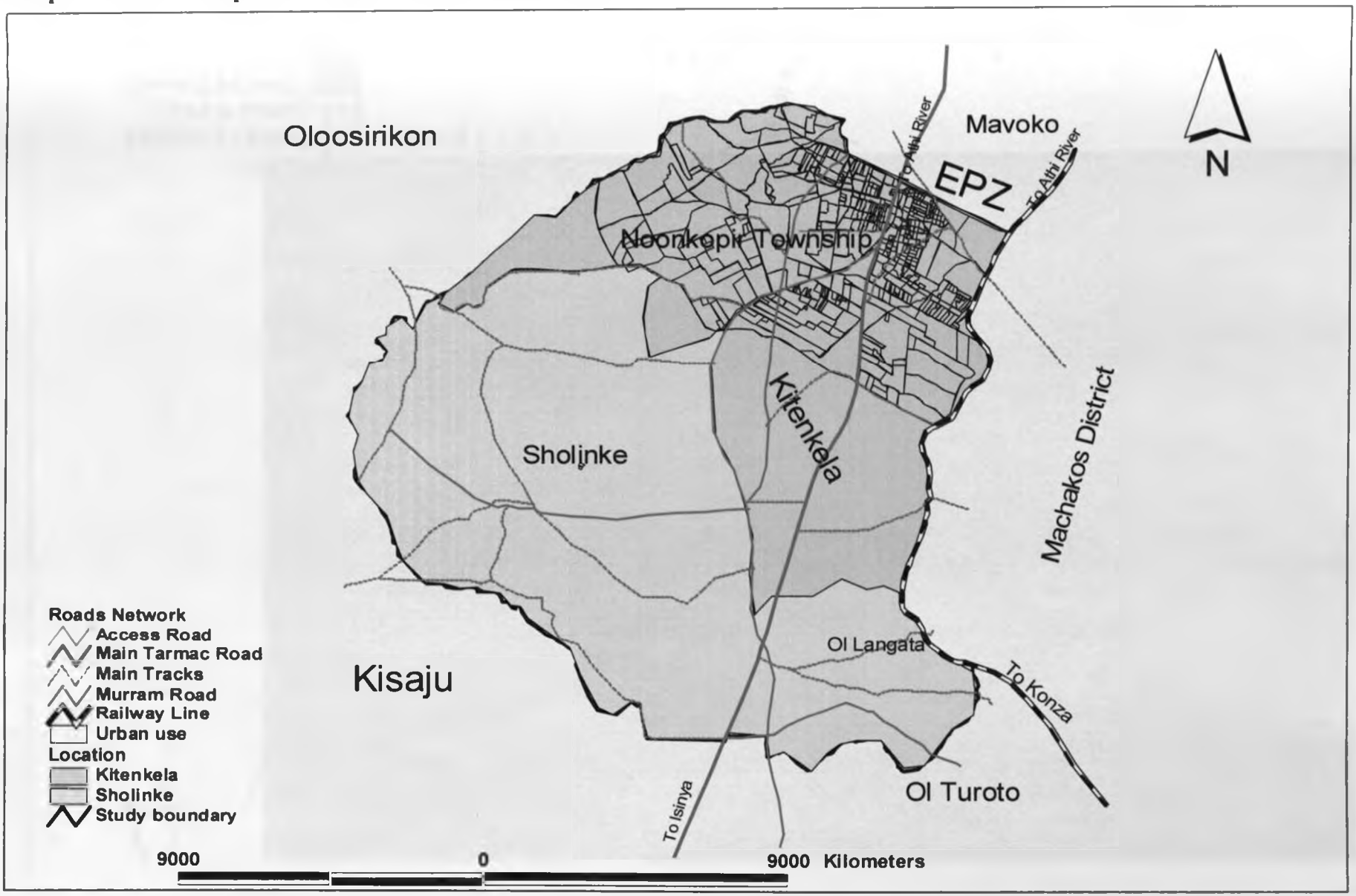
Source: Ministry of Lands, Physical Planning Dept. 2006

Map 4.3: Map of North Kaputei in District Context



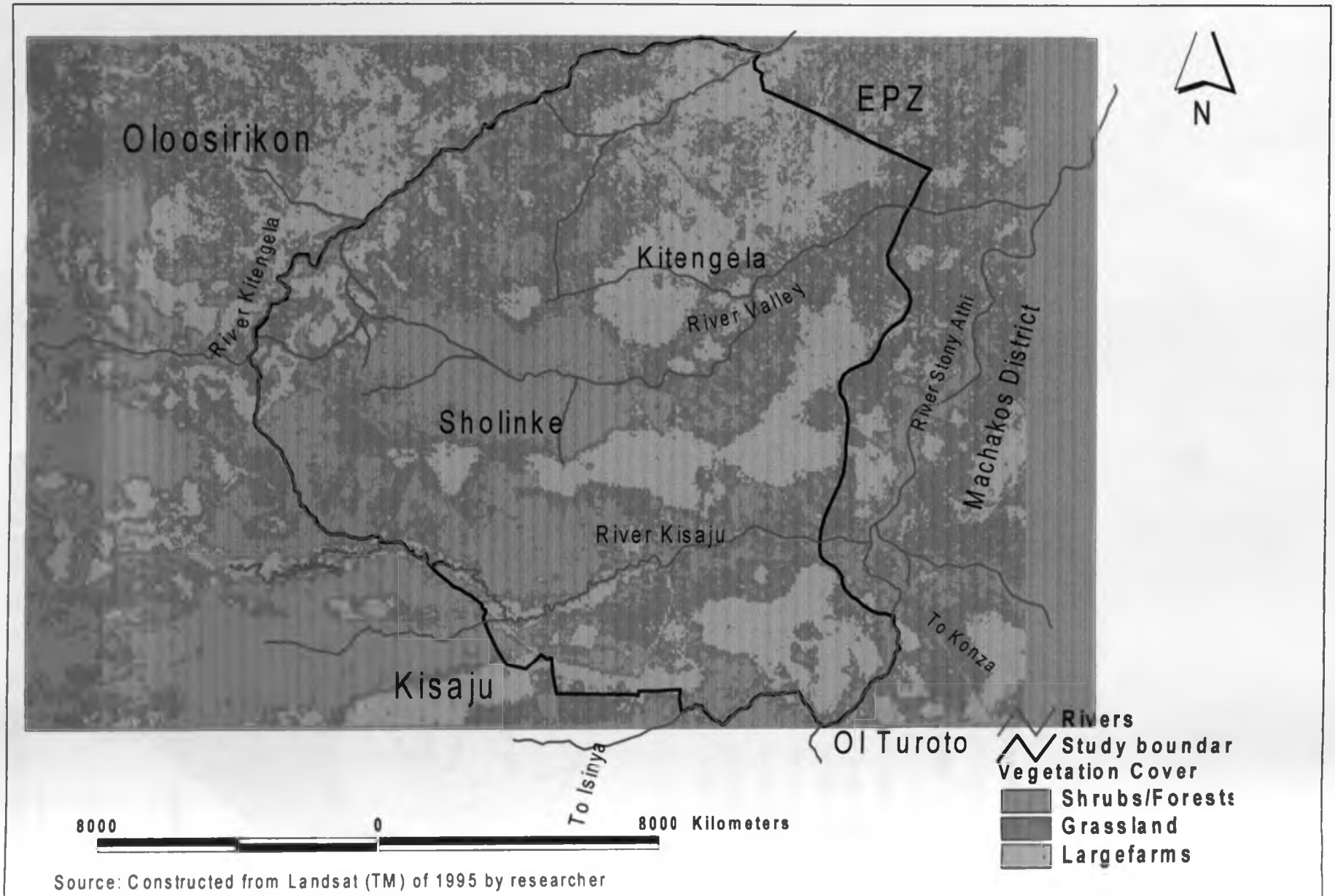
Source: Ministry of Lands, Physical Planning Dept. 2006

Map 4.3: North Kaputei Administrative Boundaries



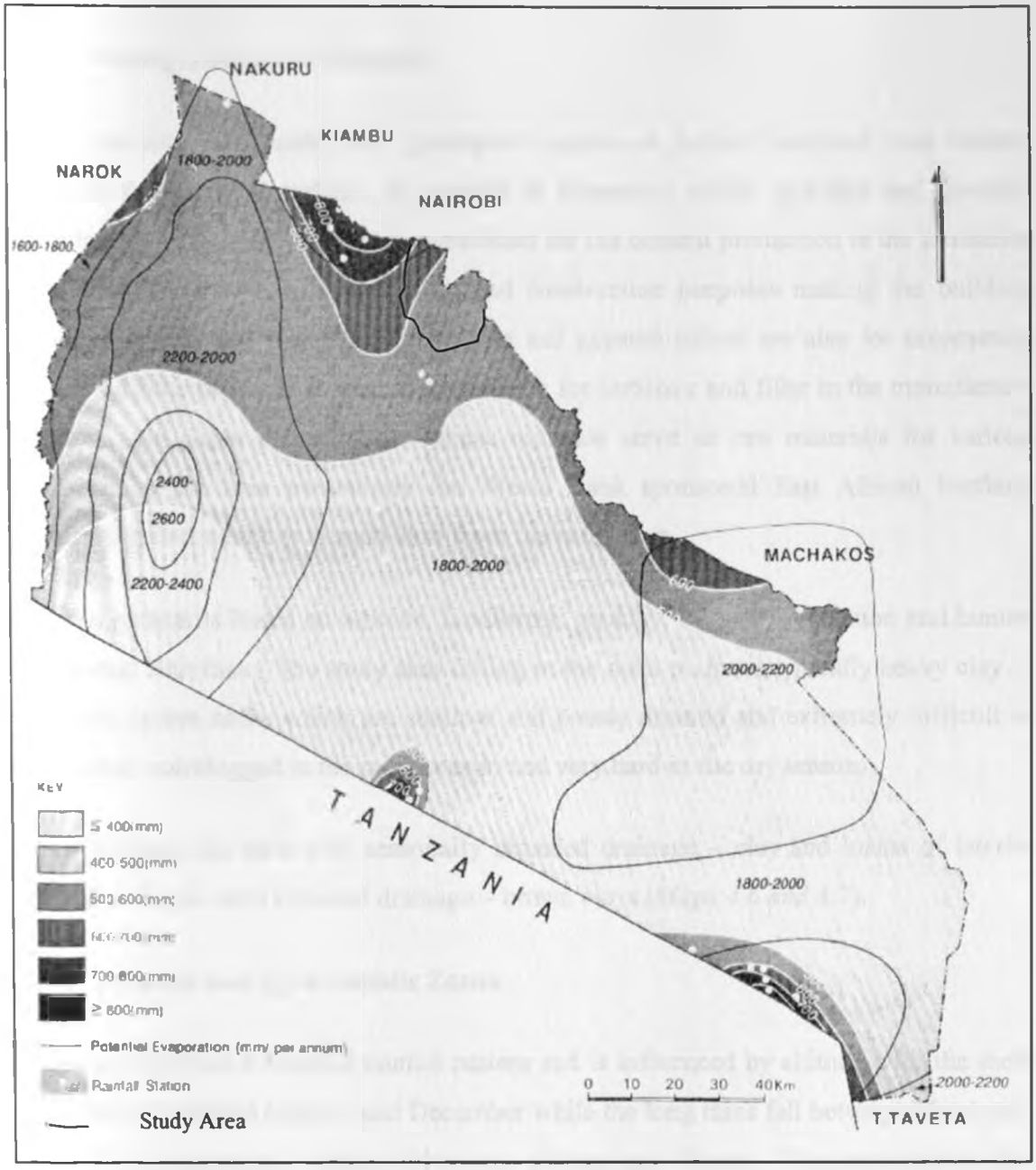
Source: Constructed from satellite images guided by Survey of Kenya Maps boundaries

Map 4.4: Topography, Drainage and Vegetation



Source: Constructed from Landsat (TM) of 1995 by researcher

Map 4.5: Kajiado District Rainfall Pattern



Source: Kajiado District Atlas, 1992

4.1.4 Geology, Soils and Minerals

North Kaputei falls under the geological region of tertiary volcanic and tertiary sedimentary basement system. It consists of limestone, schist, quartzite and gneisses rocks most of which are important ingredients for the cement production in the industries in Athi River as well as for building and construction purposes making the building industry cheaper and lucrative. Limestone and gypsum mined are also for ornamental stones and lime products as well as ingredients for fertilizer and filler in the manufacture of paints and paper respectively. These minerals serve as raw materials for various industries in the area particularly the World Bank sponsored East African Portland Cement Limited which is located 2km from the study area.

The soil pattern is based on altitude, landforms, geology, climate, vegetation and human and animal activities. The study area falling in the open plains is typically heavy clay of the black cotton soils, which are shallow and poorly drained and extremely difficult to work often waterlogged in the rainy season and very hard in the dry season.

North Kaputei has soils with seasonally impeded drainage – clay and loams of laterite horizon and soils with impeded drainage – brown clays *(Maps 4.6 and 4.7)*.

4.1.5 Climate and Agro-climatic Zones

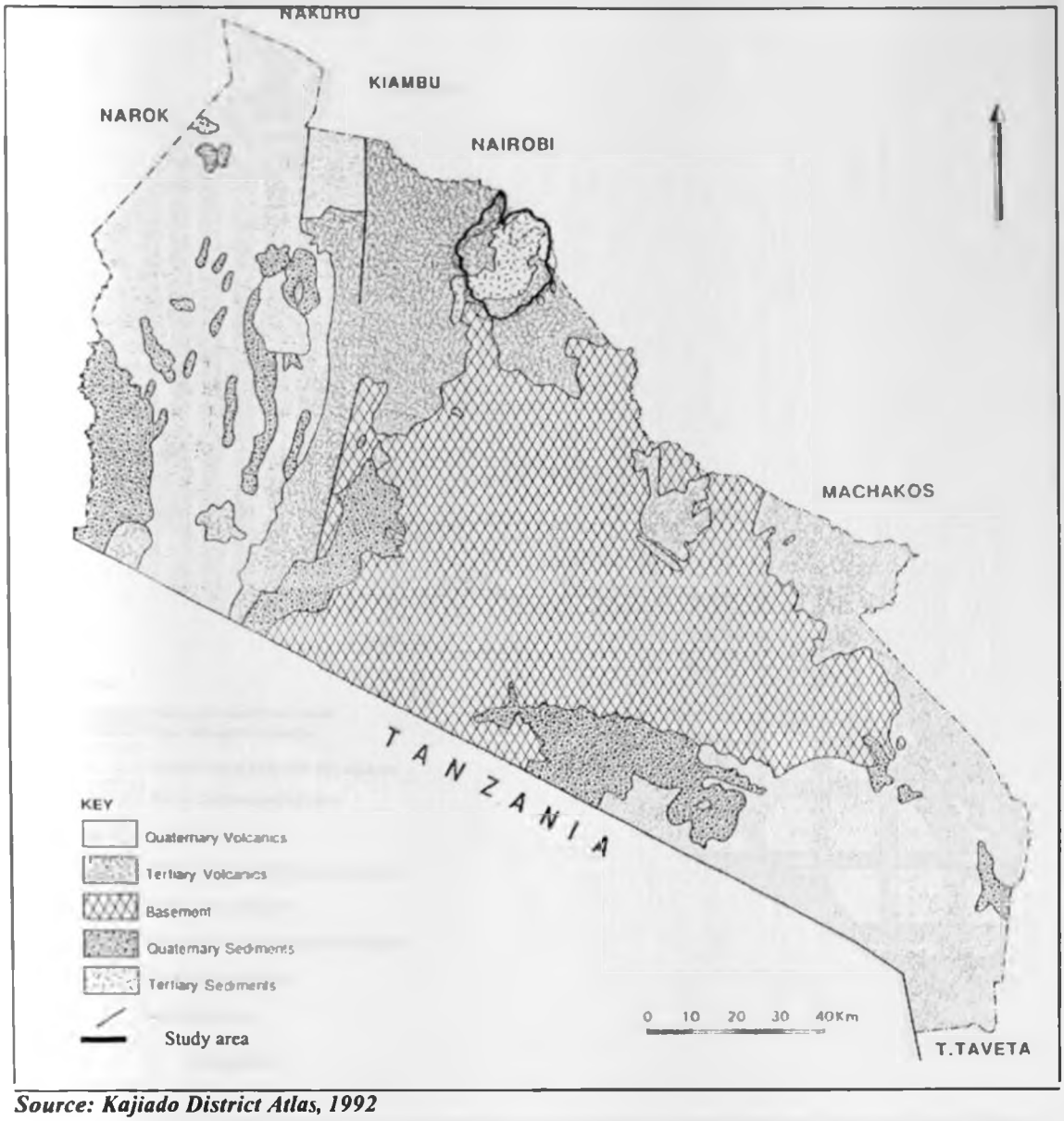
The study area has a bimodal rainfall pattern and is influenced by altitude with the short rains falling between October and December while the long rains fall between March and May. It receives annual rainfall of between 500mm and 700mm. The temperatures also vary with altitude and seasons range between 10^0C and 30^0C. The coolest period is July and August while the hottest period is between November and April. This influences the grazing patterns in the region.

Agro-climatic zones provide information about the ecological potential of the land. Each zone has two main characteristics:

- Moisture availability usually expressed as a ratio of average rainfall and potential evaporation
- Average annual temperature

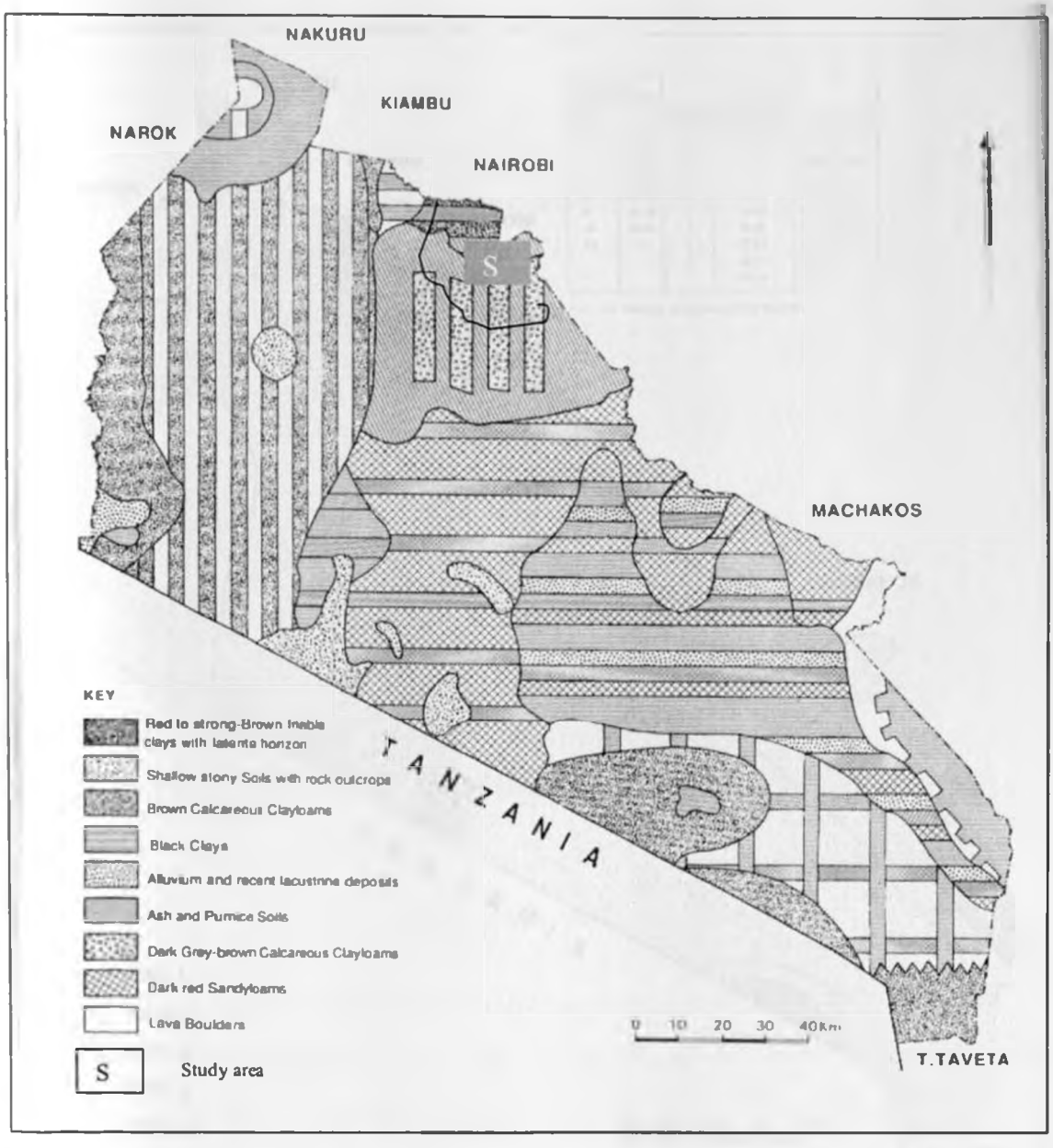
The study area falls under agro-climatic zones V-VI classified as semi-arid where ranching forms most appropriate land use *(Map 4.8)*.

Map 4.6: Geology Map of Study Area in Kajiado District



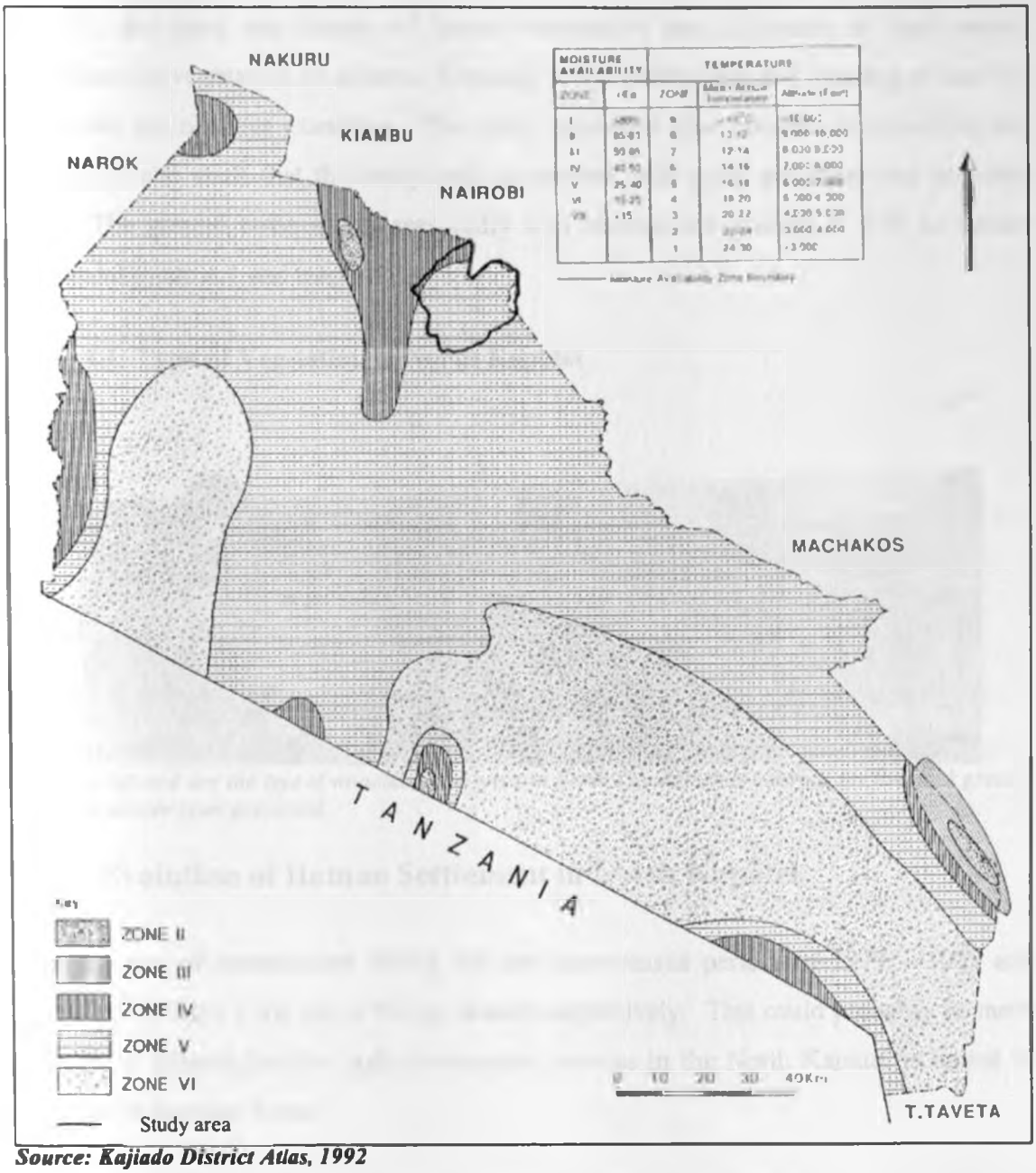
Source: Kajiado District Atlas, 1992

Map 4.7: Kajiado District Soil Map



Source: Kajiado District Atlas, 1992

Map 4.8: Agro-Ecological Zones in the Study Area



Source: Kajiado District Atlas, 1992

4.1.6 Vegetation

Altitude, soil type and density of human occupation and utilization of land mainly determine the vegetation of an area. Grazing, forest destruction and clearing of land for settlement are obvious examples. The main vegetation type consists of woodland and open grassland such that the study area is covered with open grassland and scattered trees. The ground cover varies seasonally with rainfall and grazing as well as human settlement (plate 4.1 and map 4.4).

Plate 4.1: Type of Vegetation in North Kaputei

In the foreground are the type of woodland and grass in North Kaputei while centre is the livestock grazing on the expansive open grassland.

4.2 Evolution of Human Settlement in North Kaputei

National rate of urbanization during the two inter-census periods of 1979 – 1989 and 1989 – 1999 were 3.4% and 4.3% per annum respectively. This could probably be more now but it reflects that the high urbanization process in the North Kaputei is bound to continue in the near future.

The growth of North Kaputei has not been a smooth one, in 1969, there was no human population and there was a sharp rise in 1979 to 10215 due to the expansion and rapid human settlement in the area.

Table 4.1: Urbanization in North Kaputei

Year	Total pop.	Urban pop.	Urban pop. (As % of total	Urban pop. Increase	Growth rate of urban	Growth rate of total
1969	0	0	-	-	-	-
1979	10215	Not available	-	-	-	-
1989	11449	6548	57.19			
1999	17347	9327	53.76	2779		

Source: Central Bureau of Statistics Report, 2000

4.2.1 Historical Evolution of the North Kaputei

An attempt is made here to trace the historical evolution of the town in order to place the current land use changes under examination in their proper context. The current land use changes have their roots deeply entrenched in the steady growth which the town has experienced so far since 1979.

North Kaputei established its origin in the late 1970s the time when the first shop owned by an Arab was established at Kitengela near the swamp. It was also during this time when the area was predominantly a rangeland/grazing ground for the large group ranches. In 1979, a stop over shop was set-up. The early settlement was indirectly connected with the Great North Road passing through the area to Namanga. The area then served as a resting place for long distance travelers both from Mombasa and Namanga/Tanzania, a function that it still plays to the present day.

In 1989 the North Kaputei was classified as a trading center. It was in 1975 that the area was surveyed and subsequent development plans have been prepared since then.

Human occupation in such centre as Noonkopirr or Kitengela as is today known began as early as 1969 with only a few shops and later with the establishments of the government institutions like the Athi River G.K. Prisons attracted various immigrants. Further, the construction of the Great North Road passing through the study area to Tanzania up to

Cape Town in South Africa enhanced accessibility and further opened up the area as well as attracting the construction of the World Bank sponsored Export Processing Zone. These have further attracted more people into the area and have contributed to change in land use pattern.

Urbanization began in North Kaputei particularly in Noonkopir Township with the growing importance of Athi River as an industrial zone as well as the establishment of Export Processing Zone in the vicinity. Within the vicinity, there were large group ranches belonging to the Maasai community, which mainly supplied meat to the Kenya Meat Commission near Athi River Township.

Since 1969, the population census reveals the area had no human population as it was under communal ranching expanding towards Kajiado town. The population of North Kaputei in 1979 was only 10215 covering an area of 1496 square kilometer, with only 1666 households. At this time, North Kaputei was a location within Central division, which is currently Isinya Division.

While in 1989, population census revealed a different scenario such that the area was further divided into two sub-locations of Kitengela and Isinya. The total population was 11,449 people covering an area of 971 square kilometer with 1958 households.

In 1999, the administrative boundary area changed and North Kaputei location became Isinya division consisting of Isinya, Ol Turoto and Kitengela (which falls within the study area) locations. This administrative expansion has been as a result of rapid population growth mainly attributed by the influx from the rural hinterland and the expansion of Nairobi towards its peri-urban fringes. North Kaputei of the study area is administratively divided into Sholinke and Kitengela sub-locations.

4.2.2 Population Densities

Over the intercensal years, North Kaputei has shown a steady growth. This is attributed to its proximity to Nairobi and other industrial towns such as Athi River. It is clearly shown

that these high densities have concentrated in the urban center of Noonkopir and the areas towards the Kitengela Game Conservation Area. The area towards the Railway line to Konza is less populated and this could be attributed to the minimum land use activities in the area.

4.2.3 Population Growth Trend

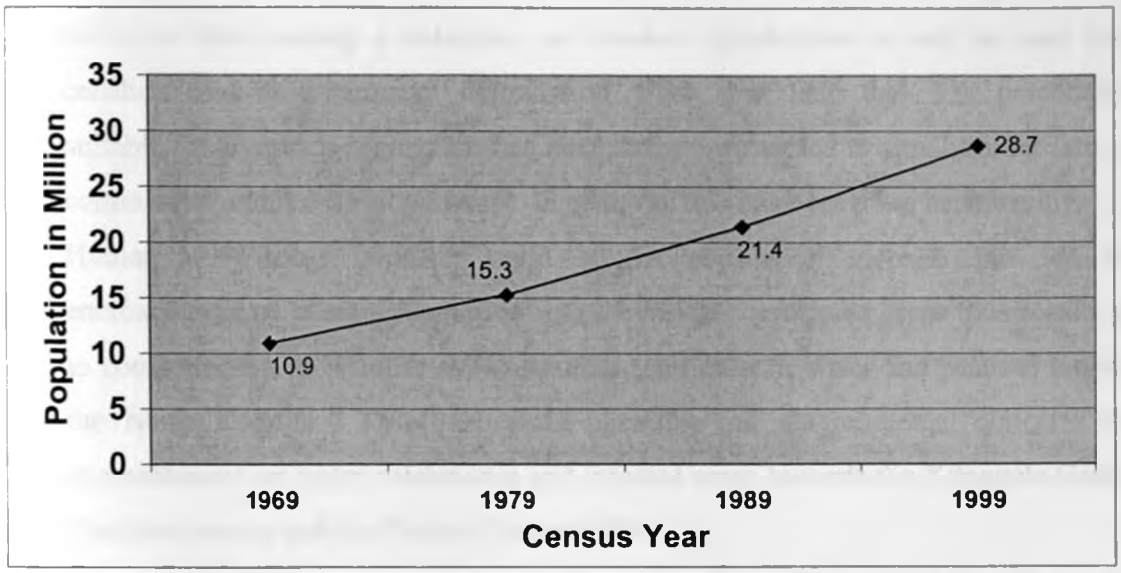
The projections show that the population of North Kaputei will continue to experience an upward surge at a higher growth rate than the preceding years. Trend of population growth in an area is of valuable importance to the planner because as population increases so does the demands for facilities and other supporting infrastructure increase. Not only does the rate of population growth in any urban or rural setting determine the development rate of the area but it also plays a significant role in determining the pattern which development is going to adopt.

The earliest records of North Kaputei population can be traced to the year 1979 when the population was ten thousand two hundred and fifteen people (10215) with 1666 households. The density was 6 per km sq., which was considerably low.

The 1989 population census showed a considerable increase of 89% from the 1979, which were 11,449 persons with 1959 households and 12 persons per km sq. It is worth noting the trend in specific area and not the broad figures, which can be misleading. The emerging scenario has been this spectacular growth currently registering a growth rate of 3.5% a rate, which is rather slightly lower than the national growth rate of 3.8%.

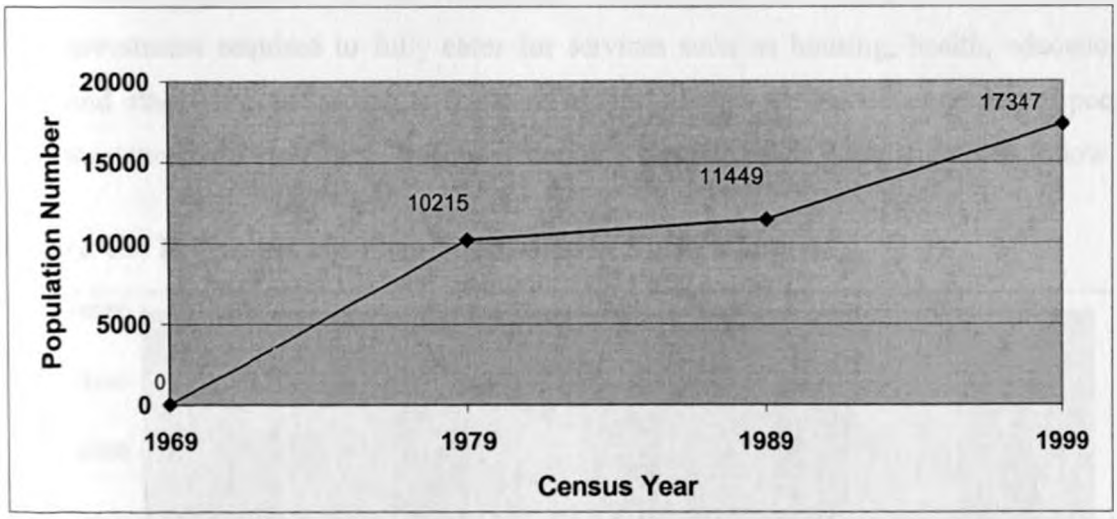
The population growth trends in this year were as illustrated in figure 4.2 compared to the national population growth in figure 4.1 below.

Figure 4.1: National Population Growth by Census Years – 1969 to 1999



Source: 1999 Population Census Report

Figure 4.2: Population Growth since 1979 in North Kaputei



Source: 1999 Population Census Report

The above figures on population growth reveal that the study area has experienced high population growth. This has had important bearing on the following:

- On land: The area's proximity to Nairobi has attracted a lot of immigrants putting

more pressure on the area as far as land demand is concerned. Most of the area has been devoted to expansion of sedentary settlement and livestock production activities thus causing a reduction on livestock production as well as land use conflicts and environmental degradation. Such that land that was potentially suitable for livestock production has been mainly converted to small holder farms, commercial and industrial purposes. In addition, this has been done haphazardly.

- Human – Wildlife conflict: rapid human population increase has led to encroachment of human population into the wildlife protected areas thus resulting to competition with wildlife over resources (particularly, water and pasture) within the North Kaputei. This has raised planning and environmental concerns as encroachment on water catchments and forested areas towards the Kitengela Game Corridor reserve and the Nairobi National Park.
- Urbanization: the urban centre has also experienced rapid population growth due to population influx from other hinterland as well as serving as a dormitory for Nairobi population. As such Noonkopir Township has not been able to raise capital investment required to fully cater for services such as housing, health, education and other services leading to conflicts of land uses as well as development of poor structures and insecurity. The projection of Kitengela urban population is as follow:

Figure 4.3: Projection of Urban Population in North Kaputei

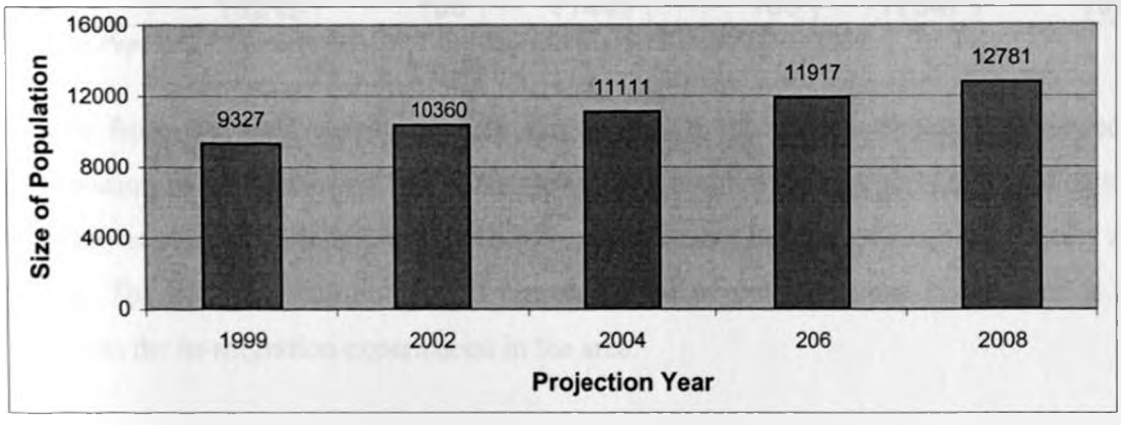


Table 4.2: Urban Population Projection in North Kaputei

1989	1999	2002	2004	2006	2008	% Growth Rate
6548	9327	10360	11111	11917	12781	3.5

Source: Field Survey, June 2002

4.2.4 Population Compositions and Structure

Kajiado district is dominantly Maasai ethnic homeland. As a result the composition tends to skew favourably towards large Maasai number but nevertheless there is a notable decline of these Maasai numbers with an equivalent rise in representation by other tribes as shown in table 4.3. The study area is cosmopolitan in nature as other communities such as Kikuyu, Kamba, Somali, Kisii, Luo and Luhya etc, have bought land here and settled bringing with them their beliefs, culture, norms and practices that influence the development of North Kaputei.

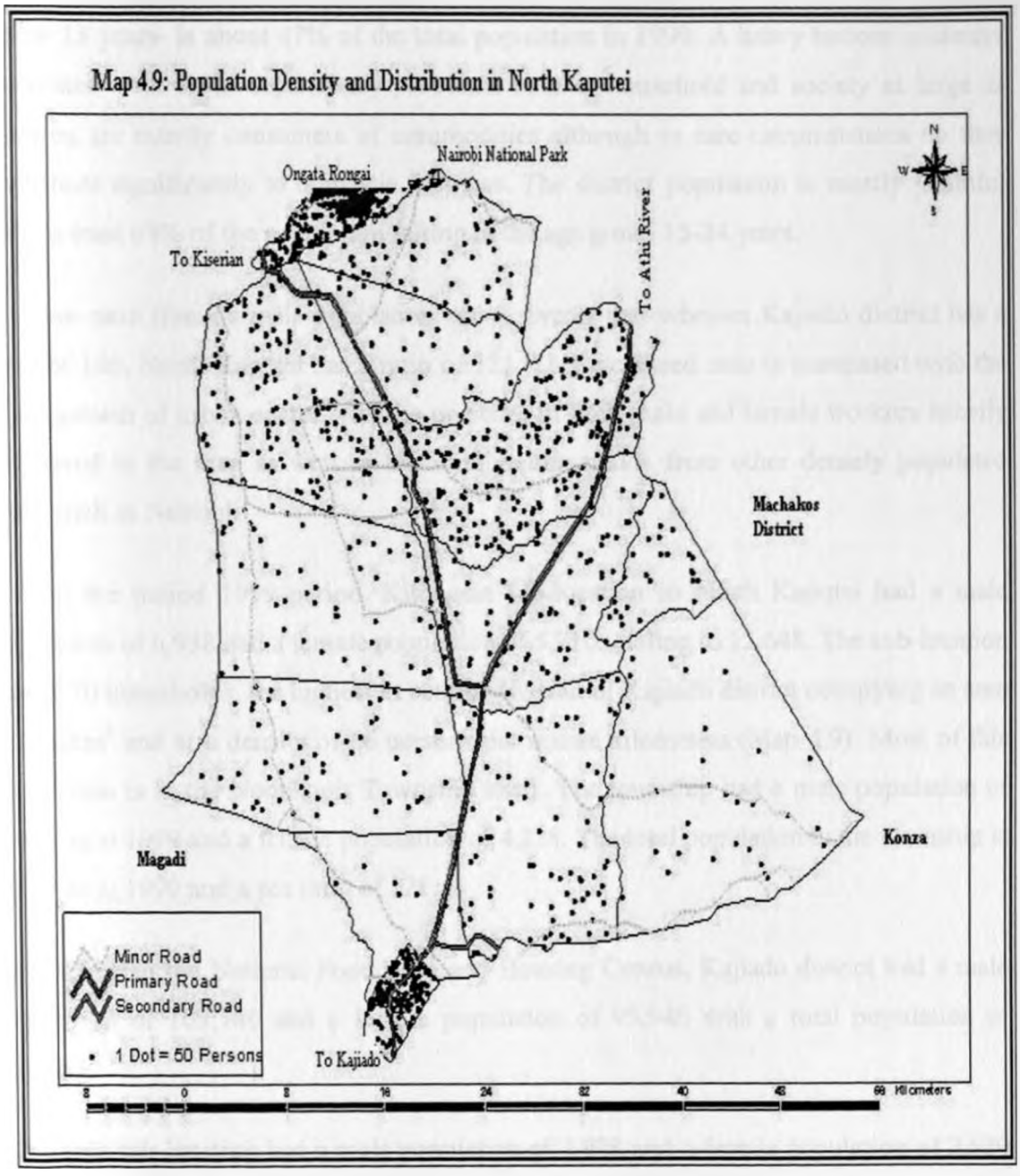
Table 4.3: Population composition by Tribes

Tribe	1979	%	1989	%	1999	%
Maasai	8461	82.83	9056	79.10	11277	65.01
Kamba	321	3.14	498	4.35	764	4.40
Kikuyu	958	9.38	1230	10.74	3453	19.91
Luo	216	2.11	307	2.68	554	3.19
Luhya	59	0.58	93	0.81	412	2.38
Kisii	115	1.13	140	1.22	558	3.22
Others	85	0.83	125	1.09	329	1.90
Total	**10215**	**100**	**11449**	**100**	**17347**	**100**

Source: Population Census 1979, 1989 and Kajiado District Social Survey 2000

Results from the field survey confirm this trend. Of the 65 households interviewed, composition patterns showed that Maasai were represented by a larger 42.2% followed by Kikuyus at 23.8%, Kamba at 11.3% with an increasing number of Kisii community at 13.7%. The heterogeneity and broad representation of various tribes in the area is a pointer to the in-migration experienced in the area.

Map 4.9: Population Density and Distribution in North Kaputei



Source: Modified and Constructed by researcher from Satellite Images and Physical Planning Office, Kajiado District - 2005

The population structure of North Kaputei reflects the wider national scenario with a heavy bottom reflecting a youthful one because of the proportion of the children – aged below 15 years- is about 47% of the total population in 1999. A heavy bottom is always associated with child dependency problems both at household and society at large as children are mostly consumers of commodities although in rare circumstances do they contribute significantly to domestic incomes. The district population is mostly youthful with at least 68% of the population falling in the age group 15-24 years.

The sex ratio (female male population ratio) reveals that whereas Kajiado district has a ratio of 105, North Kaputei has a ratio of 121. This increased ratio is associated with the rapid growth of urban center with the presence of both male and female workers heavily registered in the area as well as the immigration trends from other densely populated areas such as Nairobi.

During the period 1999 period, Kitengela sub-location in North Kaputei had a male population of 6,938 and a female population of 5,710 totaling to 12,648. The sub-location had 4070 households, the highest in central division of Kajiado district occupying an area of 192km^2 and at a density of 66 persons per square kilometers (Map 4.9). Most of this population is in the Noonkopir Township itself. The township had a male population of 5,099 as at 1999 and a female population of 4,228. The total population in the township is 9,327 as at 1999 and a sex ratio of 121.

In 1999, from the National Population and Housing Census, Kajiado district had a male population of 103,740 and a female population of 95,946 with a total population of 199,683.

Kitengela sub-location had a male population of 3,928 and a female population of 2,620 all totaling to 6,548. During the same period, there were 1,044 households occupying an area of 386km^2 at the density 17 persons per square kilometers.

During the same period, (1989) Nairobi province had 752,000 males and 571,973 females

totaling to 1,324,570 persons. The household number in Nairobi in 1989 was 382,863 covering an area of 693km2. The overall density in 1989 was 1,911 persons per square kilometer.

1999 Population by Sex in North Kaputei

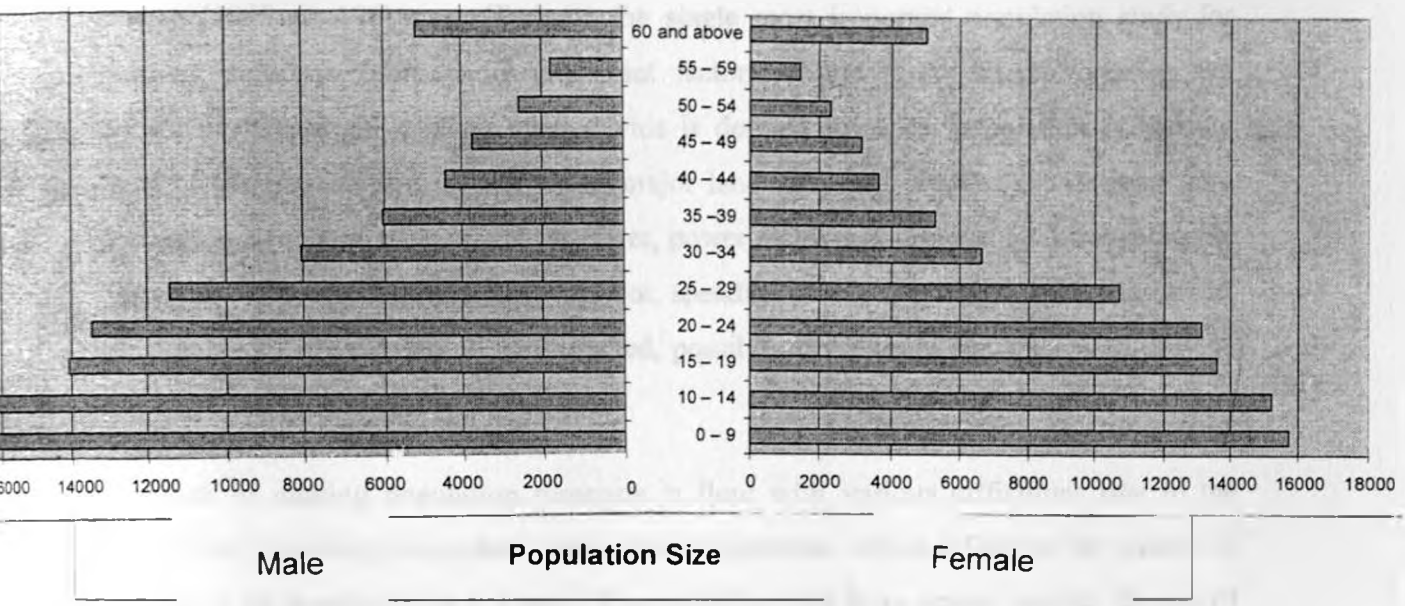
Male	Female	Total
9473	7874	17347

Table 4.4: Population Pyramid for Kajiado district and study area

Age	Population by sex in Kajiado District (Population Census, 1999)		Population by Sex in North Kaputei (Household Survey, 2002)	
	Male	Female	Male	Female
0 – 9	16349	15725	6	7
10 – 14	16575	15192	4	5
15 – 19	14050	13603	6	3
20 – 24	13424	13122	2	6
25 – 29	11421	10655	0	2
30 –34	8044	6648	1	2
35 –39	6020	5268	2	2
40 – 44	4431	3644	0	2
45 – 49	3728	3149	3	2
50 – 54	2590	2325	4	2
55 – 59	1729	1439	2	2
60 and above	5186	5017	0	0

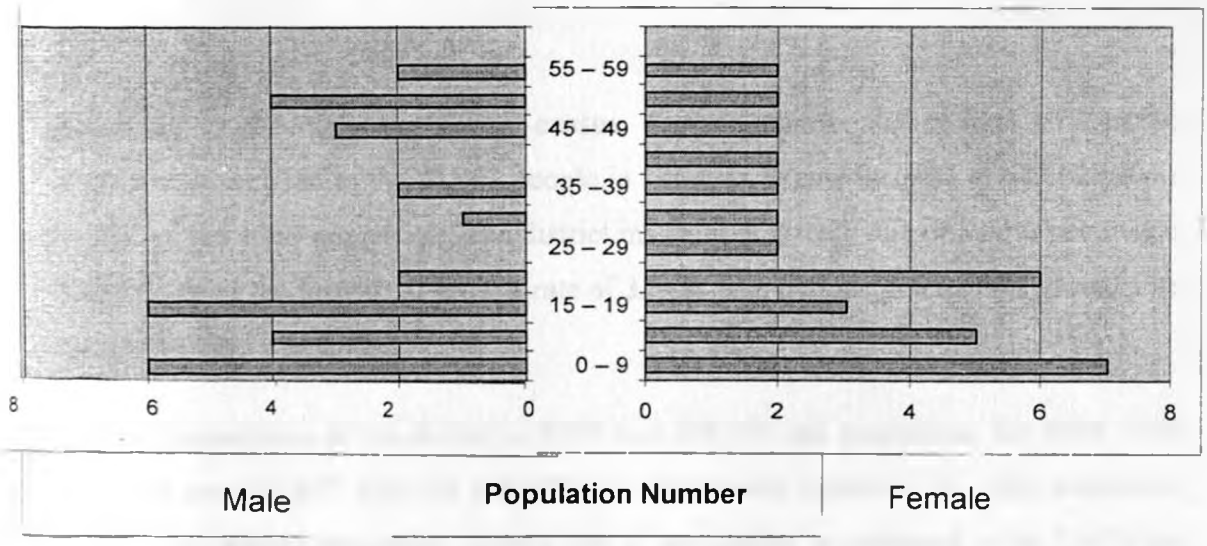
Source: CBS, Population Census Report (1999) d Field Survey, 2002

Figure 4.4: Kajiado District Population Pyramid



Source: CBS, Census Report, 1999

Figure 4.5: North Kaputei Population Pyramid



Source: Household Survey, 2002

4.2.5 Population Projection of North Kaputei

Chapin (1965, p. 196) says, 'Perhaps the single most important population study for planning purposes. Very many important factors of the future situation facing the community which the planner must advice is derived from the population projection. Most of the important decisions about major land uses and services are derived from population estimates, the demand for water, power and waste disposal facilities, housing, open space and schools, the supply of labor, spending power available for the retail trade, the number of private cars to be expected, possible recreational demands – all may be estimated from the projected population.

The task of making population forecasts is flout with various difficulties due to the insufficient knowledge regarding demographic dynamics, which influence the pattern of growth of the population as a whole. Even with the data from census reports, the use of inter-censual data for population projections is very limited because the effects of migration on population growth were difficult to determine, changes in administrative boundaries between one census and the next renders inter-censal data of very little use indeed.

According to the 1979 population census, Kajiado district had a total of 149,000 inhabitants compared to the 85,903 people in 1969, an annual increase of 64,102 people or 76% of the 1969 population. The district intercensus growth rate of 5.66% per annum nearly doubled the provincial growth rate of 3.84%. The national intercensus growth rate during this time was 3.9%.

The total population of the district in 1989 was 258,659 and projections, for 1997, 1999 and 2001 are 402,907, 450,118 and 502,861 respectively based on the 1989 population census. The annual population growth rate of the district is estimated to be 5.54% per annum, which is even higher, compared to the National annual of 3.4%. By 2009, the district population will be about double its size in 1989. This high population will strain the provision of essential services and facilities and is likely to impact negatively on land

use development due to over exploitation of the districts natural resources.

4.2.6 Migratory Patterns

Population projections of an urban fringe like North Kaputei contain elements of in migration but the migration tendencies of any settlement are difficult to predict with any certainty. Migration to and from and between North Kaputei areas is largely on human behavior response to changing conditions in people's physical and emotional surroundings, and it is indeed difficult to predict human behavior, however, it was possible to make some forecasts, which can be used for planning purposes.

A field survey carried out on places of origin of the households to establish the functional relationships between the study area and other areas, confirm what is generally held about urban fringe areas of sub-urbanization processes. In figure 3.18, out of 65 interviewed, 42% state that Nairobi was their last residential place. Regarding inter-area patterns, 28% revealed that Athi River was their last residential place, noting that Athi River is the nearest center to North Kaputei with almost similar characteristics.

Asked why they had move to study area from Nairobi, 62% of the respondents had done so because of the attraction of cheap land and cheap rents. A small percentage of 18% indicated that they had moved closer to their places of work – EPZ and other industries within and near Noonkopir Township in the study area. Others indicated reasons such as marriage.

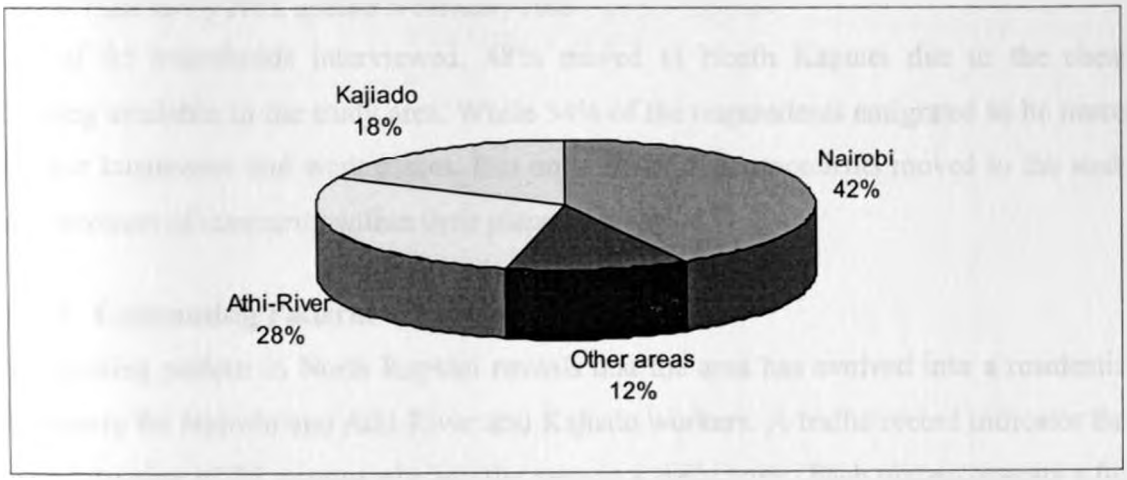
The study also revealed a strong migratory functional relationship between the study area and other provinces of the country and even wider regions. In general the field results show that the study area has attracted more population from the central province and Machakos district than other parts of the country. This could be attributed to current land pressure in central province and its proximity to Nairobi and the study area. While most of the other provinces are too far and therefore do not have a direct migratory relationship with North Kaputei.

Table 4.5: Net Migration in Nairobi and Kajiado Excluding Vagrants

Area	Enumeration in district 1989	Born in the district 1989	Net migration 1989	Net migration 1979	Net adjusted 1979 net adjustable for mortality	Difference 1989 adjusted 1979	Percentage change
Nairobi	1285703	513079	772624	524372	487666	284958	58.43
Kajiado	255078	197877	57201	28839	26820	30381	113.28

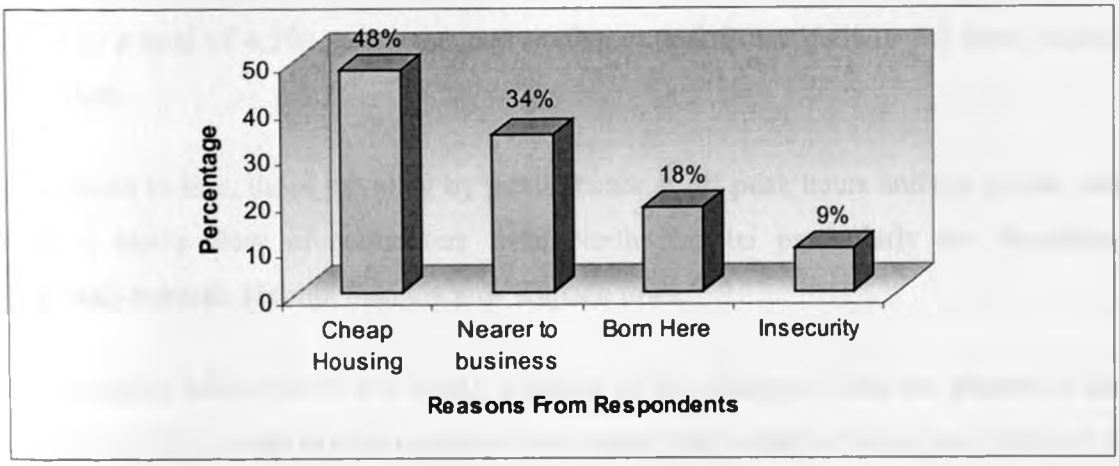
Source: Population Dynamics, 1996

Figure 4.6: Place of Origin



Source: Field Survey, 2002 updated February 2006

Figure 4.7: Reasons for Migration to North Kaputei



Source: Field Survey, 2002

Table 4.6: Reasons for Migration to North Kaputei

Reasons	Frequency	Percentage
Cheap Housing	28	48
Nearer to business	22	34
Born Here	12	18
Insecurity	6	9
	65	100

Source: Field Survey 2003, updated in February 2006

Out of 65 households interviewed, 48% moved to North Kaputei due to the cheap housing available in the study area. While 34% of the respondents emigrated to be nearer to their businesses and work places. But only 9% of the respondents moved to the study area because of insecurity within their place of origin.

4.2.7 Commuting Patterns

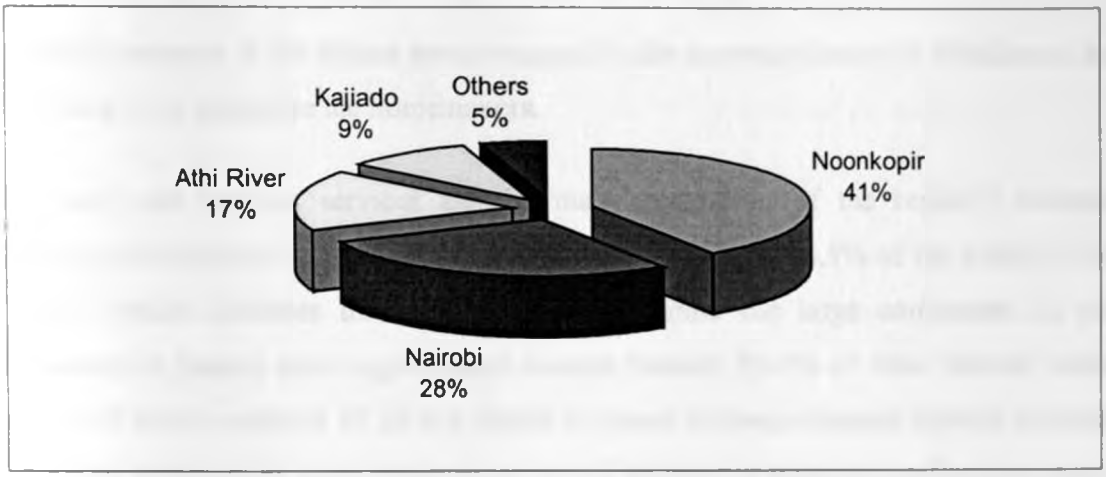
Commuting pattern in North Kaputei reveals that the area has evolved into a residential dormitory for Nairobi and Athi River and Kajiado workers. A traffic record indicates that a total number of 85 matatus ply into the area on a daily basis. Each matatu operate a full capacity of 18 passengers all bound from Nairobi in the morning and evening and makes an average of 3 trips at the peak hours of 6.00 am – 8.00 am and 4.00 pm – 7.00 pm. This works to a total of 4,590 passengers commuting at peak hours daily to and from Nairobi by Matatu.

In addition to that, those traveling by public buses at off peak hours and the private cars show a heavy flow of commuters from North Kaputei particularly the Noonkopir Township towards Nairobi than towards Kajiado town.

A commuting labour force is a strong indicator of the change in land use pattern in that North Kaputei is home to urban workers who extend their urban activities and behavior to the area, transforming it into suburban with rural urban dichotomy of land uses. The field survey shows that 28% of the respondents stated that they work in Nairobi while 41%

works within North Kaputei

Figure 4.8: Place of Work



Source: Field Survey, 2002 updated February 2006

4.3 Socio-economic Set-up

Socio-economic characteristics of North Kaputei can be looked at as economic activities and the cultural activities which serve as a source of livelihood to the populace of the study area.

4.3.1 Income and Employment Sources

Income and employments vary with the various distinctive population types in the area. The population has income ranging from low to a few substantial landlords and businessmen. These can be divided into the following:

- The group that owns land in the area. They are self-employed and own businesses like shops, bars, supermarkets and residential houses. Majority are the indigenous Maasai.
- The second group is those owning plots particularly in the informal structures in Noonkopir Township.

- Third group consists of people who own a few acres of land and whose incomes are formal jobs. Majority of this group have high and middle income.

The third category is the largest group engaged in the monetary sector in middle and high level jobs. 60% comprise the homemakers.

Livestock and tourism services ate the main foundation of the region's economy. Available data shows that in 1987, livestock income formed 44.1% of the district's total income (which includes livestock produce but omits the large component of mild consumed at home) while agricultural income formed 29.4% of total district income while off farm consisted of 26.4% which is based on wage-income earned by people employed in the public and private sector as well as those in trade and self-employment.

Athi River town provides employment opportunities to many residents of North Kaputei with its industries. This is an old town where a railway station locates. It is here that a private inland Port has now located. This is speculated to have some economic benefits to North Kaputei and further trigger accelerated light industrial growth. The Export Processing Zone Authority has also provided employment and other socio-economic opportunities to residents of North Kaputei.

The study established over 20 income-generating activities in North Kaputei. Employed labor included casual and permanent industrial workers in the Athi River-based export-processing zone; waiters in the various eateries, slaughterhouse workers, bar attendants, drivers, matatu operators, shop attendants and farm managers as well as land allocation agencies.

Casual workers comprising construction and quarry workers, artisans such as tailors, carpenters, and cobblers, welders, mechanics and households members. There are also a high proportion of hawkers, among them including road side vegetable sellers, maize roasters, and cloth vendors amongst others as seen in **plate 4.2.** Small business owners who included shop owners, garages, eateries, clothes stalls, hair salons and barber shops.

Other income generation activities included herbalists and entertainers.

This economic pattern is perhaps the reason for the rising social needs and demands by the resident population. The high and middle-income levels form the basis upon which the Ol Kejuado County Council authority can derive the finance necessary for effective land use management.

4.3.2 Consumption

The main areas of daily usage of money were identified as food, transport, water, education and health care. The average amount spent on food daily was Ksh. 100 for the low income, Ksh. 300 for the middle-income group majority of whom are found in the rural area and the informal settlement of Noonkopir Township. Over Ksh. 500 for the high-income group residing in the controlled settlement of Noonkopir and the outskirts. Transport costs range between Ksh. 20-100 particularly to those commuting to Nairobi and other surrounding towns such as Namanga, Kajiado, Isinya, and Athi River. The average household expenditure per day is between 150 – 250 shillings in the township.

4.3.3 Earning Ability

The study established that the average household income was Ksh. 5000 per month. This figure however might be inaccurate because the occupational profile shows that majority of the working people are daily wage earners and can only estimate their income when asked for their monthly income. The survey, however, showed that in the whole township there were far more self employed people than formally employed.

Plate 4.2: Kiosks mushrooming in the study area as small businesses

New land uses mushrooming in the study area

4.3.4 Economic Activities

The main economic sector in the study area continues to be the livestock/ranching sector despite the drastic land use changes since 1969 in the study area. A subtle shift has been noted from the traditional semi-nomadic pastoralism to a more sedentary form of ranching and other income-generating activities. The area falls under the agro-ecological zones of V and VI, which are suitable for animal production although kitchen gardening is also common but only to supplement the household subsistence.

The household survey established a monthly per capita income of Ksh. 5000 per household, which roughly translates to a daily per capita income of Ksh. 130/= (US$1.6)

shared between the average of three people per household.

Trade is another major economic activity that has picked up with the growth of Noonkopir Township. Various commercial activities are carried out geared towards satisfying the needs of the livestock farmers and the increasing residence population in the study area. These include among others the supply of veterinary requirements, wholesales and retail shops for various goods for domestic consumption (Figure 4.9).

Significant commercial activities are coming up in the urban centre. A dominance of general retail shops are noted in the area especially in Noonkopir Township as in table 4.7

The survey tallied different occupations undertaken by the residents. These have been grouped for convenient analysis. The largest single occupational group (37.2%) are small scale business people and include shopkeepers, hawkers, vegetable sellers, second hand cloth sellers, charcoal dealers and so on. 26.8% of the respondents cited casual labor as their main occupation and included construction workers and part-time matatu touts. A third significantly large group were semi skilled Jua Kali artisans (22.7%) who included mechanics, carpenters, tailors, cobblers, scrap metal fabricators etc. A smaller group at 8.6% was the formally employed workers. Lastly is a miscellaneous group that includes housewives and the unemployed.

Significantly, it was noted that North Kaputei is home to the biggest cattle slaughtering industry within the fringes of Nairobi supplying most of the surrounding areas such as Athi River and Nairobi with beef. Estimates put the total population capacity of the slaughterhouse at over 80 animals slaughtered everyday. This facility is located within the CBD area of the Noonkopir Township. The figure 4.10 gives an indication of the proportion of business type in the township.

Plate4.3: Trading activities in the study area

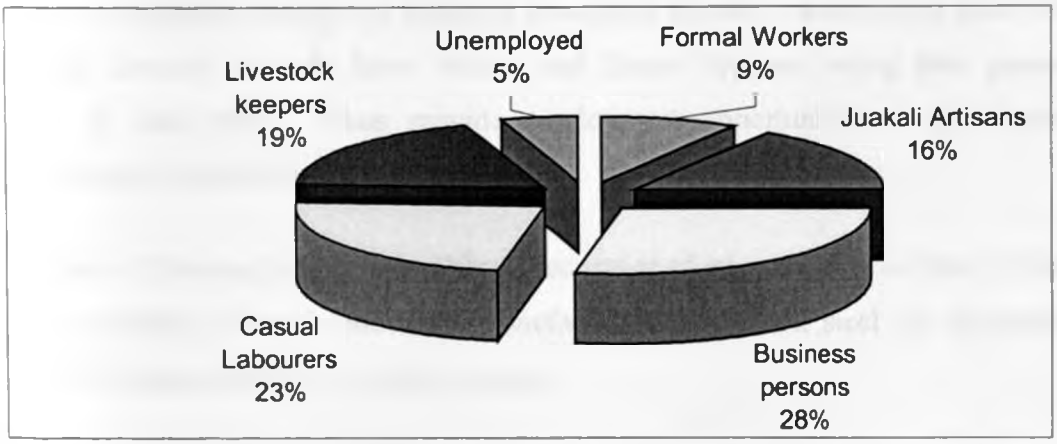
Source: Field survey, 2002 updated February 2006

Table 4.7: Commercial Activities Within North Kaputei

Activity	Total Number	Activity	Total Number
Retail Outlet	200	Butchery	40
Tailoring Shops	12	Petrol Stations	4
Hair Salons/Barbar shops	33	Hardware Shops	19
Hotels	16	Photo Studio	2
Agrovet	10	Motor Repairs	6

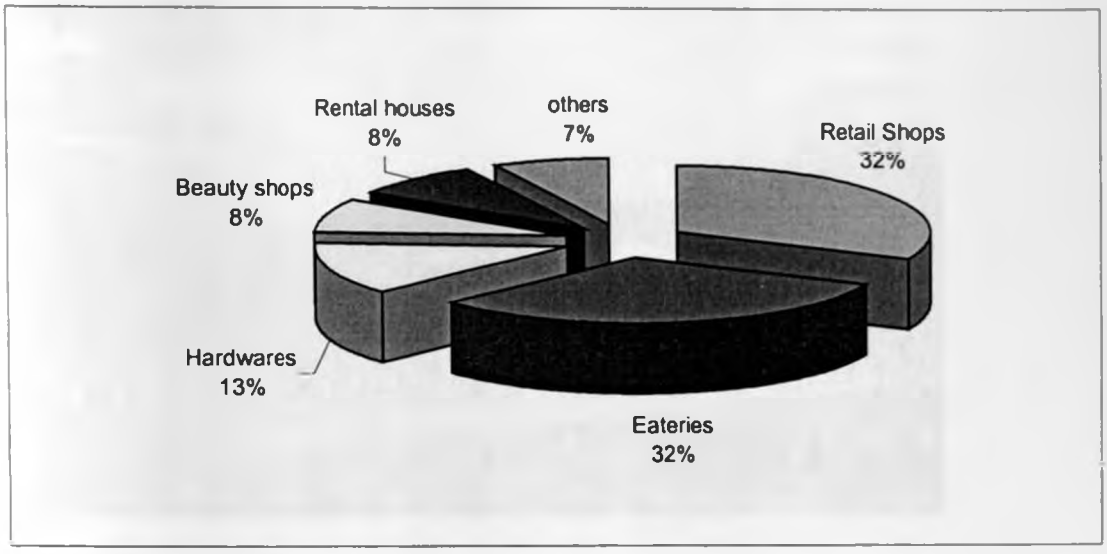
Source: Field Survey (2003) and Dept of Trade and Industry, Kajiado District (2005)

Figure 4.9: Proportion of Occupational Group in North Kaputei



Source: Field Survey, June 2002Updated in February 2006

Figure 4.10: Proportion of Businesses by Type in North Kaputei



Source: Field Survey, June 2002 updated February 2006

According to the field survey report, significant growth was recorded in the game ranching and horticultural productivity. The industrial sector has been the major influence in land use change and it is dominated by mining industries (presence of various mines in the study area, steel-related manufacturing industries and the travelers' lodges. The informal industries are mostly concentrated in the Noonkopir Township and its environs.

Various small-scale mining are scattered throughout the study area but the East African Portland Cement and Athi River Mining and Kenya Gypsum having their processing plants at Athi River. Thus provide employment opportunities to the increasing immigrants of North Kaputei and environs.

Noonkopir Township boasts a number of industries of its own such as food processing and engineering or steel industries (manufacture of structural steel for construction), metal fabrication and stone crushing namely:

- Naciti Engineers
- Super Roofings
- Athi River Mining company
- Kensoya Foods
- Kivia company
- Dandora Black Trap Quarries
- Western Beef
- Ashut Engineers

Plate4.4: Mining site Near Noonkopir Township

Source: Field Survey 2002

Further, there are several agro-based industrial activities sparsely distributed within the township on small-scale. There is 1 slaughterhouse and 2 slabs within the study area, the meat produced at the slaughtering facilities are transported to Nairobi and other parts of its environs. The hides and skin are transported to Isinya Tannery operated by Maasai Rural Training Centre in the nearby Isinya location. Despite being an important marketing center for the livestock farmers around Noonkopir Township, the slaughterhouse poses environmental hazards such as pollution to the surrounding residents. The area around it has obnoxious smell.

In the peri-urban areas of Noonkopir Township, a number of commercial flower growing enterprises have sprung up. The hinterland supports a rich agricultural, livestock and ostrich farming. Tourism is an important factor in the growth of the area. Although a number of tourist-related establishments have come up but there is still high potential for eco-tourism which could be a better alternative land use that is in compliant with the former land use. The major tourist attraction is the Ostrich farm and the Kitengela game reserve, Whistling Thorn and Camping Sites. (Plate 4.5, showing the site map for eco-tourism). High revenue is earned due to the proximity to Nairobi whose residents frequent the area for recreational purposes. Furthermore, the Maasai culture and lifestyle in itself is a tourist attraction, however this is a potential yet to be fully exploited.

Plate 4.5: Maasai Ostrich Farm in North Kaputei

Source: Field Survey, 2002

4.3.5 Transport and Communication Network

The area has a road network that includes both classified and unclassified roads. Of the classified road is the international trunk road A104 that joins Nairobi through Athi River to Namanga, linking Tanzania and Kenya. It forms a part of the Great North Road that runs from Cape Town in South Africa to Cairo in Egypt. It is in good condition. This road has enhanced the accessibility of the study area in terms of human settlement. Thus is a major influence of land use change in the area.

At the local level, the study area has a network of roads laid out in an irregular pattern providing access to all areas. The field survey shows that 80% are loose surface and during rainy seasons, access becomes almost impossible. Some roads have narrow widths, not allowing two vehicles to easily by pass each other. Where tarmacked, drainage structures like culverts, channels and ditches are altogether lacking or blocked. (Plate 4.6)

The area also has various access roads that have also promoted accessibility particularly to the new immigrants as it eases the movement around the plots ready for sale (Map 4.10).

The railway line also passes through North Kaputei from Nairobi to Mombasa. Post office and Telkom services as well as Mobile companies also plays a vital role in providing communication link which are essential in economic development as well as contribute to land use change for people residing in the area can easily communicate with those in other areas. The services offered are mainly the mobile services as the network covers the whole of the study area. In the urban center (Noonkopir township), telephone and mailing services are offered.

Plate 4.6: Condition of Road Surface in Dry Season

Source: Field survey, 2002

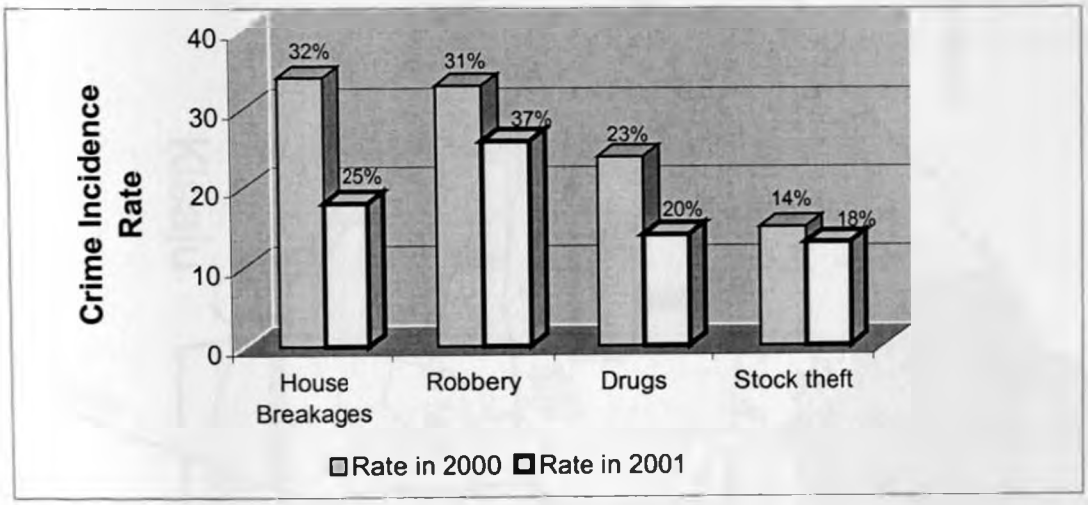
The survey established that security is a major concern for the residents of the township. Common criminal activities in the area were identified as house breaking, mugging and violent robbery as well as stock theft particularly in the rural part of North Kaputei. Police department and the Chief's Camp in the study area is bestowed with the task of receiving and preventing the increasing cases of crime rate in the study area particularly the urban centre and stock theft. Figure 4.11 illustrates on the crime type and rate in the study area.

Table 4.8: Incidence of Crime Rate in North Kaputei

Incidence of Crime Rate	2000		2001	
	Rate	Percentage	Rate	Percentage
House breakage	34	32	18	25
General robbery	33	31	26	37
Drug	24	23	14	20
Stock theft	15	14	13	18
Total	**106**	**100**	**71**	**100**

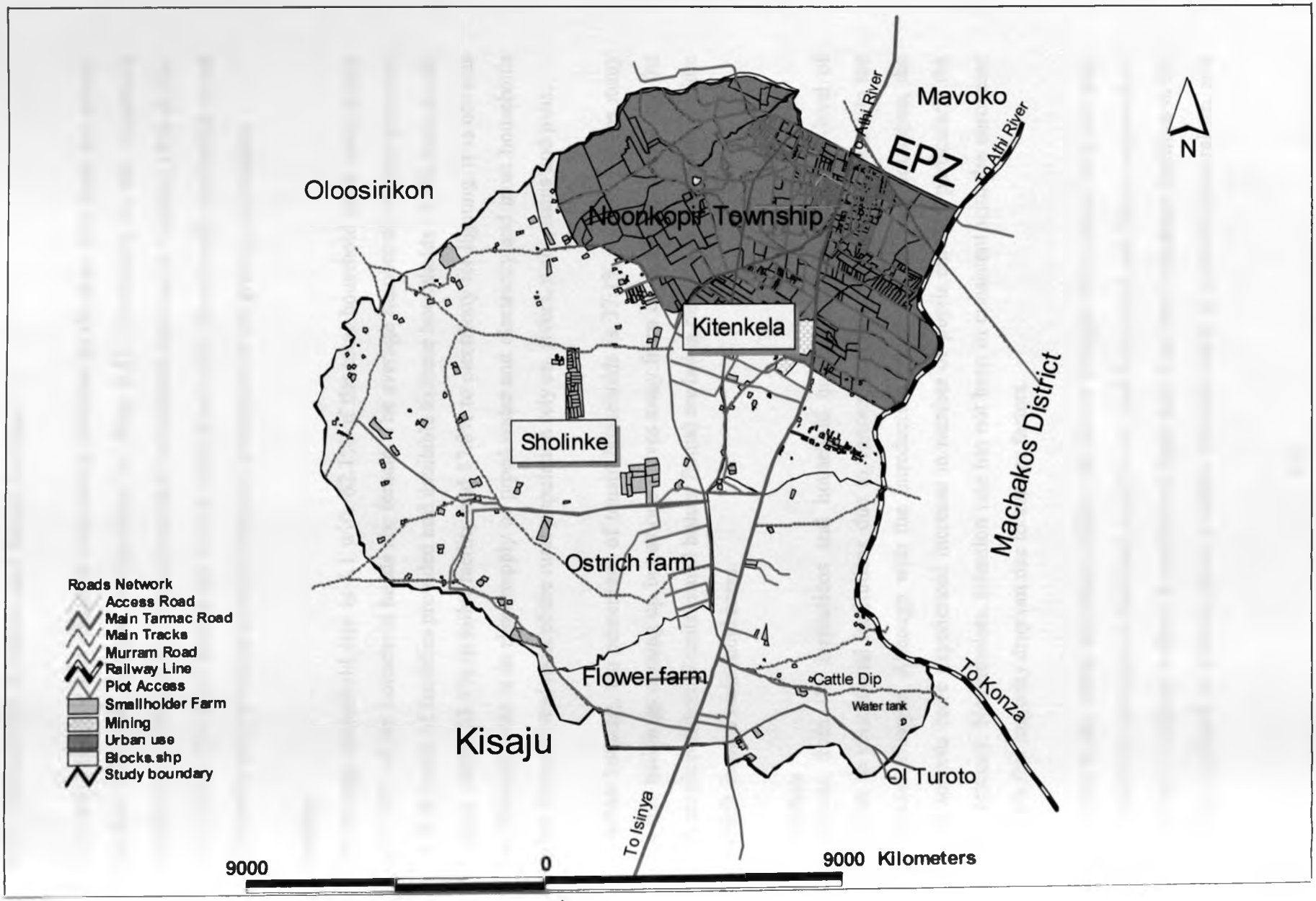
Source: Computed from Household questionnaire June 2002

Figure 4.11: Incidence of Crime Rate in North Kaputei



Source: Computed from Police Record on Crime Rate in 2000 – 2001

Map 4.10: Infrastructure Network in North Kaputei



Source: Constructed from Satellite images by researcher

4.3.6 Community Facilities and Social Services

There are no proper and adequate community facilities in the area. But there are several churches and one mosque as illustrated in Map 4.11. According to the household questionnaires, 60% of the respondents seek recreational services in Nairobi, 15% in Athi River while 25% don't seek at all. As for medical services, there is only one health center in the study area, which is already becoming inadequate to the growing population.

Housing

The average household size is 4.1 with 62.1% of the total household head being males and 37.9% of the household heads are female. The average number of persons per room is 1.8. in terms of facilities provided and available to these households 15.8% have access to piped water, 63.1% to toilet facility and 17.8% to electricity for lighting. It is obvious that the study area is in short supply of piped water and electricity and most households rely on boreoles and most of the rural population rely on rivers, wells, dams and pans.

On urban housing, the percentage of tenant households is 37.1%. Noonkopir has many high rise buildings coming up but as one moves away from town towards Isinya and the Park, single residential units (small holder farms) are being built on plots denoting middle and high income residential areas.

Education

Responses from the institutions and household questionnaires indicate low-level of retention to educational institutions due to various factors particularly attributed to the pastoralist lifestyle. Although with the introduction of the free primary education, the public schools have experienced increase in number of pupils enrolled particularly the lower primary. Nevertheless, retention rate has not been in consistent with the enrolment rate such that majority drop out due to various factors.

According to the zonal education officer, the factors brought out included lack and poor accessibility to educational facilities, insufficient land for current and future expansion of educational facilities without a coordinated basis such that most education facilities in the area are confined to limited space, cultural practices such as nomadic-pastoralism, and

food security as most opt to drop out particularly during drought for lack of adequate food.

Equity has therefore been compromised in Noonkopir Township with regard to educational facilities. Nevertheless, since January 2003, the enrolment level in public school in the area has increased with the introduction of free primary education. Since then, there has been increase in the establishment of more private schools to cater for the increasing demand.

There exists only a single public primary school, whose location is in a public purpose user (G.K. Athi River Prison). There is therefore an urgent need to establish more public primary schools to realize the universal primary education. But the number of private schools has increased from 6 in 2002 to 16 in 2006 with an average enrolment of 200 pupils per school. According to the field survey 2002, the area had only 2 secondary schools of which one is a private Girls school while the other is Noonkopir Secondary School. But this has increased as follows:

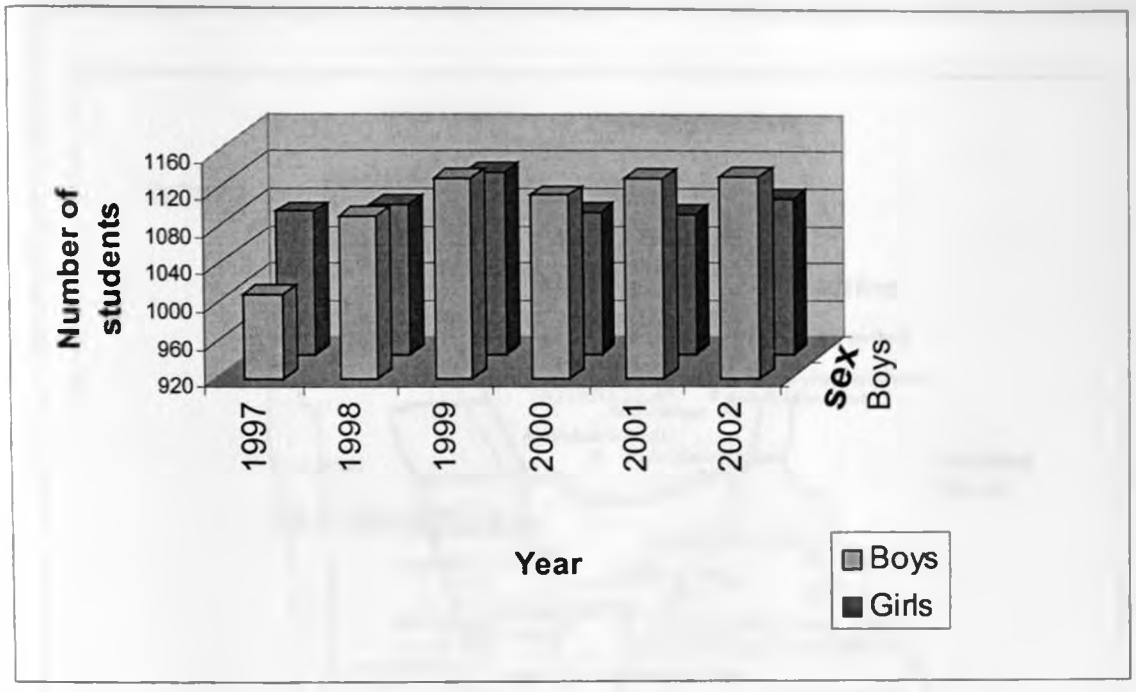
- 3 public secondary schools – 1 boy school and 2 girls school with average enrolment of 300 pupils per year.
- 5 private schools – 2 boys, 1 mixed and 3 for girls.
- 9 primary Schools

Table 4.9: School Enrolment per year by sex in North Kaputei Zone

Year	Boys	Girls	Teacher Establishment
1997	1011	1074	69
1998	1096	1082	75
1999	1137	1117	78
2000	1118	1072	78
2001	1136	1071	73
2002	1139	1087	79
2006	2227	1972	109

Source: Field Survey 2002 with updates February 2006

Figure 4.12: School Enrolment per year by sex in North Kaputei



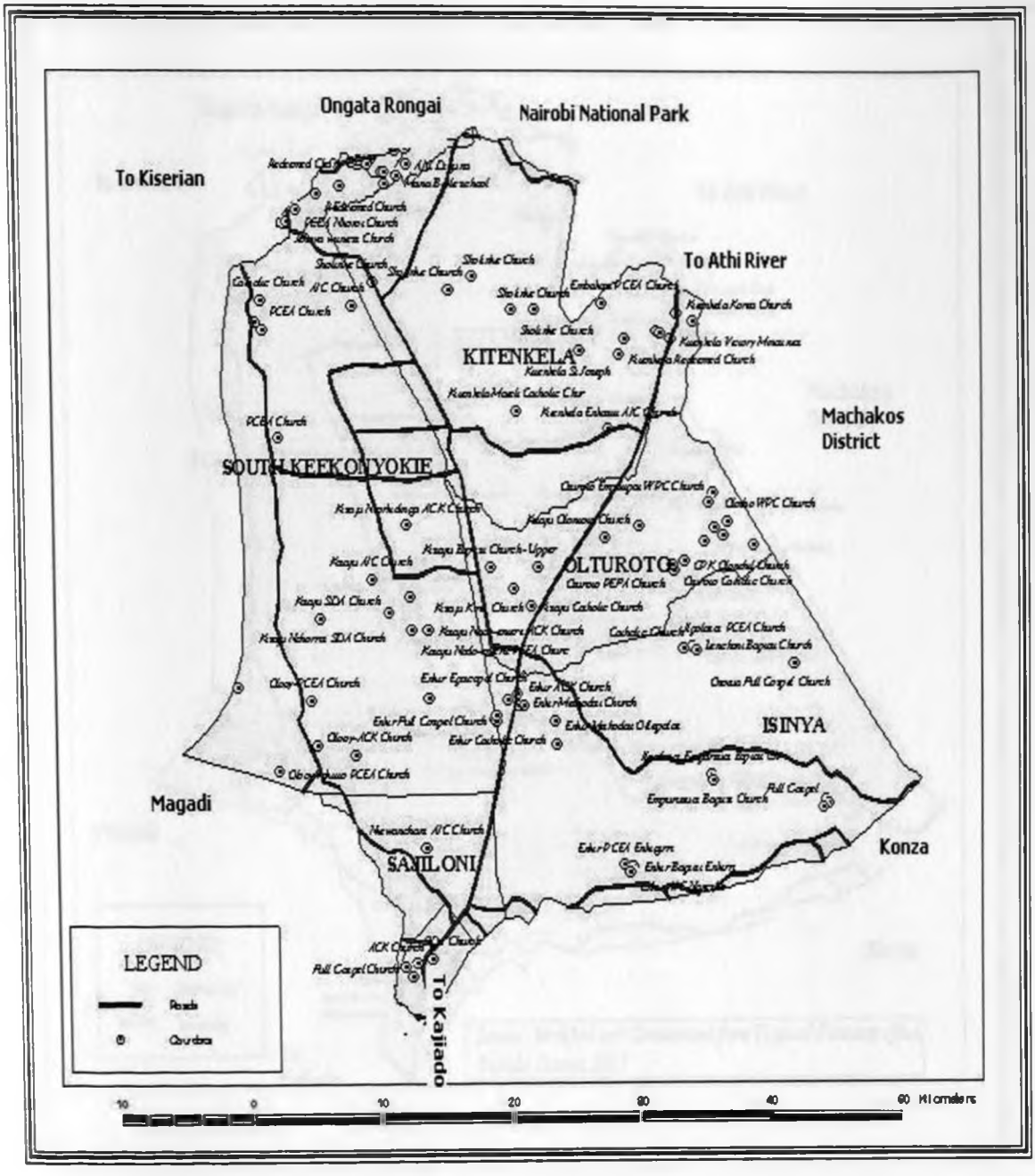
Source: Field survey, 2002

4.4 Land Use Change Perception

In the study area, the land use change process is reflected in the increasing population densities, land sizes, commuter patterns and migratory trends. However, this trend manifests itself in the form of urbanization. The heterogeneous nature of the population in the study area has been accelerated by in-migration from city of Nairobi and other parts of the country. This is a population that relies on cash economy for their daily needs unlike the rural areas that rely on subsistence production, a phenomenon that spurs land use change.

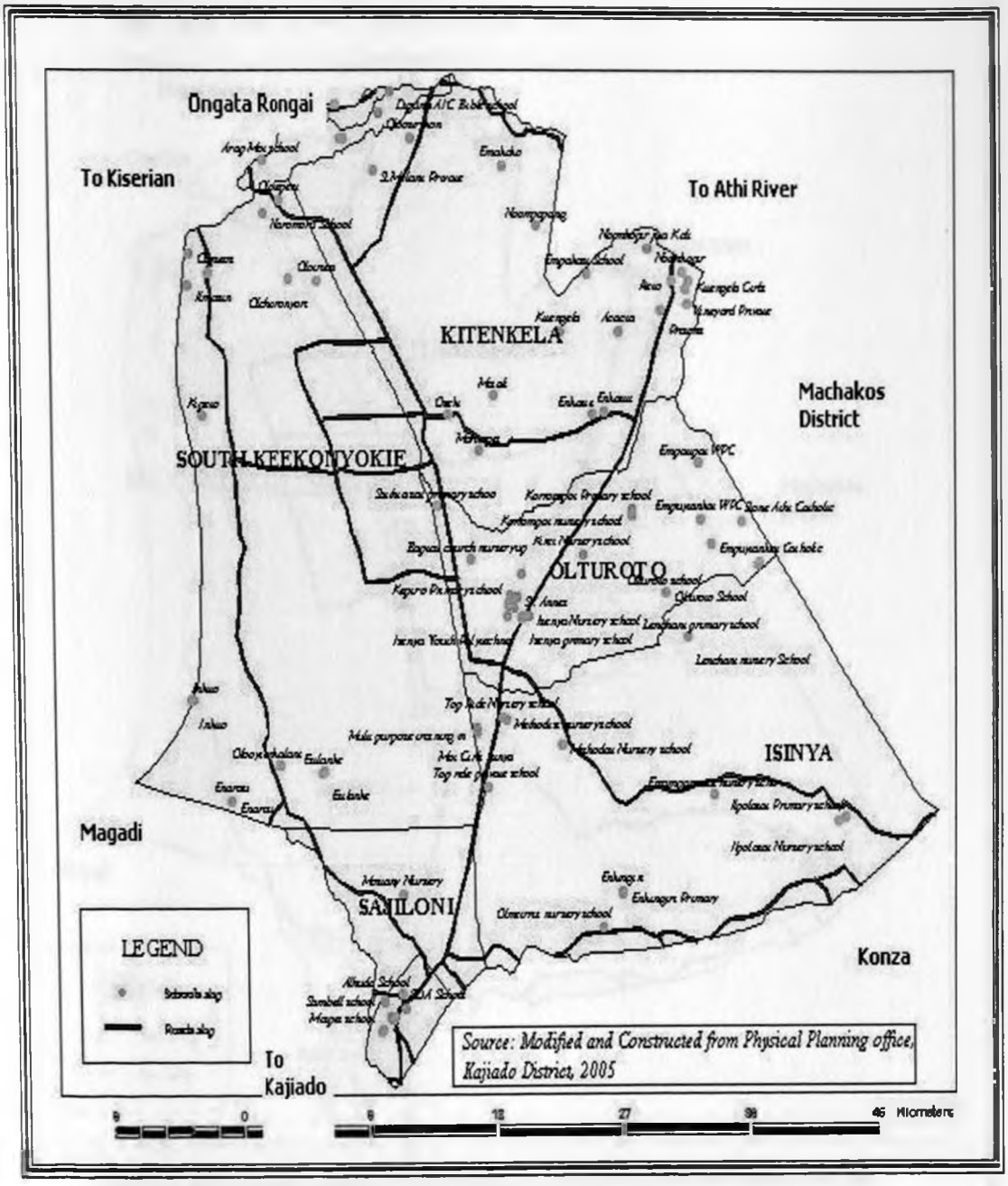
A strong dependence on the city of Nairobi brings in the element of rural-urban linkage with the city acting as the magnet to the study area in terms of employment and high level of services while the study area acts as a residential dormitory due to its available cheap housing as well as ample land for residential development.

Map 4.11: Distribution of Churches in North Kaputei



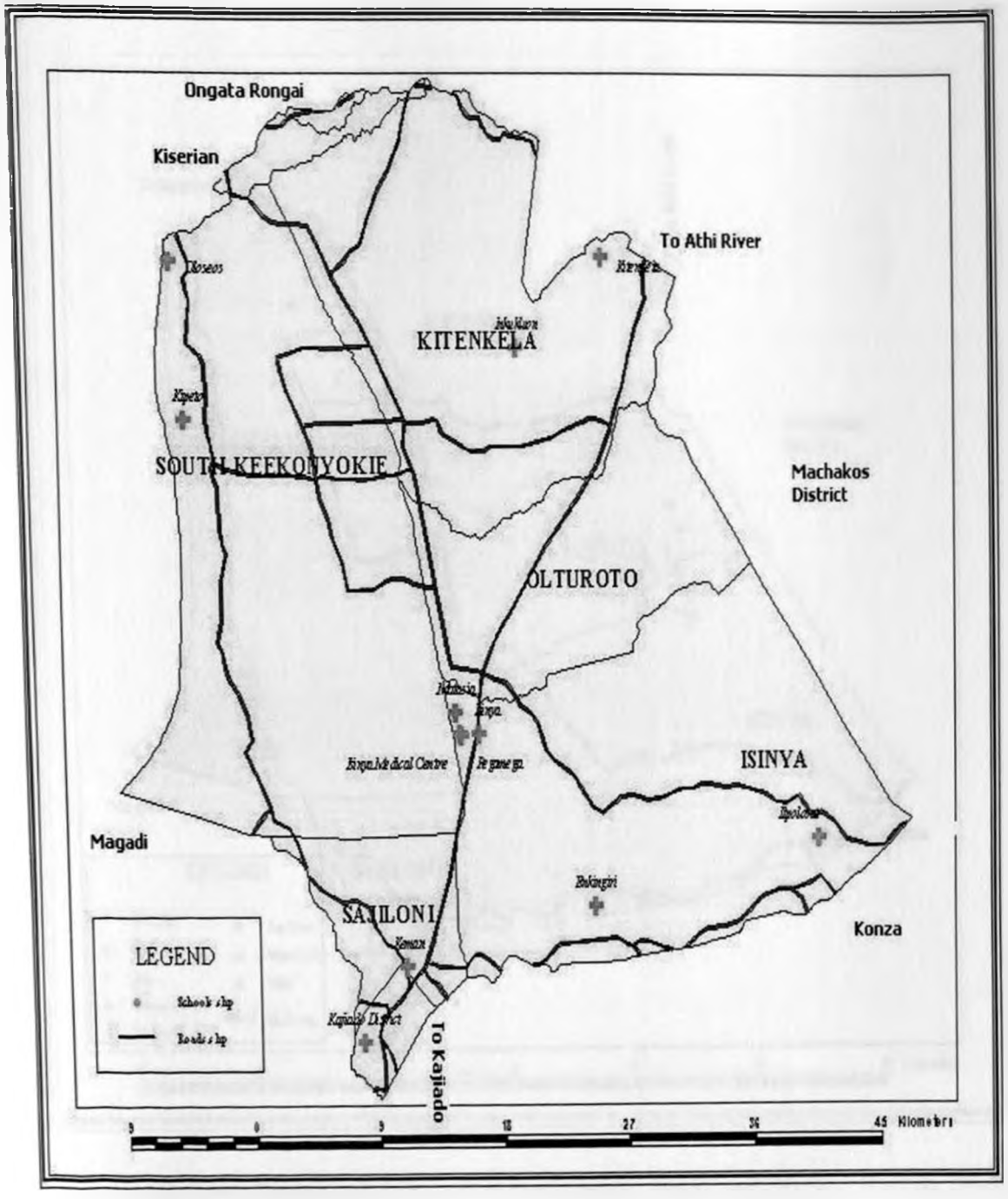
Source: Modified and Constructed by researcher from Satellite Images and Physical Planning Office, Kajiado District - 2005

Map 4.12: Distribution of Schools in North Kaputei



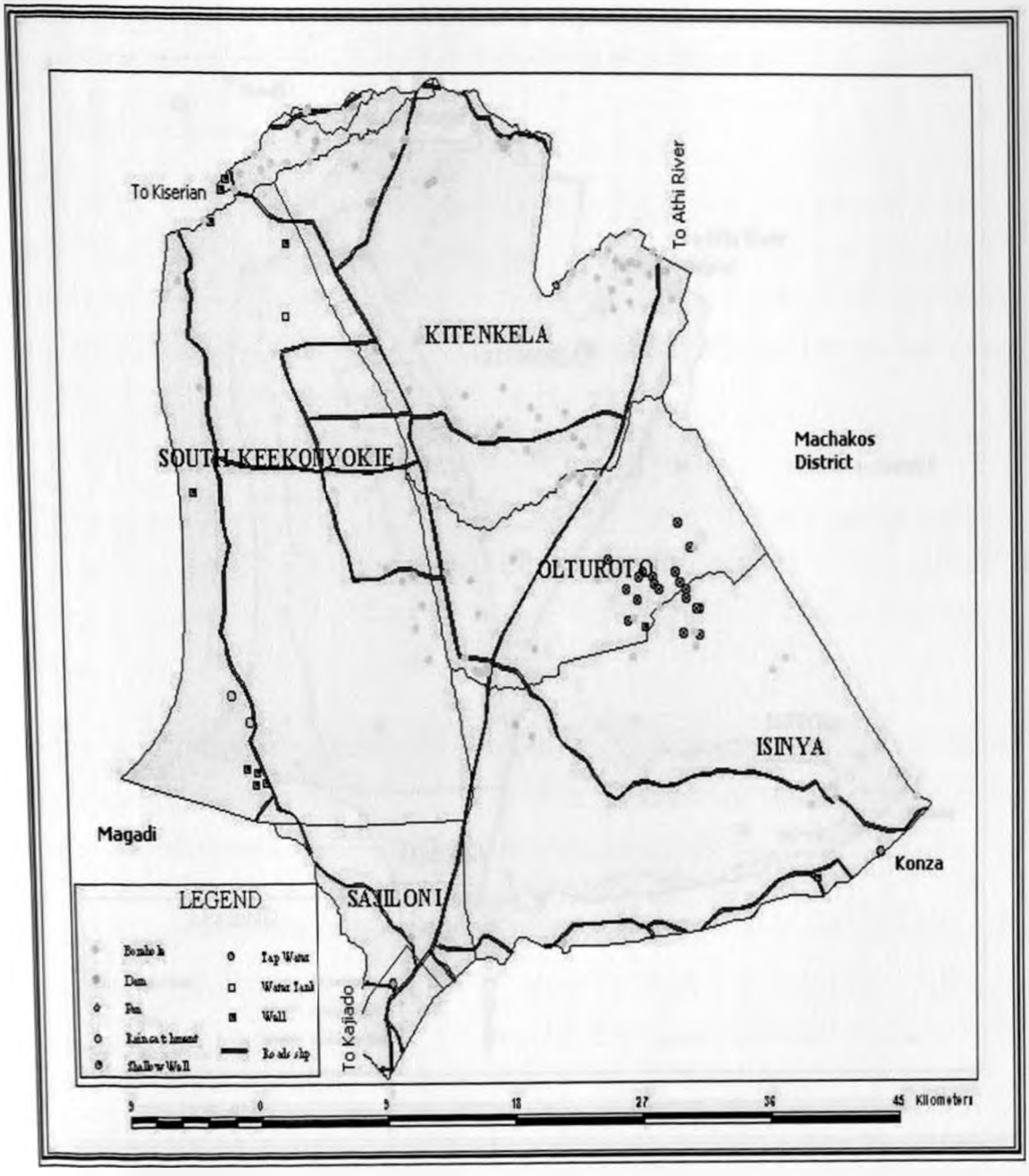
Source: Modified and Constructed by researcher from Satellite Images and Physical Planning Office, Kajiado District - 2005

Map 4.13: Distribution of Health Facilities in North Kaputei



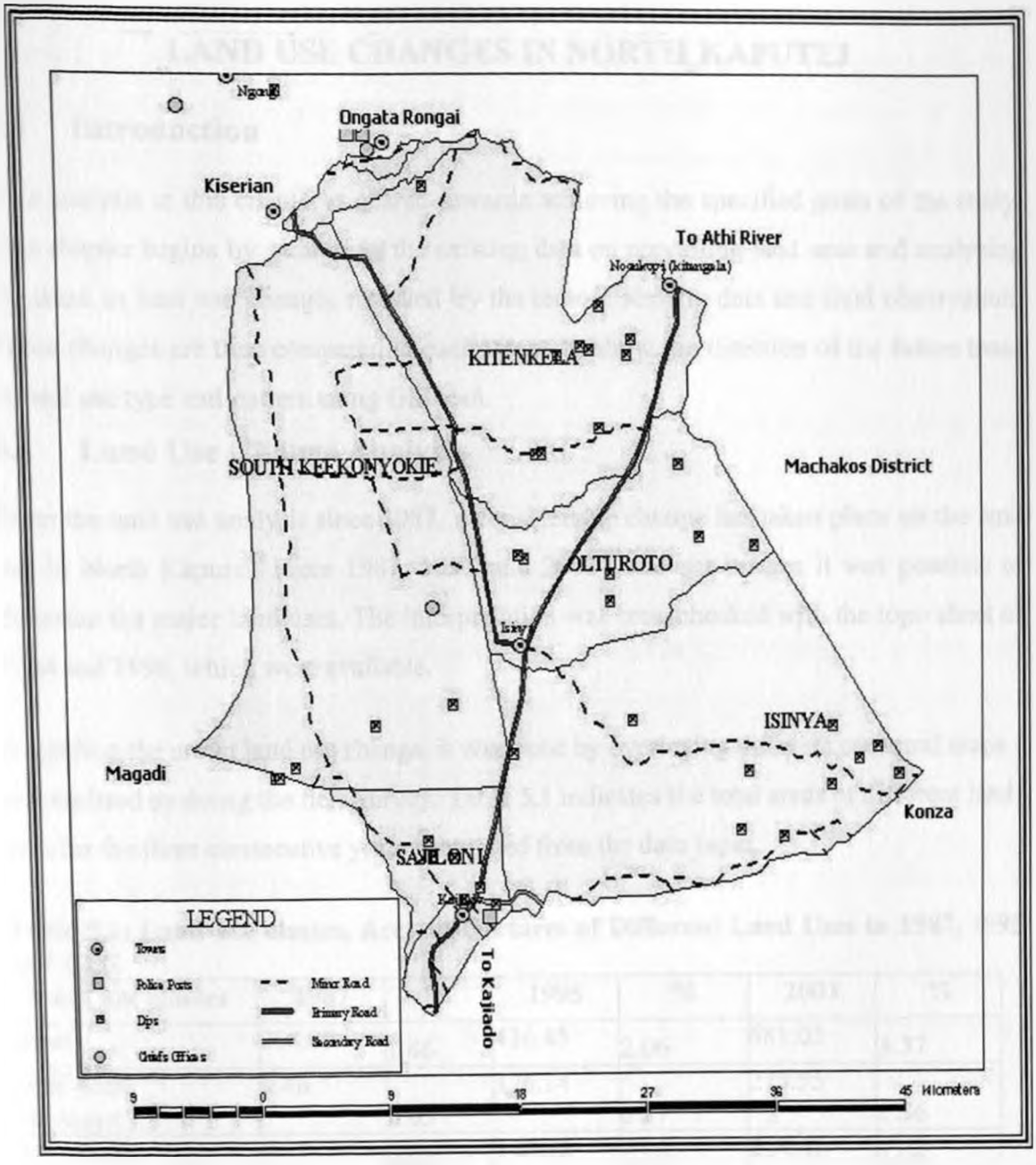
Source: Modified and Constructed by researcher from Satellite Images and Physical Planning Office, Kajiado District - 2005

Map 4.14: Distribution of Water Points in North Kaputei



Source: Modified and Constructed by researcher from Satellite Images and Physical Planning Office, Kajiado District - 2005

Map 4.15: Distribution of Basic Infrastructure in North Kaputei



Source: Modified and Constructed by researcher from Satellite Images and Physical Planning Office, Kajiado District - 2005

CHAPTER FIVE

LAND USE CHANGES IN NORTH KAPUTEI

5.0 Introduction

Data analysis in this chapter is geared towards achieving the specified goals of the study. This chapter begins by examining the existing data on prevailing land uses and analyzing the trend in land use changes revealed by the remote sensing data and field observation. These changes are then compared in each tempo to show the direction of the future trend in land use type and pattern using GIS tool.

5.1 Land Use Change Analysis

From the land use analysis since 1987, a considerable change has taken place on the land use in North Kaputei. From 1987, 1995 and 2003 Land sat images it was possible to delineate the major land uses. The interpretation was crosschecked with the topo sheet of 1984 and 1996, which were available.

Regarding the urban land use change, it was done by overlaying different cadastral maps and updated by doing the field survey. Table 5.1 indicates the total areas of different land uses for the three consecutive years calculated from the data input.

Table 5.1: Land use classes, Area in Hectares of Different Land Uses in 1987, 1995 and 2003

Land use classes	1987	%	1995	%	2003	%
Urban	294.89	1.46	416.45	2.06	681.05	3.37
Small-scale settlement	9.46	0.05	176.14	0.87	273.55	1.36
Ecotourism	9.57	0.05	140.53	0.70	214.47	1.06
Industrial Mining	31.3	0.16	57.47	0.28	316.12	1.57
Grassland	9615.03	47.64	9674.81	47.94	7893.85	39.11
Shrubs & Forest	10221.75	50.65	9716.1	48.14	8396.31	41.60
Large farms					2406.65	**11.92**
Total	**20182.00**	**100**	**20182.00**	**100**	**20182.00**	**100**

Source: Computation from satellite scenes of 1987, 1995 and 2003

5.1.1 Changes in Land Use from 1987 - 1995

During the period 1987 to 1995, 176.14 hectares of total study area was converted into small scale residential. Therefore small-scale residential land use increased by 18.62 hectares which more than tripled during this period. In fact there was a substantial change in small-scale settlement in the study area.

416.45 of total area were converted to urban land use in 1995 unlike 294.89 hectares in 1987, therefore, urban land use increased by 1.41 hectares or 41.22%.

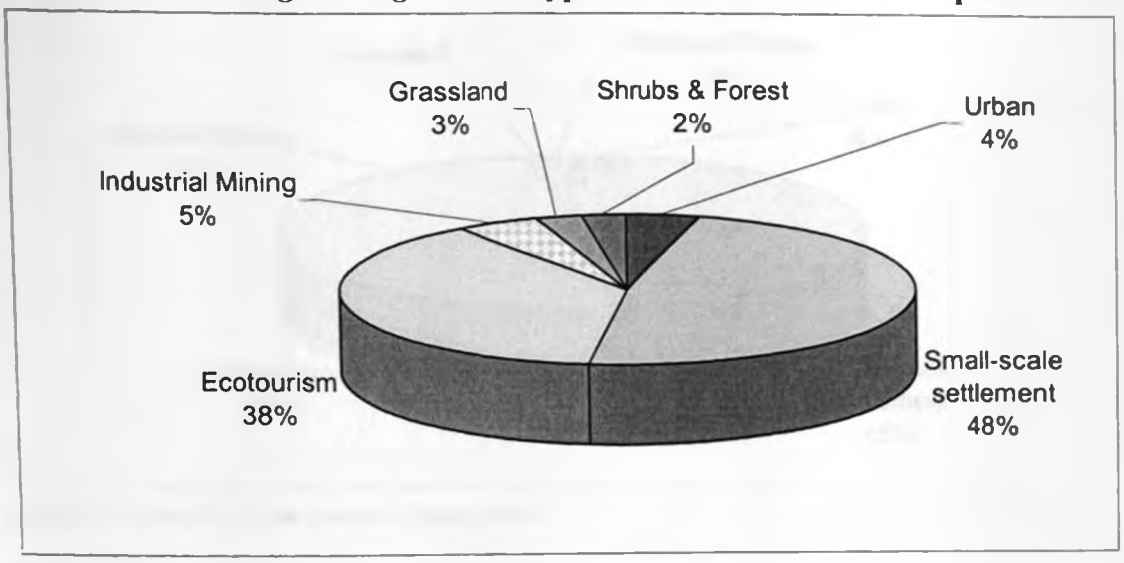
During this period, the area experienced an increase in ecotourism, which was mainly the game ranching and horticultural activities. 140.53 hectares of total area was converted to ecotourism in 1995 from 9.57 hectares in 1987. Therefore, ecotourism increased by 14.68 hectares.

Mining activities in the area increased during this period from 31.30 hectares of total area in 1987 to 57.47 hectares in 1995 therefore, the mining activities increased by 83.61% or about doubled to 1.84 ha. This is also reflected in the demand for building materials that led to the increase in urban development.

Whereas the vegetation cover decreased during the period as the other land uses emerged in the study area. Grassland decreased by 0.14 % or 1 ha and shrubs decreased by 4.95% that is about 0.95 ha. During this period, the large ranches were under the grassland and shrubs classification. Nethertheless, these remained the dominant land uses in the study area (Figure 5.3 – 5.5 and Map 5.2). During this period, the subdivision of group ranches into individual plots was taking place as well as the sale to private developers.

During this period both small-scale settlement and ecotourism land uses showed a substantial change as shown in the figure 5.1. This change was attributed to population influx in this period as revealed in chapter three.

Figure 5.1: Percentage Change in each type of Land use in 1987/1995 period



Source: Computation from Land use analysis table

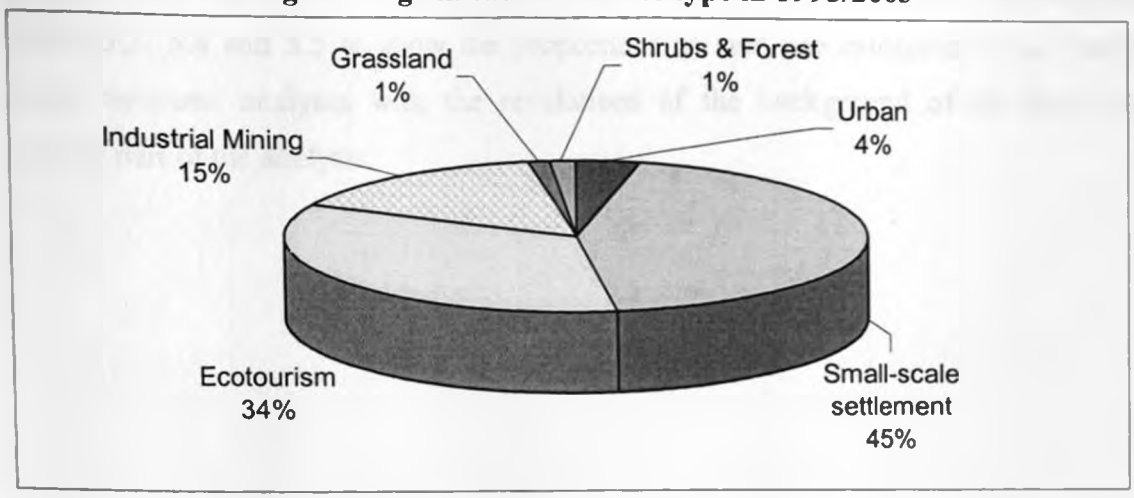
5.1.2 Changes in Land Use from 1995 - 2003

During the period 1995 to 2003, 273.55 hectares of the total area was converted to small-scale residential use. Therefore small-scale residential land use increased by 55.30% or 28.95 hectares during this period.

During the same period, urban land use increased by 38.96% from 490.45 in 1995 to 681.05 in 2003 while mining activities recorded an increase of 316.12 ha from 57.47 in 1995. Therefore, industrial mining increased by 10.10 ha.

Ecotourism recorded a 52.56% increase during the period of 1995-2003. 0.82 hectares of grassland is changed into other land uses. Therefore grassland land use decreased by 0.82 hectares during this period. While shrubs or forests also recorded a decrease by –13.58%, which was converted into other land uses in the study area as illustrated in Map 5.3.

Figure 5.2: Percentage Change in each Land use type in 1995/2003



Source: Computation from Land use change table

5.2 General Changes in Land Use Patterns

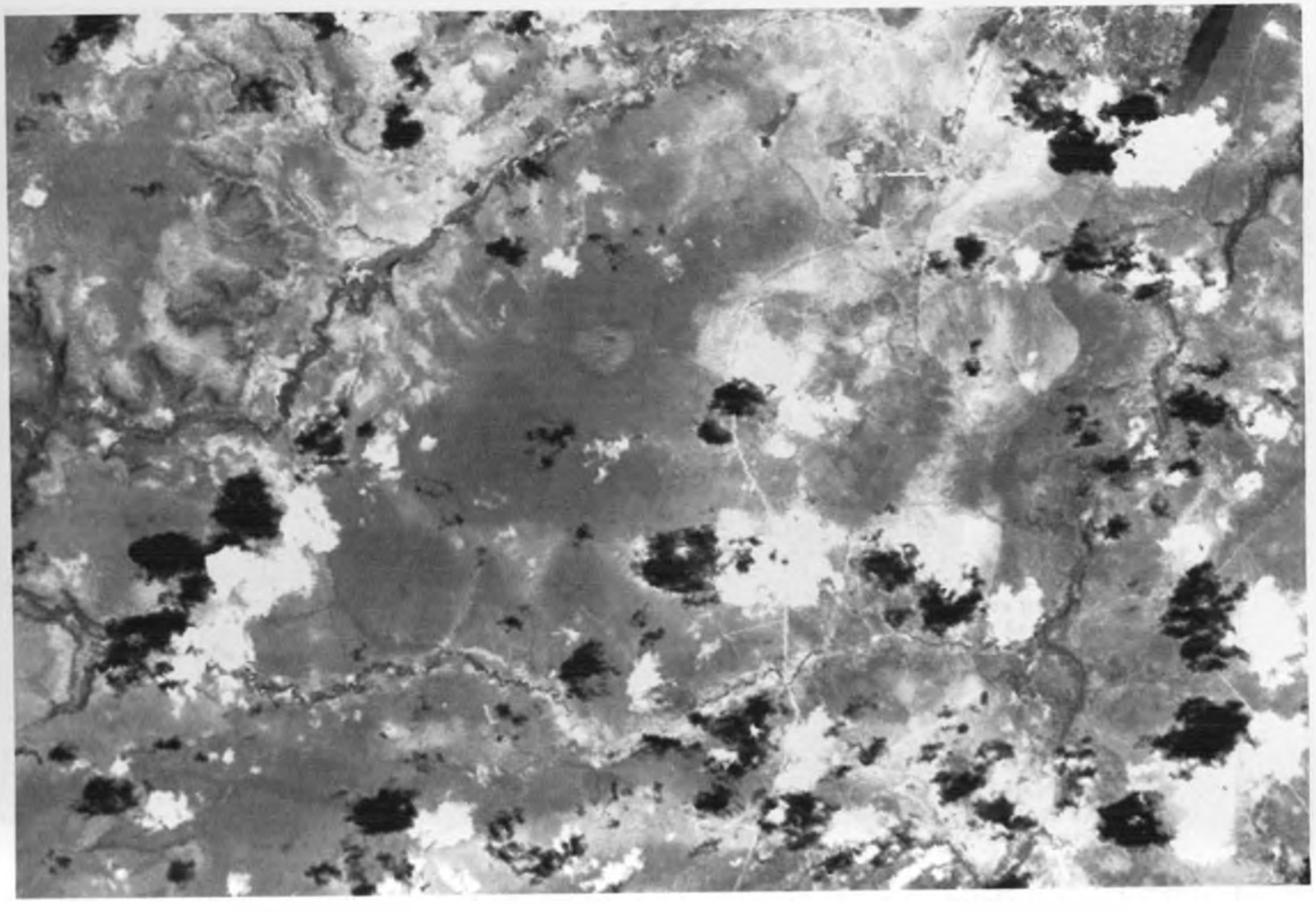
The impacts of population growth, cultural perception on land and change in land tenure from group ranching (communal) to individual tenure (private ownership) have had effects on land cover and land uses in North Kaputei towards the year 2006. A substantial proportion of land users/developers in North Kaputei are tenants who have leased land from the livestock oriented owners. There are four major land use categories in the study area: extensive Pastoralism/Ranching falling under the vegetation types, Game ranching, and Small scale settlements as well as Urban land development and Natural vegetation.

Due to its proximity to the City of Nairobi, a number of unique land use patterns and activities have emerged on the Kaputei plains. There have been changes in land use within this area since mid 1960s when the land was adjudicated to large group ranches, which have today given way to individual land ownership. This change in land tenure has promoted emergence of different land uses attributing to conflicts and environmental concerns as the changes have led to increasing permanent settlement and cultivation as well as other land uses within the area that have blocked the migratory routes for the wildlife.

The Satellite scenes of the periods 1987, 1995 and 2005 are shown in Plates 5.1, 5.2 and 5.3 respectively. These satellite images have been classified and interpreted to derive the

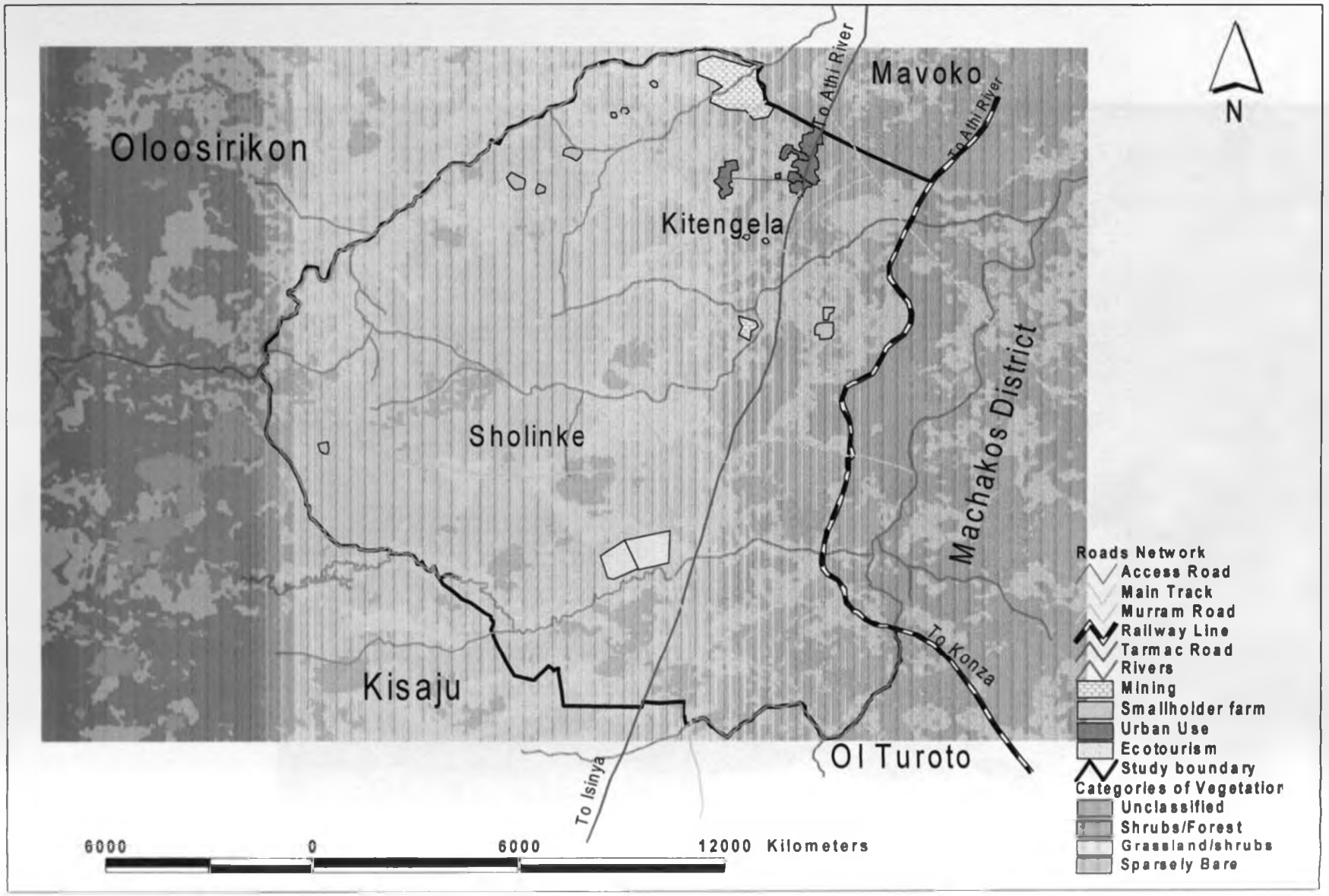
general land use pattern and proportions in each respective year thereby represented in figures 5.3, 5.4 and 5.5 to show the proportions of land use categories in the various spatial temporal analyses with the revelations of the background of the study area forming part of the analysis.

Plate 5.1: Landsat (TM) of 1987



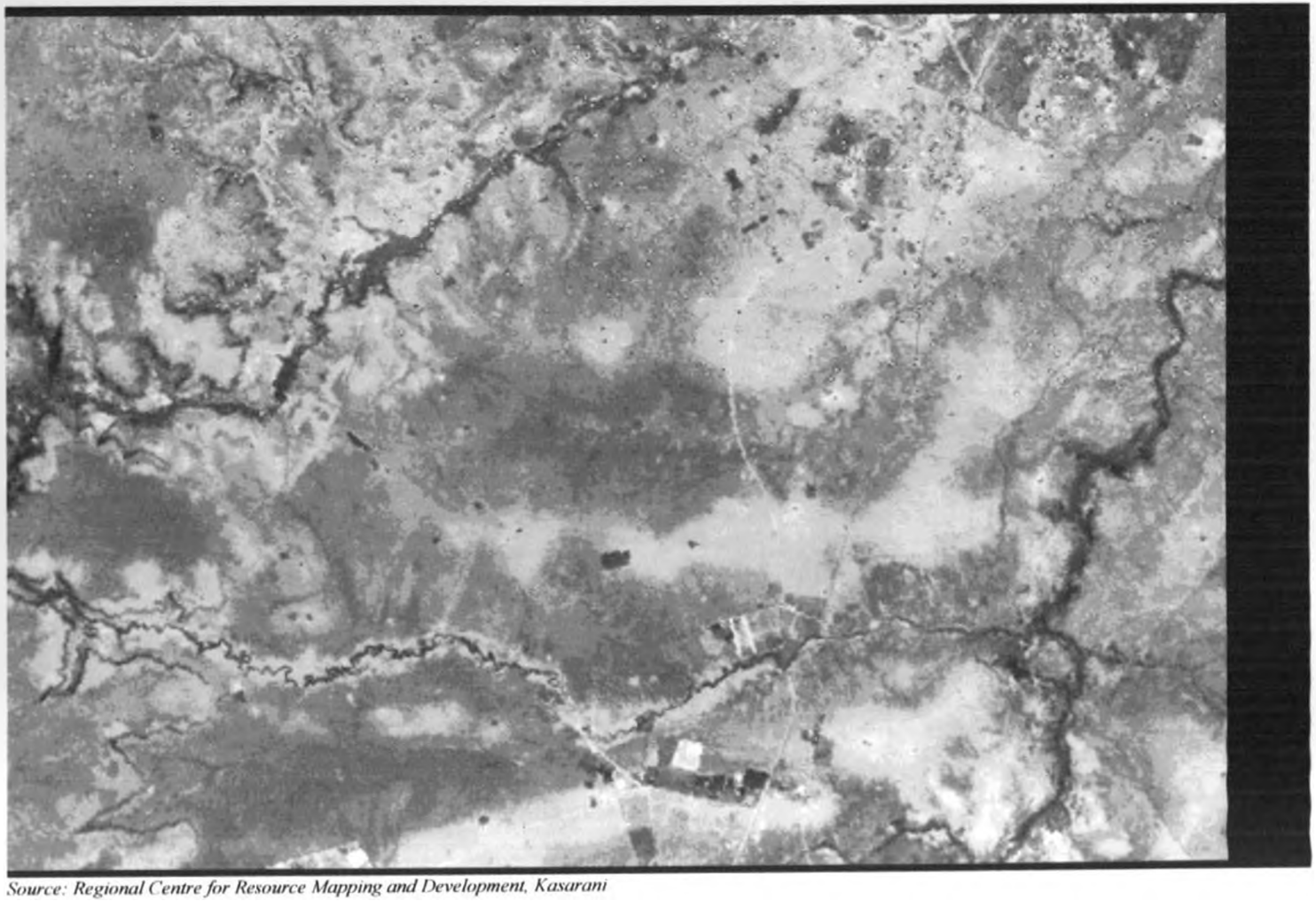
Source: Regional Centre for Resource Mapping and Development, Kasarani

Map 5.1: Land Use Pattern in 1987



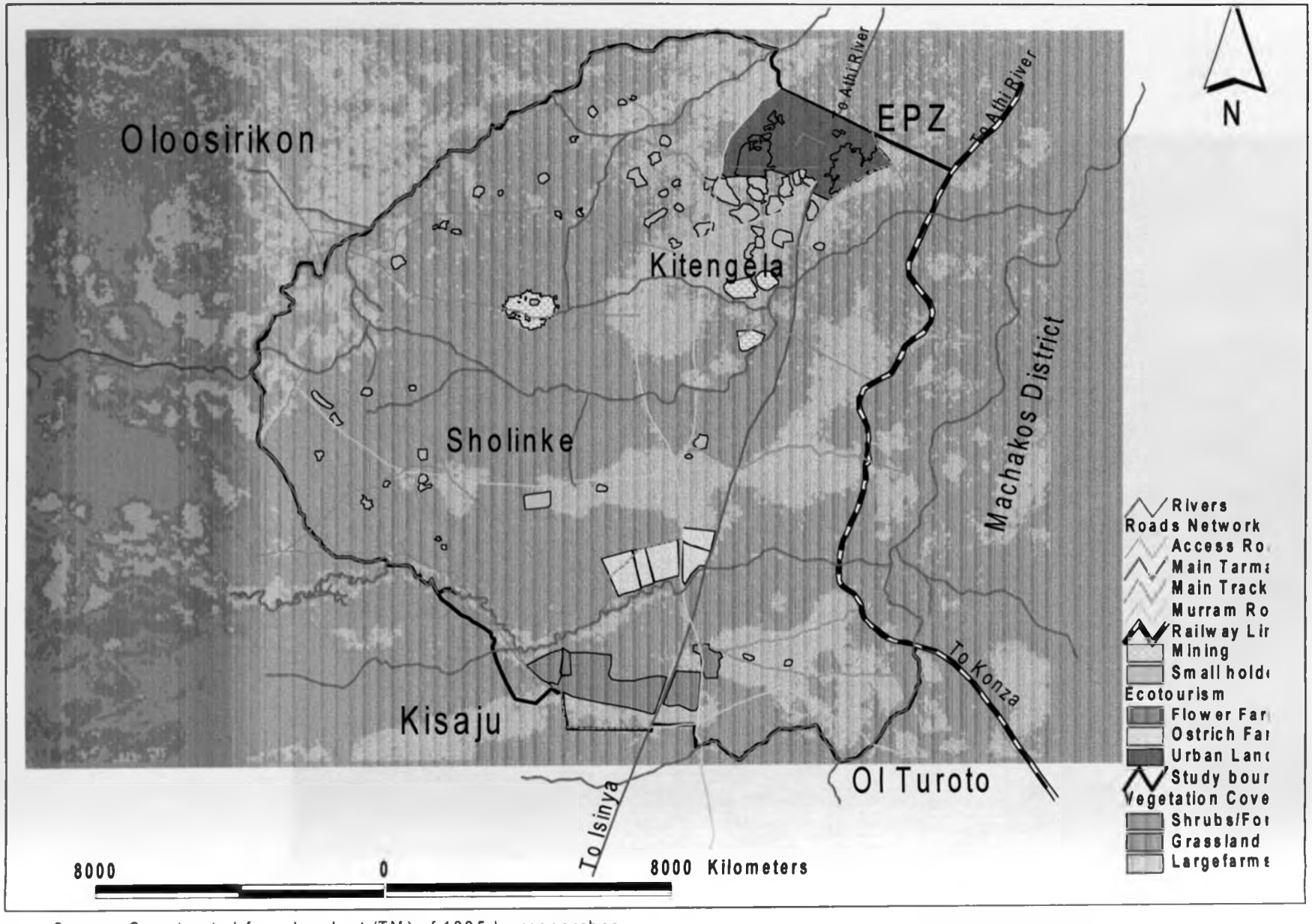
Source Constructed from Landsat (TM) 1987 by researcher

Plate 5.2: Landsat (TM) of 1995



Source: Regional Centre for Resource Mapping and Development, Kasarani

Map 5.2: Land Use Pattern in 1995

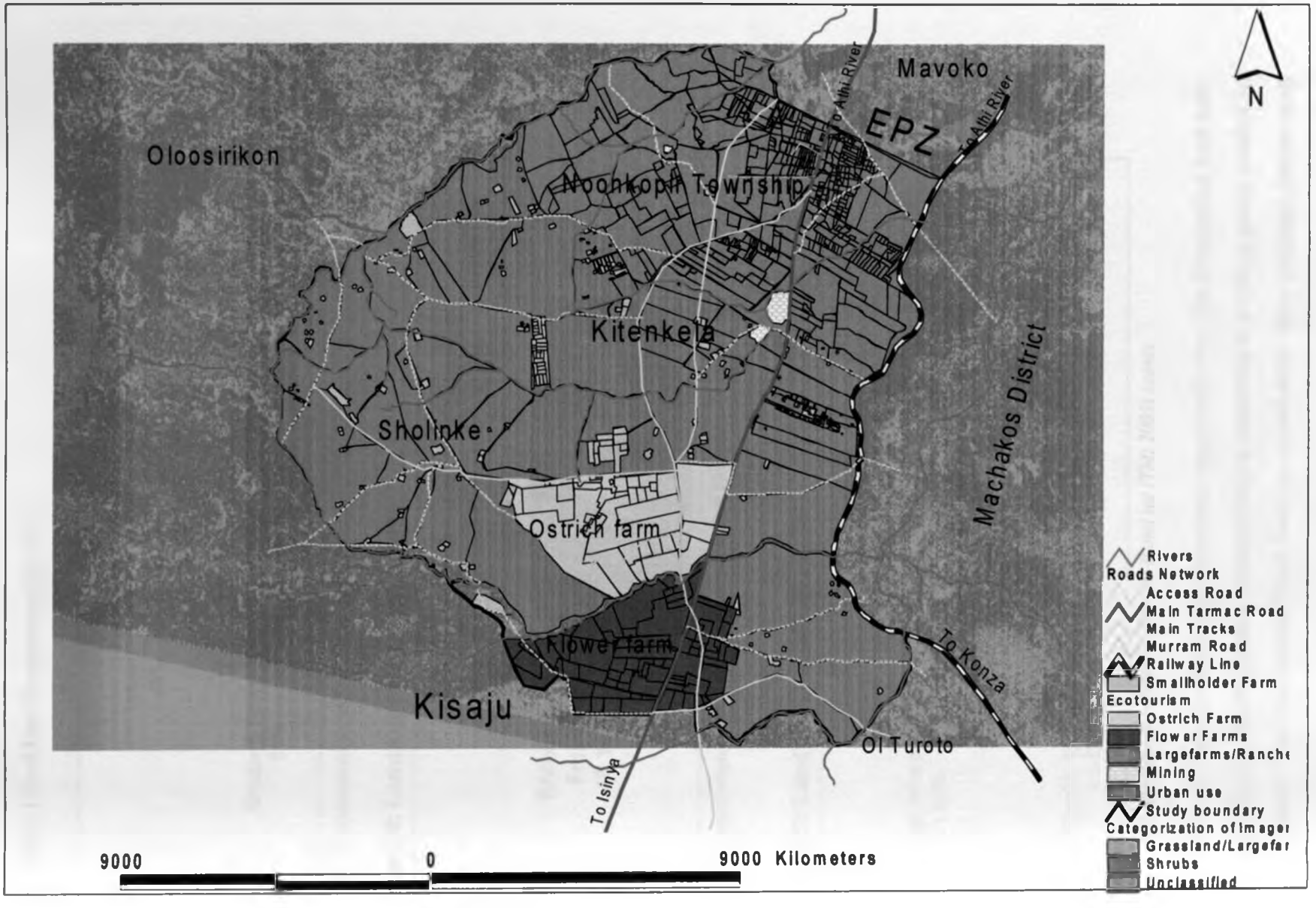


Source: Constructed from Landsat (TM) of 1995 by researcher

Plate 5.3: Spot Image of 2003

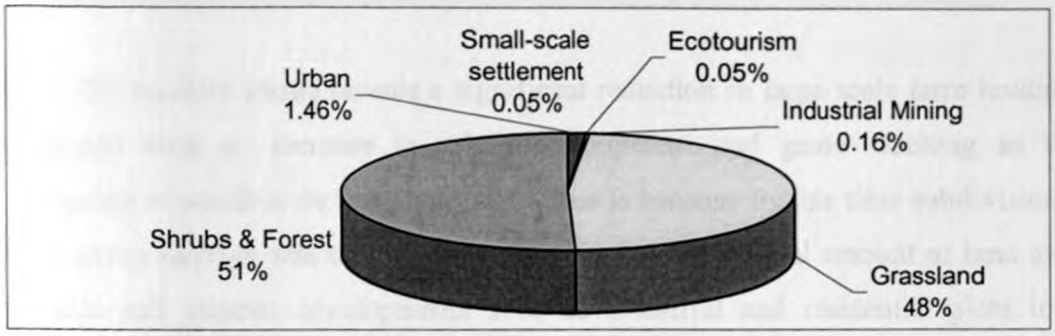
Source: Regional Centre for Resource Mapping and Development, Kasarani

Map 5.3: Land Use Pattern in 2003



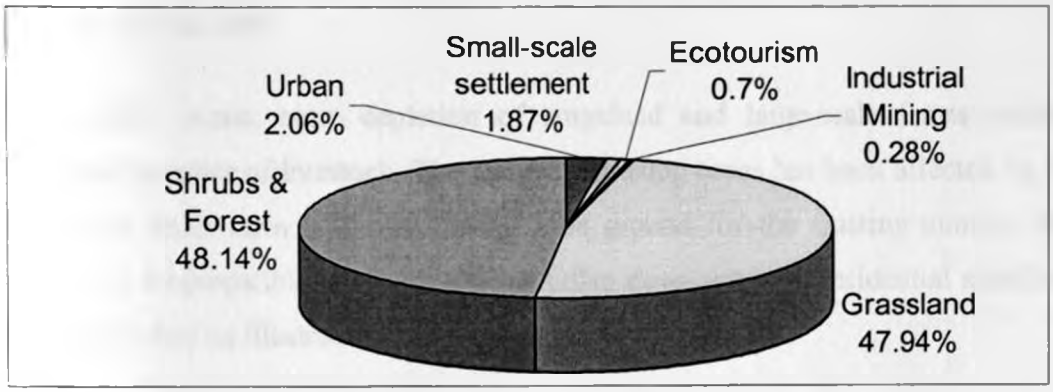
Source: Constructed from Spot Image of 2003 by researcher

Figure 5.3: Land Use Proportions in 1987



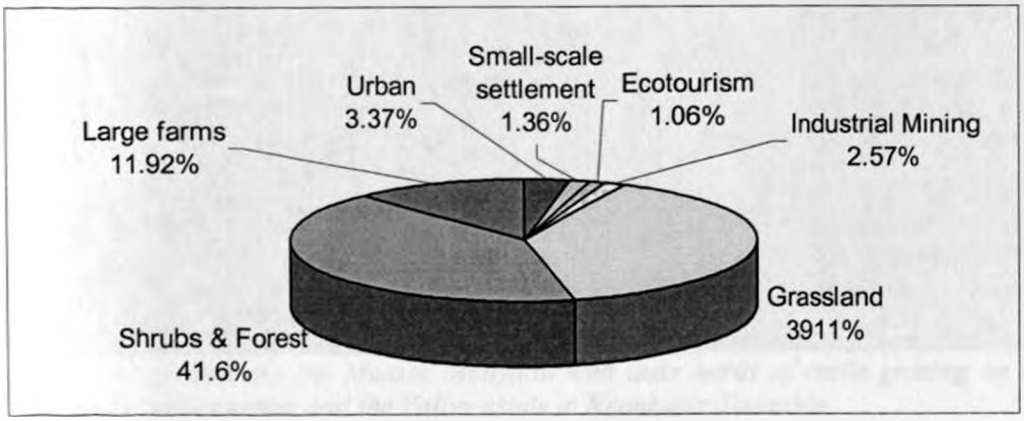
Source: Computations from Satellite Images (Land sat (TM) 1987) scenes

Figure 5.4: Land Use Proportions in 1995



Source: Computations from Satellite Images (Landsat 1995) scenes

Figure 5.5: Land Use Proportions in 2003



Source: Computations from Satellite Images (Land sat (TM) 2003) scenes

The 1987 image is one where large farms and rangelands were the dominating land uses. These large farms and rangelands belonged to the members of the large group ranches in North Kaputei. At this period there were no small-scale farm holdings rather most

residential land uses were concentrated within the Kitengela Township. Large farms accounted for 81% of the total study area that is about 201.82 square kilometer.

The 1995 satellite image reveals a significant reduction in large-scale farm holdings and rangeland with an increase in urban development and game ranching as well as emergence of small-scale farm holdings. This is because by this time subdivision of the large group ranches was taking place. There was a substantial amount of land available for sale and various developments such as industrial and residential plots in North Kaputei. Consequently, this led to reduction in stock as there was unviable grazing land left. According to range officer interviewed, the range stock has decreased from 4000 in 1987 to 1500 in 2003.

In the 2003 scene, more depletion of rangeland and large-scale farms resulting to decreased number of livestock. The available grazing areas has been affected by fencing of private small farm holdings leaving little ground for the existing number of stock leading to incompatible land uses among urban developments, residential smallholdings and pastoralists as illustrated in plate 5.4.

Plate 5.4: Invasion / Encroachment of Dense Human Settlement

At the fore ground are the Maasai Manyatta with their herds of cattle grazing on the space between the urban center and the Valley estate in Noonkopir Township

Increased population and immigration have exerted pressure on valuable grazing land. From field survey, one respondent revealed that with the promise of higher returns from land subdivision sales, the indigenous landowners have opted to sell their land to

potential investors from Nairobi and other parts that have not necessarily carried on with the former land use practices. This has tremendously reduced rangeland with favourable grazing land being converted to residential area as well as increased fencing of subdivided plots making the land unviable for grazing. The result is overstocking which has led to increased land degradation and conflicts.

According to Range Officer of Kitengela location, increased subdivisions within the former large-scale farms and the rangelands together with the fencing of plots have left little space adequate for grazing. Overgrazing has resulted that further leads to degradation of soil and soil erosion and eventually consequent reduction in stock.

The field survey indicates that of the respondents interviewed, only 34% had any agricultural activity on their farm but even this was alongside residential activities while 46% had pure residential activities on their land.

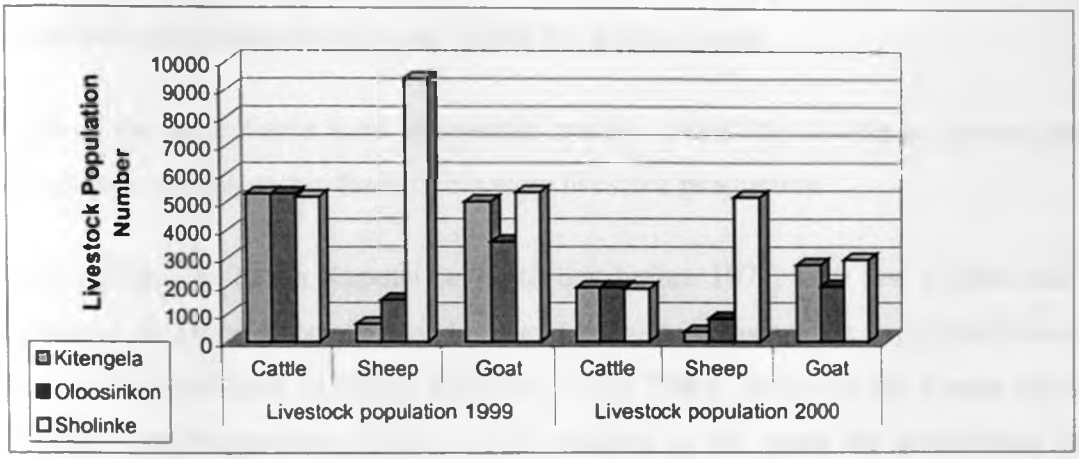
It is evident that areas with high erosion hazard have been overgrazed. Overgrazing and overstocking attribute to soil erosion and/or loss of grass cover that subsequently reduce livestock productivity which has been the basic source of livelihood to the majority in North Kaputei.

Table 5.2: Livestock Population in North Kaputei by Sub-location and Year

Location	**Sub-location**	**Livestock population 1999**			**Livestock population 2003**		
North		**Cattle**	**Sheep**	**Goat**	**Cattle**	**Sheep**	**Goat**
Kaputei	*Kitengela*	5295	641	5007	1933	353	2754
	Oloosirikon	5295	1504	3589	1933	827	1974
	Sholinke	5183	9396	5343	1892	5168	2938
	Subtotal	15773	11541	13939	5758	6348	7666

Source: Kajiado District Livestock Department 2003

Figure 5.6: North Kaputei Livestock Population in 1999 and 2003



Source: Kajiado District Livestock Department

Table 5.3: North Kaputei Livestock Population

Stock		**1988**	**1999**	**2003**
Cattle		3443	5295	1933
Sheep		10306	641	353
Goat		3751	5007	2754
Growth Rate per Year	10%			
Mortality rate	3%			

Source: Field Survey, 2003

The projections given by the livestock officer in North Kaputei was that, livestock increased by 10% per year while the mortality rate is 3% per year. Losses following 2003 prolonged drought estimated 30% mortality rate.

5.2.1 Trends in Large-scale Farms or Ranches

Ranching or Large-scale farms as land use covers an area of 2406.65ha in 2003 as compared to 19836.78ha in 1987. These acreages constitute of cattle ranches owned by members of the Maasai community and land owning co-operatives falling under the vegetation cover.

Rangeland with their low carrying capacity should be best left to ranching or livestock keeping and management of grazing zones. Currently, most parts of the large ranches are subdivided and sold out to individual holders who have fenced the parcels leaving very little ground for grazing. The cattle density deliberately kept low to avoid overstocking

and overgrazing with their related consequences. Virtually grazing ground covers about 8% of total study area can be found within the grazing zones.

Some of the large farms were large-scale ranches owned by the Maasai group ranches. The main activities within these farms were livestock production.

Range Officer in North Kaputei revealed that before 1977, very few people had been registered as proprietors of individual land parcels. Most of the registered ones were those with big parcels as Group Ranches. From 1980s, failure of the Kenya Livestock Development Programme (1968 – 1982) resulted in the quest for subdivision by the members of group ranches. The main reasons according to one former member of group ranch were lack of individual benefits to members, continued registration of new members and entry of the success of individual ranches. The other reason leading to subdivision of ranches was because of higher land value as a result of the proximity of North Kaputei to City of Nairobi.

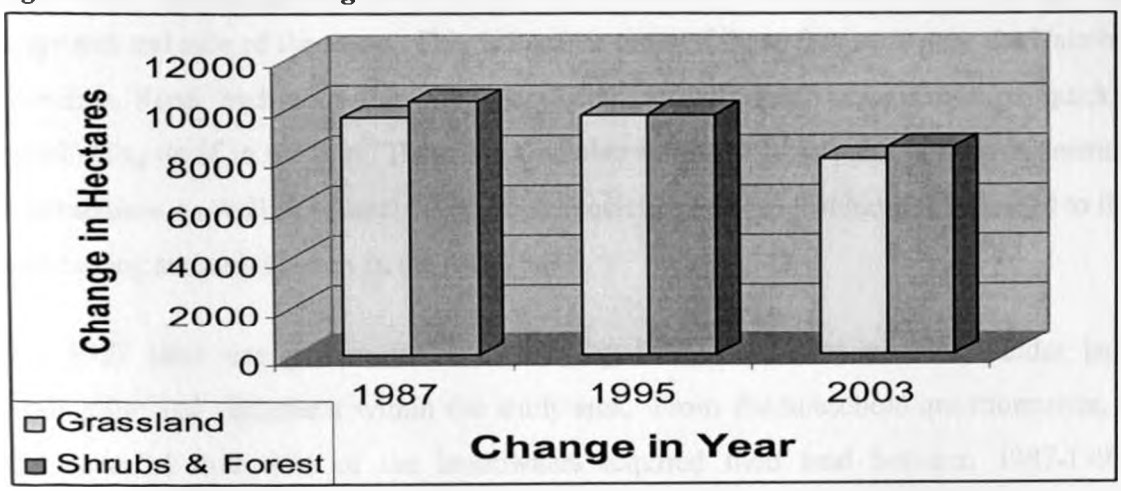
After subdivision of ranches to group members, land fragmentation and sales have continued at a higher rate, giving rise to small and individual holdings. Today, there is no single group ranch remaining in North Kaputei while the rest have been dissolved and title deeds issued to individual owners giving way to corporate land ownership.

Six years ago, the area was under ranching as farmers depended fully on livestock such as cattle, sheep and donkey. But the demarcation of land to individual ownership has facilitated many locals to sell their pieces of land to new comers especially from overpopulated areas who started to develop the land particularly through drilling of borehole, crop production and construction of buildings for various purposes.

As a result many indigenous owners of land have been left with little space suitable for livestock production. According to the Veterinary officer, there has been a decrease of stock per person from 100 heads to 30 heads since 1995. This has forced them to go into other enterprises such as farming, poultry, pig keeping, dairy (zero) grazing. Land has become a limiting factor together with frequent drought that has led to farmers loosing a number of stocks, hence this has forced them to go into other enterprises.

The rising demand for urban development, small scale farm holdings for residential housing and/or even speculative purpose is bound to have all large-scale farm holdings and rangeland within the North Kaputei particularly towards the Ngong division and the park turned into other land uses. Mining and game ranching have gained popularity as new land uses. The trend is that, ecotourism has picked up from only 0.096 square kilometers in 1987, 1.41km^2 in 1995 to 2.14 km^2 in 2003 out of 201.82 km^2 of the total area. This reveals a new trend in land use pattern where ecotourism is becoming one of the most economical productions of land as illustrated in figure 5.7.

Figure 5.7: Trends in Large Ranches



Source: Computations from Satellite Images 1987 – 2003 scenes

Most large-scale landowners interviewed expressed intentions of subdividing their parcels further and selling them as small parcels citing non-profitability of large-scale holdings. The owners of individual farms are already subdividing them to very high density for either commercial or residential land uses.

5.2.2 Trends in Small Holder Settlement

Smallholder farmland in this study is regarded to be private farm holding sizes of less than an acre. The emergence of small farm holding is as a result of increasing demand for land posing high land value due to the proximity of the study area to Nairobi and other industrial settings like Export Processing zones as well as the existence of good transport and communication network.

Land is seen as the most important possession however small with disregard to its economic unproductivity. Before 1980s, there were no small holding farms. From almost nonexistent in 1987, the smallholding farms have grown to be a major dominant land use in North Kaputei today. The rate of demand for small farm holdings is quite high as the people's perception of land and the insistence of owning a piece of land however small is an indicator that large ranches are a dying land use in North Kaputei.

Land buying companies and industries have been the major vehicles in which small-scale private farm holdings have grown. Another contributing factor is the increasing subdivision of the group ranches and the subsequent fragmentation of the private rangeland and sale of the same. This is because most of these farms are near the Nairobi-Namanga Road and with the high population growth rate; urbanization is quickly establishing itself in the area. There are a number of social groups and non-governmental organizations as well as several co-operative societies (sacco) that have contributed to the land buying and subdivision in the area.

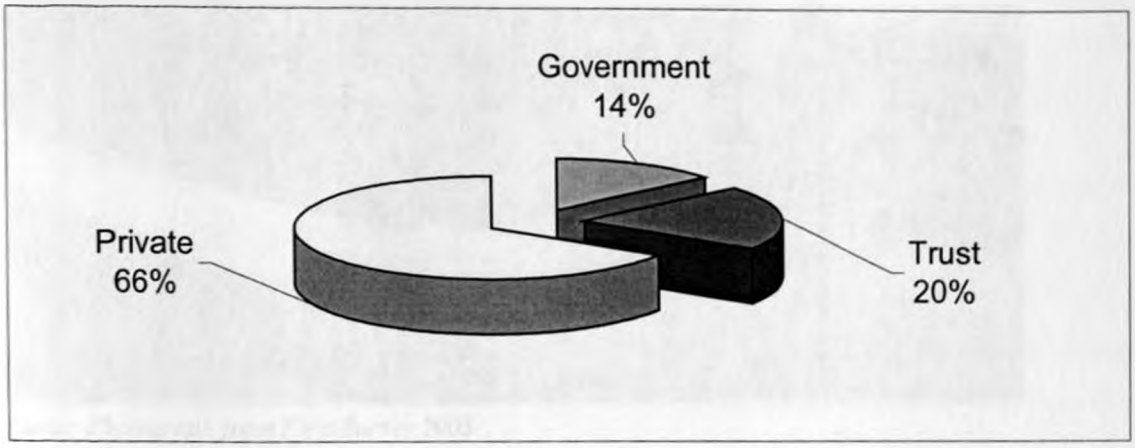
The 1987 land use pattern indicates that by then, there was no smallholder land subdivision and settlement within the study area. From the household questionnaires, it was revealed that 44% of the landowners acquired their land between 1987-1995. However, only 66% percent of the households settled in the area after 1995 majority of who settled within the urban centre. But the increase in small scale holdings has increased tremendously between 2003 and 2006.

Table 5.4: Period and Percentage of Land Acquisition and Settlement in North Kaputei

Percentage of Households		
Period	**Acquired Land**	**Settlement in North Kaputei**
Before 1987	13.8	12
1987 - 1995	20	22
1995 - 2003	66.2	66

Source: Computations from Field Survey 2003

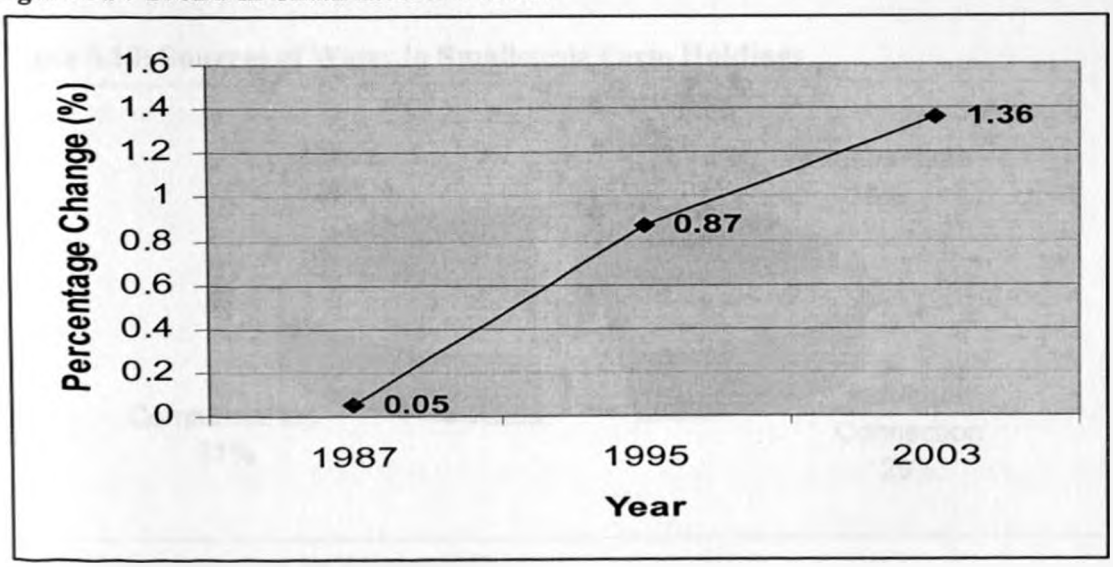
Figure 5.8: Land Ownership in North Kaputei



Source: Computations from Field Survey June 2002

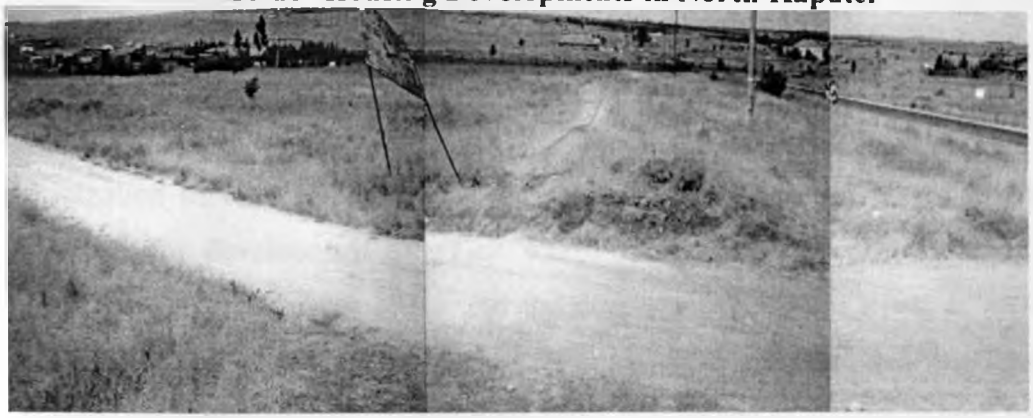
Subsequent subdivision of the individual large parcels of land have aided in the rapid increase of small-scale individual farmlands, which have grown from 0.05% in 1987, 0.875% in 1995 to 1.36% of the entire North Kaputei in 2000 (Plate 5.4).

Figure 5.9: Trend in Small Holder Farms



Source: Computations from Satellite Images 1987 – 2003 scenes

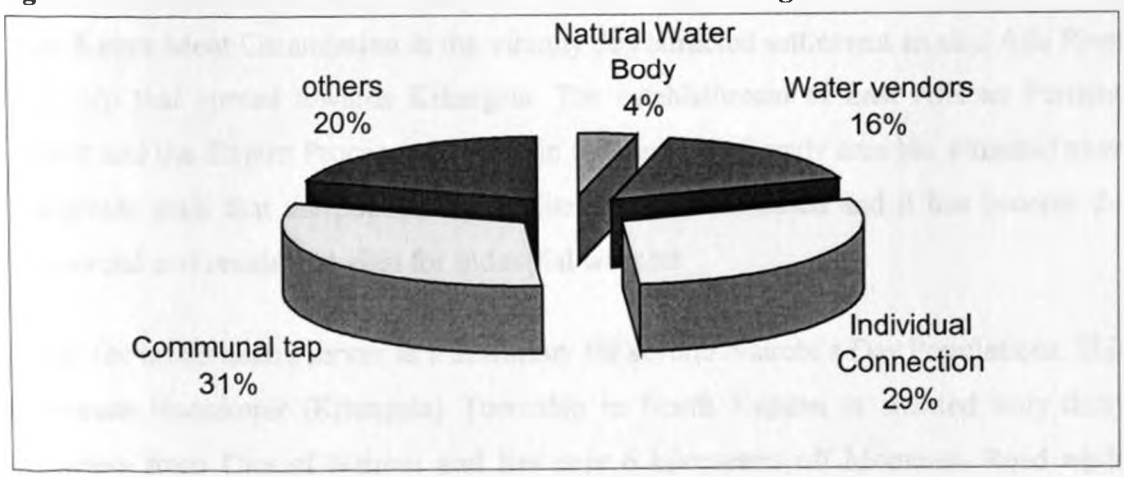
Plate 5.5: Small Holder Housing Developments in North Kaputei



Source: Photograph from Field Survey 2003

Small holder farm holdings pose a major planning concern. Majority of these farm holdings are not planned but are haphazardly located. They lack proper waste disposal systems and sanitation as well as water supply network. 20% households revealed that they source water from boreholes and shallow wells while 16% of the households interviewed get water from water vendors and source form common collection points.

Figure 5.10: Sources of Water in Small-scale Farm Holdings



Source: Computations from Field Survey 2003

5.2.3 Trends in Urban Growth

Although the urban area is far smaller than is generally recognized, its rate of growth in the past has been relatively faster. It has actually doubled its extent and density within fifteen years, but the high point of conversion rate is not a recent one as each year thousands of farmlands are being converted and absorbed by the sprawl of unregulated

suburban development. At the same time land is easily and cheaply bought with hardly any regulations imposed by land use planning authorities who are mainly concerned with licensing of trade activities.

Urbanization in North Kaputei is synonymous with the establishment of Noonkopir Township, the development of which was influenced by the construction of Kajiado Namanga road in the early 1970s and the development of Athi River as an industrial zone. Before this period, the area was natural savannah grassland and woodland mainly inhabited by Maasai nomadic pastoralists and it also served as grazing ground for wildlife herbivores (Plates 5.1 and 5.5).

The present site of Noonkopir Township is as a result of the expansion of industrial development due to its flat plains and existence of expansive land for various commercial developments that has acted as focus of attraction.

As early as 1969, the area around the G.K Prisons was covered with sisal plantation and this attracted the establishment of the first shop run by an Arab. With the establishment of the Kenya Meat Commission in the vicinity this attracted settlement around Athi River Township that spread towards Kitengela. The establishment of East African Portland Cement and the Export Processing Zones in the vicinity of study area has attracted more immigrants such that the population of Kitengela has increased and it has become the commercial and residential sites for industrial workers.

Today, the urban centre serves as a dormitory for several Nairobi's Day Populations. This is because Noonkopir (Kitengela) Township in North Kaputei is situated only thirty kilometers from City of Nairobi and lies only 6 kilometers off Mombasa Road while Nairobi-Kajiado-Namanga road passes through it also has cheap housing facilities. These have opened up the area to other immigrants and enhanced the accessibility.

Plate 5.6: Leapfrog of Urban Development and an Overview of Noonkopir Township

In the foreground is the original land cover and use in North Kaputei while in the background is the density of Noonkopir (Kitengela) town as it is today.

Currently, North Kaputei is becoming urbanized without proper guidelines of any physical development plan (Plate 5.6). Urban expansion and industrial developments have continued to eat the grazing grounds and attributing to the increased demand for land for settlement in the North Kaputei.

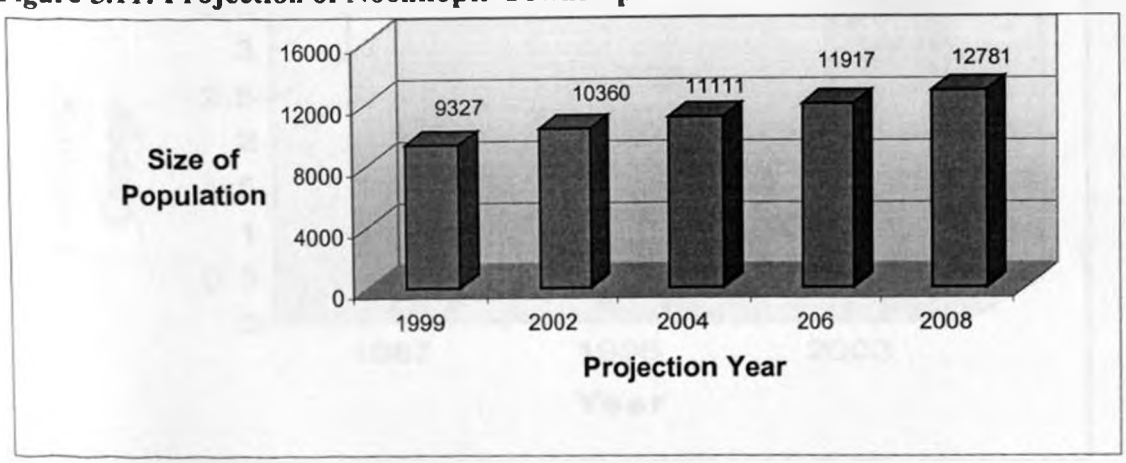
Population Size and Growth

Table 5.5: Noonkopir Population Projection

1989	1999	2002	2004	2006	2008	% Growth Rate
6548	9327	10360	11111	11917	12781	3.5

Source: Field Survey, 2002 updated 2006

Figure 5.11: Projection of Noonkopir Township



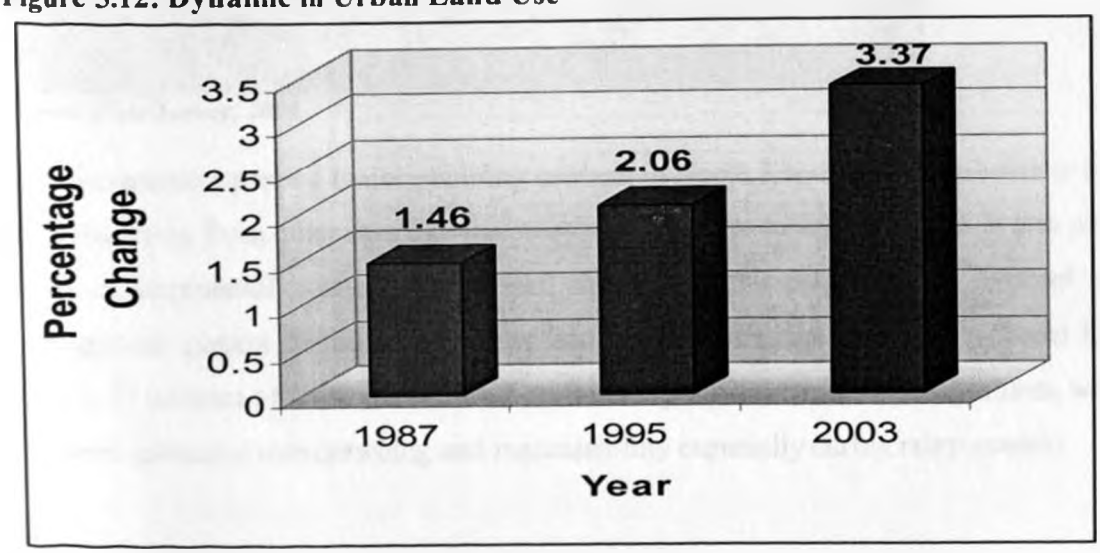
Source: Field Survey, 2003 updated 2006

During the period of 1995, the situation had quite changed from the 1987 scenario. Urban land covered 4.16 square kilometers that is about 2.06% of the entire study area in 1995 from 2.95 km^2 or about 1.46% of the total study area. While in 2003 scene, urban land covered 6.81 km^2 or 3.37% of the total study area. The change was gradual in the first two scenes while from 1995 to the year 2003 the change in urban land has been rapid spurred by various factors including rampant subdivision, cheap housing and available land for sale among other as discussed later in the chapter.

Plate 5.7: Haphazard development of Kitengela town in North Kaputei

Haphazard growth of Kitengela town leading to juxtaposition of land uses. The road system is not well developed but the access is through man-made footpaths.

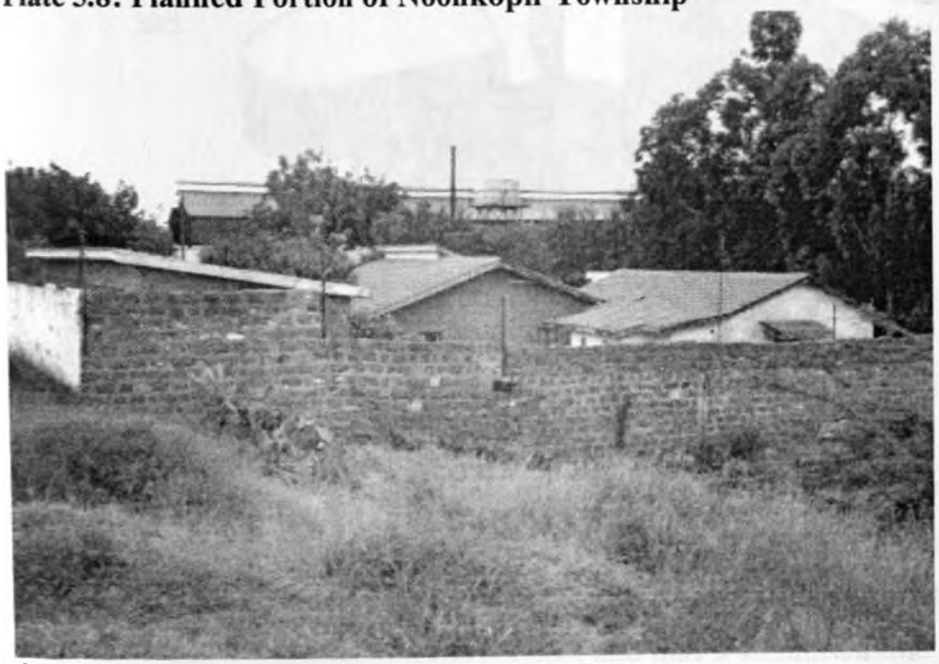
Figure 5.12: Dynamic in Urban Land Use



Source: Computations from Satellite Images 1987 – 2003 scenes

Urban land has facilitated various land use activities and operations such as industrial, residential, commercial, educational and recreational activities. It is an industrial centre with 11 registered industries ranging from steel manufacturing, slaughterhouse, timber yards, Jua Kali artifacts and building and stone mining. The town is a commercial centre with hotels, retail and wholesale shops, posho mills, fueling stations and others. It also serves as a market for produce from the environs such that 57% of the livestock keepers interviewed sell their animal products (milk, meat) to the residents of Kitengela town. The town is mainly residential centre ranging from planned and serviced to unplanned and slum-like settlement.

Plate 5.8: Planned Portion of Noonkopir Township



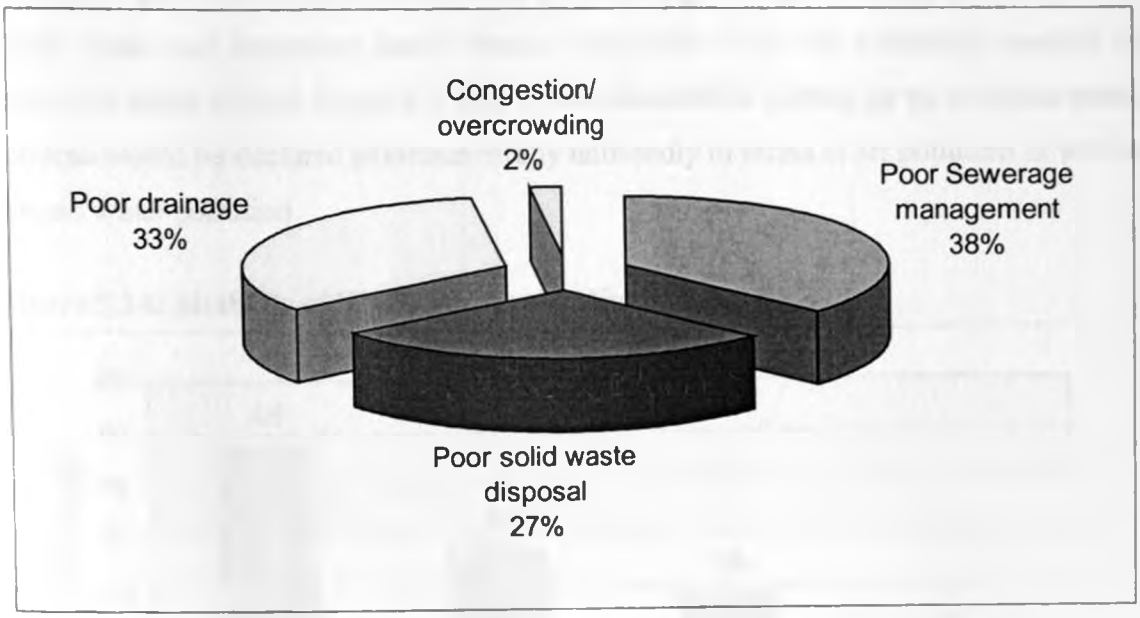
Source: Field Survey, 2003

Urban expansion poses a major planning concern in North Kaputei. It contributes to land use conversion from other uses like livestock production to mixed urban use. It also poses some environmental concerns such that, the area lacks proper waste disposal and management system in the urban center and the surroundings settlements. From field survey, 37 percent of those interviewed experience poor sewerage-related problem, while 2 percent indicated overcrowding and inaccessibility especially during rainy seasons.

Table 5.6: Sanitation Problems Faced in the Noonkopir Township

Problem	Percentage
Lack of Sewerage network	37
Poor solid waste disposal	27
Poor drainage	33
Congestion/Overcrowding	2
Total	**100**

Figure 5.13: Sanitation Problems Facing Urban Residence



Source: Computations from Field Survey 2003

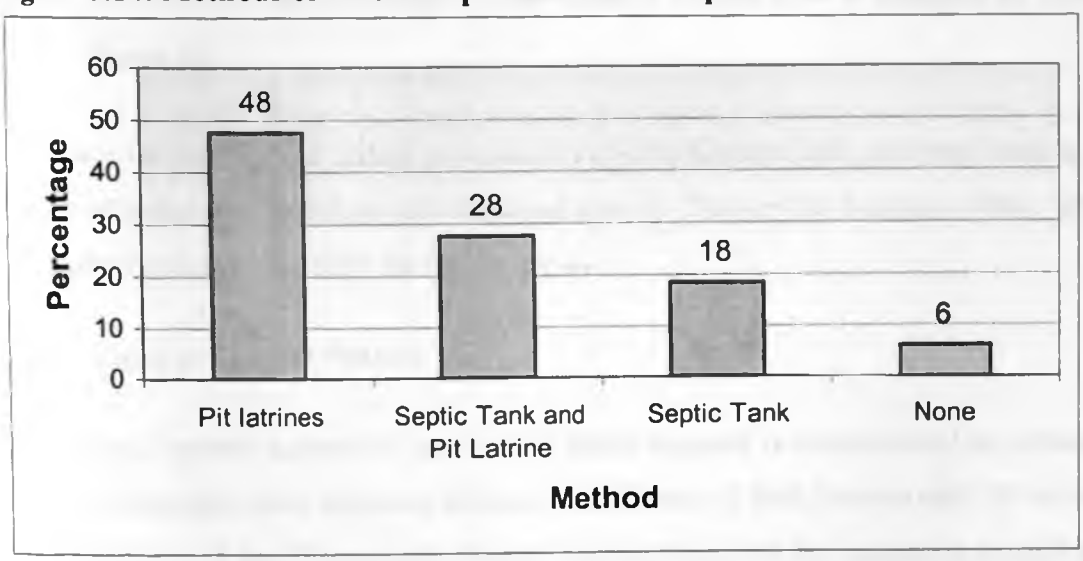
Adequate and timely provision of infrastructure facilities and services including electricity, water, sewerage and drainage is essential for the efficient running of an urban area. Apart from enhancing the general welfare of the residents, availability and spatial location of varied infrastructure and services also play a significant role in giving an area a physical form.

Sewage disposal involves the mechanism of disposing domestic and industrial liquid wastes. In the study area, the disposal of domestic (human waste) is done through septic tanks and pit latrines. But there is no sewerage network reticulated in the study area. The field survey revealed that the most common method of waste disposal used is the pit latrine at 31% while septic tanks was used by 60% mainly those residing within the controlled and planned estates like EPZ residents and Valley estate as well as a few of those residing within the CBD of Noonkopir. While 9% have no method of domestic

waste disposal. They represented a few cases of the upcoming informal settlement within the urban center particularly those operating Kiosks.

The challenge here is the obvious need for a sewer reticulation system with the Physical Planning Handbook postulating that a sewer line will be considered for all settlements with a population of 30,000 or more having an urban layout. Noonkopir in North Kaputei urgently requires this essential service as the area is growing too rapidly that the pit and septic tanks are becoming health hazard especially with the increasing number of boreholes being drilled. Imagine if every 5005 households putting up pit or septic tanks, the area would be declared environmentally unfriendly in terms of air pollution as well as ground water pollution.

Figure 5.14: Methods of Waste Disposal in North Kaputei



Source: Field Survey, 2003

Solid waste management

The management of solid wastes is the responsibility of Olkejuado County Council and is strictly limited at Noonkopir town center and in the market area only. In the surrounding neighborhoods, solid wastes disposal is largely left to the responsibility of individual households. The survey attests to this fact with 98% of the respondents disposing wastes in their own pits or open fields and in their farms.

The county council has been slow in meeting the need for an efficient domestic waste management programme and this is completely lacking in North Kaputei particularly the urban center. According to the council's officer in charge of North Kaputei, the top priority for the OCC in this sector is that of finding new dumpsites away from the residential and other land uses.

As urban development increase, there is need for a corresponding shift in waste management in the area. Already large mound of wastes are being dump along the access roads making the area aesthetically very unattractive and disease prone. The rapid demographic growth clearly gives more prominence to waste disposal and management as one of the top priorities.

5.3 Factors Contributing to the Rapid Land Use Changes in North Kaputei

There are various factors pulling population to North Kaputei such as cheap housing and failure of authorities to enforce development control. This section brings out these factors in order to understand clearly the forces at play.

5.3.0 General Growth Pattern

The general growth pattern of land use in North Kaputei is characterized by urbanized area of Noonkopir town center as well as the influence of both Nairobi only 30 km away and Athi River, 5 km. The overall change is strengthened by the increasing densification of rural areas adjacent to the urban center in an infilling pattern.

The urban and rural areas are interdependent on each other in aspects of social, economic and ecology. Nairobi National Park act as a physical barrier to further development to the west while to the east are expansive institutional lands belonging to various co-operative societies such as University of Nairobi's Chyuna Sacco, Kenya Airways and Kenya Police Saccos. This leaves south and southwestern of North Kaputei as well as the area around Noonkopir Township where settlement patterns have been spurred on by

spontaneous sub-divisions. North Kaputei has registered more human settlement due to its spatial structure as well as a result of various factors discussed below.

5.3.1 Cheap Housing

In chapter two we saw that the value of land in the city center is higher relative to that in the urban fringe such as North Kaputei. The low land values coupled with high rate of uncontrolled subdivision of plots and the availability of construction and building materials in North Kaputei have translated into low cost of housing and land use development. This in turn has attracted people in search of cheap housing. 48% of the respondents revealed that they moved into North Kaputei because of cheap housing available compared to the areas around.

5.3.2 Rampant Subdivision

Land subdivision in North Kaputei is a phenomenon that has been on by rapid influx of population as well as urbanization. It has a long history brought about by Group Ranch subdivisions in the area. North Kaputei had four group ranches and 5 individual ranches covering an area of 19,282 ha of land. Due to increased number of members, these ranches were subdivided into individual farms leading to small parcels of 10.6 ha. With Nairobi and Athi River being within the vicinity of 30km and 5km respectively the area was set for further subdivisions. Currently, the Olkejuado County Council has put a stop to further subdivisions of plots unless the plot size is over 5 acres.

The subdivisions trends over the years show that the land parcels are getting smaller and smaller particularly within and around Noonkopir urban center with ¼ and $^{1}/_{8}$ of an acre plots currently featuring in most areas. The Land Control Board, which is supposed to control subdivisions in agricultural, rangeland among other transactions, has allowed for subdivisions up to ¼ acres on individual plots. When asked the challenges facing the Board, the chairman noted that the rate of subdivision has been enormously faster than they can control. Their responsibilities have also been conflicting with other institutions dealing with land. Table 5.1 shows the subdivision trends over the past 15 years.

Table 5.7: Subdivision trends in North Kaputei over a period of 15 years

Year	Total Number of Subdivision	Most recurrent land size in acres	Change of user application
1987		2 – 5 acres	-
1990		1 acre	10
1992		0.5	-
1995		0.25	15
1997		0.25	9
1999	852	50 x 100	22
2000	1200	50 x 100	32
2003	1050	50 x 100	20

Source: Field Survey Kajiado Lands Registry

If this trend is allowed to continue, then we envisage an area that will be urbanized with maximum land area as less than ¼ acre or even $^{1}/_{8}$ acre. This will have various implications on infrastructure, as well as the livestock production, which has been a dominant economic activity in the area as already seen in livestock population trend. This calls for need to control subdivisions of land in the area such that the rate is not uncontrollably rampant. Otherwise one suspects that we will have a situation in North Kaputei similar to those experienced in Ngong or Ongata Rongai towns, which are already having high rate of subdivision of small land parcels (less than $^{1}/_{8}$) that are unviable for agricultural or any economical production (Bureza, 2002).

From the field survey, it was also realized that the reason for this subdivision is the demand for land in North Kaputei by Nairobi residents and those from areas around North Kaputei, who use the land for mainly residential activities. Of the 65 respondents, 48% had come to stay in North Kaputei because they had bought land to build while 34% had moved to North Kaputei as their place of work.

The land use planning and management challenges are evident in the plot structures and haphazard subdivision. No wonder provision of services to these plots is compromised such that most of them are not served by any sewer or water systems. Both Survey and Physical Planning Departments admits that they have inadequate professional and technical capacities to record and capture the rate of subdivisions which is further complicated by beauracratic process. As a result the registry Index Maps are not a representative of what is actually on the ground.

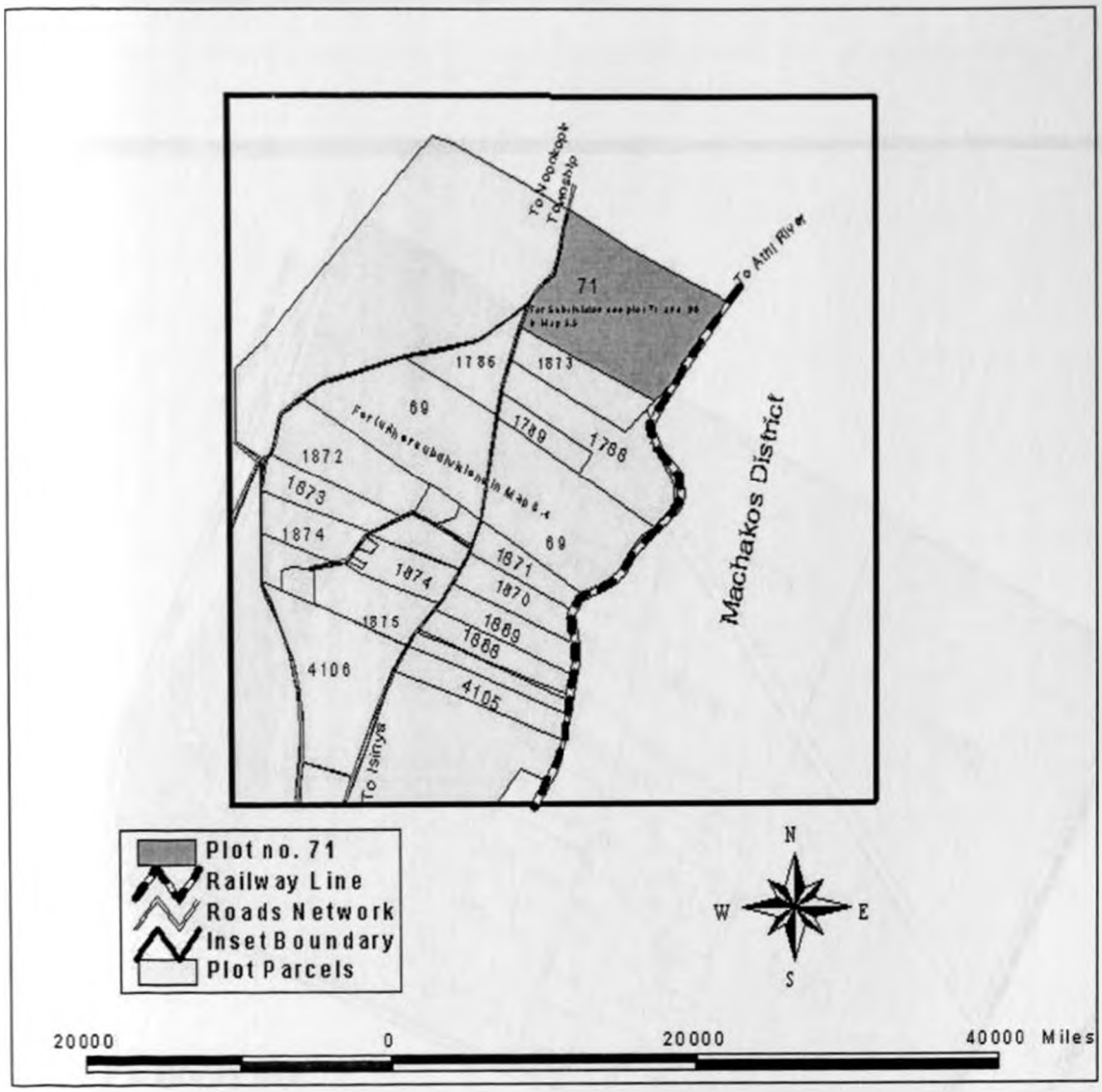
5.3.2.1 Case Study on Rampant Subdivision in North Kaputei

A case study was examined in which a plot in 1989 has undergone tremendous change in terms of subdivision, which subsequently has been converted to various land uses. The case illustrates some of the land use challenges the study area experiences as a result of being rapidly changing in terms of population with resultant land sizes. The case study is on Plot No. 71 and 69 in Map 5.4 below:

In case A, the area was comprised of large farms as shown with the size of subdivisions but due to the various factors already discussed. Plot number 71 was subdivided into plots 77 – 90 by 1996 as shown in Map 5.5 and subsequently, plots 77 – 90 have also undergone substantial subdivision yielding plots in Map 5.6 by 2003. In a nutshell, plot 71 has significantly experienced high level of subdivision from a single plot to over 500 plots within a period of 10 years.

This illustration is not only on plot 71 but it illustrates what goes on in other plots within North Kaputei.

Map 5.4: Location of Plot No. 71

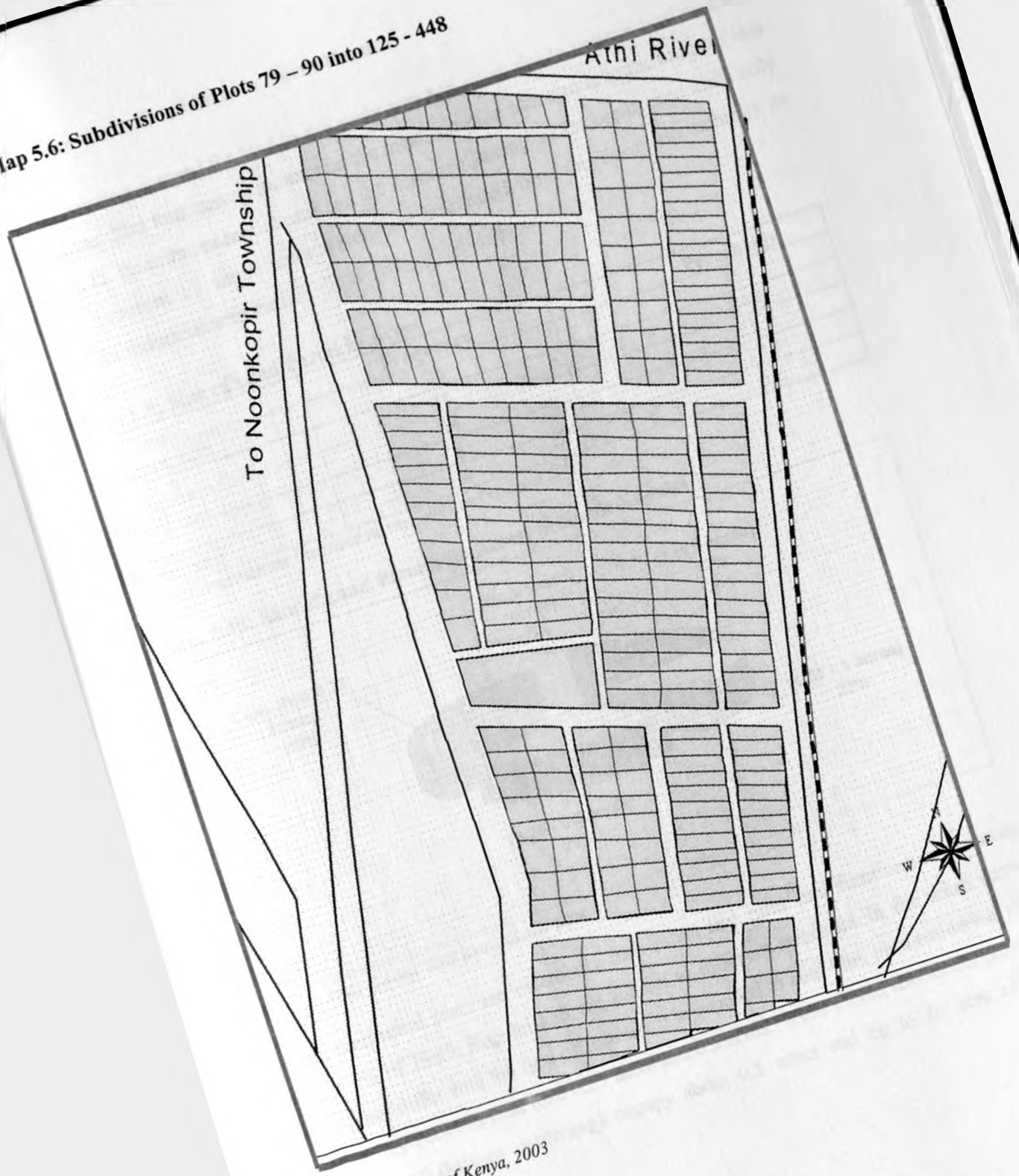


Source: Modified and Constructed from Survey of Kenya, 1989

Map 5.5: Subdivision of Plot 71 into 77 - 90

Source: Survey of Kenya, 1996

Map 5.6: Subdivisions of Plots 79 – 90 into 125 - 448



Source: Survey of Kenya, 2003

5.3.3 Resultant Land Sizes in North Kaputei

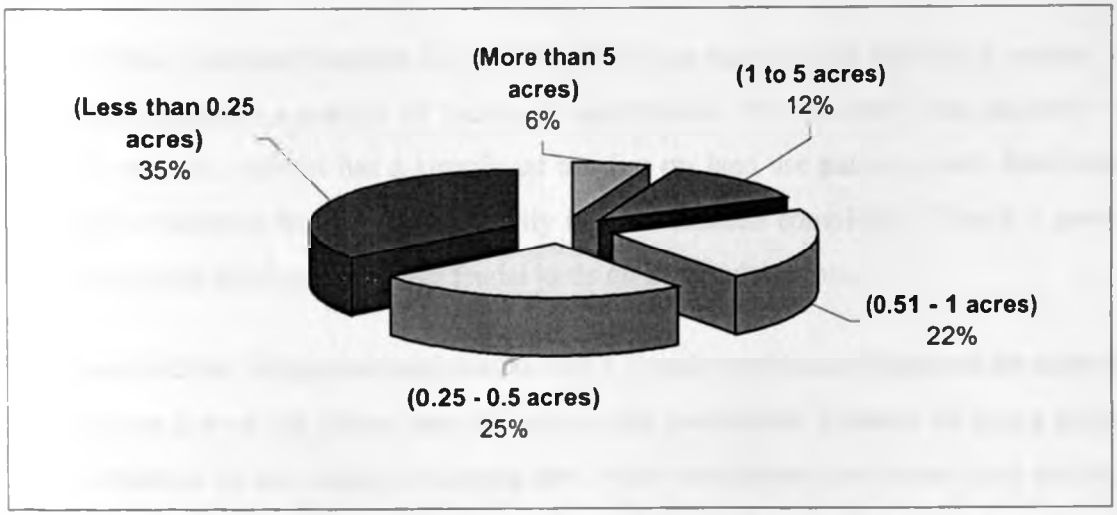
The increasing demand for land in the study area has given rise to various land uses and land sizes. The field survey shows that the most common plot size is in the range of less than 0.25 (mainly residential use) and 0.5 acres registering 30.8% occurrence while only 7.7% represent 1 - above acres which it was revealed from the Township authority as used for industrial activities.

Table 5.8: Size of Land Parcel in Acres

Land Size	Frequency	Percentage
Less than 0.25	23	35.4
0.25 - 0.5	16	24.6
0.51 - 1	14	21.5
1 to 5	8	12.3
More than 5	4	6.2

Source: Computations from field survey, 2003 and updated 2006

Figure 5.15: Size of Land Parcels (in Acres) in North Kaputei



Source: Field Survey, 2003 and updated 2006

First, residential plots are essentially both urban and rural land functions representing about 5% of North Kaputei and are subject to different standards. In the urban center, land sizes differ with the type of land use it is exposed to such that, pure residential plots are mainly between Less than 0.25 acres and 0.5 acres. While mixed residential plots and agricultural (kitchen gardening) occupy about 0.5 acres and up to an acre of land.

Ranching, institutional (Hospitals, Schools, playgrounds) and industrial activities occupy more than 2 acres both in the urban center and rural land.

In the urban center, mixed residential and commercial land uses are dominant occupying smaller plot sizes of up to eighth of an acre. There has been a tendency by the residents to make financial gains out of these two functions, by having both activities side by side. The emerging scenario is that there arise conflicts such that some residential areas are juxtaposed between incompatible commercial activities such as nightclub and bar as well as heavy industrial activity within a residential plots. Another conflict arises where there are heavy industrial activities near the residential plots. Some residents noted that, they experience bad smell and pollution from Ashut Steel factory, which is right next to their plot. It is the land use planner's duty and responsibility to capture this scenario and put measures in readiness for this eventuality.

5.3.4 Individual Plot Development

The individual plot development in North Kaputei is as varied as the individual owners. It is also influenced by a number of factors all interrelated. The revelation that majority of residents work in Nairobi has a significant bearing on land use patterns, such that those with higher incomes have invested heavily in ultra-modern complexes. This is a group who believe that they are miniature feudal lords on their private lots.

Then there are the indigenous landowners with a simple rural house improved by sales of land and stock over the years. Not left out are the pastoralists Maasais all going about their businesses in this rapidly changing area. Also notable are the vacant land parcels, which are held for speculative purposes thereby grazing grounds and in some cases encouraging leapfrog development. The resultant is a vibrant competition of land uses in the study area. There is need for intervention through the planning function, yet this is not taking ground in North Kaputei. The area has emerged into haphazard arrangement of individual units over space (Plate 5.9).

Plate 5.9: Haphazard arrangement of individual plot units

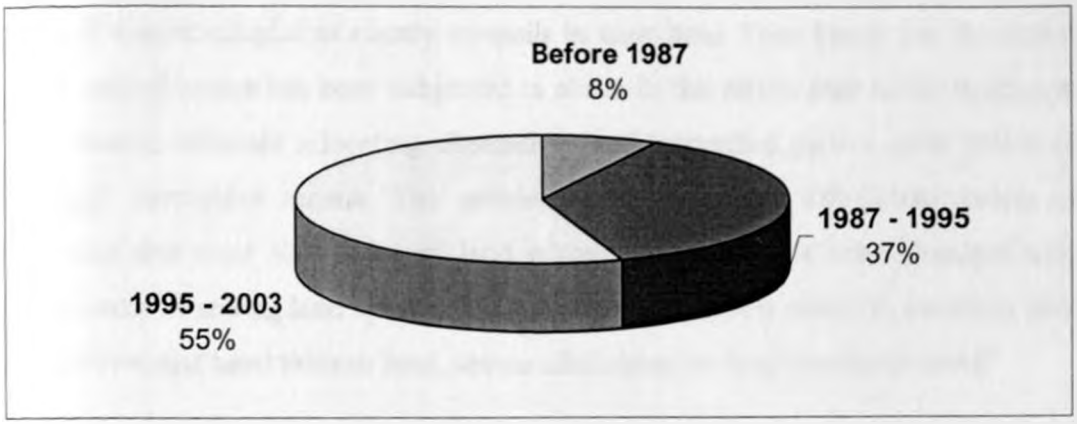
Source: Field Survey, 2003

5.3.5 Land Values

The issue of land values in the study area is covered in the light of how they contribute to land use changes in the study area. North Kaputei has been referred to as real estate broker's paradise. Values tend to vary from area to area but the average value of ¼ an acre is Ksh 250,000 within the Noonkopir Township for residential purpose only. This has progressed with distance from the town with similar acreage costing between Ksh 100,000 and Ksh 150,000 in rural areas depending on the seller. While for commercial purposes, 50 x 80 commercial plots goes for Ksh 50,000 within the town center and Ksh 100,000 outskirts of town.

While recognizing that land has a propensity to appreciate in value, the land values in North Kaputei show a peculiar sharp rise in the period of 1987 to 2003. This corresponds to the field survey observation that this was the period in which the highest number of immigrants to the area was recorded. A Land Valuation Officer with the Ministry of Lands made observation that North Kaputei is very active in property sales despite the depressed economy. When asked which year the respondents came to the study area, it was revealed that 55% came to the study area between 1995 and 2000 while only 8% had bought land in the area before 1987.

Figure 5.16: Period and Percentage of Land Acquired in North Kaputei



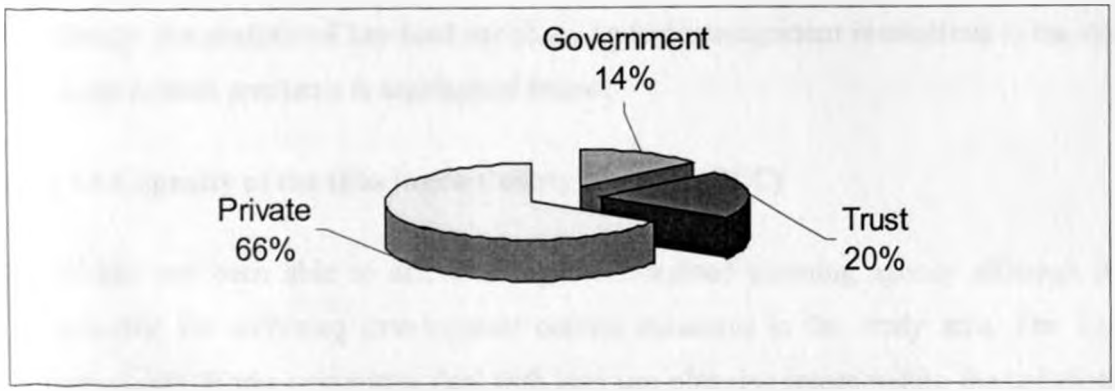
Source: Computations from Field Survey 2003

5.3.6 Land Tenure

Land tenure refers to the collection of rights, which influence ownership, and management of land. Before 1987, very few people had been registered as proprietors of individual land parcel. Most of the registered ones were those under group ranches which occurred in the 1960s.

Land tenure in North Kaputei falls within two categories: private and public. Within these two broad tenure systems, there exist various sub-tenure arrangements such that almost all private land outside the urban boundary is held under freehold under the Registration Land Act cap 300 whereas those within the urban center are under leasehold. The field survey proves this with 32% being freehold owners while 68% leasehold.

Figure 5.17: Nature of Tenure



Source: Field Survey, 2003 updated in 2006

Olkejuado County Council has large tracts of land under the Trust Land Act. In chapter two, it was revealed that county councils in trust hold Trust Lands for the community. This sort of tenure has been subjected to abuse in the recent past in the study area with the council officials allocating themselves and interested parties such pieces of land through corruptive means. The administrative officer in Olkejuado county council revealed that over 3000 acres of land in the study area have been allocated using this instrument of setting land apart. On the other hand, when it comes to assisting those who really own and need titles to land, severe administrative bottlenecks are cited.

5.3.7 Institutional Capacity

The study area is characterized by a diversity of organizations that converge in decision-making process, but they lack clearly established institutional arrangements to articulate their interventions. There are various local groups – women, church and political parties. In addition various NGOs like ASAL, SARDEP, together with quasi governments like KWS and central government bodies like Land Control Boards, Local Authorities and various government departments also have a stake in the study area.

Unclear coordination and operational responsibilities among sector agencies characterize this phenomenon. Separate sector agencies plan for and provide individual planning services, but coordination between agencies is inadequate or lacking altogether. Whereas public agencies lack the necessary autonomy and resources to make provision of land use planning and management more efficient with the reason that public agencies put less effort to involve other sectors. Therefore reaching a consensus is thus the planning challenge. An analysis of key land use planning and management institutions in the study area and related problems is highlighted below:

5.3.7.1 Capacity of the Olkejuado County Council (OCC)

OCC has not been able to afford a large well-trained planning agency although it is responsible for enforcing development control measures in the study area. The Town Planning and Works committee deal with land use planning issues within the jurisdiction of OCC. This committee gives advice on land use planning matters related to

subdivisions, change of user, and extension of user and part development plans. On the other hand the district physical planner is a key resource member of this committee on matters pertaining to development control and planning.

The OCC has an administrative office in Noonkopir Township for the purpose of collection of rates, license fees, rents and market fees. Only one officer mans the Kitengela office. It is realized that OCC activities are biased towards collection of revenues rather than real land use planning and management. It is not surprising that OCC does not have a planning unit; consequently, weak enforcement capacities have led to problems of land use development control in the study area. On the other hand, the Olkejuado County Council does not have the powers to deal with land administration without going through the department of Lands. As land administration has remained a central government responsibility even when managerial functions have been delegated to the local authorities.

The field survey revealed that the land use planning and management incapacity of the Olkejuado County Council has been attributed to the following:

- Financial management: like any other local authority in Kenya, it is faced with serious financial constraints. Financial resources are constrained by over employment. The council's own assessment shows that the expenditure structure is skewed toward salaries and wages (LADP 2000 – 2005). The council has been unable to maintain a surplus budget over the years and in the last financial year 2001-2002; a budget deficit of Ksh 870,628 was realized (LADP 2002). Such deficits occur when revenue collected is less than the expenditure patterns.
- Staff Structure: is heavy on the junior level staff, with limited middle and senior staff. Over 80% are low cadre staff and the overall impact is the high cost of effective management and delivery of services.
- Service delivery: expanding demand for both rural and urban services especially in North Kaputei is increasing as the area becomes urbanized and the population increases. The nature, scale and scope of service provision by the council is far

from being adequate to meet present and future needs of the rapidly increasing rural and urban population.

- Information management: the council deals with complex land use related information however, this information is rarely updated, and reports are filed manually, which proves to be cumbersome in terms of retrieval. The field survey confirmed this for the whole district office land information management as summarized in Table 5.9.

The current land allocation, registration and administration procedures applicable in the study area are extremely cumbersome, ambiguous and open to abuse. The table above has reveals that the council has not yet computerized its land related information but rather relies on manual methods of collecting, processing, analysis, and storage.

Table 5.9: Land Information Types in Olkejuado County Council

Purpose	Type of information	Form	Storage	Problems/Difficulties
Subdivision	Subdivision schemes plans	Copies of plans	Chests (ammonia paper)	It takes a long time to amend any plans that may be destroyed or lost
Building approvals applications	Building permits	Plot files	Cabinets and shelves	Adequate storage but lack of files
Plot ownership details	Plot owners, sizes, ground rent	Plot files	Cabinets/shelves	Adequate storage but lack of proper filing files
Area information or lists	Parcel Nos., uses, area, owners etc., rate books	Block files	Cabinets and shelves	Adequate storage but lack of proper filing files
Building	Building plans, report from checking and inspecting the building during inspection	Copies of plans, tracing papers	Ammonia sheets kept in plot files, shelves	Ammonia and tracing papers due to subdivision
Inspection cards	Inspection of buildings during construction or extensions	8 cards per building filed in plot files	Plot file in shelves and old ones in the archives	Too many plot files due to the subdivisions

	for change of user			
Valuation	Rating for tax purposes			
Allotment	Copies of allotment letters	Plot file folders	Shelves	Adequate
Easements approvals	Way leaves	Block files	Shelves, cabinets	Okay since there are not too many files under this.

Source: Olkejuado County Council office

5.3.7.2 The District Physical Planning Department

The district physical planning office is based in Kajiado town, some 40km from the study area. The expansive nature of the district stage a set for planning challenge and the district office has got only four staff members namely; district physical planner, one draughtsman, one secretary and one subordinate staff. As a result such acute shortage of staff does not augur well for the district large and in particular to those areas along the fringe of Nairobi like the study area and are experiencing rapid urban and population growth. The field survey revealed that the district office does not have a vehicle to facilitate movement in this vast planning area. The planner relies on the council's vehicles for inspection purposes and on some different occasions, he uses his own means or the client's vehicle, a factor that can swing decisions in favour of the client. Neither is there sub-branch office within the study area or any other part of the district.

Therefore it can be deduced that the department is technically unprepared for the rapid rate of land use change (urbanization) experienced in the study area. This is noted in the methods used in land use data processing, analysis and plan implementation which are outmoded, slow and cumbersome being manually done.

Therefore most developments have escaped controls and the market forces override the planning activities, a feature obvious in Noonkopir Township and its environs.

5.3.7.3 The Land Control Board (LCB)

The LCB controls transactions in agricultural land. It is composed of a total of eight board members chaired by the District officer. One secretary who records all transactions in any given month mans the office. The secretary estimated that an average of 40–80 transactions or applications in former group ranches are processed every month. Of these applications, 65% constitute subdivision schemes thus averaging 52 transactions in a month and 624 subdivisions in a year in the North Kaputei area only. The secretary noted the slump in transactions and subdivisions attributing it to the prevailing economic conditions as well as an legal order to stop subdivision of plots issued by the OCC such that since January 2003, no subdivision applications has been received from North Kaputei with past applications averaging 240 – 350 applications per month in the year 1994 - 1996.

Field findings indicate that the board has no register for transactions and instead relies on a hand typed list of applications. To capture past trends becomes tricky as one has to go through a pile of such applications all kept exposed to dust, which is a horrendous task.

Other than poor record keeping and management, it could not be established how and when the board started to allow subdivisions of up to less than 1/8 acre particularly in the former grazing grounds. This is done despite the Land Control Act, under which the board is formed, which states clearly that the Act shall control transactions in agricultural land not less than 20 acres. This implies that policy changes occur without corresponding amendments to the respective legal provisions. The board members as indicated by the secretary are handpicked by the local politicians to protect their interests.

The field survey drew out the resident's dissatisfaction with the LCB with about five respondents particularly from Maasai community dismissing it as a 'toothless bulldog', which gives consent to questionable transactions. They gave an example in which the same board had authorized the sale and transfer of a large and prime tract of land belonging to absentee Maasai pastoralists who were away with their herd of cattle in a period of prolonged drought. It was believed that the sitting board members were some of

the beneficiaries of the same. Some respondents claimed that the board issued fake receipts, which are later rejected in the event of land disputes and charge extra fees for a consent to be given. The general view of the respondents was that the LCB is responsible for most land disputes in the area and it performs fewer duties to enhance land development to control transactions/subdivision.

5.4 Land Use change in North Kaputei

From the foregoing discussions, it is realized that North Kaputei experiences various land use challenges most of which are spurred on by the rapid urbanization. These problems are interrelated – demand for land in the area has brought about rampant subdivisions and high densities without infrastructural support services. Haphazard developments many of which are in the traditionally grazing grounds, loss of grazing land by pastoralists and upsurge of violence and robbery are all indicators of unmonitored developments in the fringe zone of North Kaputei.

The rising land values from 10,000/= an acre in 1980s to 500,000 for an eighth of an acre in 2003 are a strong indicator of the demand for land in the study area spurring on the land use change.

In most cases, the transactions on land take place without the proper guidance of any form of planning for the areas. This together with weak institutional framework has led to a deteriorating environment characterized by haphazard and uncontrolled land use developments. The institutional framework has proved inadequate in its operations in tackling land use planning and management issues affecting the study area. Indeed no significant attention is paid to land use planning matters from all levels of government.

The difficulties are themselves not new but they are only taking new dimensions and the old methods of treating these difficulties are proving increasingly outdated and inefficient.

CHAPTER SIX: TOWARDS EFFECTIVE LAND USE CHANGE MANAGEMENT IN NORTH KAPUTEI

In the previous chapters, analysis of the issues, challenges and problems facing the study area has been made. But this chapter goes further in synthesizing these issues and problems with an aim of finding better alternatives for monitoring, planning and managing land uses in the study area. This chapter offers strategies as development options with the aim of checking the trend of land use development to take a desirable spatial structure. The study further gives recommendations to abate rampant land use changes and how the same can be monitored for effective planning and management.

6.1 Impact of Rapid Land use Changes in North Kaputei

The analysis of land use changes in North Kaputei reveals that the rate of change is very rapid presenting numerous land use planning and management challenges. The unprecedented rapid population increase has come with corresponding increase in demand for basic service and infrastructure. In addition, this population influx that is spilling over from the city of Nairobi introduces new land use with urban form that was non-existent in North Kaputei. Similarly, urban activities are increasingly encroaching on prime agricultural land and onto areas which are not suitable for such land uses.

6.1.1 Unplanned Urban Growth

The growth of urban centre has increased within North Kaputei in the recent past as discussed in chapter five above. The study found out that the resultant plot sizes from the aforementioned rampant and uncontrolled subdivision of land parcels imply that the study area is developing into urban in character and scale. Yet the study area lacks a comprehensive spatial framework to guide these urban developments. It is revealed that areas within around the township have emerged rapidly into urban residential developments without spatial plans to guide their growth. This subsequently has led to mushrooming of uncontrolled developments. It seems the planning authorities have assumed that urban development would automatically arrange itself. This growth should be checked and correlated to the social institutions of land ownership, operation of the

market and other playing forces rather than those of the market like it has been the case. Unless there is urgent systematic and planned intervention a large proportion of the study area will have no planned settlement.

6.1.2 Uncontrolled Developments

Development in North Kaputei has been piecemeal and only concentrate on issue of licensing to control business activities thus has been unable to fit individual developments into a coherent pattern of land use.

6.1.3 Land use conflict

The spill over of unplanned urban growth and the uncontrolled development in North Kaputei particularly Noonkopir Township has led to land use conflict, which has taken many forms – some urgent and others are less so. The conflict occurs especially between industrial and residential land uses. Pollution is taking place especially where the industries are located and mining companies. These companies involved include the flower farm, the mining and cement industries by discharging dust into the air. The conflict also occurs in the area of expanding urban growth and the dwindling grazing grounds.

The incompatible mix of land use is the norm in Noonkopir Township with bars and restaurants put up in the residential unit or industrial activities such as steel manufacturing are juxtaposed with residential units. A good example is the slaughter house too.

Erosion and siltation is also a major problem attributed by land use practices which have little environmetal and resources sustainability. Accelleration of erosion along river banks has also been noted.

Therefore, there is need to harmonize land uses by directing the urban wave to avoid conflicts that arise from land use development.

6.1.4 Loss of Grazing Land

The rapid change in Land use in North Kaputei has affected the livestock production in the area which was the economic lifeline of these people. With the rampant uncontrolled subdivision of parcels of land into smaller units that have become very unviable for grazing such that most of the individual farm owners have fenced off their land leaving no room for grazing. Most of the residents have now opted to carry out zero grazing which is not economically and culturally sustainable to the indegineous production system.

6.1.5 Summary of Emerging Issues, Problems and Strategies in North Kaputei

Factors that have led to the rapid land use change in North Kaputei

- Proximity to Nairobi City and an international A104 great north road is within the area
- Proximity to Mombasa road and the JKIA has encouraged the growth of industries
- Proximity to Athi River and the export processing zones and other industries provide housing for workers
- The town lies along one of the livestock routes that lead to the Kenya Meat Commission. It also has its own holding grounds and slaughter house and livestock market
- Availability of cheaper land compared to Nairobi and its environs with landowners opting to commute to Nairobi and other surrounding towns and back
- The presence of industrial and agricultural activities especially the horticultural activities and mining.
- Further subdivision or ranches to smaller units that have allowed for residential and commercial land uses. Also for this reason the local community is forced to settle down and abandon their pastoral lifestyle
- The presence of public institution e.g. the G.K. prison

There are various issues and problems confronting North Kaputei as revealed in the study from the afore discussed chapters and are summarized in table 6.1.

Table 6.1: Summary of Emerging Issues, Problems and Strategies in North Kaputei

ISSUES	PROBLEM	OBJECTIVE	STRATEGY	ACTORS
Subdivision	• -uncontrolled • -unplanned • -lack of standards	• Conserve the traditional pastoral activity systems • Conserve wildlife • Protect the fragile physical environment	• Develop standards for land carrying capacity • Delineate the wildlife corridors and dispersal corridors • Set standards for minimum plots sizes • Segregate the land uses.	• County council • Lands ministry • KWS • Developers
Lack of development control	• Mushrooming of unapproved developments e.g. subdivisions, buildings • Haphazard change of user • Narrow road reserves • Blocked roads • Poor connectivity • Incompatibility of land uses • Inadequate provision for way leaves and service lines • Poor institutional co-ordination	• To prepare appropriate framework for efficient management of development activities • -to widen the road reserves • Improve connectivity • Provide for adequate way leaves and service lines • Build institutional capacity for plan implementation • Improve institutional plan implementation	• Enforcement to comply with plans and standards • Routine monitoring and evaluation • Enforce the requirements of building lines, plot coverage and land users • Staffing, training and equipping the staff meetings, consultations and liaison meetings	• County council • Lands ministry • Physical Planning Dept • KWS • Developers • Locals residents
Uncontrolled and Uncoordinated Land use	• Incompatible land • use e.g. steel industries etc in residential areas	• Ensure orderly and coordinated developments • Reduce environmental	• periodic environmental impact assessment and environmental audits	• County council • District Environment

Development	• Pollution e.g. noise water, air contamination of underground water • Constraining on existing infrastructure and lack of amenities and services for upcoming developments • Unplanned/haphazard development • Affected the growth of designated centers • Lack of urban form and character	degradation • Ensure adequate provision for amenities and services	• limit industries to designated areas • separate land uses through zoning • provide appropriate spatial frame work for orderly urban development and service provision • Develop Land information system that will integrate all the land use issues for easy monitoring and management	officer(DEO) • DPO • Developers
Diminishing grazing land	-rapid loss of grazing land through sub division, speculation and urban sprawl	-to safeguard grazing lands -change peoples attitude -encourage diversification and intensification of livestock production activities	-set minimum land sizes -zone certain areas for grazing -sensitization of people	-Lands ministry -county council -developers
Environmental degradation	-encroachment onto rivers and drainage system -high noise levels and dust -loss of forest cover	-protect fragile ecosystem -regulate and control land use activities	-introduce set backs through riparian reserves -encourage agroforesty through appropriate tree specie -zoning of land uses	-forest Dep't -environment Dep't -county council -physical planning
Wildlife human conflict	-human settlement along the wild animal migratory corridor	- to minimize the wildlife human conflicts	-segregation of land users -prepare zoning plans -impose development conditions on	-KWS -County council -Lands ministry

	-the wild animal killing human/animal -human beings killing animals -spread of diseases from wild animals and livestock		the corridors -introduce conditional titles along the wildlife migratory corridors	-Developers
Poor infrastructure especially in urban areas	-undeveloped drainage system -poor road network and conditions -inadequate water supply -poor sanitation	-to improve infrastructure provisions	-provision of drainage system by the relevant authorities -plan for adequate road networks -provide an independent water supply to the town -provide an effective waste disposal system	-Public works -Council -Developers -Privatesector/ donors -EPZ
Inadequate provision of public utilities	-no dumping site -inadequate space for cemetery -no slaughter house -no water tank sites -no fire stations	-to ensure adequate provision of public utilities	-land acquisition for the said utilities -enforce provision of public utility land during sub divisions	-Lands ministry -Council -Developer/ investors
Lack of public purposes land and public recreations	No sites for market, bus park, parking, public toilets, playgrounds, Baraza park, livestock holding yard, administration offices, lack of council offices, and school sites	To provide adequate land for public purposes and recreational facilities	-acquiring and setting aside land for public purpose and recreational facilities	As above
Institutional framework	-poor institutional linkages and capacity -poor management and	-to strength institutional linkages and capacities -improvement management	-appropriate training -upgradethe townships -educationand sentization for	-Local government -Central government

	commitment to service delivery	and attitudes	positive attitudes	-Other development partners

Table 6.2: Emerging issues and Problems confronting Rural Areas in North Kaputei

ISSUE	PROBLEM	OBJECTIVE	STRATEGY	ACTORS
Grazing land	-Diminishing grazing land -Uncontrolled sub division along pipe line road D57	- to safeguard grazing lands -to control sub division	-set minimum threshold limits for sub divisions -prepare a spatial framework with standards for sub division	-lands ministry -council
Educational institutions	-mushrooming of private academies -haphazard location of schools -inaccessibility to educational institutions	-enforcement of standards for educational institutions -restrict schools to particular zones -to provide for affordable and proximal educational institutions	-routine monitoring and evaluation to ensure complianance -develop a spatial framework for location of schools	- council - physical planning - education dpt - health - developers
Emergence of commercial nodes	-unplanned and undesignated centres - lack of basic services	-restrict commercial activities to designated areas -to plan for the provision of basic services	-designate areas for commercial activity -provide a framework for provision of basic services -encourage public participation in the provision of service	-council -p/planning dpt -developers
Road conditions and connectivity	Poor road conditions and poor connectivity	To improve connectivity and road conditions	-opening the road to create connectivity gravelling of roads	-council -development partners/ CDF -neighbourhood assoc.

Dispersed/scattered settlements	- difficult and high costs of service and infrastructure provision	-encourage nucleated settlements	-provide spatial framework for nucleated settlement -provide services	-council -p/planning dpt -local community
Human-animal conflicts	- human settlements encroaching the national park - danger of national park being turned into a zoo - animal/human traffic conflict	-minimise human animal conflict -to minimize animal human traffic conflict	-create buffer zones between human settlement and the park -designate the corridors and dispersal areas -create viable incentives for land owners to co-exist with animals -to create flyovers, under passes, sign posts, barriers to manage traffic	-KWS -local community -council -planning dpt
Interference of water courses	- blockage by human settlement	To limit development away from the rivers	-create riparian reserves -regulate land sub divisions	-lands ministry -council developers
Poor road conditions	- inaccessibility of the roads	To improve the road conditions	-opening the roads -gravelling of roads	-public works -council -local community and developers

6.2 Summary of Findings

From the analysis, it is evident that there exists a land use-planning problem in North Kaputei. These problems can be summarized as uncontrolled development brought about by rapid urbanization which manifests itself in rampant subdivisions of grazing land in to residential and urban holdings, absence of attendant services in the study area particularly the township to cater for the growing urban population, lack of adequate physical development plan to guide development, and lack of an integrated land use information management.

The study also recognized the failure by the institutions involved in land use planning and administration to evolve efficient land use monitoring strategy that would guide and control urban development. The future situation in terms of land parcels and population is likely to be unmanageable. The study revealed that the average land size is 0.25 of an acre, which is slowly reducing to the 0.125-acre level due to the increased land values in the study area. Unless there is some systematic and planned intervention, a large proportion of expected population increase will have no alternative planned settlement and instead conditions of extreme squalor and differentiation are set to continue. The basic argument of this is that the pace and scale of land use changes in North Kaputei will soon be such that planning programmes and policies will lag behind and thus will not make any effective contribution to the solution of the current situation.

The study also revealed the current methods of capturing, processing and analyzing land use information as being outmoded, cumbersome, disorganized and in manual form. Moreover in a number of cases, such information lacks copies or backups in case of misplacements, destruction or corrupt practices that result to the disappearance of files.

6.2.1 Causes of Rapid Land use Change in North Kaputei

The first objective of the study was to examine the nature and trend of land use changes in North Kaputei. The study identified several push and pull factors at work in North Kaputei causing uncontrolled land use development. The push forces are urbanization, rampant subdivision, increasing land values in the city center relative to North Kaputei

while the pull forces are the lack of enforcement of development control legislations, and available cheap housing.

6.2.2 Institutional Capacities

It has been realized that OCC, which is the attendant local authority, has not been able to manage land use problems arising from the rapid urbanization process in the area. It is both financially and technically unprepared for the rapid changes occurring not only in the study area but also other rapidly changing areas in the district.

The LCB on the other hand, which is charged with regulating transactions in agricultural land has been reduced to one that approves subdivision schemes and transfers of plot sizes. Indeed it has accelerated the subdivision process leading to urban users by sanctioning the subdivision of up to $^{1}/_{8}$ of an acre plot.

The Physical Planning department in the district is also technically incapacitated in monitoring and controlling development in the study area due to the expansive nature of the district.

6.3 Conclusion

The study set out to investigate the land use changes using remotely sensed data and GIS tools to discover the trend of development of North Kaputei as a rural urban fringe of Nairobi city. North Kaputei is experiencing physical expansion along with its horizontal intensification. Using Land sat TM of 1987, 1995 and for the year 2003 coupled with GIS technology has provided important information about the development, which is taking place in rural urban fringe, and there by plays an important role in planning and managing the city. The purpose of this study was twofold.

First to examine the land use changes which have occurred during the period from 1987 to 1995 and from 1995 to 2003. In spite of interpretation limitations due to the spatial resolution in Landsat (TM) data the land use change analysis shows higher magnitude of change in Small scale residential and urban land uses during the period 1995 to 2003, which constitute 37.1 ha and 9.7 ha respectively of the total area change.

North Kaputei has emerged to be an area that has experience rapid land use changes since 1987 with indications that changes are bound to continue. These changes have seen rampant and random subdivision and sale of group ranches to individual holders. Urban land has been seen to have the highest rate of growth as well as the smallholder farms, which although were classified as so but have mixed use. Since the changes from rangeland to large-scale farmlands to small-scale individual holdings is a result of increasing population influx and subsequent subdivision of land parcels, and then such change can be regarded as move toward urban development or urbanization. The study then arrives at the conclusion that urban land use is the most influential land use in the study area

Specific areas to be addressed are regular monitoring of land use and their planning interventions, planning of the upcoming small holder settlements given that they are the major cause of unplanned settlement and challenge to exercise development control measures. The study revealed the importance and application of rapid land use change information system and its management. Satellite remote sensing and GIS have been identified as the most effective methods of collection, analysis and management such land use information at multi-dated periods. It is the lack of use of these modern techniques that has resulted to the unmanaged and uncontrolled land use development. This study suggests a move towards that end.

6.4 Recommendation

6.4.1 Need for integrated Land use Information System

The study established that there are gaps and bottlenecks in land use planning and management. Therefore there is need to determine measures that could be adopted to update the situation in order to ensure adequate coverage and to address the existing inefficiency and lack of proper co-ordination. The study also reveals that the use of modern technology and methods to monitor land use changes by availing up to date information based on cadastral maps. Comprehensive land information is important for policy makers to achieve optimum use of land and sustainable development. Given the status quo of the nature of land use planning and information management in Kenya and

in particular North Kaputei, the study recommends that land use information be computerized to accrue many benefits, which include the followings:

- Provide the best available data for use in land transactions and decisions
- Improve the accuracy and equity of real property assessments
- Provide mechanism to eliminate inconsistency that exist with some land information collected and managed at different public offices
- To provide a standard foundation for accurate geographical referencing of land information
- Reduce or eliminate effort by different public offices

Once computerizing land information, the study area stands a chance of accruing various benefits such as:

- Guaranteed ownership and security of tenure
- Reduce land disputes
- Improve urban planning and infrastructure development
- Produce statistical data
- Develop and monitor land markets
- Support land and property taxation

The major problems with land information in Kenya and in this case, North Kaputei emanates from the data types. It is fragmented, not updated and often not crosschecked by those the legislation requires to do so e.g. the Director of Physical Planning. The study established that one reason for this (outdated and fragmented data) is the inadequate, archaic equipment (records, base maps) which is obsolete, and manual systems of data management is not orderly (many topics under the same data source) lacking proper back-up systems.

Therefore a parcel based land information system which is a multipurpose cadastre is recommended to be developed. It is a tool for legal, administrative and economic decision making and an aid for planning and development. The tool consists of a data base containing spatially referenced land related data for a defined area as well as

procedures and techniques for the systematic collection, updating, processing and distribution of the data.

The base of this land information system consists of GIS integrated with remotely sensed data thus provides a uniform spatial referencing system which links the data within the system with other land related data, including data on land ownership, location, values and other attributes such as infrastructure and land use.

An integrated land use information system requires various factors such as Institutional setup, Organizational procedures, Legal framework, human and financial resources, and implementation plan for its sustainability.

Institutional Framework

The study revealed clearly that one of the problems bedeviling the existing system is the multiplicity of institutions dealing with and having legal jurisdiction over land use planning and information. An effective land use information system must operate within a conducive institutional set up, therefore, co-operative efforts between central and local governments, various departments, as well as the local institutions and the private sector be encouraged to provide more cost effective means of monitoring and managing land use development.

Organizational Procedures

These must be based on clearly defined performance criteria in respect of type and quality of information to be provided, time lags between and receipt of information by users and the formats, which this information will be provided.

Legal Framework

The legal framework must protect the right or access to vital information necessary to ensure good governance in the management of land. To this end, the legal framework must: clearly identify which institutions have the mandate to collect and collate information on land and how they must relate to each other; identify enforceable

sanctions accessible to those collecting information on land and those seeking access to the same.

6.5 Areas for Further Research

In a nutshell, the study has not exhausted the full scope of monitoring land use changes in rapidly changing areas. The study recommends further studies on how best to manage rapid land use changes with specific inquiry directed to such studies as:

- The use of geoinformatics in mapping of informal settlement on the fringe areas of main urban centers
- Applications of remote sensing and mapping and environmental management
- A more detailed study on land information system in the area

REFERENCES

Agatsiva, J. L. (1987), **Remote Sensing for Resource Mapping**. Lecture notes for training course at Regional Center for Mapping and Remote Sensing.

Albedo, 1993. **Down on the Farm**. The Newsletter of the National Remote Sensing Centre Limited.

Alonso, W. (1964), Location and Land Use. Washington.

Aruna Saxena, (1999) **Monitoring of urban fringe areas using Remote Sensing and GIS techniques**. Lecture notes, Department of Architecture and Planning, Bhopal.

Assoko-Assoko Rene-Joly (1997), study of Yaounde head of geography department at the University of Douala, Cameroon.

Blumenfeld, H. (1971), **The Modern Metropolis**

Bracken, I. and C. Webster (1990), **Information Technology in Geography and Planning, Including Principles of GIS**, Routledge, London

Burrough, P.A. (1996), **Principles of Geographic Information Systems for Land Resource Assessment**. Oxford: Clarendon Press.

Calkins, H. W. and Tomlinson, R. F. (1977). **Geographic Information Systems: Methods and Equipment for Land Use Planning**. IGU Commission on Geographical Data Sensing and Processing and U.S. Geological Survey, Ottawa.

Chapin, F. S. (1972), **Urban Land Use Planning**. University of Illinois Press, Illinois.

De Bruijn, C.A. (1986), **Aspect of Physical Planning**, lecture notes for the Urban Survey Course, ITC, The Netherlands.

Dionnet, M. C. (1985), **Recent Evolution of Land Use System in the Abbruzi Region Italy,** Land Use Policy, October 1985, 327-335

Edmonds, R. L and William J. K. (1998), **Land Use in Macau: Changes between 1972 and 1994**, Land Use Policy Vol. 15 No.4, 1998, 223-236

Ezigbalike C. (2001): **The Future Orientation of Geo-information Activities in Africa** A publication for United Nations Economic Commission for Africa (UN-ECA)

Erickson, D. L (1995), **Rural Land Use and Land Cover Change: Implications for Local Planning in River Raisin Watershed**, Land Use Policy Vol.12 (3), 223-236

FAO (1994), **Guidelines for Land Use Planning**, FAO Development Series 1. FAO Rome.

Halid, M. (1998), **Land Use-Cover Change Detection Using Knowledge based approaches: Remote Sensing and GIS.** Kalaysian Center for Remote Sensing (MACRES) Kuala Lumpur Malaysia

Harris, D. and Ullman, L. (1962), The Nature of City Reconsidered, Papers and Proceedings of the Regional Science Association, Philadelphia.

Kohler, T. (1987), **Land Use in Transition: Aspects and Problems of Small Scale Farming in a New Environment, The Example of Laikipia District, Kenya,** Geographica Bernesia Switzerland.

Kyariga T. (2001); Urban **Authority Support Unit**, Tanzania; Paper, 2001).

Lovejoy, D. (ed) (1973), **Land Use and Landscape Planning**, Barnes and Noble, New York.

Lagarde, M. (1995), SPOT image's sales manager for Africa

Marble, D.F., et al. (1983), **Geographic Information s\Systems and Remote Sensing: the Manual of Remote Sensing**. American Society of Photogrammetry, Vol.1, pp 923 – 958, Falls Church.

Mackenzie, R. D. (1933), The Metropolitan Community New York, McGraw-Hill Coy

Meyer, W.B and B. L. Turner (1994), **Changes in Land Use and Land Cover: A Global Perspective**, UCAR, New York

Meyer, W.B and B. L. Turner (1992), **Human Population Growth and Global Land Use Changes**; Annual Review of Ecology and Systematic, Vol. 23, 39-61.

Misrati, A. M (1983), **Land Conservation to Urban Use: Its Impacts and Character in Libya**, Eristics 300 May/June, 1983, pp183-194.

Nigam, R. K. (2000), **Application of Remote Sensing and Geographical Information System for land use / land cover mapping and change detection in the rural urban fringe area of Enschede city, The Netherlands,** unpublished paper from Dept. of Urban survey, Enschede, Netherlands.

Omoto, O. W. (1997), **Physical Land Suitability Evaluation for Urban Development in the Fringe of Nakuru Municipality**, Masters in Arts thesis, University of Nairobi.

Patahn, S. K et al (1993), **Urban Growth Trend Analysis Using GIS Techniques: A Case Study of Bombay Metropolitan Region**; International Journal of Remote Sensing Vol. No. 17, 3169-3179.

Paulson, B. (1992), **Urban Application of Satellite Remote Sensing and GIS Analysis,** Urban Management Programme, Series No. 9. The World Bank, Washington, D.C.

Roberts, T. H (1988), **Land Use Planning in Catannese**, A. J and J.C Sunder (eds.) Urban Planning, McGraw Hill, New York.

Ramachandran R. (1991), **Urbanization and Urban Systems in India,** Oxford University Press, Delhi India.

Raouf, S. (1991), **A Manual GIS Systems For Machakos District in Kenya.** ROSTOM, Kenya

Star, J and John E. (1987), **Geography Information Systems: An Introduction; Prentice** Hall, Englewood Cliffs.

Syagga and Gitau, S. (1999), **Land information Systems in Kenya**. Habitat publications, Nairobi.

Thampy, R. J. (1995), **An Overview of Human Occupation, Changing Land Use and Environmental Impacts in the Lake Nakuru Catchment Basin in KWS** Workshop Proceedings; No. 1 KWS Nairobi.

UNCHS (Habitat) (1985), **Guidelines for the Planning of Rural Settlement and Infrastructure: Using Automated GIS in Network Planning**, UNCHS, and Nairobi.

UNCHS – Habitat, ***(1996)***; **Urbanizing World**, Global Report on Human Settlement.

UNECA, (1986). **Patterns, Causes and Consequences of Urbanization in Africa**.

USGS (2002), **URLhttp://www.usgs.gov/research/gis/special4.html,** USGS Web Team, Reston, VA, USA

Van Lier, et al (1994), **Sustainable Land Use Planning.** ELSEVIER, Amsterdam.

APPENDIX A

Household Questionnaire Schedule

Declaration: The information given in this questionnaire will not be used for any other purpose, besides academic only.

Questionnaire Number _____ Date of interview _____

Name of respondent _____ Sex _____

1. Household composition

Serial	Relation to HH/H	Sex	Age	Marital status	Education Level	Occupation	Work place	Income

2. Type of House: a) Temporary b) semi-permanent c) flat d) bungalows e) others
3. Number of rooms in the housing unit _____
4. Housing unit ownership: a) owner occupier b) private rented c) employer d) others
5. For how long have you lived in this house/area? _____
6. Where did you live before? _____
7. What is the size of the farm/plot? _____
8. How many households live in this farm/plot? _____
9. Nature of land tenure: a) Freehold b) leasehold c) others, specify
10. How did you acquire the land a) bought b) inherited c) gift d) others
11. Do you have a title deed for it? a) yes b) No
12. What is the total size of the farm/plot? _____
13. What is the present market price for an acre of land in this area? Ksh _____
14. What is the main land use activities carried out on the farm/plot?

    Farming

    Grazing

    Business

15. What other land uses are undertaken on the farm?
16. What is the dominant land use in the neighbouring farms?
17. What other commercial activities take place in the farm/plot?
18. Are there any plans for new land use changes on the plot/farm? a)Yes b) No
19. Since you started living here, what land use changes have occurred in this area?
20. What were the land use conditions in this area before 1987 in terms of plot size and type of land use?
21. What land use do you expect in this place in the next 15 years?
22. In your opinion, what would you like to see on this land in future?
23. In your opinion, what do you suggest to be done in order to achieve these visions?
24. What are the conflicts or competition between different forms of land use arising?
25. In your opinion, suggest how these land use conflicts above can be resolved?
26. Other comments on land use and planning interventions
27. What is your source of water: a) borehole/well b) river c) piped water d) water vendor e) individual connection f) roof catchments g) others
28. What problems with water supply do you experience: a) irregular b) quality c) expensive d) availability e) others
29. Do you experience storm water drainage? a) Yes b) No
30. What sanitation facility is used in your household: a) pit latrine b) septic tank c) sewerage system d) others
31. What is your source of power: a) electricity b) fuel wood c) charcoal d) paraffin e) gas f) others
32. How do you dispose solid wastes generated in your household? a) Compost pit b) burning c) on farm d) collected by county council authorities e) others
33. What sanitation problems do you face in this area?

Thank You

APPENDIX B

Questionnaire Schedule for Institutional Assessment

Declaration: The information given in this questionnaire will not be used for any other purpose, besides academic only.

1. Name of Institution _____
2. Land use activities engaged in:
3. Area of operation _____
4. Institutions collaborating with

Institution	Nature of collaboration

5. Type, current source and methods of collecting information used in land use and planning and management

Information type	Current Source(s)	Current collection method	Status

6. Is there information you require but lacks ways of acquiring? Yes: No:
   If yes, which ones?
7. Current method of information management (storage and retrieval) and data analysis.

Activity / Method	Information Management	Data Analysis
Manual		
Automated or digital		

8. Approximate personnel trained in information management
9. What are the 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?

Problems	Solutions

APPENDIX C

Scheduled Questionnaire for the Physical Planning Officer and County Council Official – Kajiado District

1. What is the extent of your services as regards planning the district and its environments?
2. What has been the council's role in land use development in the North Kaputei area?
3. Your area of jurisdiction (Ol Kejuado County Council) has the significant element of being very closely related to Nairobi (the capital city) and Athi River in Machakos district, what are the emerging land use planning and management elements?
4. What are the various tools you use to plan and develop various land use activities in the rapidly changing area like North Kaputei?
5. What are some of the problems you face in enforcing land control regulations?
6. What are the land use management agencies, standards, policies, legislation or other systems in operation in North Kaputei Area?
7. How are these related or coordinated in operation?
8. What are the common problems or conflicts experienced in the course of their practical operation and use?
9. How could this be harmonized or made to operate efficiently for effective land use development and management in this area?
10. In your opinion, what are the major limitations of land use regulations and control with the present planning legislation?
11. Who else apart from the physical planning department and county council provides physical planning services in North Kaputei?
12. How often does the public seek you over the preparation of subdivision plans, change of user, extension of leases especially for the North Kaputei?
13. In your opinion, what is the way forward for effective planning of rapidly changing area like North Kaputei?

Thank You

APPENDIX D

Questionnaire for the Chairman of Land control Board (Kajiado District)

1. As the chairman of the LCB, briefly outline the functions of the LCB
2. Who are the other members of the board?
3. When do you meet as a Board?
4. This being a land control body, what are your responsibilities?
5. Are your responsibilities effective in managing land use development in North Kaputei? In your daily execution of duties as chair of the Board, what challenges do you face?
6. In what ways has the board fostered or hindered land development in North Kaputei? What is the future of LCB in the country as a whole and in the rapidly changing North Kaptuei?
7. Any other comments:

Thank You