REPUBLIC OF KENYA

MINISTRY OF ENVIRONMENT & NATURAL RESOURCES

Lake Victoria Environmental Management Project Phase II Preparation

ASSESSMENT OF THE POTENTIAL OF LAND SUITABILITY MAPPING WITH ENVIRONMENTAL OVERLAYS AND POTENTIAL USEFULNESS OF SPATIAL PLANNING FOR MANAGING THE LAKE VICTORIA BASIN

FINAL REPORT - NOVEMBER 2006

Submitted by:

Regional Centre for Mapping of Resources for Development
P. O. Box 632-00618 Ruaraka Nairobi
TEL: 8560227/8561775 FAX:8561673/8563767
E-mail: farah@rcmrd.org

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS USED

BOG:	Biochemical Oxygen Demand
CAA:	Cumulative Impact Assessment
CBO:	Community Based Organization
CDF:	Constituency Development Fund
CIA:	Critical Area Analysis
DDC:	District Development Committee
DO:	Dissolved Oxygen
DRB:	District Roads Board
EIA:	Environmental Impact Assessment
ET:	Evapotranspiration
FAO:	Food and Agricultural Organization of the United Nations
GIS:	Geographical Information Systems
HMB:	Health Management Board
KARI:	Kenya Agricultural Research Institute
KPLC:	Kenya Power and Lighting Company
LA:	Local Authority
LATF:	Local Authority Transfer Fund
LBDA:	Lake Basin Development Authority
LVEMP:	Lake Victoria Environmental Management Project
MCA:	Multi Criteria Analysis
MOA:	Ministry of Agriculture
MOL:	Ministry of Lands
MLG:	Ministry of Local Government
NEMA:	National Environment Management Authority
NGO:	Non Governmental Authority
NIB:	National Irrigation Board
NTU:	Normalized Turbidity Units
PPD:	Physical Planning Department
PT:	Planning Team
RS:	Remote Sensing
TDS:	Total Dissolved Solids
TN:	Total Nitrogen
TP:	Total Phosphorous
TSS:	Total Suspended Solids
TVA:	Tennessee Valley Authority

Acknowledgement

We would like to thank the Permanent Secretary of the Ministry of Environment and Natural Resources, Prof. George Krhoda for showing confidence in the Regional Centre for Mapping of Resources for Development by commissioning the later to undertake the study on *the assessment of land suitability mapping with environmental overlays and spatially planning for management of the Lake Victoria basin*. We are grateful to the Permanent Secretary and his staff for the cooperation and assistance accorded to us during the entire period of the work. Special thanks go to the World Bank and the Japanese government for providing the financial resources needed to undertake the work.

We would like to thank the staff of the Department of Physical Planning of the Ministry of Lands for providing us with valuable information required for this work. We acknowledge the contribution of Lake Basin Development Authority, National Environmental Management Authority, the Lake Victoria Environmental Management Project staff in Kisumu, Mumias Sugar Company and the Ministry of Economic Planning and National Development. Special thanks go to all stakeholders who participated in our workshops and gave valuable comments to improve this document.

Executive Summary

Introduction

Lake Victoria is Africa's largest and the world's second largest freshwater lake. It is one of the most important shared natural resource of Eastern Africa. The basin comprises of eleven major river basins and a large lakeshore. It supports a population estimated to be over 30 million which is considered to be one of the poorest segments of rural population in the world. Historically, the vegetation of the Lake Victoria shores was dominated by papyrus in extensive wetlands and most of the basin was covered by forests. However, a combination of rapid population growth rates in rural and urban areas, increasing dependency on natural resources as a livelihood means, inadequate planning on use of land and water resources and high poverty levels in the basin has put considerable pressure on land, vegetation and water resources. This pressure is resulting in unsustainable development in the basin with negative effects such as accelerated soil erosion, increasing deforestation, rising air and water pollution, declining fisheries, loss of biodiversity and incremental wetland loss. The consequences are a decline in food security, rising health problems, reduced incomes from agricultural, livestock and fisheries activities and hence increasing poverty.

Implementation of phase one of the Lake Victoria Environmental Management Project (LVEMP) has resulted in improved ability in the riparian States to embark on a long term program of the basin's resource management and environmental improvement. After phase one of LVEMP ended, it is envisaged that phase two of the project, will be implemented building on the work and lessons learnt in phase one. The priority areas of focus for phase two have been identified as socio-economic development, management framework and applied research programme. The next step is to develop interventions that use the information and capacity developed to promote environmentally and socially sustainable economic development of the basin. Land suitability mapping and land use planning are thought to be important for the successful implementation of such interventions.

Objectives of the study

Poor land use leading to the degradation of the Lake Victoria Basin's natural and environmental resources is partly attributed to the inadequacy of data and information on environmental, ecological and socio-economic parameters. Decision-making on the use of the scarce land resources is seldom based on current data and information on available resources and their respective comparative advantage in supporting sustainable livelihood systems and provision of quality environmental/ecological

services and hence the need to have in place basic data and land use plans that may inform decision-making processes on land use alternatives.

The overall objective of this study is to enhance informed decision-making and planning process on the use of scarce land resources with the specific objectives being:

i) To assess the potential of land suitability mapping based on physiological, environmental, ecological and socio-economic factors and information.

ii) To assess the potential usefulness of spatial planning for managing the Lake Victoria Basin and in particular in reducing nutrient inflows into the lake.

iii) To recommend the most appropriate implementation strategy.

Methodology

The work was undertaken in two stages: An inception phase and the main stage. During the inception stage, the focus was on:

- Carrying out preliminary assessment of available data through desk reviews
- Conducting preliminary field appraisals and contacts with the held of relevant stakeholders, projects and programmes, and
- Drafting and presentation of an inception report.

The main phase of the study similarly focused on the following:

- Extensive field-based data and information collection and analyses, and interpretation,
- Drafting of the paper and per the ToRs and presentation of the same to stakeholders during national workshops

Land Suitability Mapping and Land Use Planning: Conceptual Issues

Land suitability mapping is the process of assessing land for specific kinds of use. The basic feature of the process is the comparison of the requirements of land use with the resources offered by the land. Fundamental to the assessment process, is the fact that different kinds of use have differing requirements. Land suitability mapping requires information from three main sources: land, land-use and socio-economics. This is because considerations of economic, social consequences for the people concerned and consequences, beneficial or adverse for the environment, have to be taken into account. Suitability mapping provides information on which decisions on land use interventions can be made and land use plans prepared. To be useful in this role, the products of suitability mapping should provide information on two or more potential

alternatives for use for each area of land including the consequences, beneficial or adverse.

The function of land use planning is to guide land use in a way that the resources are put to the most beneficial and sustainable use. The process involves assessment of land and water potential, alternatives for land use and economic and social conditions, in order to select and adapt the best land use options. The purpose of land use planning is to select and put into practice those land uses that will best meet the needs of the society while conserving resources for the future. The motivation to plan is the need for land use change, the need for improved land management and/or the need for a different land use pattern as dictated by changing circumstances. Land use planning involves all kinds of urban and rural land use such as agriculture, forestry, wildlife conservation, tourism, transportation, water resources and industries among others.

Potential usefulness of land suitability mapping and land use planning

Land suitability mapping becomes important where change is anticipated. This may be a change in kind of land use such as bringing into production land formerly under another use. Prediction is needed of the suitability of the land for different forms of production, or other benefits and the consequences of such change on the environment. These include adverse consequences such as the warning that certain land should not be cultivated owing to severe hazard of soil erosion. Land suitability mapping has high potential for the management of Lake Victoria basin by providing resource inventory and project feasibility information to developers and investors. Resource inventory enables developers to see for example, where the best areas for large scale food crop production are to be found. Identification of alternative development projects can then follow. Project feasibility is required before a decision to invest is taken. Land suitability mapping provides one of the sources of data for land use planning.

Land use planning has immense usefulness in the management of the Lake Victoria Basin. A land use plan would provide the following:

- Enhance environmental sustainability,
- Create harmony in various land uses,
- Reduce regional development imbalance,
- Optimize resource utilization for maximum returns,
- Manage land as a scarce resource.

If the above objectives are achieved, it would lead to orderly, coordinated and harmonious development in the basin in order to promote health, safety, efficiency, social equity, social choice and environmental conservation.

Proposed Implementation Framework for Land Suitability Mapping and Land Use Planning

Planning, both land use and economic at the regional level takes place within a national policy and legal context which are spelt out in Sessional Papers, policy documents and legislation. The policies indicate in very broad terms the desired development goals and the means of achieving the goals. There are also several development strategies that guide rural and urban planning. These include District Focus for Rural Development, Human Settlement Strategy, Growth and Service Centre Strategy, Rural Trade and Production Strategy and Poverty Eradication Strategy which is currently being implemented.

There are a number of legislative provisions that have been passed by parliament that affect land use planning in Kenya. Some of the laws are broad based and affect the whole country while others may be crop specific. The Physical Planning Act (Chapter 286) is the main law concerned with land use planning and physical development control issues that ensure orderly and sustainable development. The Act provides for the legal mandate for the preparation of land use plans to the Director of Physical Planning in the Ministry of Lands. The Director or his representative may initiate planning and appoint a suitable team or agency to accomplish the task. Although it is clear who prepares the proposed land use plans, its implementation is less clear. This is because land use plans contain proposals on multi-sectoral development strategies such as agricultural land management, infrastructure, urban and industrial development and natural resources conservation. Strengthening of the legal framework for plan implementation is required.

The institutions involved in the development of plans and implementation can be categorized as public, civic and private. The following institutions are proposed for coordinating the preparation and implementation of land suitability mapping and land use plans at the district level; District Development Committee (DDC), Physical Planning Department of the Ministry of Lands and Local Authorities. Unfortunately the DDC has no legal basis as it only works as an administrative structure. It is therefore, important to strengthen the DDC to enhance coordination and reduce duplication of development activities. The Physical Planning Department of the Ministry of Lands and Local Authorities should also be strengthened by having enough trained personnel and physical facilities at the district level. The preparation and implementation of sectoral components of the plans such as agriculture, water, health,

education and roads among others, need the full participation of all concerned government ministries and departments, NGOs and CBOs. Their participation is done at the District Development Committees, Divisional Development Committees and thematic group meetings.

The following are the proposed steps to be followed in land use planning at the district level:

1. *Consensus building*
2. *Sensitization of stakeholders*
3. *Formation of sectoral planning teams*
4. *Data collection, review and analysis*
5. *Consultative meeting with focused groups*
6. *Plan formulation*
7. *Review of draft plan*
8. *Final plan preparation*
9. *Plan implementation*
10. *Participatory monitoring and evaluation/review*

It is estimated that it will take about twenty months to prepare a land use plan for one district. This time includes time for preparation stages in institutional capacity building. The total cost is estimated to be US$ 253,425 (Ksh.18,500,000)[1]. It is suggested that land use plans for two districts; one in the upper catchments of the basin and the other in the lower catchments be prepared in a pilot phase.

[1] Assuming an exchange rate of Kshs. 73 for US$

1. INTRODUCTION

1.1 Overview

Lake Victoria is Africa's' largest and the world's second largest freshwater lake. It is one of the most important shared natural resources of Eastern Africa. It straddles the common boarders of the three East African Community Partner States of Kenya, Tanzania and Uganda. The lake and its catchment form a basin that is valued for its socio-economic potential in addition to its immense ecological values. The economic potential of the catchment is based on the good agricultural soils, abundant rainfall, and significant mineral deposits, among others. The Lake itself has a critical importance to the region's society and economy as a source of food, potable water, transportation, agricultural water, power production and tourism.

Historically, the vegetation of the Lake Victoria shores was dominated by papyrus in extensive wetlands and most of the basin was covered by high canopy forests. However, a combination of rapid population growth rates in rural and urban areas, expanding dependency by the riparian population on the natural resources for livelihoods, inadequate planning on the use of land and other associated resources and high poverty levels in the basin have exerted considerable pressure on land, vegetation and water resources. This pressure is resulting in unsustainable development in the basin with negative effects such as accelerated soil erosion, increasing deforestation, rising air and water pollution, declining fisheries, loss of biodiversity and incremental wetland loss. The consequences are a decline in food security, rising health problems, reduced incomes from agricultural, livestock and fisheries activities and hence increasing poverty (Aseto and Ong'anga, 2003).

The 1997 Participatory Poverty Assessment (PPA) cited the main causes of poverty as being linked to environmental factors including lack of water for irrigation, crop failure, floods, water hyacinth and landlessness amongst others. Environmental degradation adversely affects the rural poor economically and this has led the Government of Kenya to recognize that prudent environmental management, poverty reduction and economic growth are all closely linked. As stated in the 9th National Development Plan, 2002-2008, the full integration of environmental concerns in

development planning at all levels of decision making remains a challenge to the country. It further acknowledges that in view of the high incidence of poverty in the country, the need to integrate environmental concerns in development activities should be given high priority. The National Poverty Eradication Plan (NPEP) and the Interim Poverty Reduction Strategy Paper (IPRSP) further highlight these linkages. The plan does not however specify mechanisms for ensuring integration.

Although the Environment Management and Coordination Act (EMCA) of 1999 could provide the mechanism for the integration of the environment into national development process through National Environment Action Plan (NEAP), Provincial Environment Action Plan (PEAP) and District Environment Action Plan (DEAP), this has not been achieved. Land suitability mapping combined with land use planning approaches could be important mechanisms of achieving this goal of integrating environmental concerns in the development process.

1.2 The Lake Victoria Basin

1.2.1 Physical Characteristics

Lake Victoria with a surface area of 68,000 km^2, is the largest lake in Africa and the second largest lake in the world, after Lake Superior in the United States of America. The lake straddles the equator at an altitude of 1,135 meters above sea level. It is among the three EAC Partner States, i.e., Republic of Kenya (6%), Republic of Uganda (45%) and United Republic of Tanzania (49%). The shoreline is irregular and is about 3,450 km long, with 17% in Kenya, 33% in Tanzania and 50% in Uganda. Of the total catchment area of 180,950 km^2, Uganda accounts for 15.9% , Kenya 21.5% (see Figure 1), Rwanda 11.4%, Tanzania 44.0% and Burundi 7.2%.

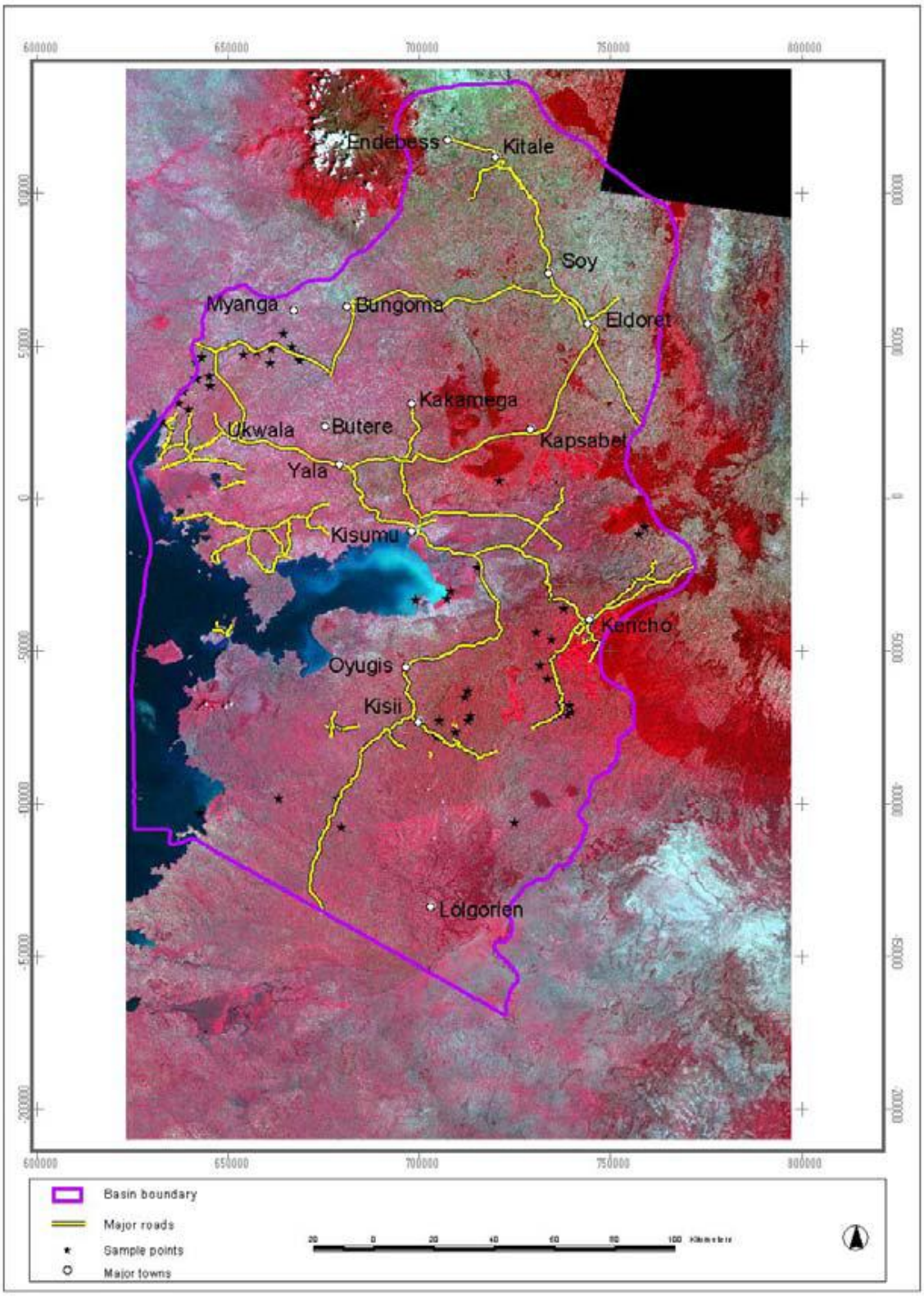


Figure 1. The Lake Victoria Basin on the Kenyan side (source: Ambasa and Lupe, 2005)

The climate varies from alpine zones on Mount Elgon to semi-arid plains near Lake Victoria. Similarly, annual average rainfall varies from 800 mm to 2,000 mm with highest being experienced in Kakamega, Kericho and Kisii highlands. The rainfall is more or less continuous in the year with little distinction between the short and long rains as experienced in the rest of the country. The soils are mostly not fertile as there is little volcanic or other young parent material. Generally most soils are senile, diluted and in some places with laterite horizons. A lot of fertilizers have to be applied to increase crop production.

The basin has a rich diversity of wildlife resources which include Rothschild giraffe, endangered Sitatunga, the endangered de Brazza monkeys, the Faschons hartebeests, leopard, lions, buffalos, reptiles and birds. The basin has also many tourist attraction sites such as national parks, game reserves and a variety of scenic features. A number of mineral resources are found in the basin. These include graphite, limonite, copper, gold, iron, limestone, soapstone, tin and nickel.

1.2.2 Population

The basin comprises of eleven major river basins and a large lakeshore. The population is estimated to be about 30 million. It supports one of the poorest segments of rural population in the world with densities of up to 1,200 persons per square kilometer in parts of Kenya (Hoeskstra and Corbett, 1995). The average is about 165 people/km^2. Table 1 shows the population by river basins.

Table 1. Population within the Lake Victoria Basin

River Basin	Population(in '000)	% of total basin population
Kagera	10,711	42.9
Isonga	430	1.7
Majoga	499	1.8
Disma/Simiyu	485	1.9
Mbalageti	211	0.8
Mara	640	2.6
Kuja	1,481	5.9
Sondu	788	3.2
Nyando	746	3.0
Nzoia/Yala	3,346	13.4
Lake Edge	5,411	21.7
Total	**24,259**	**100.0**

Source: (Hoeskstra and Corbett, 1995)

The lake catchment, provides for the livelihood of about one third of the combined population of the three riparian countries and about the same proportion of the combined GDP. Majority of the people in the basin live in rural areas and rely on fisheries, subsistence agriculture and pastoral production for their livelihoods. There is a rapid and unplanned urbanization taking place while social services such as piped water supply, sewerage systems, transport infrastructure and energy supply are inadequate or non-existent and are highly constrained where available. The Gross Domestic Product (GDP) of the lake catchment is in the order of US$ 3-4 billion annually, with per capita ranging between US $ 90 and US $ 20 (Aseto and Onganga, 2003). Poverty levels are high, while production is low. The average annual value of crop output per hectare for selected district in basin ranges from US$ 92.6 to US$ 150.2 as shown in Table 2 (Owour, 1998).

Table 2. Average Annual Value of Crop Output per Hectare

District	Ksh- Value of Crop Output per Hectare
Kisumu	6,761
Siaya	6,761
Kisii	8,275
Vihiga	8,275
Kakamega	10,965
Bungoma	10,965

The figures for the districts shown in Table 2 are very low compared to Ksh 14,126 for Nakuru and Uasin Gishu districts and Ksh 21,653 for Nyeri, larger Murang'a and larger Meru districts (Owour, 1998).

About 56% of the country's population lives under the poverty line. Absolute poverty is expected to increase to 65% by 2015 in the basin if radical measures are not instituted – land use planning for optimal utilization included. Poverty threshold adapted in Kenya is US $ 17 per month for rural areas and US $ 36 per month for urban areas (CBS, 2005). The percentage of people living below the poverty line is therefore, higher in the basin compared to the national average. Nyanza and Western provinces which are in the basin average poverty rates of 65% and 61% respectively. Table 3 illustrates poverty levels in selected constituencies in the basin.

Table 3: Population living below the Poverty Line in selected Constituencies in the Basin

Province	Name of Constituency	Poverty (%)
Nyanza (65%)	Kuria	81
	Kasipul Kabondo	72
	Karachuonyo	72
	Rangwe	72
	Bunchari	74
	Mugirago Borabu	71
	Rongo	44
	Migori	47
	Uriri	49
Western (61%)	Ikilomani	72
	Butula	70
	Funyula	70
	Budalangi	70
	Bmula	52
	Amagoro	50
	Mt Elgon	55

1.3 Lake Victoria Environmental Management Project

Lake Victoria Environmental Management Project (LVEMP) and other bilateral efforts have developed significant knowledge base and technical capacity in the national agencies to enable assessment of the environmental stresses confronting the lake and its catchment. The first phase of LVEMP commenced in July 1997 and ended on 31st December 2005. Implementation of phase one of LVEMP has resulted in improved ability in the riparian States to embark on a long term program of resource management and environmental improvement. After phase one of LVEMP ended, it is envisaged that phase two of the project, will be implemented, building on the work and lessons learnt in phase one. The priority areas of focus for phase two have been identified as socio-economic development, management framework, applied research and public education and communication. The next step is to develop interventions that use the information and capacity developed in phase 1 to promote environmentally and socially sustainable economic development of the basin. Land suitability mapping and land use planning are certainly to be important for the successful implementation of such interventions.

1.4 Objectives of the study

The main environmental problems of the Lake Victoria Basin are due to the poor land use management, agricultural expansion in the basin and irresponsible industrial and municipal waste management. Land is the most critical resource. It contributes 30% of G.D.P and employs 60% of labour force (World Bank,1998). Per capita land holding in the basin is on a steady decline and is expected to fall from the current 0.75 ha to 0.35 ha by 2025 (Ocholla, 2004). Since 1980, an estimated 150,000km^2 of land has been severely eroded of which 60% is agricultural land, while 75% of wetlands have been significantly affected by human activities and about 13% are severely degraded.

Poor land use leading to the degradation of Lake Victoria Basin's natural and environmental resources is partly attributed to the inadequacy of data and information on environmental, ecological and socio-economic parameters. Decision-making on the use of the scarce land resources is seldom based on current data and information on available resources and their respective comparative advantage in supporting sustainable livelihood systems and provision of quality environmental/ecological services.

The overall objective of this study is to enhance informed decision-making and planning process on the use of scarce land resources. The specific objectives are:

i) To assess the potential of land suitability mapping based on physiological, environmental/ecological and socio-economic information.
ii) To assess the potential usefulness of spatial planning for managing the Lake Victoria Basin and in particular in reducing nutrient inflows into the lake.
iii) To recommend the most appropriate implementation strategy.

The specific tasks to achieve the above objectives are:

1. Review the importance of land suitability mapping in the production of land use maps.
2. Review the importance of land use maps in the correct allocation of land resources to competing uses or needs.

3. Compare and contrast status of environment in areas where land suitability mapping has been done and used as compared with those without.
4. Propose implementation framework of the proposed land suitability and spatial planning approaches.

1.5 Methodology

This report was drafted through a consultative process which entailed, desk review, detailed discussions with various stakeholders and presentation of inception report, mid-term report and final report during a series of workshops. Workshop participants were drawn from various interest groups – Government departments, Non-Governmental Organisations, Civil Society Organisations (CSO), institutions of higher learning, Beach Management Units, research institutions, private sector and local communities. The workshops were aimed at enriching the list of proposed interventions, improving the focus and content of the report and, enhance awareness among the various stakeholders on the on-going process of formulating LVEMP II.

1.6 Structure of report

This report is founded on earlier reports i.e., inception and mid-term reports and comments given during the 3 workshops during which it was presented and discussed.

This report is organized as follows. The first chapter gives an introduction, objectives of the study and a brief background of the Lake Victoria Basin. Chapters two and three give literature review on the principles and processes of land suitability mapping and land use planning respectively. The current land use practices in the basin are detailed in Chapter four. Chapter five highlights the effects of the current land use on the environment while Chapter six gives the previous initiatives of land suitability mapping and land use planning in the basin. The potential usefulness of land suitability mapping and land use planning in the management of the basin are given in Chapter seven. Chapter eight presents a proposal on the implementation framework for land suitability mapping and land use planning.

2 LAND SUITABILITY MAPPING

2.1 Introduction

The demand for land suitability mapping arose when it was appreciated that mapping of natural resources alone did not provide sufficient guidance on how land could be used and what would be the likely consequences in economic and ecological sense. Natural resource surveys express their primary results in terms of environmental factors mapped. Soil maps show soils, vegetation maps are based on plant associations, climate is expressed in terms of averages and variability of rainfall, temperature and other parameters. None of these, as such, indicates whether the land can be used to grow say tea. To be of value in land use planning and management, a further stage is needed, that of relating features of soils, vegetation and climate among others to the requirements of different kinds of land use. This is the stage in which the requirements of land use are compared with qualities of land, thereby assessing the value of each type of land for each kind of use considered.

Land suitability mapping is concerned with the assessment of land performance when used for a specified purpose. It involves the analysis and interpretation of basic survey data of climate, soils, vegetation, economic, social and infrastructure. Land suitability mapping is part of the process of land use planning. It is the main basis on which decisions on rational land use planning and appropriate and sustainable use of natural and human resources are made.

Certain concepts and definitions are required as a basis for the subsequent discussions in this chapter. This is because in the literature some of the terms used, have slightly different meanings when used by different authors. For the sake of clarity, some definitions are given in the text while formal definition of the terms used are given in the Glossary (see Appendix 1)

2.2 Land Suitability Mapping

Land suitability mapping is the process of assessing land for the specific kinds of use (Dent and Young 1981). The basic feature of the process is the comparison of the requirements of land use with the resources offered by the land. Fundamental to the

assessment process, is the fact that different kinds of use have differing requirements. Land suitability mapping requires information from three main sources: land, land-use and socio-economics. This is because considerations of economic, social consequences for the people concerned and consequences beneficial or adverse for the environment have to be taken into account. Successful land assessment is a necessarily multi-disciplinary process and therefore, the use of a standardized framework is essential to ensure logical, and quantitative analysis of the suitability of the land for a wide range of possible land uses.

Suitability mapping does not involve the determination of land use changes or proposals but rather provides information on which decisions on land use interventions can be made. To be useful in this role, the products of suitability mapping should provide information on two or more potential alternatives for use for each area of land including the consequences, beneficial and/or adverse of each.

2.3 Principles of Land suitability assessment

The basic principles that are fundamental to the methods used in land suitability mapping are: (FAO, 1976):

i) Land suitability is assessed and classified with respect to specified kinds of use. This principle gives recognition to the fact that different land uses have different requirements. The concept of land suitability is only meaningful in terms of specific kinds of land use, each with their own requirements, e.g. for soil moisture and rooting depth among others. The qualities of each type of land, such as moisture availability or liability to flooding, are compared with the requirements of each use. Thus the land itself and the land use are equally fundamental to land suitability assessment.

ii) Assessment requires a comparison of the benefits obtained and the inputs needed on different types of land. Suitability for each use is assessed by comparing the required inputs, such as labour, fertilizers or road construction, with the goods produced or other benefits obtained.

iii) A multidisciplinary approach is required. The process requires contributions from the fields of natural science, appropriate land use technologies, economics and sociology. In particular, suitability assessment always

incorporates economic considerations to a greater or lesser extent. The comparison of benefits and inputs in economic terms plays a major part in the determination of suitability.

iv) Evaluation is made in terms relevant to the physical, economic and social context of the area concerned. The assumptions underlying suitability evaluation differ from one country to another and, to some extent, between different areas of the same country. Many of these factors are often implicitly assumed; to avoid misunderstanding and to assist in comparisons between different areas, such assumptions should be explicitly stated.

v) Suitability refers to use on a sustained basis. The aspect of environmental degradation is taken into account when assessing suitability. There might, for example, be forms of land use which appear to be highly profitable in the short run but are likely to lead to soil erosion, progressive pasture degradation, or adverse changes in river regimes downstream. Such consequences would outweigh the short-term profitability and hence such land is classed as not suitable for such purposes.

vi) Suitability assessment involves comparison of more than a single kind of use. This comparison could be, for example, between agriculture and forestry, between two or more different farming systems, or between individual crops. Often it includes comparing the existing uses with possible changes, either to new kinds of use or modifications to the existing uses.

2.4 Level of suitability assessment

Although the procedures of land suitability mapping are common to all types of suitability assessment, there are different levels or intensities at which the assessment can be done. There are three levels which can be distinguished depending on intensity of the surveys and studies carried out. These are reconnaissance, semi-detailed and detailed. These are usually reflected in the scale of the suitability maps produced.

Reconnaissance surveys are concerned with broad inventory of resources and development possibilities at regional and national scales. Economic analysis is only in very general terms and land suitability assessment is qualitative. The results contribute to national plans, permitting the selection of development areas and

priorities. Surveys at the semi-detailed level are concerned with more specific aims such as feasibility studies of development projects. Economic analysis is considerably more important and suitability assessment is usually quantitative. This level provides information for decisions on the selection of projects or whether a particular development or land use change is to go ahead. The detailed level covers surveys for actual planning and design or farm planning. It is often carried out after the decision to implement a project has been made.

2.5 Land suitability mapping procedures

2.5.1 Introduction

The procedures and main activities in suitability mapping are as given in Figure 2-. The first step is that of setting the objectives of the assessment. This is done through consultations with stakeholders such as land owners, government departments, NGOs, CBOs and the private sector. The objectives are specified activities to be carried out on the land for purposes of attaining defined goals which are in most cases have quantifiable outputs.

The next step is the identification and description of the kinds of land use to be considered and establishment of their requirements. Land qualities required for particular land uses are determined. Land qualities are measurable attributes of land on which decisions on suitability of land for specific uses can be made. Land quality determination should be done by a multi-disciplinary group of experts representing all considered land use objectives. Such experts include, among others, agriculturalists, range scientists, foresters, nutritionists and planners.

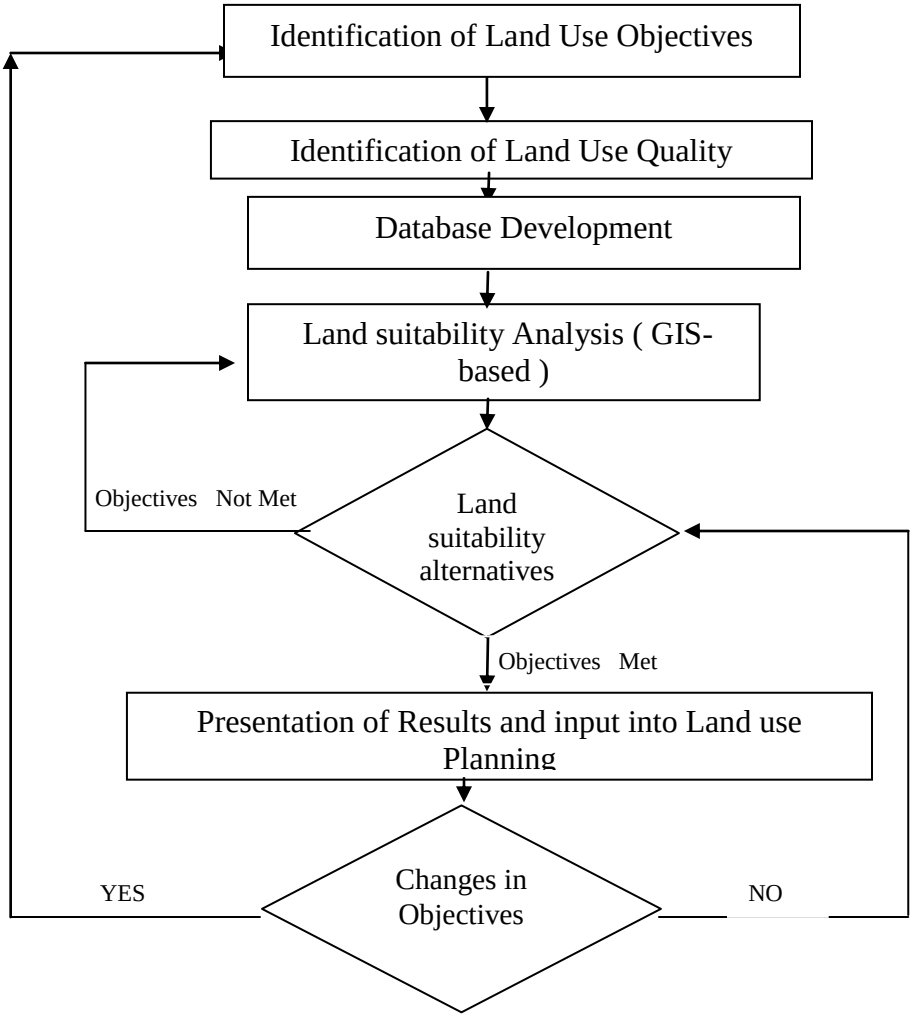


Figure 2: Flow chart for the Land Suitability Mapping Processes

Appendix 2 gives examples of land qualities related to various production systems and management practices. Examples of land qualities for specific land uses are given in Table 5.

Database development involves collecting background data on the physical, economic, social and environment parameters to give the context of the study area. These data include:

- Location and accessibility,
- Climatic zone,
- Relief,
- present state of land improvements (e.g. reclamation, drainage),
- Population and its rate of change,

- Level of living (e.g. gross domestic product per capita),
- Education,
- Basis of the present economy,
- Economic infrastructure (e.g. roads, urban services),
- Government subsidies,
- Size of farms or other landholdings,
- Land tenure system and
- Political system.

This database creation involves the development of a digital database which is used in the next stage of land suitability analysis which is most efficiently done in a Geographic Information System (GIS) environment. GIS is a computer based information system that enables capturing, modelling, manipulation, retrieval, analysis and presentation of geographically referenced data. It is a facility for preparing, presenting, and interpreting facts that pertain to the surface of the earth. All the above data are brought together as layers and analysed systematically. The GIS integrates the land qualities from the physical, biological and socio-economic spheres and supports and guides decision making through Decision Support System (DSS). DSS is a mechanism that can be used to provide information needed to make sound decisions on the land use to be allocated to a particular piece of land. Figure 3 illustrates the land suitability analysis process in a GIS environment.

In the DSS land under consideration is ranked according to its suitability in the performance of specific land uses on the basis of simultaneous evaluation of all land qualities known to affect the specific land use. The output from this process should provide guidance for land use allocation decisions. If there was only one objective the allocation decision would simply involve identifying the highest ranked sites and allocating them until the projected demand area is satisfied. With multiple objectives, it is likely that some objectives will pick the same land units as the most suitable. In such circumstances, decisions have to be made on which objectives to allocate to which land units.

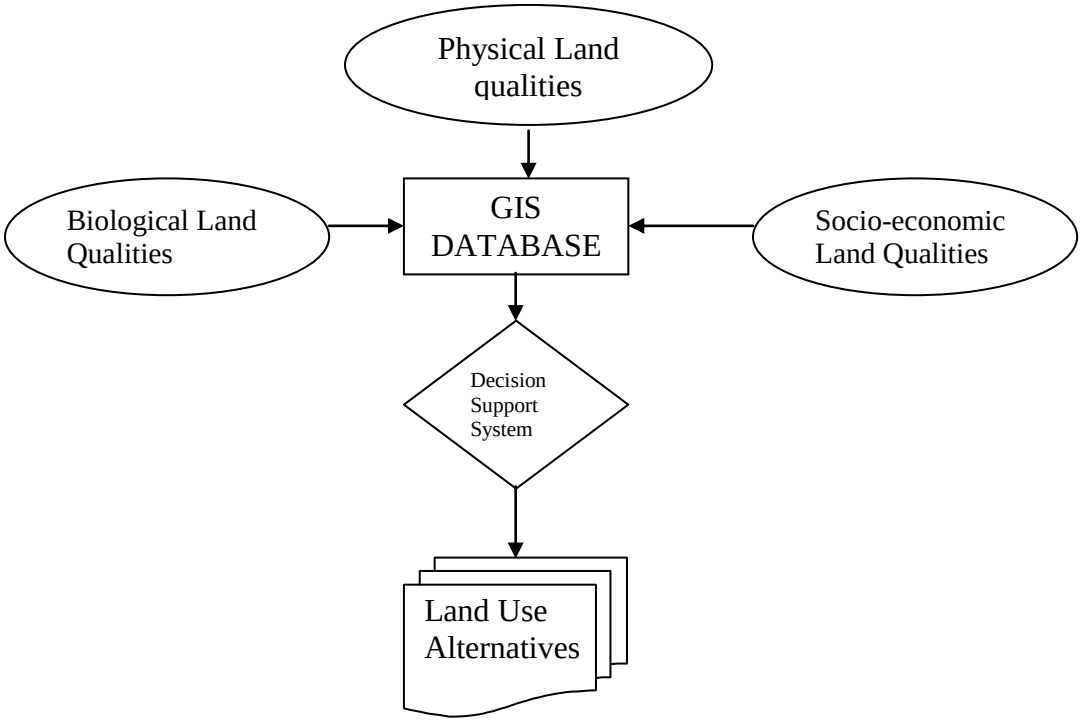


Figure 3. Land suitability determination process

Although the procedure indicates that the activities are undertaken successively, there is considerable amount of iteration in the procedure. For example some revision of the early activities may become necessary upon findings in the later activities. More specifically if there are changes in objectives during the land suitability process or land use planning due to changes in socio-economic characteristics or identified land qualities then the whole process has to be repeated as shown in Figure 2.

2.5.2 Suitability classification

Table 4 illustrates the structure of land suitability classification. The suitability of land for a particular use is categorized as most suitable, suitable, moderately suitable, marginally suitable and not suitable. In some cases, classes may be specified in terms of relative yield, for example S1: >80% optimum yield, S2: 40-80%, S3: 20-40%. N: yield < 20% of optimum yield where this is the break-even point.

Table 4. Structure of land suitability classification

Classification	Description
Class **S** Suitable	Land that can support the land use type without degrading its productive capacity and yielding benefits that justify the inputs
Class **SI** Most Suitable	Land without limitations or with only minor limitations that will not significantly reduce productivity nor require extra inputs. Not necessarily perfect, but the best that can reasonably be hoped for
Class **S2** Moderately Suitable	Land having limitations that will reduce productivity or increase the inputs required to maintain productivity compared to S1 but still clearly suitable and offering attractive benefits for use.
Class **S3** Marginally suitable	Land having limitations so severe that benefits are reduced and/ or require inputs increased so that this expenditure is only marginally justified.
NOT SUITABLE **N**	Land that cannot support a specified land use type on a sustained basis . Either the land use is technically impractical or cannot be sustained because it leads to progressive destruction of land and water resources or is financially unprofitable.

The suitability classification is based on land qualities and land characteristics. A *land quality* is an attribute of the land that has a specific effect on land use. Examples are water availability, nutrient availability drainage, flood hazard and erosion hazard. *Land qualities* can rarely be measured directly because they are determined by the interaction of several individual land characteristics. However, they are frequently described by land characteristics. Erosion hazard as land quality is for example determined by rainfall intensity, ground cover, soil permeability and structure, slope angle and length, which are all land characteristics. Individual characteristics are usually unsuitable for assessing land suitability. Sometimes they act in opposing directions: for example slope angle must be used to assess erosion hazard. The steeper the slope the worse the hazard but slope also determines drainage, the steeper the slope the quicker the drainage. There are numerous land qualities required for any particular land use types. However, in practice only a few critical ones have major influence on suitability. The critical land qualities will depend on the land use type and management practice proposed. Therefore, they have to be determined specifically, case by case for each proposed land use type. Appendix 2 gives examples of land

qualities related to various production systems and management practices. Because of the many possible land quality requirements for a particular land use type, some criteria for the identification of critical land qualities have to be determined as follows:

i. Does it affect the land use in question? Some land qualities apply in all situations e.g. water availability. Others are restricted for example "conditions for ripening"; applies to cereals and fruit crops but not to rubber which depends on vegetative growth.
ii. Do critical values occur in the area? For example many tropical crops are sensitive to frost but if frost does not occur in the area this factor can be ignored.

With the identification of the critical land qualities requirements, each land use type can be specified in terms of a limited number of land qualities. Having set the land qualities relevant to the assessment, the next step is to decide which land characteristics will be used to measure them and what limiting values will be assigned to each land suitability class and sub-classes. This is a critical stage where information is required on actual performance under a range of conditions to arrive at reasonable values. Table 5 gives an illustration for rain fed arable farming.

Table 5. Land requirements for rain fed arable farming.

Land use type		Rain fed arable cultivation by small holders using traditional methods and low inputs
Cropping characteristics		Inter cropped maize and groundnuts
Land quality		Water availability
Land Characteristics	1) soil water deficit during the growing season(mm) 2) Soil water storage(depth: texture)	S1: <120 S2: 120-200 S3: 200-400 N: >400 S1: >1m if SL or finer >1.2m if coarser S2: 0.6-1m if SL or finer 0.75-1.2m if coarser S3: 0.4-0.6m if SL or finer 0.5-0.75m if coarser N: <0.4 or 0.5
Land Quality	Drainage	
Land characteristics	Soil drainage class	S1: well / moderately drained S2: well drained S3: imperfectly drained N: poorly drained

2.6 Presentation of the results of land suitability mapping

Each land use type must be assessed in terms of production potential and inputs, demand for production and availability of inputs, the social consequences of change and their environmental impact. The final results of a land suitability assessment can be presented as maps on a common base of:

a) Land units: – areas of land with distinctive land qualities. These may be soil series, soil associations or landscapes, land systems or facets, depending on the scale of the surveys and the time and money available for the mapping,

b) Present land use:- current spatial land use patterns;

c) Tables and textual material showing degree of land suitability: - sharing the suitability of each land unit for each alternative land use type;

d) Land use problems:- for example flood hazard, soil erosion hazard, drainage problems and soil salinity;

e) Economic and social analysis of the consequences of the various kinds of land use considered;

f) Information on the reliability of the suitability estimates. Such information is directly relevant to planning decisions.

.

3 LAND USE PLANNING

3.1 Introduction

Demand on land is ever increasing as population increases and as our aspirations increase but the demands have to be met from a fixed area of land. So we must plan and work to make the best use of our land resource. Land use planning is not a new activity. Farmers have made land use plans season after season, deciding what to grow and where to grow it. But today, land use planning is becoming increasingly complex where many competing demands and large areas of land are involved. It has to relate to social and economic needs to the qualities of particular areas of land. It also highlights unsuitable kinds of use, those that destroy the productive capacity of the land or are socially unacceptable or not economically viable (Dent and Ridgeways, 1986). This means avoidance of unsuitable use is one important task of land use planning. The other is to work towards the best use of the land and this is achieved by examining alternatives. Land suitability assessment and mapping has first to be done so as to come up with optimum land use plan under given land characteristics and potential possible uses.

The function of land use planning is to guide land use in such a way that the resources of the environment are put to the most beneficial use while at the same time conserving those resource for the future. The process involves assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adapt the best land use options. The purpose of land use planning is to select and put into practice those land uses that will best meet the needs of society while conserving resources. The motivation to plan is the need for land use change, the need for improved land management and the need for a different land use pattern as dictated by changing circumstances. Land use planning involves all kinds of urban and rural land use such as agriculture, forestry, wildlife conservation, tourism, transportation, water resources, industries etc.

In the literature, the terms spatial planning, land use planning and physical planning are interchangeably used. However in some cases, especially in more recent literature

some distinction is made. For example, in South Africa, it is being proposed that the term spatial planning be reserved for planning at the regional (area larger than municipality) level and is meant for guiding and informing land development issues while land use planning be used to describe more detailed planning of actual development and management of land (Ministry of Agriculture and Lands Affairs, 2001). In Kenya, the term physical planning is more commonly used and refers to spatial planning and all types of land use planning. In this report the terms land use planning and spatial planning will mostly be used and will mean the same as physical planning.

3.2 The focus of land use planning

The focus of land use planning are, the people, the land, available technologies and their integration (FAO, 1976). The people's needs are the main driving force of the planning process. Meaningful land-use planning must be positive. The people's requirement must be determined and also the local knowledge, skills, labour and capital that they can contribute. The problems of the existing land-use practices must be examined and alternatives sought while drawing the public's attention to the hazards of continuing with present practices as well as the potential opportunities likely to arise out change.

Land as a resource is also the other focus of land-use planning. Land cannot be moved and different areas present different opportunities and different management problems. Good data and information about land resources is thus essential to land-use planning. Another element in planning is knowledge of land-use technologies: agronomy, silviculture, livestock husbandry and other means by which land is used. The technologies recommended must be those for which users have the capital, skills and other necessary resources – they must be feasible, that is, appropriate technology. New technologies may have social and environmental implications that should be addressed.

Finally another focus of land use planning is integration. Land-use decisions are not made only on the basis of land suitability but also according to the demand for products/services and the extent to which the use of a particular area is critical for a particular purpose. Planning has to integrate data and information about the suitability of the land, the demands for alternative products/services or uses and the

opportunities for satisfying those demands on the available land, now and in the future.

3.3 Scales of land use planning

Land use planning can be implemented at the national, district and local levels. Different decisions are taken at each level, hence the methods of planning and type of plans produced at the different levels will also differ. There is need at each level for a land-use strategy, policies that indicate planning priorities, projects that tackle these priorities and operational planning to get the work done.

Planning at the national level is mainly concerned with national goals and does not involve the actual allocation of land for different uses, but the establishment of policies and priorities for district-level projects. A national land use plan usually contains land use policy, legislation on land, national development plans and coordination of sectoral organizations involved in land use.

At the district or regional level, the tasks performed may include the following:

- the siting of developments such as new settlements, forest plantations and irrigation schemes;
- the need for improved infrastructure such as water supply, roads and marketing facilities; and
- the development of management guidelines for improved kinds of land use on each type of land.

In Kenya, the plans prepared at the district level are referred to as regional physical development plans or simply regional plans (Republic of Kenya, 2004). The function of regional plans are also for interpreting the regional land use development policies in terms of appropriateness to the local area, providing a framework for guiding the use of land for the various purposes and providing a platform for coordinating the efforts of agencies involved in the implementation of the plans.

At the local level, planning involves people directly. This is the level where the implementation of land use changes or management is carried out with the aid of the local people's knowledge and contributions.

The plans can also be categorized as long term or short term. The long term plans provide a framework for development of a region for period of about 30 years and give the basis for the location of the various competing users. Regional plans are usually long term plans. The short term plans are specific site plans, action plans or subject plans based on the long term plan and take a year or less to implement.

3.4 The process and stages of land use planning

Although each land use planning programme is different in terms of their objectives and local conditions and hence require different approaches, there are common procedures that can be used as general guidelines. The following stages form the guidelines (FAO,1976):

*Stage 1. Establish goals and terms of reference***.** Ascertain the present situation; find out the needs of the people and of the government; decide on the land area to be covered; agree on the broad goals and specific objectives of the plan; settle the terms of reference for the plan.

Stage 2. Organize the work. Decide what needs to be done; identify the activities needed and select the planning team; draw up a schedule of activities and outputs; ensure that everyone who may be affected by the plan, or will contribute to it is consulted.

*Stage 3. Analyze the problems***.** Study the existing land-use situation, including in the field; talk to the land users and find out their needs and views; identify the problems and analyze their causes; identify constraints to change.

*Stage 4. Identify opportunities for change***.** Identify and draft a design for a range of land-use types that might achieve the goals of the plan; present these options for public discussion.

*Stage 5. Evaluate land suitability***.** For each promising land-use type, establish the land requirements and match these with the properties of the land to establish physical land suitability.

*Stage 6. Appraise the alternatives: environmental, economic and social analysis***.** For each physically suitable combination of land use and land, assess the environmental, economic and social impacts, for the land users and for the community as a whole. List the consequences, favourable and unfavourable, of alternative courses of action.

Stage 7. Choose the best option. Hold public and executive discussions of the viable options and their consequences. Based on these discussions and the above appraisal, decide which changes in land use should be made or worked towards.

Stage 8. Prepare the land-use plan. Make allocations or recommendations of the selected land uses for the chosen areas of land; make plans for appropriate land management; plan how the selected improvements are to be brought about and how the plan is to be put into practice; draw up policy guidelines, prepare a budget and draft any necessary legislation; involve decision-makers, sectoral agencies and land users.

Stage 9. *Implement the plan*. Either directly within the planning process or, more likely, as a separate development project, put the plan into action; the planning team should work in conjunction with the implementing agencies.

*Stage 10. Monitor and revise the plan***.** Monitor the progress of the plan towards its goals; modify or revise the plan in the light of experience.

3.5 Methods of land use planning

There are a variety of land use planning techniques and methods. The methodologies are derived from a number of disciplines such as natural sciences (climatology, soil science, ecology), from technology (agriculture, forestry, irrigation engineering) and from the social sciences (economics, sociology). In many countries, the detailed explanation of the techniques and methods are usually given in manuals or handbooks. In Kenya, there is the Regional Planning Handbook produced by the Physical Planning Department of the Ministry of Lands (Republic of Kenya, 2004). In the handbook, several analytical methods, guidelines and procedures that apply to planning have been harmonized and interlinked to provide an effective planning process.

3.6 Data collection, management and analysis

Decision-making depends on timely data and information on the present land-use situation, on possible ways of improving this situation and on the consequences of implementing each alternative solution. The collection and analysis of data requires

much time and is costly to undertake, but is not an end in itself. Therefore, there must be a trade-off between the excellence of the data and the time and cost of collecting them. Ways of making data collection cost-effective include:

- Establish what is already available but check the reliability of the data.
- Collect data incrementally. Begin with a rapid overview of the whole area. Use this to identify those areas from which more detail is needed.
- Know the method of analysis. Design each survey with the method of analysis to be used in mind.
- Organize and store the data systematically, paying attention to:
    - *Quality control*. Always list where and how data were obtained, in the field or from printed sources;
    - *Updating*. Record when data were last revised or updated.

In land use planning, large amounts of data covering large areas are handled. Complex and numerous comparisons, overlays and calculations over these areas are also undertaken. Although it is possible to carry out data management and analysis manually, it is extremely slow and tedious. A computer based management and analysis system such Geographic Information System (GIS) is more efficient in land use planning. GIS is a computer-based system of storage and manipulation of data which is organized by their unique position or location on the earths surface.

Apart from efficient storage and quick retrieval of data, GIS can offer quick solutions to undertake complex and manually tedious calculations and analysis using any combination of the data in store. In this way, tables and maps of interpreted information can be produced very quickly. Moreover, the data can be updated or corrected and the methods of calculation revised by changing the computer program so that new maps and tables can be produced rapidly when different circumstances and scenarios are considered.

3.6.1 Population analysis.

Economic and population analysis have several uses in regional planning (Republic of Kenya, 2004):

- To estimate current population and employment - estimates of current levels indicate the need for revenue for assessing per-capita conditions with respect to community services.
- To make population and economic forecasts, which determine future land use and community requirements.
- To trace and assess population and economic impact of past events and possible future events.
- To establish policy reference for population projection level, on the basis of community vision and goal.

There are several methods and techniques for population projection and estimation. They include trend extrapolation method, ratio-share techniques, holding capacity techniques, statistical association technique and joint economics. The trend extrapolation method examines trends and projects them into the future. It can be used to determine population levels, components and specific population characteristics such as fertility. The ratio-share technique is used to express a sub-region's population as a ratio of share of population of a region. In the holding capacity techniques, the available space for employment of population is evaluated. Statistical association technique applies statistical equations to indicators such as employment, housing (dwelling units), and school enrolment to obtain estimates or projection of populations. The joint economics method projects population and employment in a coordinated, sometimes iterative way. Population is based on employment and other economic analysis.

3.6.2 Economic analysis.

Employment is an important determinant of population growth and change as well as direct source of demand for space, natural resources and community infrastructure. Some of the economic analysis methods applied in land use planning include the following:

- *The Judgmental approach* is the method for obtaining a group judgment about the future and varies from single-round survey to multi round Delphi surveys to group participation techniques. Experts typically include academics, professionals and consultants and business associations.

- *Ratio share techniques* are approaches for projecting employment for state economic areas. It helps to determine the dependence of local economy on the national or international economy.
- *Shift-share analysis* or the ratio share is refined to incorporate assessment of how particular industries in the region might share differently in parent area growth (Perlooff et al., 1960). This approach divides the region economy into component industries or sector (tourism, manufacturing, agriculture) and analysis each separately. The shift is analyzed over a period of time to determine the importance of each industry.
- *Economic-based analysis* is based on the theory that the economy is made up of two components: Basic economic activities which produce and distribute goods and services for export outside the local region and non-basic activities, which produce goods and services for consumption. The economic base theory holds basic sector as the key to an area's economic strength.
- *Cost-benefit analysis* is the most appropriate method of appraising projects from the national point of view. This analysis helps planning authorities in making the correct investment decisions to achieve optimum resource allocation by maximizing the difference between the present value of benefits and cost of a project. It involves the enumeration, comparison and evaluation of benefits and costs.

The objective function of cost-benefit analysis is to establish Net Social Benefit (NSB). The function can be written as NSB = Benefits – Costs where costs are measured in terms of shadow prices of inputs and outputs instead of the actual market prices. This is because actual market prices do not reflect social benefits and social costs as they are influenced by restrictive practices, monopolies and controls. Shadow pricing is therefore, used when placing a value on programme outcomes other than market price. Programme outcomes that cannot be bought or sold, such as social value, can be ascribed a monetary value. Some effort is required to determine correct shadow prices.

Multi-Criteria Analysis (MCA) is a decision-making tool developed for complex problems. In a situation where multiple criteria are involved, single-criterion approaches such as cost-benefit analysis cannot be used and confusion can arise if a

logical, well-structured decision-making process is not followed. In MCA, desirable objectives are specified and corresponding attributes or indicators are identified. The actual measurement of indicators need not be in monetary terms but are usually based on the quantitative analysis (e.g. ranking, weighting and scoring) of a wide range of qualitative impact categories or criteria. Another difficulty in decision making is that of reaching a general consensus which in a multidisciplinary team can be very difficult to achieve. By using MCA the members do not have to agree on the relative importance of the Criteria or the rankings of the alternatives. Each member enters his or her own judgment and makes a distinct, identifiable contribution to a jointly reached conclusion.

3.6.3 Environmental analysis

Analysis of environmental information includes environmental impact analysis, cumulative impact assessment, critical area analysis and hazard analysis (Republic of Kenya, 2004).

Environmental Impact Analysis (EIA)

The techniques in environmental impact analysis include descriptive checklist, and trade-off matrix, the spreadsheet model and the overlay screening model.

(a) Descriptive checklists- provide system procedures for ensuring that all the relevant impacts are examined for each proposed project.

(b) Trade off matrix- links the substantive impacts of checklist to affected groups.

(c) Spreadsheet models- spreadsheet programs are used to perform complex matrix relationship based on algebraic formula.

(d) The overlay screen model - It is based on the cumulative impact analysis and is accomplished by overlaying separate impacts. Overlay screening models are useful in reviewing the aggregate impacts of population on natural resources. GIS is a very useful tool where impacts can be rapidly calculated and recalculated.

Cumulative impact Assessment (CIA)

Modelling of the impacts of all existing and proposed projects is done to determine the total effect. Cumulative impact assessment could be done during the plan preparation to assess the probable impacts of implementing the planned land use proposals.

Critical Area Analysis (CAA)

This analysis is undertaken for those areas that have been identified as areas of particular environmental concern such as sensitive environments or natural areas such as wetlands, barrier islands endangered species habits, or water supply reservoir buffers The objective of the analysis is to prepare special plans to manage conflicts between development and resource conservation.

Hazard analysis

This analysis is done to examine the potential effects of hazards. There are natural and man-made hazards that need to be analyzed. Natural hazards that are important in land use planning are floods, hurricanes, earthquakes, land slides and ground subsistence. Mapping of natural hazards is done by placing the type of natural hazard on a layer in a GIS. Comprehensive hazard maps can be generated which guide the use of the areas that are likely to be affected by the natural hazards.

Man-made hazards result mainly from inadequate waste disposal and leftover of residual from industrial processes. Because the cost of clean up and potential punitive damage outweigh the value of land, it is critical to identify all existing and potential local hazardous waste sites and make necessary provision in the plans.

3.7 Information requirements

Land suitability mapping and land use planning require the following information;

- Physical land suitability,
- Socio-economic and,
- Environmental/Ecological.

Overlays of these different themes would give a spatial orientation to the problems and potential of the basin with respect to sustainable land development. Overlays of the different themes can be spatially interrelated and analyzed to derive further information and maps, for example, potential soil erosion and potential for specific land development. Moreover, sensitivity analysis can be undertaken to predict the impacts of development activities on the environment. It is also possible to give

different scenarios and alternatives for use of land resources with clear indications of the outcome of each scenario on the environment. The results are a regional/district plans, maps and reports highlighting development possibilities.

An ideal report should show prospects for:

- Investment in rural sub-sectors: agriculture, livestock, forestry, wildlife management and conservation, tourism with emphasis on eco-tourism, mining and quarrying.
- Land based investment that is natural resource dependent.
- Zones for siting of enterprises in a well planned industrial zone and which gives priority to development of facilities in terms of electricity, water, telecommunications and proper civil works for treatment of domestic and industrial waste to acceptable international standards before discharge.

In most cases three basic overlays based on secondary information are required:

a) Physical land suitability overlays:

This is derived from several overlays depicting land qualities and current land use attributes. They include:

i. Agro-climatic zones,
ii. Mean annual rainfall,
iii. Physiognomic units(land system /land units),
iv. Land suitability rating for the most important land utilization types(LUTS) for the model soil types/land unit; for example:
    -Rain fed homestead gardens,
    -Irrigated high value agriculture (e.g. rice)
    -Rain fed sugarcane
    -Cotton
    -Maize
    -Coffee
    -Tea (small scale and estates)
    -Forests (Indigenous, Plantations (exotics), unimproved pasture).

b) Socio-economic overlays:

This would include the following data and information:

i. Urban settlement, including urban and peri-urban economic activities- it should be disaggregated into urban, commercial, residential, urban industrial, other relevant infrastructure - roads, sewage treatment facilities sites etc.,
ii. Areas of land use, depicting farming system,
iii. Points of fish landing and fish processing,
iv. Incidence of poverty and diseases particularly malaria, tuberculosis and HIV- Aids,
v. Incidence of unemployment,
vi. Market centres and major towns,
vii. Roads and tracks,
viii. Human population density and distribution,
ix. Livestock numbers and distribution,

c) Environmental and Ecological overlays:

This should include the following:

i. Protected areas (parks and game reserves),
ii. Areas of high biodiversity,
iii. Wetland areas, with an indication of their biodiversity importance e.g if they are important bird areas or are home to rare animal species,
iv. Archeological sites,
v. Important cultural sites e.g cultural forests in Vihiga district, *Kaya* forests in the Coast,
vi. Areas of very steep slopes that are vulnerable to landslides,
vii. Soil erosion hotspots: steep slopes, easily erodible soils, intensively cultivated areas,
viii. Main rivers, water bodies and the quality of their water,
ix. Main point sources of pollution:
    - Agro-chemical industries,
    - Tanneries,
    - Slaughter houses,

- Factories,
- Market centres,

x. Areas with unique ecological problems e.g. tsetse fly infestation,
xi. Incidences of malaria, T.B and HIV-AIDS and other water borne diseases

A final plan should demonstrate that proposals earmarked have passed these three key tests:

i. Economic viability,
ii. Social acceptability and
iii. Environmental sustainability.

As stated earlier, sustainable land management initiatives will succeed if there is an improvement in the wealth distribution, access to state resources and economic opportunities. A good spatial plan should indicate which areas and administrative units should receive first priority for more detailed planning activities. The major features of the plan should in principle include:

- Areas where present land uses are broadly in line with potential capability or where present land use may continue with land management interventions at farm level,
- Areas of major land degradation, which need major efforts for rehabilitation. This could be further disaggregated into:
  -Areas of recent deforestation on steep slopes in major water towers or water catchment zones;
  -Overgrazed areas;
  -Areas with evidence of long term overuse;
- Areas with potential for irrigated agriculture;
- Land use conflict areas – forests, animal reserves;
- Areas with potential for large scale afforestation;
- Areas of mining and quarrying development;
- Areas unsuitable for agriculture but in locations where the land is highly suitable for new urban development or old urban expansion;
- Areas of wildlife, protected areas, Ramsar sites of rich biodiversity;
- Areas with long term value for tourist development.

4 REVIEW OF THE CURRENT AND PREVIOUS LAND USE PRACTICES IN THE BASIN

4.1 Introduction

Preliminary field visits were made to projects and key stakeholders. Selected stakeholders in Nairobi, Kisumu, Kericho, Kakamega, Mumias and Bungoma were visited and interviewed. Views of the stakeholders, concerning land suitability mapping and spatial planning were obtained and relevant literature collected. In all, 18 organizations were visited (see Appendix 3). All stakeholders felt that land suitability mapping and spatial planning were important and pre-requisites for making decisions on development interventions and to ensure sustainable economic growth and environmental protection.

The basin covers a wide range of ecological zones from forests of the slope of Mt. Elgon, through intensively cultivated areas down to rangelands and irrigated lowlands around the lake. The main agricultural enterprises are mostly of small scale growing of maize, rice, sugarcane, coffee, tea, horticulture, dairy, ranching and forestry. There are a number of major urban settlements and numerous upcoming and unplanned market centres in the basin. Agro-based industries such sugar and tea processing are also found in the basin.

The most important commercial agricultural activities are sugarcane plantations, tea (both small holder and plantations) and at one time rice. In the past about 2,400 ha were under rice cultivation, a coverage which has gradually decline. The indurty is being revived. Uasin Gishu and Trans Nzoia are intensive agricultural areas for maize , wheat and dairy production.

The greatest challenges to development in the Lake Victoria basin are the socio-economic and environmental problems, which are related to the inter-linkage between poverty and environmental degradation. These are further exacerbated by the lack of capacity among the concerned institutions to manage the resources of the basin, both human and natural in a sustainable manner.

About 25 million people in the basin rely on subsistence agriculture and pastoral production for their livelihoods. Poverty levels are high and production low (Owuor, 1998). Subsistence farming in the Lake Victoria catchments has led to enormous degradation of land resources, declining soil fertility due to land sub-divisions, degazettment and subdivision of fragile forests often on very steep gradients highly unsuitable for the settlement An estimated 150,000km^2 of land in the basin is degraded, including up to 60% of agricultural land. About 75% of wet land area has been encroached, with 13% of it irreversibly degraded.

The UNDC (2001) links land degradation to poverty and to address this problem would require the participation of resource users and appropriately providing them with alternative livelihoods (Abila, 2002). The trans-boundary nature of the lake presents further challenges in the attempts to address land related issues.

Major land use changes in the basin are due to deforestation, overgrazing and conversion of wetlands influenced by quest for new land products and change from subsistence to a market economy.

4.2 Subsistence farming in Kano plains

Livestock grazing in the Kano plains is a very common form of land use. This practice does deter any form of improvement of the land under this practice, it is relatively difficult to put in place appropriate forms of conservation structures. Indeed, culturally, people in the Kano plains do not respect boundaries. The situation in Nyando/Kano plains is compounded by the type of soils which are susceptible to degradation. The vertisols have a sodic phase in the sub soil which dissolves, tunnels then collapses. It is very difficult to protect such soils. The lower areas are therefore characterized by large gullies, which promote delivery of large suspended solids into Lake Victoria. Consequently there is heavy soil loss in the basin - up to 26 tonnes of soil are lost per hectare per year from Nyando catchment largely as a result of improper land use.

The Nyando catchment is largely under cultivation (up to 80%). This has resulted in vegetation loss in Kericho and lower Nyando. This scenario is compounded by the

small farm sizes, whose use results in high negative impacts i.e. from numerous paths, and cattle tracks among others. Indeed this situation is grim, given that maximum allowable soil loss under natural process is 12 tonnes per hectare per year (Maina J.K.M, personal comm). This is equivalent to a loss of 1 inch of soil depth and to replace this one inch of soil naturally would take 30 years.

4.3 Ahero Irrigation scheme

The Ahero rice irrigation scheme was developed in 1980's after a feasibility study, in which a soil capability survey for irrigated rice was carried out (Anyango, 2004). This was a joint World Bank and Government of Kenya project run by the National Irrigation Board (NIB). The project objectives were as follows:

i) To control floods by diverting water into the irrigation scheme,
ii) Create wealth for the farmers from rice production,
iii) Contribute to food production and food security.

However the operations became unacceptable to the local community because land preparation, purchase of machinery, and sale of all farm produce, was done by the NIB. Furthermore, the farmers who owned the land were not allowed to get title deeds. Instead the land was held in trust for the local people. Consequently the farmers rebelled against the NIB and the scheme collapsed. There are efforts in place to revive the scheme. However, no environmental audit has been undertaken. A similar effort at irrigated rice production in West Kano Scheme, also collapsed because of socio-political conflicts over the land resources and poor maintenance of irrigation infrastructure.

These schemes were created after reclaiming of wetlands. Wetlands roughly occupy 40.8% of the lake basin and as one of the most productive systems in the region, are very important in economic development and biodiversity conservation. Their important hydrological, ecological and socio-economic functions have not been fully appreciated. The draining of wetlands in the basin for food production in this poverty ridden and fragile ecosystem has tended to conflict with the conservation and the sustainable utilization of these wetlands.

4.4 Yala Swamp Scheme

The Government of Kenya also carried out large scale reclamation of wetlands in the Lake Basin for agriculture with the objective of securing food security, poverty reduction and job creation. The implementing agency, Lake Basin Development Authority (LBDA), reclaimed about 2,300 hectares of Yala swamp out of the 17,500 hectares that make up the Yala swamp ecosystem. This was done to grow maize, coffee, oranges, millet, avocadoes, bananas, rice (Mavuti ,1979). However the high production costs, poor crop prices and mismanagement of the scheme forced LBDA to abandon large tracks of reclaimed land in the 1990's. In March 2003, a rice and cotton scheme was started on the abandoned land by a US based company, after an Environment Impact Assessment Report that was accepted. Currently, a second Environment Impact Report is under preparation after proposals for more expansion were made. The scheme expects to employ 500 people and produce 450,000 metric tonnes of rice and 1 million Kgs of fish annually (Chumo, 2003).

Despite the above efforts, the importance of the vital function of wetlands as buffering ecotones, that reduce or purify the water that comes from the catchment before entering Lake Victoria, is now well established. The wetlands perform this function of buffering in the following ways:

i) Slowing down the speed of the run-off water running through them,
ii) Remove or reduce total suspended solids,
iii) Remove nutrients.

The wetlands functions occur naturally as a result of interactions between ecosystem structure and processes (Ramsar Convention Bureau, 2000). These functions include floodwater control, nutrient flow, sediment and contaminant retention, food web support, shoreline stabilization and erosion controls, storm protection and stabilization of micro-climates, particularly rainfall and ambient temperature. These functional values of wetlands are recognized but few studies have attempted to attach economic values to them. The decreased total dissolved solids, (TDS) and electric conductivity (EC) in Lake Victoria water is often attributed to the buffering capacity of the wetlands. The bigger the wetlands the greater their ability to sieve the suspended solids, absorb chemicals and nutrients from river water.

4.5 Sugar Cane Farming

Sugarcane is an example of shift from subsistence to a market economy. Although sugarcane growing is an important cash crop in the Lake basin, most of the soils are rated moderately (S2) to not suitable(N) in land suitability classification for this crop, the limiting factors mainly being low nutrient status of soils and poor drainage (Mwendwa, 1987). The implication of this is that there has to be intensive application of fertilizer and other agro chemicals to increase production. For example Chemilil Sugar Company uses 5 bags of NPK (250 kg/ha for the types 23:23:0,20:20:20 or 17:17:17). The type used needs evaluation of changes in soil. They also require 60 kg of nitrogen per ha recommended for top dressing between 7-10 months and this can be obtained from urea (150 kg/ha) or CAN (250 kg/ha). On average, 120 kg of nitrogen per hectare is required during the plant's lifecycle. For second planting, 250 kg / ha of CAN is applied one month after cutting and 150 kg/ha of urea applied when the crop is 7-10 months old. Some fertilizer is lost through runoffs and nitrogen is transported to the rivers especially during the wet season (Chemilil Sugar Environmental Audit report, 2004). The largest consumers of the fertilizers are the out growers who use up to 85% of the total fertilizer used under uncontrolled application regimes.

Herbicides for weed control are also heavily used. Efficacy trials are carried out before adoption. The popular herbicides are Glyphosate, sencor 480sc and velpa. In most cases the herbicides are applied as a combination for improved efficacy without due regard to environmental consequences. The company has a nucleus estate of 2,267 ha under cane, while 200 ha normally are left fallow, with another 160 ha under schools and lagoons and the factory on another 1 ha. The out growers account for 85% of cane crushed in the factory, about 823,000 tonnes produced in 14,000 ha of land.

Most areas have poor drainage and often suffer water logging which inhibits quality sugarcane growth. Soil erosion has been observed in areas with 15 degrees slope due to quick runoff. In the pilot irrigation project started in 1994, with 100 ha of sugarcane under irrigation using treated effluent water, a certain degree of salinization has been observed. The irrigation section uses water of questionable quality which could ruin soils; and contaminate ground water systems. This is an undertaking that is not based on any land suitability assessment.

Despite the land suitability assessment rating the area as moderate to unsuitable for sugarcane growing due to unsuitable soils (poor drainage) and inadequate soil moisture to sustain crop growth; economic considerations overran environmental issues. Therefore despite the heavy inputs the cane takes almost 2 years to mature and yields are low, an average of 100,000 tonnes per year from nucleus estate. In Sudan, irrigated sugarcane yields thrice as much and matures in less than 1 year.

4.6 Tea farming

In the Kericho and Nandi highlands, large areas were cleared for tea plantations. This was done without any land evaluation studies. The only controlled studies carried out in East Africa confirmed that there was an overall reduction in water use following clearing of forest for a tea plantation in Kericho with a marked increase in stream flow (Blackie, 1979).

However once the tea bushes were established the water yield returned to values similar to a forest mainly because tea bushes have similar evapo-transpiration(ET) values to trees and the ground still had good infiltration capacity. The replacement of trees with crops leads to a large increase in stream flow because of the loss of ET and high ground water levels, due to doubling of base flows. Indeed the vegetation in 'shambas" has only about 60% of the ET of the forest and so this increases the stream flow.

In addition the obvious disappearance of forests rich in biodiversity and major forest reduction have triggered significant changes in downstream economic, social and biological systems reliant on regular stream flows. Such effects include:

- Less regulated flow, resulting in floods in Kano and Budalangi plains.
- Less effective storage reservoirs (loss of water retention capacity by water towers).
- Decrease in hydropower and irrigation potential; indeed at one time it was doubtful if Sondu-Miriu hydropower scheme would be viable with the massive deforestation taking place in Mau forest.
- Increased sedimentation load, often ending up in Lake Victoria

- Adverse effects on fisheries due to increased siltation (Wass , 1995).

Results from ongoing studies in and around Kakamega forest in the nearby Yala Basin show the effects of the conversion of forest to cropland. Average litter in cultivated land is only 11% that of litter in forest (mean 8.6 tonnes/ha in forest as opposed to 0.9 tonnes/ha in cultivated land) (Awiti et al., 2002). The absence of tree cover and reduced litter makes the soil surface more compact and less permeable, resulting in low infiltration rates both at surface and sub-surface levels, of cultivated lands. The overall result of cultivation is the disturbance of nutrient cycles and accelerated loss of soil organic carbon through volatilization, leaching and/or erosion.

4.7 Urban settlements

Urbanization is taking place rapidly in the basin due to increasing rural to urban migration. Urban land use is therefore increasing and in many cases taking up good agricultural land. It is thought that 50% of the population in the basin will be living in urban settlements by 2050 (LVEMP, 2005). There are major urban centres and municipalities such as Kisumu, Kakamega, Kisii, Bungoma, Busia, Eldoret, Kericho, Homa Bay, Migori and Kitale. There are also many market centres coming up, that are becoming growth centres for small scale businesses and the *Jua Kali* industries.

The situation in the urban centres is not good. Because of rapid population influxes, services such as housing, water, sanitation, heath and education are grossly inadequate and majority of the population live in slums.

4.8 Infrastructure development

Infrastructure development is an important form of land use. Road networks are a major land use type and take a significant mount of land. Major roads connecting Kenya to Uganda and Sudan pass through the basin. There are all weather road networks that connect major urban centres. Most roads in the rural areas are earth roads that become impassable during the rainy seasons affecting marketing of farm products and business in general.

Water resources infrastructure is another important land use type. Water resources broadly include surface water (dams, lakes, rivers etc), ground water and all water based resources infrastructure (pipelines, water reservoirs, treatment plants etc) in the basin. Education, Health and other public utilities and services are also major land use. There are numerous primary, secondary and tertiary colleges, scattered both in the rural and urban areas. They mostly occupy public land set aside for their use. Recently more and more privately owned education institutions are being set up. Health facilities are concentrated in urban areas with few heath facilities in the rural areas.

5 EFFECTS OF THE CURRENT LAND USE ON THE ENVIRONMENT

5.1 Introduction

This chapter gives details of the effect of the current land use practices on the environment in terms of degradation of soils, vegetation and water quality and quantity. It then demonstrates how these effects can be mitigated if land use planning based on land suitability mapping is implemented in the basin.

5.2 Effects on sediment loads in rivers

Land degradation in the basin catchment areas is so intense that the rivers draining into lake Victoria carry and deposit a large quantity of silt and organic matter in the flood plain and deltaic wetlands. A series of studies monitored sediment load in 4 main rivers (Nyando,Yala, Sondu and Nzoia), with the aim of tracing the source of the sediments and soil carried in these rivers. Turbidity measurements expressed as normalized turbidity units (NTU) were calculated from the dispersion of light beam passed through a column of water (Swallow et al., 2002). Results for the period between January and November 2001 indicated Nyando carried the highest sediment load (527 NTU), Nzoia (294 NTU), Yala (276 NTU) and Sondu (116 NTU); while the overall turbidity values in Winam Gulf ranged between 26 and 36 NTU, which means Nyando sediment was 20 times higher than that of the Lake Victoria.

Gor and Okungu (2005), indicate that the Lake Victoria catchment (Kenya portion) is 42,480km^2, equivalent to 22% for the entire lake catchment. The main land use activities as discussed in the previous chapter include agriculture, settlement, agro-industrial development and road network. The objective of their study was to:

a. Determine Total Suspended Solids (TSS) loads generated from the catchment into Lake Victoria.
b. Identify the hotspots, (most degraded wetlands).

The results indicated the total annual suspended sediment load from the Kenyan catchment was 1,652,805 tonnes with Nzoia accounting for the highest annual load,

followed by Gucha/Migori, while Awach Tende and Sio transported the least load (see Figure 4). The load was influenced by different factors mainly:

a. Size of catchment,
b. Topography
c. Land use activities, farming systems, soil type and industrial development
d. River discharge,
e. Human population settlement and density.

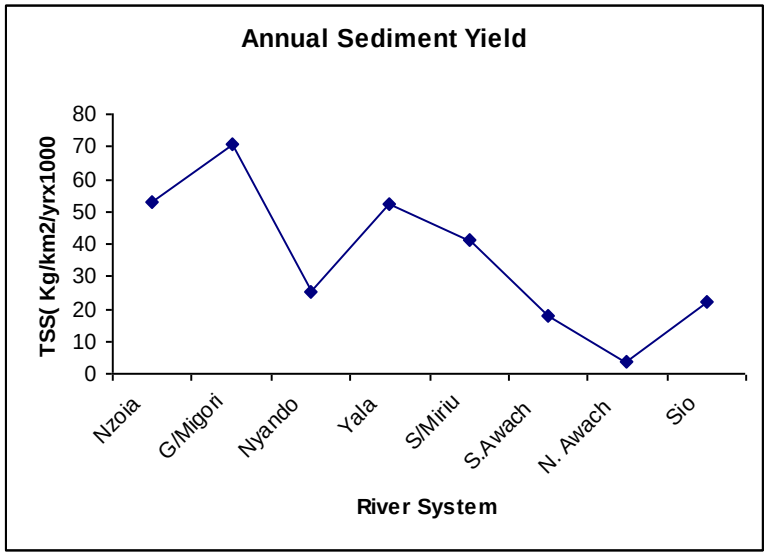
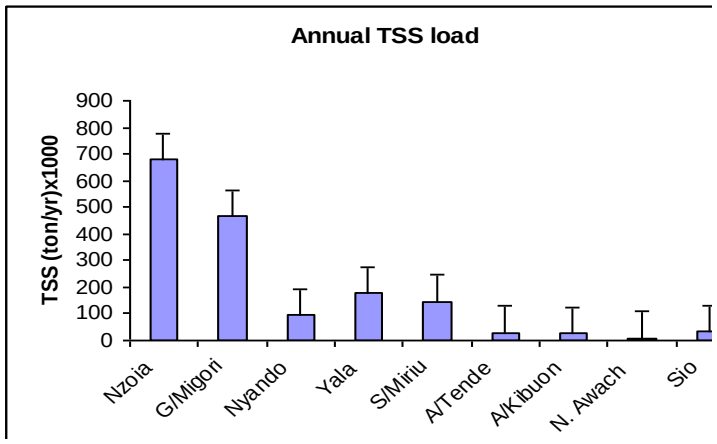


Figure 4. Annual sediment Yield (Source: Gor and Okungu, 2005)

Nzoia has the largest catchment 12,834 km^2 and highest mean annual discharge 57,498.12m^3/s. The catchment has several agro-based industries such as Pan-paper Mills, Mumias and Nzoia sugar factories. The catchment is also under intensive agriculture. In terms of sediment yield, Gucha/Migori gave the highest yield followed by Nzoia, while N. Awach gave the least (See Figure 5). Gucha/ Migori with the leading sediment yield has the following characteristics:

Figure 5. Annual Total Suspended Load (Source Gor and Okungu, 2005)



i) Its upper catchment is small and has steep slopes that are under intensive agriculture,

ii) The area has a very high population density.

These two factors account for the high sediment yield.

Handa et al., (2002) used a hydrolab (series 4) to measure turbidity and other water quality values at different portions between Mukorani and the mouth of river Nyando. They also measured turbidity in Nyakach bay. The results obtained in September 2002, indicated that the high turbidity of Nyando originated at Chemilil a point source suggesting pollution from sugar factory and the agro chemical fertilizers from the sugar belt contributed significantly to river pollution. The results also confirmed that Nyando river water was of very low quality. The high sediment load reflects the high intensity erosion from the cultivated hill slopes and the removal of vital vegetation from the river banks in the catchment.

The small holder subsistence farming in the catchment has large impacts on soil fertility that is translated in very poor crop performance. Indeed the soils in the source areas of the basin are universally depleted of major soil nutrients (N,P,K) and

exchangeable cations rendering them largely unsuitable for conventional agricultural land use.

5.3 Effect on vegetation and river discharge

Okungu (2002), reported changes in river from past to present in three rivers: Sio, Nzoia and Yala. Table 6 shows the trends in discharge for the three rivers.

Table 6. Trends in River discharge

River	Mean River discharge m^3s^{-1}	
	1950-1960	**1990-2001**
Sio	10.5	11.7
Nzoia	108.8	142.2
Yala	20.7	28.6

The increases in mean river discharges indicate the steady removal of trees (c3 photosynthetic pathway) and substituting it with vegetation dominated by grasses (c4 photosynthetic pathway). The evidence for this change is illustrated Table 7 which shows the changes in cover of the Mau complex forests from 2000 to 2003 (Akotsi and Gachanja, 2003). About of 1766 Ha of the forest was removed from 2000 to 2003.

The grasses and cereal crops are strongly associated with elevated soil erosion risk in the environment. For most replacement vegetation , the decrease in evapo-transpiration is the dominant effect particularly when annual crops e.g maize replace forests. These actions increase runoff. A study conducted in a paired-catchment showed that the net effect is for the mean runoff to increase after deforestation, (Bruijuzeel and Proctor, 1995), although the amount depends on factors such as the annual rainfall, soil characteristics and type of replacement vegetation.

Table 7. Areas of significant change in the Mau Complex forests -2000-2003 (Source: Akotsi and Gachanja 2003)

Site No.	Forest	Constituency	Nearest forest station	District	Area affected(ha)	Forest type	Change type
1	Maasai Mau	Narok North	Olenguroune	Narok	195.15	Indigenous	Deforestation
2	Maasai Mau	Narok South	Olenguroune	Narok	2291.19	Indigenous	Deforestation
3	SW Mau	Kuresoi	Olenguroune	Nakuru	190.49	Indigenous	Deforestation
4	SW Mau	Kuresoi	Kerisoi	Nakuru	167.38	Plantation	Deforestation
5	SW Mau	Kuresoi	Kerisoi	Nakuru	42.15	Indigenous/ Plantation	Deforestation
6	Eastern mau	Kuresoi/Molo	Baraget	Nakuru	1971.81	Indigenous/ Plantation	Deforestation
7	SW Mau	Kuresoi	Kerisoi	Nakuru	46.34	Indigenous	Deforestation
8	W Mau	Kuresoi	Kerisoi	Nakuru	14.06	Plantation	Deforestation
9	W Mau	Kuresoi	Kerisoi	Nakuru	15.97	Plantation	Deforestation
10	Eastern Mau	Molo	Mariashoni	Nakuru	201.03	Plantation	Deforestation
11	Eastern Mau	Molo	Mariashoni	Nakuru	182.80	Plantation	Deforestation
12	West Molo	Kuresoi	Molo	Nakuru	145.97	Plantation	Deforestation
13	Mt. Londiani	Eldama Ravine/Molo	Molo	Nakuru	331.85	Plantation	Deforestation
14	Kilombe Hill	Eldama Ravine	Molo	Koibatek	64.55	Indigenous	Deforestation
15	Northern Tinderet	Eldoret South	Serengoni	Uasin Gishu	35.15	Plantation	Deforestation
16	Northern Tinderet	Eldoret South	Serengoni	Uasin Gishu	287.08	Plantation	Deforestation
17	Northern Tinderet	Eldoret South	Senghalo	Uasin Gishu	732.35	Plantation	Deforestation
18	Nabkoi	Eldoret East	Nabkoi	Uasin Gishu	120.49	Plantation	Deforestation
19	Metkei	Keiyo South	Nabkoi	Keiyo	48.43	Indigenous	Deforestation
TOTAL					**1765.87**		

5.4 Effect on nutrient flow into Lake Victoria

Reclaiming of wetlands for irrigation is also linked to land degradation. The conversion of 65,00 ha of wetlands to irrigation in the Nyando basin reduced the filtering effects of wetlands thereby contributing to the major sediment in the Winam Gulf and subsequently of the Lake Victoria (Swallow, 2004). High sediment load was

one of the main factors that led to the collapse of the scheme. The sediment load increased the maintenance costs of irrigation schemes (Ong and Orego, 2001).

The degradation taking place in the lake basin is also reflected in the quality of water. Okungu (2002) carried out an evaluation of the effects of different activities in the catchments on water quality. The parameters he used as indicators were as follows:

i) Nutrient total nitrogen(TN)

ii) Nutrient total phosphorus(TP)

These two were used to assess the impacts from agricultural activities, while the third one Total Suspended Solids(TSS) was used to assess the soil erosion and the fourth and last parameter Biochemical oxygen demand(BOD) was used to assess impacts of industrial and municipal effluents. The results from the Nyando catchments are given in Table 8.

Table 8. TN, TP, TSS and BOD loads in Lake Victoria and River Nyando (Source LVEMP 1- Water quality component).

Parameter	Lake Victoria	Nyando	%
Catchment area (km^2)	36,378	3,652	10
Discharge (m^3s^{-1})	356.16	14.7	4.1
TN ($mg1^{-1}$)	11.61	1.12	9.6
TP ($mg1^{-1}$)	1.69	0.38	11.3
TSS ($mg1^{-1}$)	3,229	364	11.3
TN (tyr^{-1})	12,193	520	4.3
TP (tyr^{-1})	2,113	175	8.3
TSS (tyr^{-1})	4,409,430	169,013	3.8
BOD (tyr^{-1})	12,220	909	7.4

The high nutrient levels in the lake means loss of fertilizers from the land, excessive growth of weeds, for example water hyacinth which appeared in the Lake Victoria in the 1980 and became a menace in mid 1990's when it disrupted transport and fishing activities. The peak water hyacinth infestation was, 17, 230 ha in 1998. This has since reduced to the current level of about 400 ha after control methods involving biological, manual and mechanical means.

The high suspended solids in the rivers indicate loss of top soil and hence the need to regularly apply fertilizers which reduce farm profits and further pollutes water quality.

Dissolved oxygen (DO) which is an important indicator of life in the lake was periodically monitored at various strategic points. The lowest Dissolved oxygen was found near the discharge point of Kisumu city sewerage works, with (DO) levels 0-0.5 milligram per litre. The rest of the Winam Gulf was much better with a range of 4-10 milligrams per litre (Njuguna, 2004). The highest levels of dissolved oxygen (8-10 milligrams per litre) were in the west of the Gulf. It is believed that the decomposition of water hyacinth after destruction by the weevils further drains the oxygen levels in the water.

The level of total phosphorus in the Nyando river was four times higher than Sondu river. Since the soils in the catchment of Nyando, Yala and Nzoia are inherently low in phosphorus, it can be postulated that the source of high phosphorus in the rivers is from application of chemical fertilizers and livestock waste in the catchment. Their continued deposit into Winam Gulf could lead to the death of the lake.

5.5 Mitigation measures

From the foregoing, it can be seen that the potential of the basin cannot be sustainably developed unless problems related to environmental degradation, deepening poverty and poor health standards among others are addressed. The interventions and problem solving strategies require an integrated resource development and management. This can only be achieved efficiently through development of a comprehensive land use development plans based on land suitability mapping. In this section the interventions required to mitigate against the effects of current land uses on the environmental will be stated and it will be argued that all the interventions need to be guided by land use planning.

As stated earlier, UNCCD (2001) noted that land degradation is intrinsically linked to poverty and to address this problem the resource users must participate and where appropriate be provided with alternative livelihoods. The trans-boundary nature of the Lake basin presents it with unique challenges. Resources like wetlands must be

sustainably utilized to guarantee the future of lake Victoria .This calls for changes in land tenure, resource access, property rights and the recognition of co-management regimes in national and local policies, legislation and development plans.

Agricultural policy reforms must also contribute to slowing down or halting of rampant conversion of environmentally fragile rangelands or ecologically valuable land to agriculture and other land uses (Ocholla, 2004). This should focus on significant areas of wetland, forests and natural grassland for protection through reforms in land user rights backed by land suitability assessment. Economic incentives should be given to those who forego the use of the ecologically sensitive or ecologically value land from production. If necessary, Environmental Management and Coordination Act should be invoked to protect the wetlands given the Act gives the Director General of National Environmental Management Authority (NEMA) sole responsibility over the wetlands management.

The key areas of intervention that are required to reverse the environmental degradation and create wealth for the basin population are:

i) Integrated soil and water resources management,
ii) Ecosystem management,
iii) Intensification of agriculture with emphasis on use of animal manure and general rural development,
iv) Management of wetland resources.

In order to get out of absolute poverty spiral, the economy would have to grow at a rate of 8% in real terms and given the dominance of agriculture in the region, it's only through significant improvement in the sector that expected growth can be achieved (Ocholla, 2004).

Matching agro-ecological potential and the current agricultural practices, combining farmers' preferences, opportunities and broad agro-ecological potentials will assist in attaining expected agricultural development as set out in the policy framework for agricultural development in the Strategy for Economic Recovery for Wealth and Employment Creation and in the Strategy for Revitalization of Agriculture (SRA).

If the key areas of interventions to mitigate the effects of current land use on the environment are to succeed they require a comprehensive land use planning based on land suitability mapping. Land use planning itself, as elaborated in chapter 3, requires current data and information on environmental, ecological, physical characteristics of land and socio-economic parameters. This will aid in sound decision-making on the comparative advantages of the different land resources in supporting sustainable livelihood systems of people in the basin.

6 PREVIOUS INITIATIVES OF LAND SUITABILITY MAPPING AND LAND USE PLANNING IN THE BASIN

6.1 Lake Basin Development Authority Master Plan

Although a number of land suitability evaluations and spatial planning have been carried out on small area for specific projects, few studies have been done at the regional level. LBDA with the support of Japan International Cooperation (JICA) produced an integrated regional development master plan for the Lake Basin area in 1987. Volume 6 of this master plan contains results of a study on the land use sector. The study was based mainly on existing reports and maps with additional information obtained from interviews with various government officials and field surveys to few selected areas for on-site examination of soil, vegetation and land use.

In producing the integrated regional development master plan, land evaluation was carried out to produce alternative agricultural land development schemes. First, the area that agriculture can be expanded into at that time covered by grassland or light bush was determined by using a few criteria. The criteria were: no agricultural development is considered in the land under forest or registered as national park or reserve; Steep slopes and existing land already intensively used and land occupied by infrastructure are removed from land that agriculture could be expanded into. The expansible agricultural area was calculated as 1,311,000 ha. This area was further categorized into three potential yield classes: very good, good and fair for different crops according to agro-climatic zones.

Based on the land evaluation, a general land development plan for agriculture was prepared. Of the total area, 345,000 ha is for food crops, 120,000 ha for cash crops and 100,000 ha for fodder crops. Table 9 summarizes the potential agricultural expansion area by district and crop. However this plan is only limited to crop production, leaving out other uses such as ranching, settlements, industrial, recreational and tourism and mining among others. Moreover, environmental considerations such as use of wetlands and pollution of rivers and hence Lake Victoria by agricultural processes were not considered.

Table 9 Agricultural Land Development Plan

DISTRICT	MAIZE	SORGUM	BEANS	WHEAT	RICE	ARABICA COFFEE	ROBUSTA COFFEE	TEA	SURGAR CANE	COTTON	FRUIT & VEG.	FOODER CROP	TOTAL
NYANZA													
Kisii	3	0	1	0	0	3	0	6	0	0	2	0	15
Kisumu	15	4	2	0	15	0	1	0	0	2	0	11	50
Siaya	19	5	6	0	3	0	7	0	0	1	0	7	48
S. Nyanza	47	7	8	0	4	0	5	0	5	3	0	12	91

(Unit: 1,000 ha)

TOTAL	84	16	17	0	22	3	13	6	5	6	2	30	204
WESTERN													
Bungoma	12	0	3	0	2	4	3	0	10	0	0	0	34
Busia	10	4	6	0	2	0	8	0	0	1	0	0	31
Kakamega	14	3	8	0	1	2	8	7	10	0	3	0	56
TOTAL	36	7	17	0	5	6	19	7	20	1	3	0	121
RIFT VALLEY													
Kericho	20	1	4	5	0	4	0	7	0	0	5	0	46
Nandi	15	0	2	10	0	3	0	4	0	0	5	7	46
Narok	10	1	1	0	0	0	0	0	0	0	0	32	44
T.Nzoia	10	0	2	10	0	1	0	0	0	0	0	10	33
U. Gishu	16	0	0	19	0	0	0	0	0	0	0	13	48
Others	15	0	0	0	0	0	0	0	0	0	0	8	23
TOTAL	86	2	9	44	0	8	0	11	0	0	10	70	240
TOTAL	**206**	**25**	**43**	**44**	**27**	**17**	**32**	**24**	**25**	**7**	**15**	**100**	**565**

6.2 Ministry of Lands –Kisumu and Nyando Districts Land use Plan

Ministry of Lands is currently preparing a regional physical development plan for Kisumu and Nyando districts. The main objectives of the plan are:

- To identify available resources and their levels of utilization.
- Suggest a framework for optimum utilization of the resources.
- Take inventory and evaluate the existing infrastructure and formulate an efficient and functional framework.
- Examine the existing institutional arrangements and suggest appropriate measures.
- Identify major disaster concerns and propose appropriate mitigating measures.

The plan will be based on secondary data such as existing information and discussion with relevant authorities. There will also be limited field work. Because of rapidly changing land use activities, the data from Ministry of Agriculture and other government ministries is usually inaccurate and/or out of date. The plan is expected to be completed by the end of 2006 and is expected to cost about ksh. 12 million.

6.3 Ministry of Agriculture Farm Management Handbook

The Ministry of Agriculture produced a Farm Management Handbook containing natural conditions and farm management information (Jaetzold and Schmidt, 1982).The handbook delineates the Agro-Climatic Zones in Kenya, in which the natural farming potential and suitable crops to be grown in different areas are given. The Districts in the basin have been covered in the handbook. The handbook is voluminous and highly technical and was compiled primarily to assist the agriculture extension officers to advice farmers. Unfortunately the handbook has not been used widely as expected. The main reason was that even the extension officers, who often have little scientific training, could not properly interpret the information from the handbook and advice farmers appropriately. Other reasons were the changing conditions since the production of the

handbook in terms of farm inputs such fertilizers and market environment of different crops. However, the information available in the handbook is a sound basis for future initiatives in land suitability mapping and land use planning

6.4 The Department of Resource Surveys and Remote Sensing Land use Reports

The Department of Resource Surveys and Remote Sensing (DRSRS) of the Ministry of Environment and Natural Resources in 1980s produced land use reports for many of the districts in the Lake Basin. The reports were based on interpretations of aerial photographs of the then existing land use types and statistics of size and location of different land use types prepared. There was no attempt to do land suitability evaluation or spatial planning. However such data would be very important for future land use planning.

More recently, land use map for the catchment areas of Rivers Oroba and Kibos was produced by Kenya Soil Survey (Kenya Soils Survey, 2005). The map is based on aerial photo interpretation and depicts current land use in the catchements. Similarly as, with the case of DRSRS work, no land suitability or spatial planning was undertaken.

7 REVIEW OF THE POTENTIAL USEFULNESS OF LAND SUITABILITY MAPPING AND LAND USE PLANNING IN THE MANAGEMENT OF LAKE VICTORIA BASIN

7.1 Introduction

In this chapter, examples of applications of the tools of overlay mapping in land suitability mapping and land use planning will be given to clearly illustrate their potential usefulness in the management of the basin environment. The identification and management of problems of soil erosion, deforestation and degradation of wetlands using the procedures of land suitability mapping, will be given to demonstrate further the potential of land suitability mapping and land use planning.

The rationale and justification of the use of land suitability mapping, the importance of land suitability mapping in the production of land use maps and the importance of land use planning in the correct allocation of land resources to competing uses are discussed in this chapter.

7.2 The potential and importance of land suitability mapping

7.2.1 Rationale:

If a farmer is already growing maize or grazing livestock, he/she does not need formal procedures for land suitability assessment; the value of the land for the forms of production can better be assessed from records of his own costs, yields and returns. Land evaluation becomes important where change is anticipated. This may be a change in kind of land use such as bringing into production land formerly under another use or introduction of mechanized farming in areas of manual or animal labour.

Prediction is needed of the suitability of the land for different forms of production, the inputs and management practices needed, the production or other benefits and the consequences of such change on the environment. These

include adverse consequences such as the warning that certain land should not be cultivated owing to severe hazard of soil erosion.

7.2.2 Justification

Justification for land evaluation in the development of Lake Victoria Basin is as follows;

i) *Resource inventory:* Land evaluation at a reconnaissance scale enables developers to see for example, where the best areas for large scale food crop production are to be found. Identification of alternative development projects can then follow.

ii) *Project feasibility:* This is normally required before a decision to invest is taken. Land evaluation provides one of the sources of data. The evaluation will normally refer to land utilization types described in the same degree of detail. This is the basis for selection of areas of arable (nucleus estate in case of sugarcane), settlement and for more detailed planning.

The economic land assessment feeds into the economic appraisal of the project as a whole. The assessment may be of either current or potential suitability according to whether a major improvement is involved. Both quantitative physical and economic evaluations are required. The map scale for evaluation varies from semi-detailed to detailed, the detailed being more appropriate in cases of large capital investment; or in cases of irrigation. In the case of layout of individual farms, village land, factory site and blocks of settlements, a detailed land suitability classification at a detailed scale is required.

In order to forego competition between alternative uses for same land area, land suitability mapping guides decision making such as for example, conversion of agricultural land to urban and industrial uses.

Land use changes from subsistence crops to e.g. small holder tea growing, calls for comparison of suitability between present and proposed uses, economic evaluation and environmental impact and social consequences of changes.

Land suitability mapping can also be done purely for land management improvement. Land suitability assists the land use planners to work towards the best use of the land; this is achieved by examining alternative uses. Decision makers can then choose between those alternatives to optimize on the benefits to both individual owners and community at large. In the short term, there may be times when they have to choose a use that cannot be sustained, but they must be aware of the risks involved and make provisions for sustainable use in the long term.

An example is given here below to illustrate the potential of land suitability mapping on soil erosion risk mapping that is very important in the identification and management of soil erosion problems.

7.3 Soil Erosion Mapping in Lake Victoria Basin, Kenyan side

Proper management of soil, water and vegetation resources are very important to arrest erosion and rapid siltation in rivers, lakes and estuaries. Prioritization of catchments on the basis of sub-catchments that contribute maximum sediment yield should obviously determine the priority areas to design appropriate conservation management strategy so that maximum benefit can be derived. Geographical Information Systems (GIS) provides convenient solution for this problem. Voluminous data gathered from the field and with the help of remote sensing techniques are better handled and utilized with the help of GIS. In this example, GIS functionalities were extensively utilized in the preparation of soil erosion risk map for lake Victoria Basin that could guide the conservation management strategy The data used are shown in Table 10.

Table 10 Data Used

1. Landsat ETM images	To produce up-to-date land use / land cover map of the basin
2. Soil map	To identify soils that could be easily eroded
3. Drainage map	To evaluate stream order and use in flow accumulation calculation
4. Rainfall measurement data	To identify higher rainfall zones within the basin
5. Slope	To use in the soil loss equation
6. Aspect map	To be used in flow accumulation calculation
7. Other auxiliary layers have been also used (roads, towns,place names etc)	1:50,000 scale maps

7.3.1 Land use/cover Data

Existing land use/ cover data was used. Figure 6 shows the land cover map. Some of the classes are aggregated to simplify the land use/cover map of the basin. The weight of each land use/cover type for soil erosion was computed from grid format of the data.

7.3.2 Soil data

An existing soil map of the basin was used to obtain soil information. Figure 7 shows the soil map.

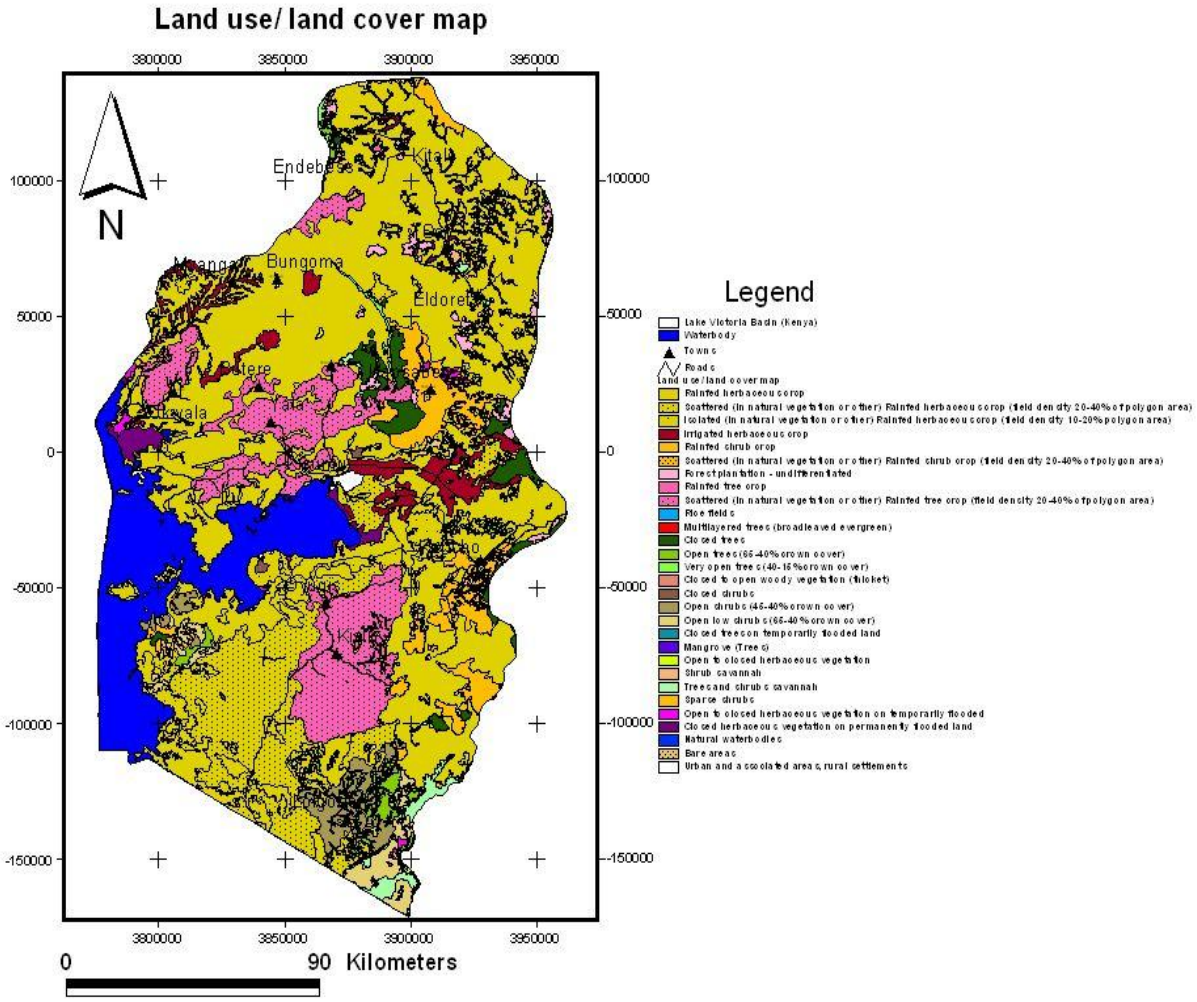


Figure 6. Land use land cover map of lake Victoria basin derived from Landsat ETM image interpretation

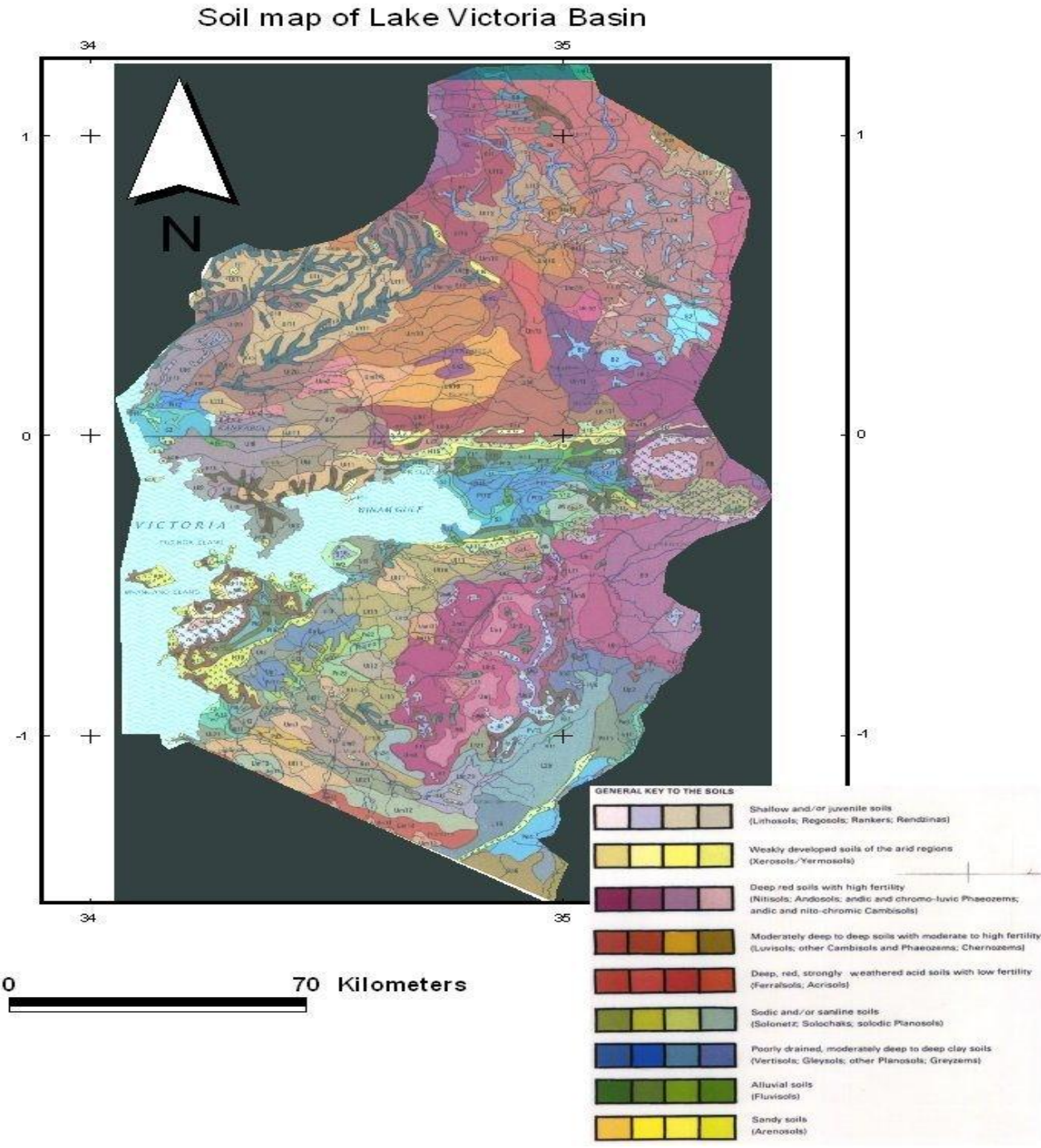


Figure 7. Soil map of Lake Victoria Basin

7.3.3 Digital Elevation Model, Slope and Aspect maps

The main digital elevation model (DEM) was obtained from satellite data that have got 90 meter pixel resolution. The cell size was re-sampled to 100m so that it can fit to the cell size of the other grid layers. Figure 8 shows the DEM of the basin. Slope (see Fig. 9), flow accumulation and aspect maps were derived from the DEM.

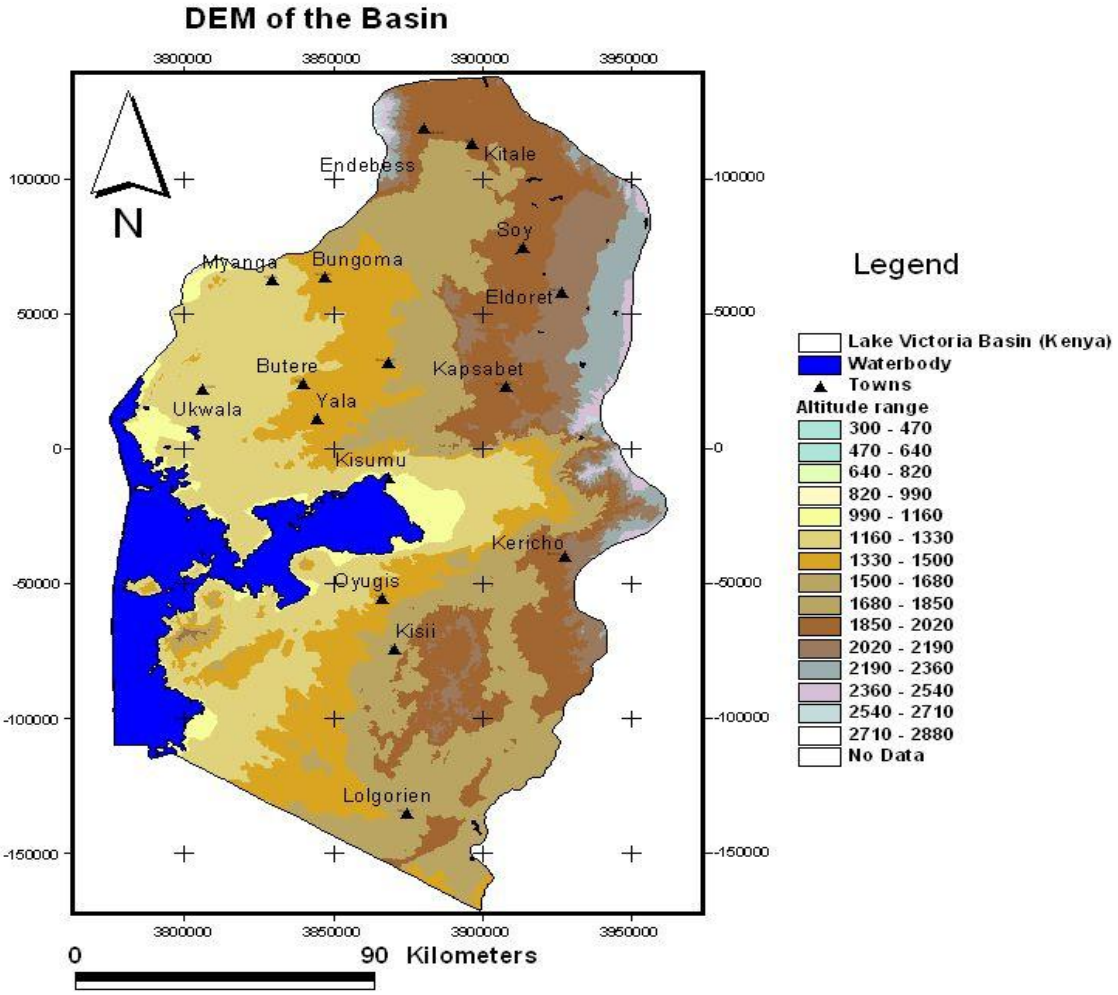


Figure 8. DEM obtained from Satellite (SRTM) at resolution of 90m.

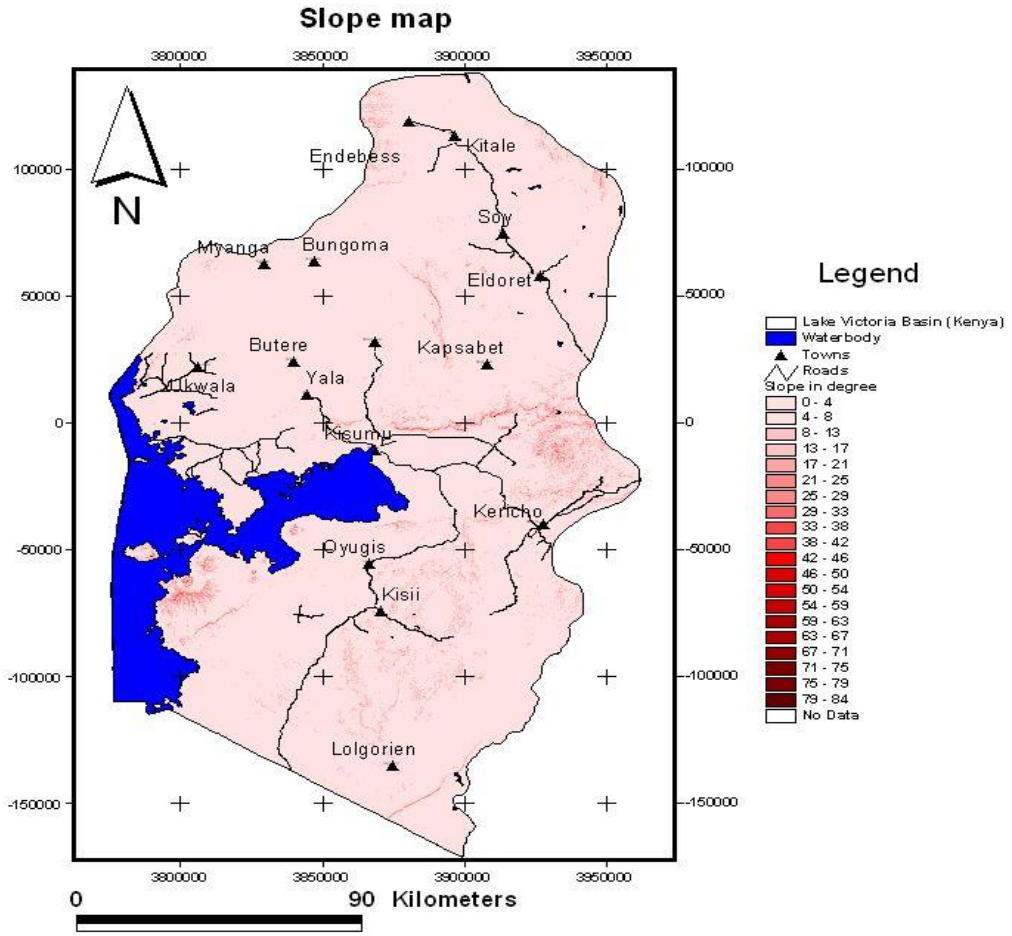


Figure 9. Slope map of the basin derived from DEM. The slope unit is degrees.

7.3.4 Rainfall map

Rainfall map (Fig.10) was derived from monthly reading of rainfall data at stations within the basin. Interpolation techniques were used to come up with 100m cell size rainfall map. The layer was used in computing the Revised Universal Soil Loss Equation factors (RUSLE).

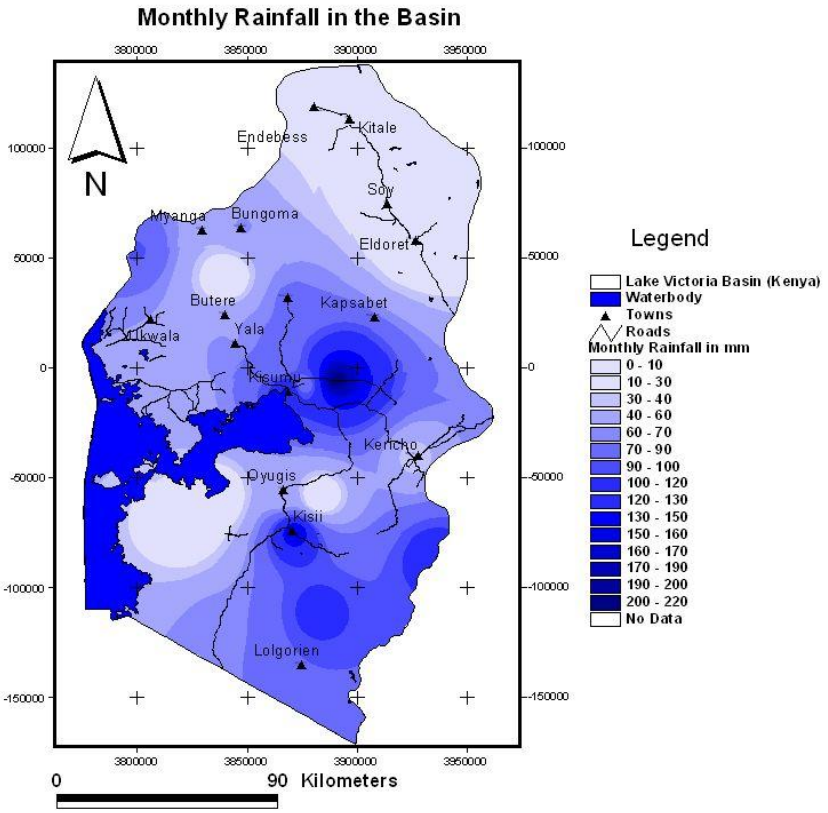


Figure 10. Monthly rainfall map of the basin

7.4 Determination of factors for RUSLE

A number of parametric models have been developed to predict soil erosion at a basin level, yet Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978) is the most widely used empirical equation for estimating annual soil loss from agricultural basins. In this example, RUSLE has been used to delineate high soil erosion risk areas in the Lake Victoria basin.

Improved empirical equations were used for the computation of rainfall erosivity (R), topographic (LS) factor, crop management (C) factor, soil (K) factor and conservation practice(P) factor.

7.4.1 Preparation of Erosion Intensity Map

All the factor maps of R, K, LS, C and P were overlaid and integrated to generate a composite map of erosion intensity and high erosion risk areas. Figure 11 illustrates schematically the GIS layer combination. Figure 12 shows map of high erosion risk areas. From the result of this example, it is clear that land suitability mapping methods are powerful tools for the qualitative as well as quantitative assessment of the problems of the catchments and provide information to guide the conservation and management of catchments.

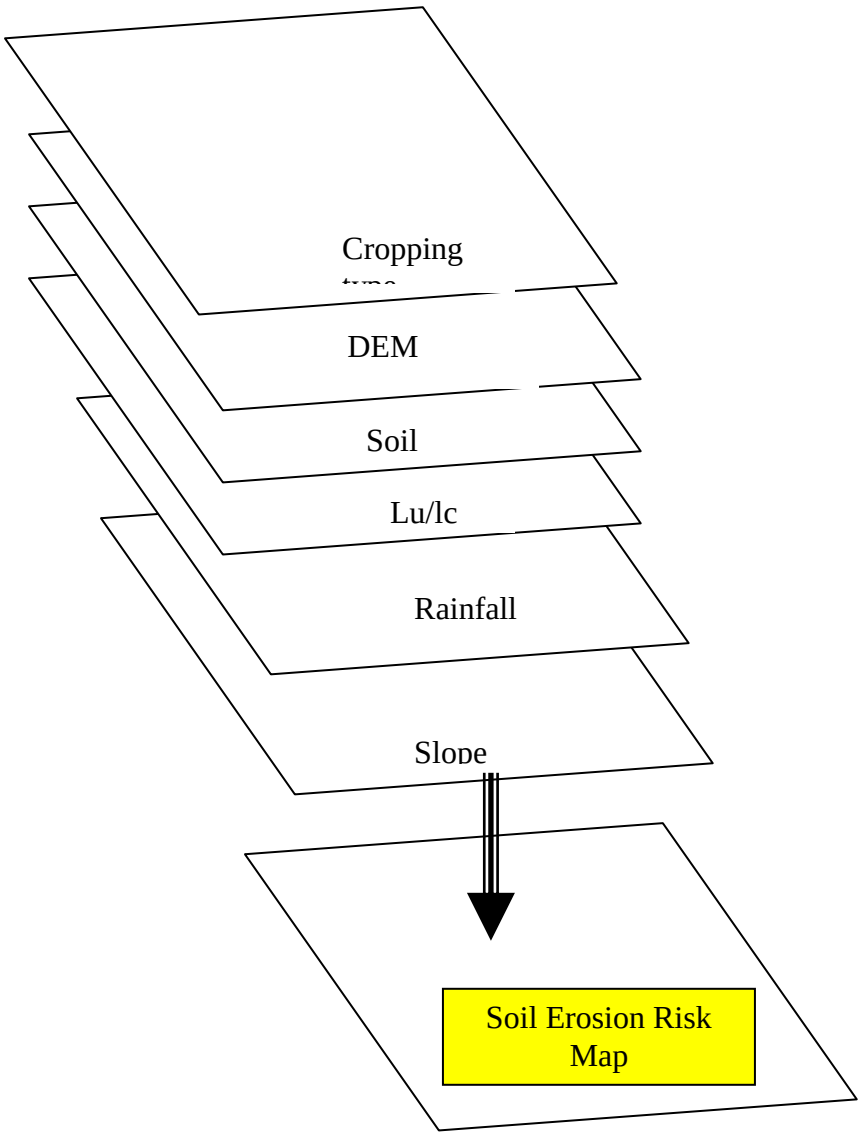


Figure 11. Schematic representation of GIS layer combinations

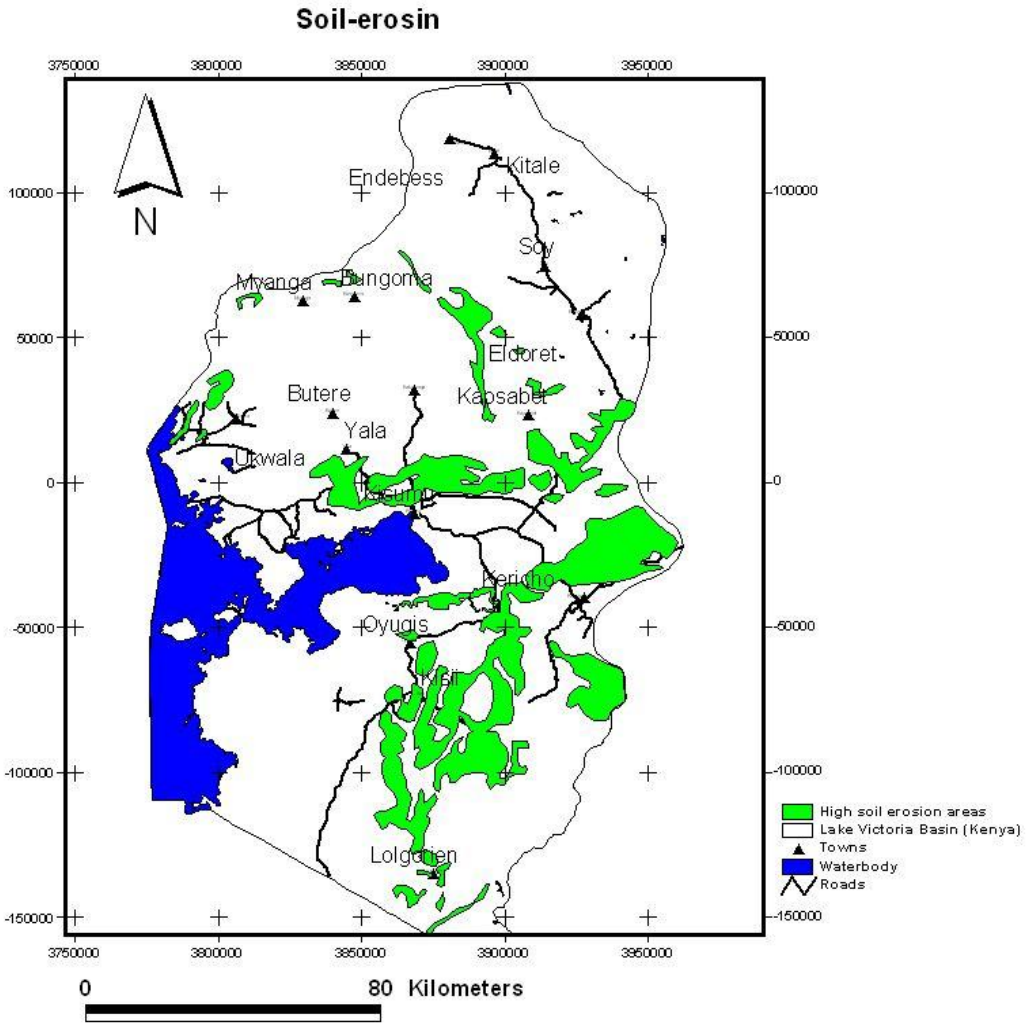


Figure 12. High soil erosion risk areas in lake Victoria basin, Kenya

7.5 Wetland mapping

The importance of wetlands in reducing sediment and nutrient inflows into Lake Victoria has already been shown. It is important to map wetlands in the basin and identify those wetlands that are under threat and encroachment from cultivation and other human activities. An example based on a study by the Regional Centre for Mapping of Resources for Development for Lake Victoria Environmental Management Project will used (RCMRD, 2005). The broad objectives of the project were to:

i) Carryout basin-wide mapping of wetlands in the Lake Victoria Basin in Kenya
ii) Carryout more detailed mapping of two wetland sites in Kericho (Dionosoyiet wetland) and Eldoret (Marula wetland).

This mapping was to be used for the conservation and management of wetlands in the lake basin. Figure 13 shows the location and size of wetlands in the entire basin. This map give a quick inventory of the wetlands. Figure 14 shows in more details one of the wetlands under encroachment called Marula wetland located near Eldoret. The map can be used to specifically identify those areas that need conservation interventions. Figure 15 shows wetlands in urban areas in Kericho town that need to be managed well. More importantly, these maps provide a basis for monitoring future trends in the specific wetlands.

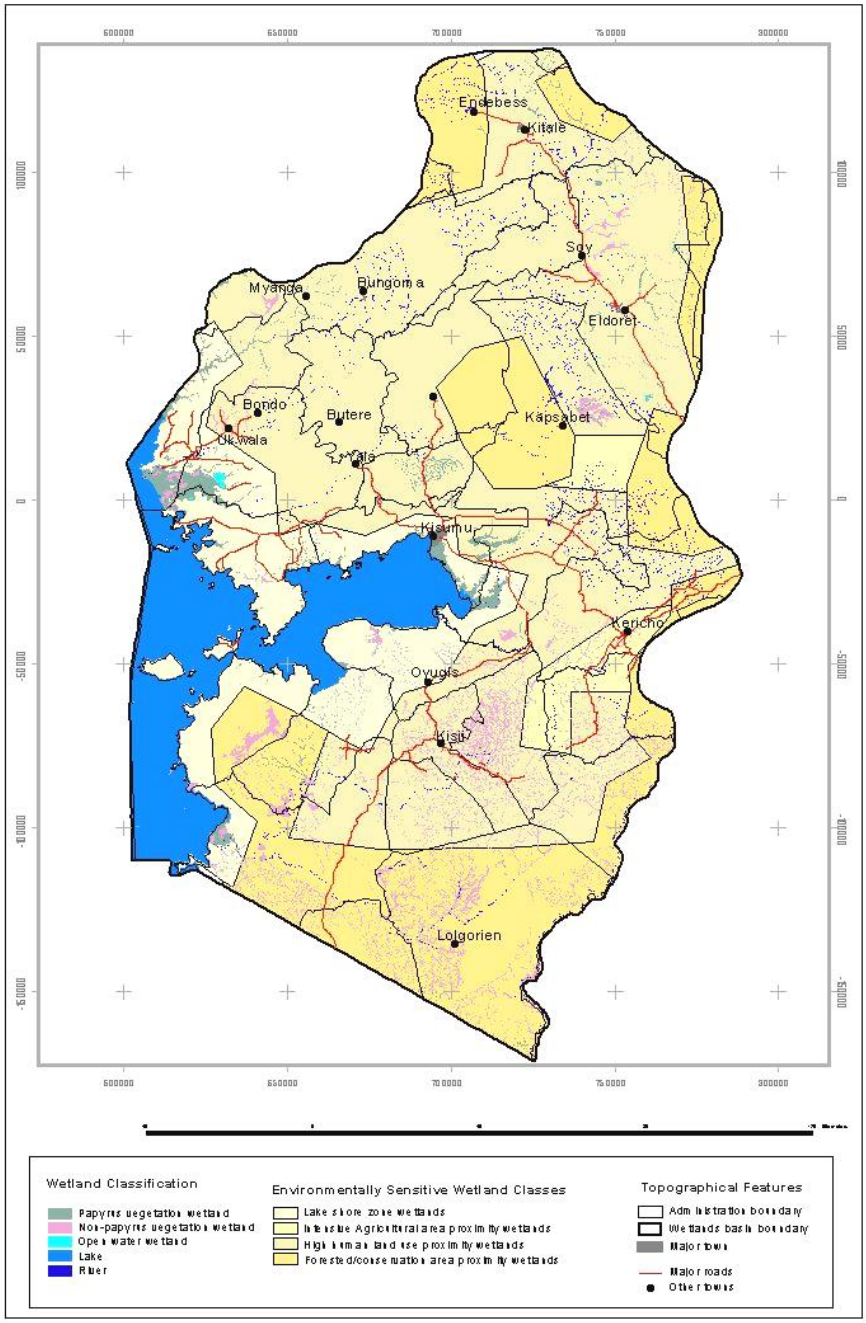


Figure 13. Wetland map of lake Victoria basin, Kenya

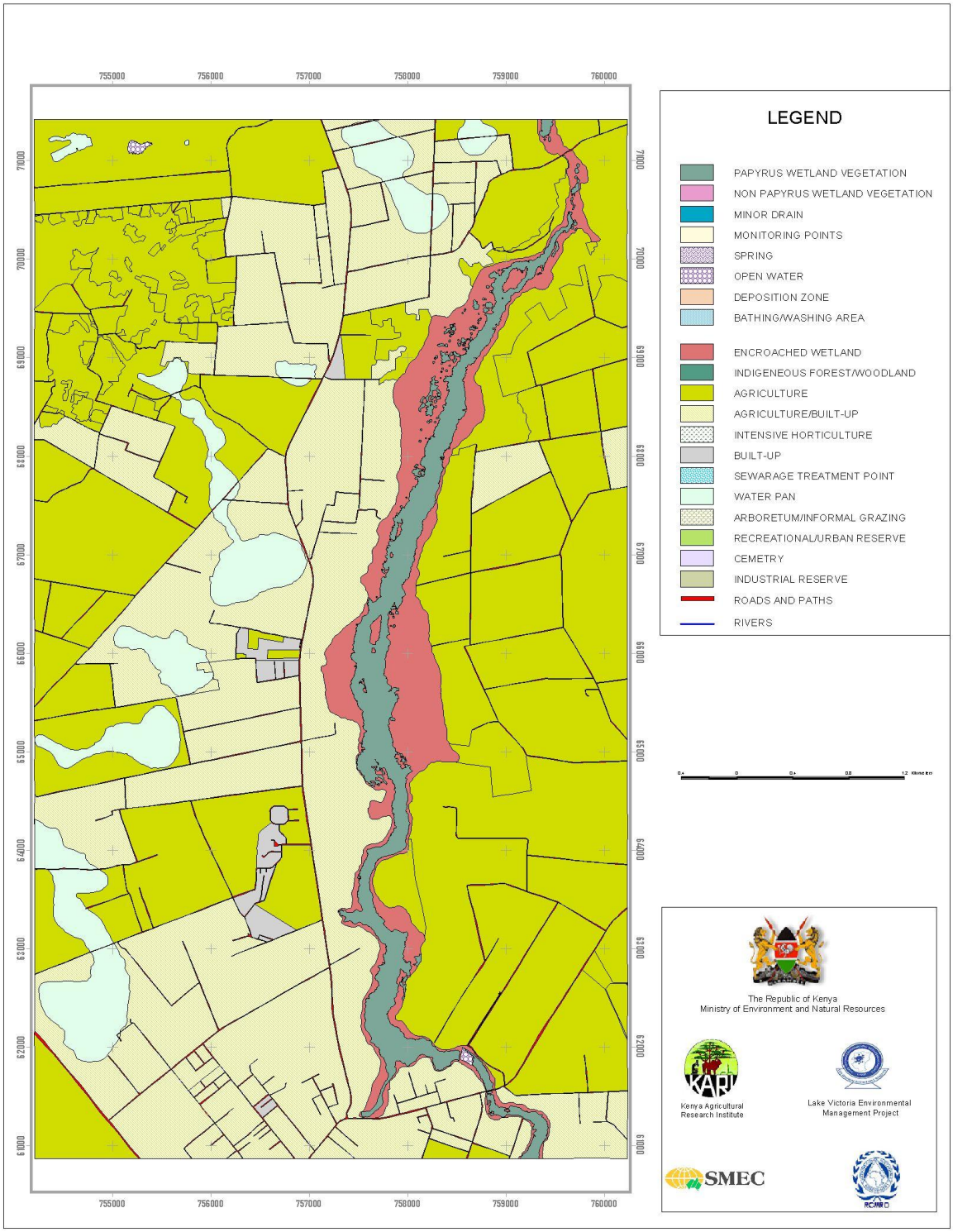


Figure 14. Eldoret area Land use/ land cover map indication areas in Marula wetlands which have been enchroached.

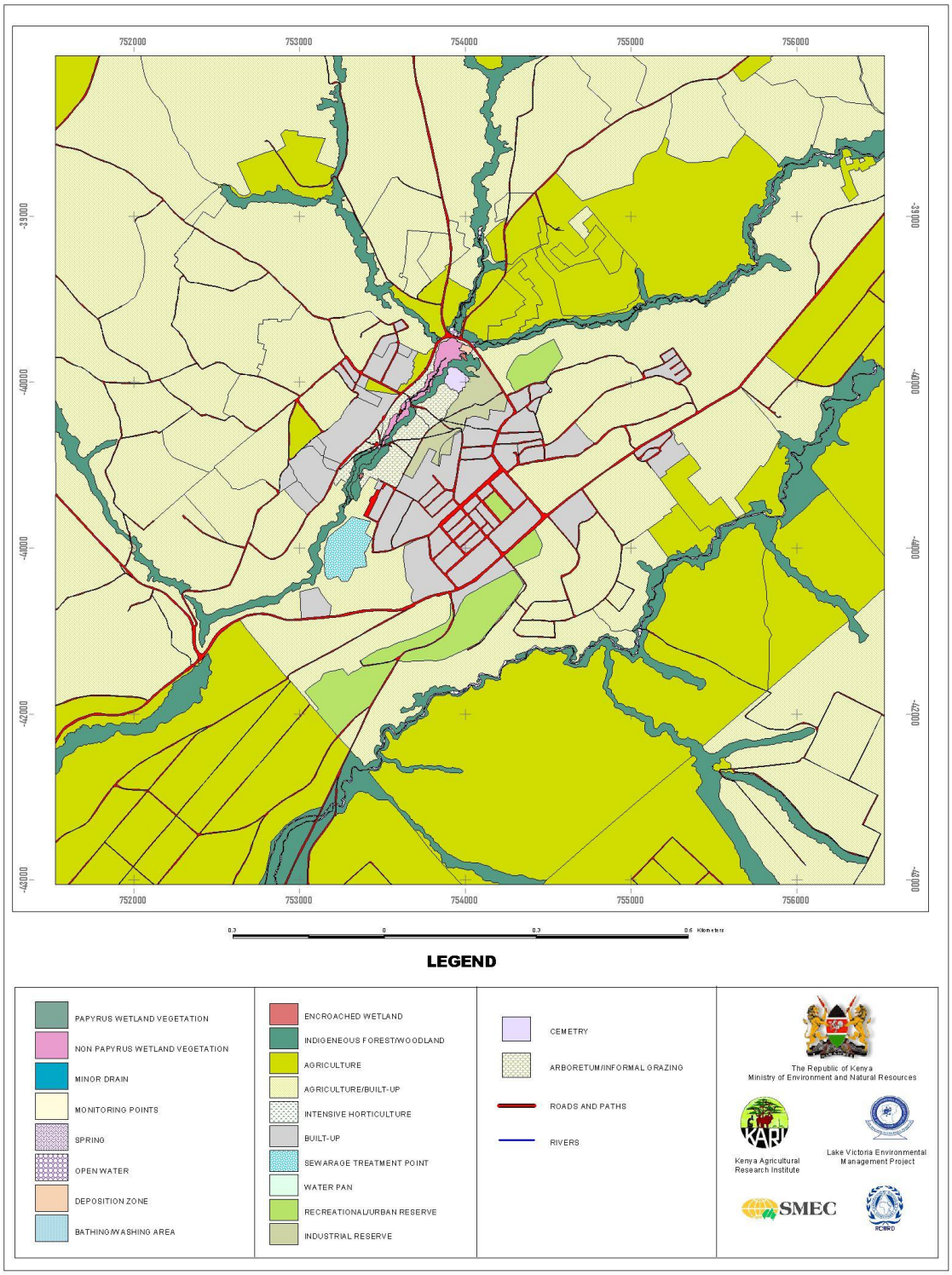


Figure 15. Wetlands in the urban areas of Kericho town that need to be managed well

7.6 Forest degradation assessment

Deforestation is a major problem in the Lake Victoria basin. Forest cover change mapping can be undertaken rapidly and cost effectively using geo-information of remote sensing, GIS and Global Position System methodologies to pin point exactly where and how much deforestation is taking place in the basin. This can greatly help in planning conservation of catchments in the basin. Figure 16 shows the location and extent of forests, degraded forests, bare soils and other land cover types in Narok district in 1986 and 2000. From this two maps the extent and location of deforestation can be determined (see Figure 17).

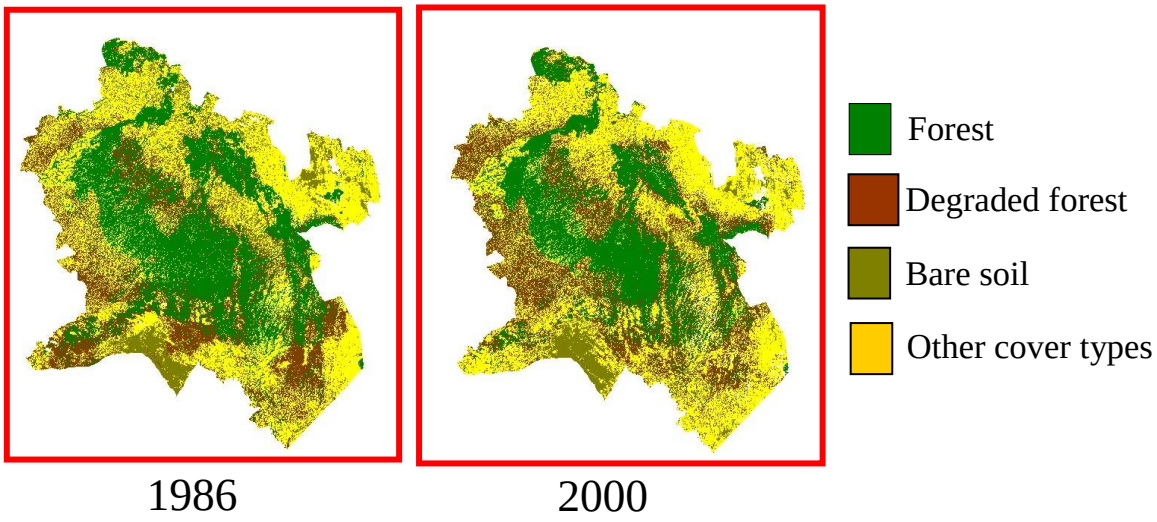


Figure 16. Forest cover maps of Narok district in 1986 and 2000

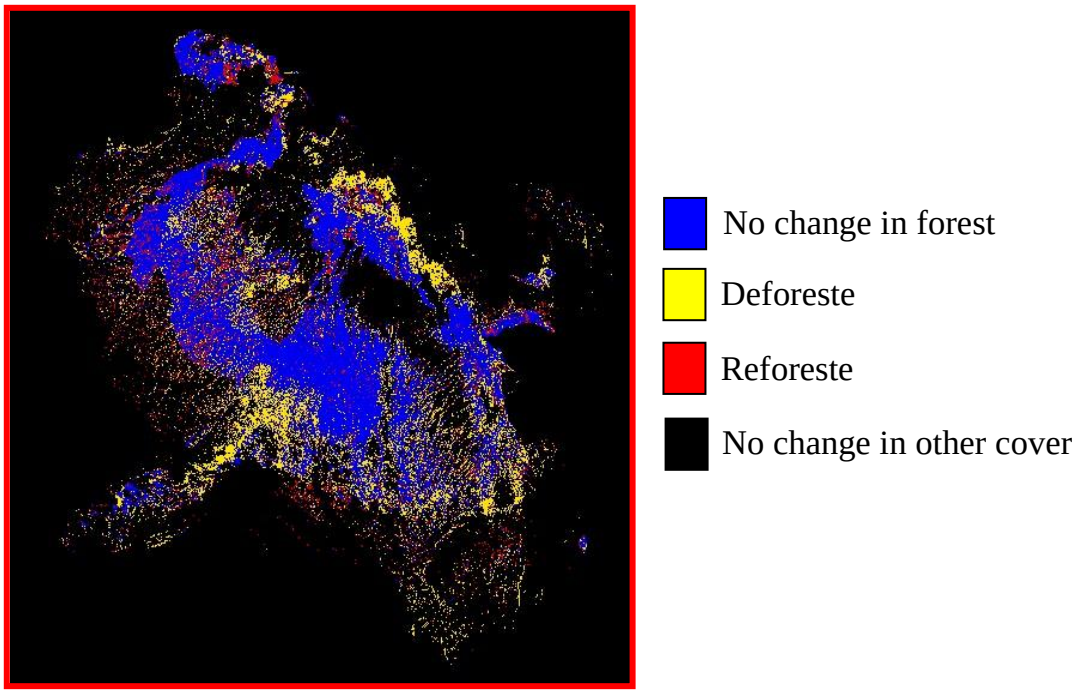


Figure 17. Forest cover change map of Narok district between 1986 and 2000

The statistics of forest cover change between 1986 and 2000 can obtained based on the administrative divisions of Narok district. Table 11 gives the statistics of the forest cover change. From these statistics a map showing the severity of forest degradation can be produced (see Figure 18).

DIVISION_ID	NAME OF DIVISION	SIZE OF DIVISION (Ha)	FOREST (Ha)	DEFORESTED (Ha)	REFORESTED (Ha)
1	LONDIAN	53127.360	20423	3578	4067
2	KAMARA	20428.763	1703	2546	1143
3	KIPKELION	31540.079	496	537	1219
4	MOLO	5888.317	442	703	231
5	ELBURGON	43627.605	16303	8048	2831
6	AINAMOI	30371.668	4119	1783	1567
7	NJORO	31360.586	2536	3487	493
8	KURESOI	28921.789	7438	2936	2049
9	KERINGET	49215.112	8349	4971	2492
10	GILGIL	105537.776	9414	3647	2358
11	BELGUT	29094.034	3593	1340	1785
12	TINET FOREST	44340.281	25775	6765	5040
13	LARE	13964.979	83	478	47
14	KIMULOT	30274.853	9427	2036	3894
15	MAUCHE	16133.044	7350	4822	671
16	OLOKURTO	121916.635	57358	9332	5374
17	MAU NAROK	18442.266	2415	2316	375
18	KONOIN	18288.677	736	1254	1602
19	OLENGURUONE	17197.427	1675	3536	1346
21	MULOT	72467.520	29718	12530	4762
22	BOMET CENTRAL	33637.412	490	1521	1815
23	MAU	260780.710	32456	31874	8107
24	CENTRAL	94309.632	30794	11180	3964
25	OLOLUNGA	151006.360	18744	19794	3114
26	LONGISA	25730.268	355	1181	744

Table 11. Forest cover change based on divisions in Narok District

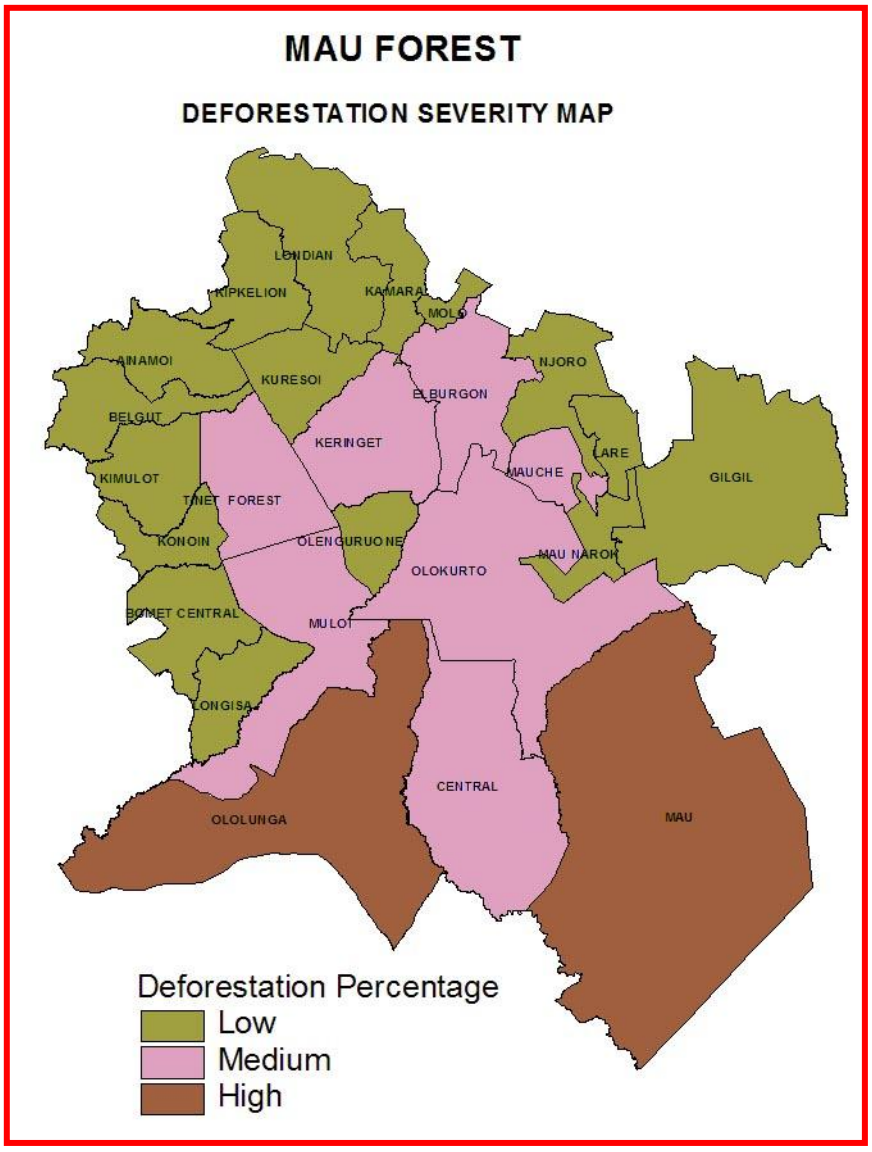


Figure 18. Deforestation severity map at the divisional level

7.7 Importance of land suitability mapping in land use planning and management

As the population and expectation of the people have increased, land has become increasingly a scarce resource. The land available per household is shrinking. Essential urban and industrial developments squeeze out agricultural land. New agricultural developments also put pressure on other resources including water supplies, forest, wildlife zones or reserves and wetlands.

Land suitability assessment assists land use planning in the following ways:

i) Identifies changes in land use that will increase production and opportunities in the rural sector, while not harming the environment.

ii) It assists in decision-making regarding where the land use changes should be.

iii) Land use planners do not want soil maps, climate, vegetation maps. They are not trained to use such maps(Mwendwa, 1987). They need an integrated interpretation of these maps on natural resources and other components of the landscape which relate these to particular land use.

iv) Land suitability analysis assists land use planning in avoidance of misuse of land that squanders resources and puts at risk the livelihood of the whole community. A case in point is the reckless cultivation of the hillsides which lead to soil erosion. Crop yields are reduced, so is the capacity of the land to hold water. Rainfall runs off more quickly, flooding the bottomlands , depositing eroded soil where it is not wanted and reducing stream flow in dry periods. This means the hill farmer looses his livelihood, the people in the valleys and bottomland suffer worse floods and drought; and the whole community losses the potential production of good water supplies, hydroelectric power, timber, tree crops and grazing that could have been maintained safely by the hill land.

7.8 Potential usefulness of land use planning for managing the Lake Victoria Basin

Land use planning as described above has immense usefulness in the management of the Lake Victoria Basin. A land use plan would provide the following:

- Enhance environmental sustainability,
- Create harmony in various land uses,
- Reduce regional development imbalance,
- Optimize resource utilization for maximum returns,

- Manage land as a resource.

If the above objectives are achieved, it would lead to the orderly, coordinated and harmonious development in the basin in order to promote health, safety, efficiency, social equity, social choice and environmental conservation. More specifically the following benefits of land use planning could greatly assist in the management of the basin:

i. Land is managed to maintain or if possible to improve its productive capacity for the future. This means sloping land must be protected against erosion and soil fertility maintained by adequate use of fertilizer or manure.
ii. Other users will be protected; this means for example that no one should use fertilizers or other chemicals that will damage crops, livestock, fish or pollute water or land onto which effluents will be carried.
iii. Farmers in the upland areas must conserve their soil, not only for their sake, but also to control the run-off of water and sedimentation, that will damage crops, lands and water supplies downstream.
iv. Minimize loss of productive land from poor land management practices that accelerate soil degradation. Prime land must be preserved for agriculture, new sites for housing, factories etc must be on poor quality land.
v. Development of water supplies by damming or diverting streams or pumping ground water should not deprive existing users of their water supplies.
vi. Assess and prepare for predictable hazards e.g. landslides and floods by putting in place necessary protective measures.

More importantly spatial planning can be used as an instrument for sustainable development and promotion of biodiversity.

7.8.1 Land use planning and sustainable development

Land use planning can be used as an instrument to co-ordinate socioeconomic development by preventing environmental problems and simultaneously protecting the natural environment and the cultural environment. The challenge for planning is to ensure the efficient use of limited land resources and to contribute to balanced regional development and balanced use of resources, including natural and landscape resources, soil, water and air. Since spatial planning has a long-term perspective, it can also include important principles of sustainability.

Based on this, using land use planning to promote sustainable development involves striving to view the concepts of development and protection as being complementary rather than contradictory.

Spatial planning is used to create solutions that are targeted to specific geographical locations. Sustainable development cannot solely be achieved at the local level. Spatial planning enables various territorial dimensions to be considered: local, regional, interregional and global. Spatial planning as an instrument creates solutions that target specific geographical territories while the solutions are integrated with solutions in other larger or smaller territories.

Spatial planning can coordinate various aspects of socioeconomic development in rural districts, urban-rural relationships, the development of infrastructure and environmentally sound use of land and natural resources. Planning procedures are based on and should be developed further to ensure the involvement of the public in democratic decision-making process so that various societal interests can be weighed and balanced in decisions on development.

7.8.2 Land use planning and biological diversity

Land use planning can manage appropriate land use to ensure that nature is protected and biological diversity promoted and can contribute to integrating nature protection into the planning of agriculture, forestry, fisheries and installations in the open country.

Land use plans can designate the location of valuable natural areas, vulnerable natural areas, buffer zones from which certain activities can influence vulnerable natural areas and wildlife dispersal corridors. Thus, spatial planning can comprise the basis of formulating differentiated demands and conditions applying to companies and farms or in connection with extracting raw materials, constructing transport installation and other activities. In addition, priority areas can be designated for special initiatives in nature protection and nature restoration.

Other interests associated with land use that influence biological diversity are related to such areas as valuable agricultural and forestry areas, wetlands or afforestation areas. Planning can establish a geographical overview of the areas with which the various interests in land use are associated. The planning process can weigh the numerous and varying interests in land use, such as urban growth, transport installations, intensive agriculture, intensive livestock farming and interests in recreation or protection, and this can create a balance between use and protection.

7.9 Status of environment in areas where land suitability mapping and land use planning principles are implemented as compared to those without

7.9.1 The Tennessee Valley

The Tennessee Valley, in the United States of America is one of the best known success stories in the world of the results of good land use planning. The Tennessee Valley was environmentally and economically in very bad shape in 1933. Much of the land had been farmed too hard for too long, eroding and depleting the soil. Crop yields had fallen along with farm incomes. Serious deforestation had taken place and the best timber had been cut. Tennessee Valley Authority (TVA) was created by the United States government to develop the valley and pull it out of the environmental and economic crisis. Right from the start, TVA established a unique problem-solving approach to fulfilling its

mission:-Planning for integrated resource management. Each issue TVA faced, whether it was reforestation, erosion control, flood control, disease prevention, navigation and power production, was studied in its broadest context. TVA weighed each issue in relation to the others. From this beginning, TVA has held fast to its strategy of integrated solutions, even as the issues changed over the years.

TVA introduced farm management plans, taught farmers how to improve crop yields, and helped replant forests, control forest fires, and improve habitat for wildlife and fish. The most dramatic change in Valley life came from the electricity generated by TVA dams. Electric lights and modern appliances made life easier and farms more productive. Electricity also drew industries into the region, providing desperately needed jobs. By the 1960s, unprecedented economic growth was taking place in the Tennessee Valley. Farms and forests were in better shape than they had been in generations. Electric rates were among the lowest in the world.

7.9.2 Machakos conservation success story

With good planning that is implemented at the farm level, good results can be achieved in environmental protection and conservation and improvement of the livelihoods of the people. This is the lesson offered by the 1.4 million-hectare of land Machakos district. A region of steeply sloping land that receives erratic rainfall, Machakos was first settled in the early part of the 20th century. By the 1930s, it had been severely degraded by overuse, with less than 5 per cent tree cover and soil erosion visible in 75 per cent of the inhabited area. Some observers at that time (1930s) predicted ecological collapse. Instead, the reverse happened. Over the next six decades, the population of Machakos expanded almost six-fold. Yet soil erosion decreased, tree cover increased, and the district moved closer to self-sufficiency in food. More people were taking better care of scarce, and therefore precious, land, even as they coaxed more production out of each hectare.

Surprisingly high population densities may be compatible with sustainable land use under certain conditions. Within Machakos, many farmers were able to diversify their income by finding non-farm jobs, applying the additional income to land conservation. Education, land tenure, community-government partnerships and prominent leadership roles for women also enhanced conservation efforts. Of course there are some negative effects of the population increase from the 1930s to present. The diversity of natural vegetation and wildlife in Machakos has declined, and local soils may also be deteriorating in quality.

7.9.3 Bura Irrigation Scheme

The Bura irrigation project is an unmitigated disaster, the result of remarkably poor land suitability studies and planning. The irrigation project which the World Bank funded in the 1980s, was to irrigate about 35,000 acres to grow cotton and maize at an estimated cost of US Dollars 98million. However, the area actually irrigated peaked at just about 6,000 acres, while costs shot up to USD108 million. In a country where per capita income is only about USD350 per year, the project spent an incredible USD55,000 for every settler on the project site. Yet today, these settlers and their families' suffer abject poverty and drought and famine are a daily reality. The project also led to the destruction of evergreen flood plain riverine forests, which were rich in plant and animal species.

Although project Managers knew that settlers would need fuel to meet their cooking needs, the project did not address the question. No woodlots were planted early on to provide fuel wood. Settlers had no choice but to plunder the riverive forest, the only green strip of land in this arid region. The forests and wildlife protection component of the project never got off the ground, and deforestation ensued.

Technical studies on the lack of suitable soils for irrigation in the areas existed but were not taken seriously. Project Manager's rushing to get the ill-prepared

project, without proper land suitability and planning, approved by the World Bank, downplayed the risks and vastly underestimated its costs.

7.10 Critique of the application of land suitability mapping and land use planning

Although the procedures described in the preceding sections can produce rational land use plans which make appropriate and sustainable use of natural and human resources, two conditions need to be fulfilled if the plans are to achieve their objectives. First the land use plans must be accepted by the people concerned and secondly there must be the political will to put the plan into effect. These two conditions are not clearly entrenched in the planning process. In cases where the land is already heavily settled, acceptance of proposed land use plans may be difficult. From past experiences of planning in Kenya, urban plans have been prepared without involving the local people concerned and without the political backing to implement the plans. This has resulted in beautiful urban plans just on paper and largely ignored in urban development. It is therefore important that the two conditions are met before any land use planning initiatives can be undertaken for the Lake Victoria Basin. However, in case the conditions are not met and yet inappropriate land use is a pressing problem in the basin, awareness campaign could be mounted and demonstration areas set up to create the conditions for effective planning.

Another issue is the institutional and legal framework to carry out, coordinate and implement the plans. This is another important issue that the planning process is weak in. The Physical Planning Act (Chapter 286 of the Laws of Kenya), provides the legal mandate for the preparation of land use plans to the Director of Physical Planning in the Ministry of Lands. The Act stipulates that the plan is for the improvement of the land and provide for the proper physical development of such land. The plan is also to allocate land for transportation, public purposes, utilities and services, commercial, industrial, residential and recreational areas. The problem here is that the Director of Physical Planning has only skeleton staff in a few districts. This staff, do not have the capacity to undertake and coordinate land use planning at the district level. Because of this,

only three district land use plans have been prepared so far. Furthermore, since the focus of land use planning is the people concerned and affected by the plans, staff are required at the lowest level possible to enhance maximum contact with the people.

The Physical Planning Act gives the Local Governments or Authorities, the mandate to implement land use plans. However, the Local Authorities do not have the institutional capacity in terms of trained personnel and the legal framework to implement the plans. Therefore alongside preparation of spatial plans, institutional and legal reforms should be carried out, in-order to put into practice the plans.

The processes of land suitability mapping and land use planning are data intensive and time consuming. Current data has to be collected from the field and through aerial and space based surveys. This can make the task of undertaking such an exercise extremely costly. This tends to discourage National and Local Governments from undertaking comprehensive land use planning at the district or regional level. Since the products of land suitability mapping and land use planning are required and used by organizations in all sectors, it is important to coordinate and pool resources together to achieve a comprehensive regional plan. This will minimize duplication of efforts and hence wastage of resources.

Finally, a major weakness in the application of the planning process in Kenya, is the low technical capacity to collect and manage large amounts of data and undertake complex and numerous analysis. Planning at the regional level requires sophisticated computer based information management systems and diverse multidisciplinary and trained staff to analyze data and produce land use plans. These resources have to be in place if any meaningful plans are to be produced.

8 PROPOSED IMPLEMENTATION FRAMEWORK FOR LAND SUITABILITY MAPPING AND LAND USE PLANNING - THE APPROACHES

8.1 Introduction

From the discussions in the preceding chapter on the anticipated challenges in the application of the processes of land suitability mapping and land use planning in Kenya, an implementation strategy will be proposed that clearly takes into account the context of the prevailing local conditions and lead to the successful out come of the objectives of the planning initiative. This will solve land resources management and environmental problems in the basin. A framework will be proposed that is focused in approach and systematic in the search for most appropriate and effective methods of implementation given the constraints in resources, institutions, legal instruments and socio-economic conditions.

8.2 Planning policies and strategies

Land use and economic planning at the regional level take place within a national policy and legal context which are spelt out in Sessional Papers, policy documents and legislation. The policies indicate in very broad terms the desired development goals and the means of achieving the goals. The earliest policy in district planning is contained in Sessional Paper No. 10 of 1965 on African socialism. Its application to planning in Kenya established the principle of state direction of development processes and decentralization of planning based on the local inputs. This Sessional Paper had very important objectives of achieving political equality, social justice, human dignity, freedom from disease, equal opportunities and high growth per capita income.

Other important Sessional Papers are Nos. 8 of 1981 and 1 of 1986. Sessional Paper No. 8 of 1981 is on national food policy. It focused on market distribution and storage of food and was to be implemented through the Ministry of Agriculture. Sessional Paper No. 1 of 1986 gave policy direction on economic

management for renewed growth. Its focus on rural-urban development balance, has implications on setting of priorities in planning.

8.3 Planning and development strategies

There are several development strategies that guide rural and urban planning. These include District Focus for Rural Development, Human Settlement Strategy, Growth and Service Centre Strategy, Rural Trade and Production Strategy and Poverty Eradication Strategy which is currently being implemented.

The District Focus for Rural Development strategy which was introduced in 1983 is the most important that the government has used for regional planning. The strategy established the district as the basic unit for planning and implementation of development projects and programmes. The main objectives of District Focus for Rural Development were to:

- encourage local participation in decision-making in development matters,
- broaden the base for rural development and enhance utilization of local resources,
- strengthen inter-sectoral coordination and cooperation at the district level,
- arrest rural urban migration and
- reduce delay in decision-making and speed up project implementation.

This strategy established the District Development Committee (DDC) as an institutional framework for planning and development implementation at the district level. The DDC brings together central government, local authorities, parastatals, politicians, NGOs, religious groups etc and is therefore an important all inclusive and consultative forum that could provide the structure of participation of all stakeholders in planning and development.

Unfortunately the DDC has no legal basis as it only worked as an administrative structure. Its effectiveness and role is being eroded with the introduction of Constituency Development Fund and Local Authorities Transfer Fund that have been introduced in the last few years. It is therefore, important to strengthen the DDC to enhance coordination and reduce duplication of development activities.

8.4 Land use development plans

8.4.1 Sectoral plans

These are plans prepared by different sectors. For example, the Ministry of Water and Irrigation prepares Water Master Plan, the Ministry of Public Works prepares Roads Master Plans and Local authorities prepare Local Authority Development Plans. The Physical Planning Department prepares regional spatial development plans that combine the sectoral plans and give them a spatial context.

8.4.2 Regional plans

These plans cover district, catchment or even a province. In the 1970s, the Department of Physical Planning prepared a regional plan for Nyanza province. LBDA in the 1987 produced a regional development plan for the Lake Victoria Basin. Volume 6 of this master plan contains results of a study on the land use sector. These plans are extremely general and only give an overview and a guide to development priorities. Moreover, a lot of planning and development changes have occurred since the production of these plans. There is therefore, a need to prepare new plans at the district level to put into consideration the new developments and priorities and give better plans that can be implemented at the community level.

8.4.3 District plans

Since 1974, district development plans have been prepared for all districts in Kenya by the Ministry of Planning and National Development. The plans prepared every five years mainly focus on economic planning with little mention of land use planning. These plans identify the district development resource potential and problems and suggest possible development strategies. The

physical Planning Department prepares district land use development plans. Three plans for Kwale, Nakuru and Nyandarua have been completed and one for Kisumu and Nyando districts is under preparation. These are long term plans covering 30 years but implemented through a series of short term (2-3 years) to long term (5-7 years) development plans. These plans integrate the above mentioned district development plans and sectoral plans and therefore address both sectoral and spatial development concerns.

We propose that long term land use plans for Lake Victoria basin be prepared at the district level to effectively address the present development and environmental issues and to ensure meaningful implementation of the plans.

8.5 Legal Framework

There are a number of legislative provisions that have been passed by parliament that affect land use planning in Kenya. Some of the laws are broad based and affect the whole country while others may be crop specific. The Physical Planning Act (Chapter 286) is the main law concerned with land use planning and physical development control issues that ensure orderly and sustainable development. The Act provides for the legal mandate for the preparation of land use plans to the Director of Physical Planning in the Ministry of Lands. The Director or his representative may initiate planning and appoint a suitable team or agency to accomplish the task.

Although it is clear who prepares the proposed land use plans, its implementation is less clear. This is because the land use plans contain proposals on multi-sectoral development strategies such as agricultural land management, infrastructure, urban and industrial development and natural resources conservation.

The Land Control Act (Chapter 302) deals with the control of agricultural land transactions such as sub-division, lease and sale. The Act is meant to regulate land transactions through Land Control Boards based at the division level so as to

maintain the economic viability of agricultural land. This is an important Act that could be used as a basis for implementation of planning standards at the farm level.

The Forest Act (Chapter 385) is concerned with forest management and conservation and forms the basis for implementation of natural resource conservation strategies proposed by the land use plans. The Water Act (Chapter372) has provisions for water catchments conservation to ensure water from the catchments are conserved both in quantity and quality. The Agriculture Act (Chapter 318) and a number of crop specific Acts stipulate management policies that can be the basis for the implementation of planned proposals on agricultural development and land management.

The Local Government Act (Chapter 265) gives some powers to Local Authorities to control land use and development in their areas of jurisdiction. This is an important and useful legislation that could assist in the implementation of land use plans. Environmental Management and Coordination Act of 1999 gives authority to National Environmental Authority to manage wetlands in the country. The Act also requires an Environmental Impact assessment (EIA) to be carried on all industrial and major urban and rural developments. This greatly aids in the implementation of major proposals by ensuring proposed land use does not negatively affect the environment.

8.6 Institutional framework

The institutions involved in the development of plans and implementation can be categorized as public, civic and private.

8.6.1 Public institutions

Public institutions include central government, local authorities and parastatals. The mandate of the central government is to implement government policies and legislation. The central government is represented at the provincial and district

levels by government ministries and departments. Some ministries are represented at lower administrative level such as the division level.

Local authorities (County Councils, Town Councils, Municipal and City Councils) make development and land use policies and controls and implement them within their areas of jurisdiction. Parastatals are specialized and autonomous government agencies created to decentralize some of the functions of the central governments. Parastatals represented at the provincial and/or district levels include Kenya Power and Lighting company, LBDA, National Cereals and Produce Board, Agriculture Finance Corporation, Telkom Kenya, Postal Corporation of Kenya and Kenya Tea Development Authority among others.

To coordinate planning and development at the district level, the DDC is best placed institution. This is because, as already mentioned, the DDC brings together all heads of government ministries and departments, local authorities leaders, members of parliament, heads of parastatals, non-governmental organizations and religious bodies. A committee similar to the DDC exists at the divisional level called the Divisional Development Committee. The functions of the DDC are to:

- Assess local development potential and needs,
- Enhance planning capacities at the local level,
- Establish development priorities,
- Enhance inter-sectoral coordination and cooperation in planning and, implementation of projects and provision of services,
- Promote self- help and greater resource mobilization at the local level, and
- Improve project sustainability.

There are several sub-committees of the DDC such as the District Agriculture Committee, District Education Board, District Environment Committee and District Social Development Committee.

There are also a number of district based committees that are established under various Acts of parliament as described above that deal directly with planning. District Physical Planning Liaison Committee established under the Physical Planning Act, is mandated to deal with conflict resolution on matters related to land use planning in the district and to determine development application relating to industrial location, dumping sites and sewerage treatment works, which may have negative impact on the environment. The Divisional Land Control Board established under the Land Control Act, is composed of the District Commissioner, the District Agricultural Officer, representatives of the Ministry of Lands and Local authorities and local leaders. The board's main function is to control and adjudicate over land transaction of agricultural land in the districts. Other important committees are District Roads Board and Hospitals Management Board.

There are many Non Governmental Organizations, Community Based Organizations and private companies at the district and divisional levels that are important players at all levels of the planning process. They are usually represented in the above government committees but should be given more involvement in the various committees as the trend in the last decade has seen greater involvement of NGOs and private sector in planning and development and the planning process itself becoming more participatory.

8.7 Proposed institutional framework

The following institutions are proposed for the preparation and implementation of land suitability mapping and land use plans at the district level.

8.7.1 The District Development Committee

The importance of the DDC as a forum of bringing all stakeholders together has already been explained in the preceding sections.. It is therefore proposed that the DDC and Divisional Development Committees be the institutions for leading

the consultative process of preparing and implementing land use development plans. However, the DDC needs to be strengthened.

Firstly, the DDC has no legal mandate and depends greatly on the goodwill of the people. Secondly, since the start of the government policy of channelling development funds through the Constituency Development and Local Authority Transfer Fund and not through the DDC, the DDCs in many districts are gradually losing their importance and effective role as stakeholders' consultative institution. We therefore suggest that DDCs be revitalized to take the important role of giving effective participation in the planning process and particularly to enhance the need for integrated planning. Improvement is also required in the linkage between the DDC and Divisional Development Committees on the one hand and the local communities on the other to enhance the acceptability and implementation of land use plans.

8.7.2 Physical Planning Department

We propose the preparation and coordination of land suitability and land use planning be led by the Physical Planning Department of the Ministry of Lands, since they have the legal mandate and experience as they have undertaken similar work elsewhere. However, the capacity of the Department needs to be improved at the district level. The Department needs sufficient qualified multi-disciplinary staff and appropriate facilities (hardware and software) to undertake the task. Resources are required to collect and collate existing data and acquire new data where necessary.

8.7.3 Local Authorities

Local authorities are major stakeholders in land use planning. They are responsible for the control of land use development being the local approving authority for land development especially in urban settlements and market centres. They have little role in agricultural land activities, although they collect taxes from farmers to maintain roads.

Since it is being proposed that the planning process be fully participatory, the local authorities can provide the link between the local people and the planning process. Furthermore, the local authorities will be able to use the proposed district plans as basis for the preparation of their local development plans. We therefore propose that the local authorities together with the Physical Planning Department be lead agencies in the preparation of the plans.

Most local authorities have serious deficiencies in service delivery because of lack of staff, resources and management problems. It is therefore important that as part of plan preparation, technical and management capacity of local authorities be built to enable them participate and effectively take their rightful role in planning.

8.7.4 Other government and non-governmental institutions

The preparation and implementation of sectoral components of the plans such as agriculture, water, health, education, roads etc needs the full participation of all concerned government ministries and departments, NGOs and CBOs. Their participation is done at the DDCs, Divisional Development Committees and thematic group meetings. Figure 19 shows the institutional organization for district development planning. The structure brings together policy makers, development facilitators and citizens together at the DDC

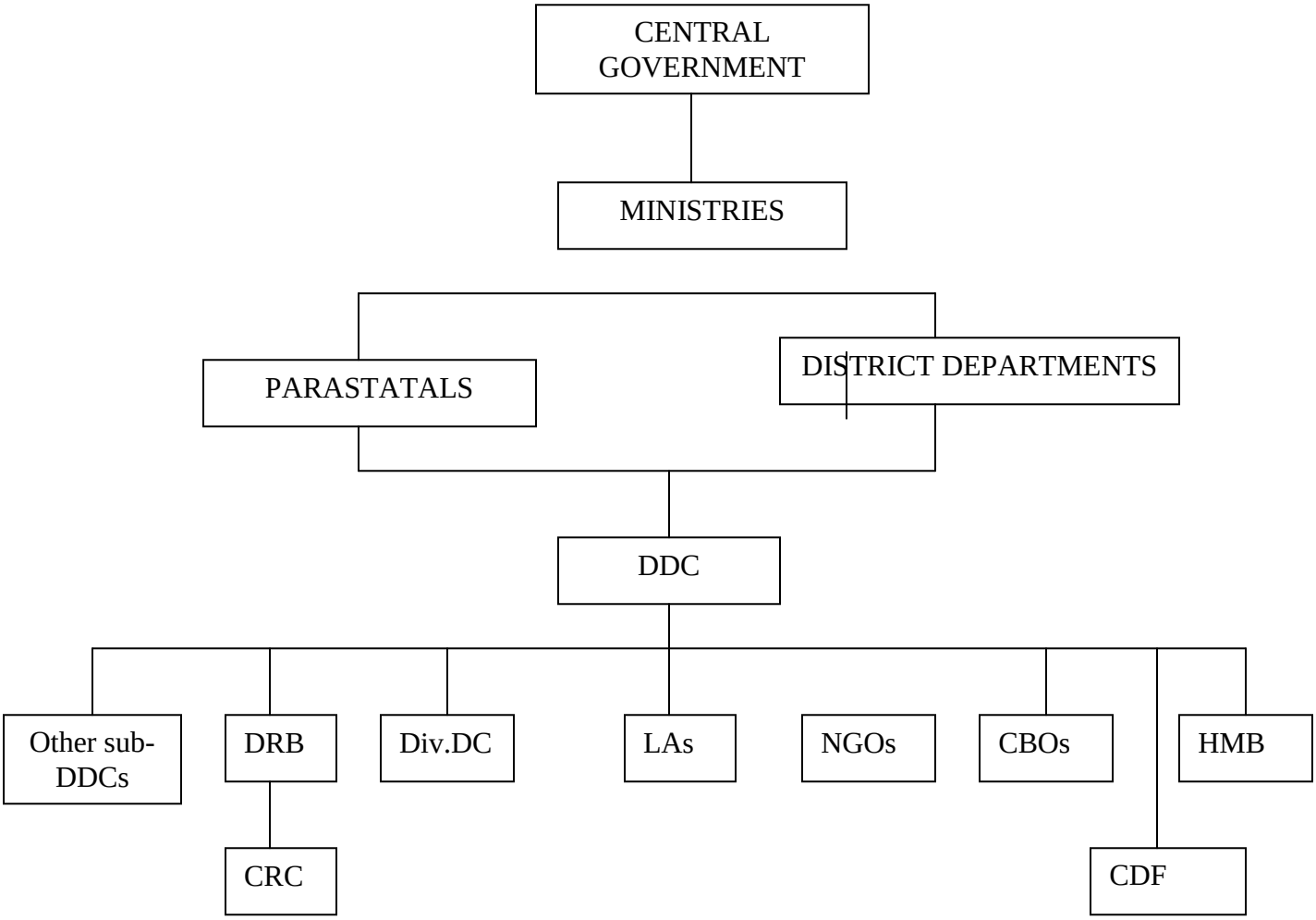
8.8 The planning process

8.8.1 Introduction

The district regional land use development plan integrates sectoral and spatial development concerns of the government ministries and departments, local authorities, parastatals, NGOs and local communities. The land use preparation process should therefore have very strong vertical and horizontal linkages established among all institutions and communities involved. In the vertical plane, the plan should draw from national policies that have to be translated into concrete programmes at the district level. For example, the national policy on promotion of agricultural production is expected to sustain food self-sufficiency,

generate income for people and hence alleviate poverty and provide raw material for agro-industries. The plan should therefore consider the socio-cultural, economic and environmental factors that have effects on agricultural production and propose strategies and programmes that can be implemented at the district level and farm level.

Figure 19. Institutional Organization for District Development Planning (source: Ministry of lands, 2003)



DRB=Distrcit Roads Boaard; CRC=Counstituency Road Council; CDF=Constituency Development Fund; HMB=Health Management Board

In the horizontal plan, the plan should establish effective coordination among the various sectoral actors in the implementation of proposed strategies and programmes. Therefore all stakeholders should be involved and participate fully in the plan preparation to enable them have ownership of the plan and hence facilitate its implementation. Figure 20 illustrates this concept of partnership in plan preparation and implementation.

District regional plans are long term covering period between 20 to 30 years. However the plans are implemented through a series of short term (2 – 5 years) development and work plans. To make the plans implementation oriented, an implementation matrix must be prepared which indicate the specific activities or progrmmes, time frames, responsible persons and budgets. Table 12 shows an example of an implementation matrix.

Figure 20. Partnership in plan preparation and implementation (Source: Ministry of Lands, 2003)

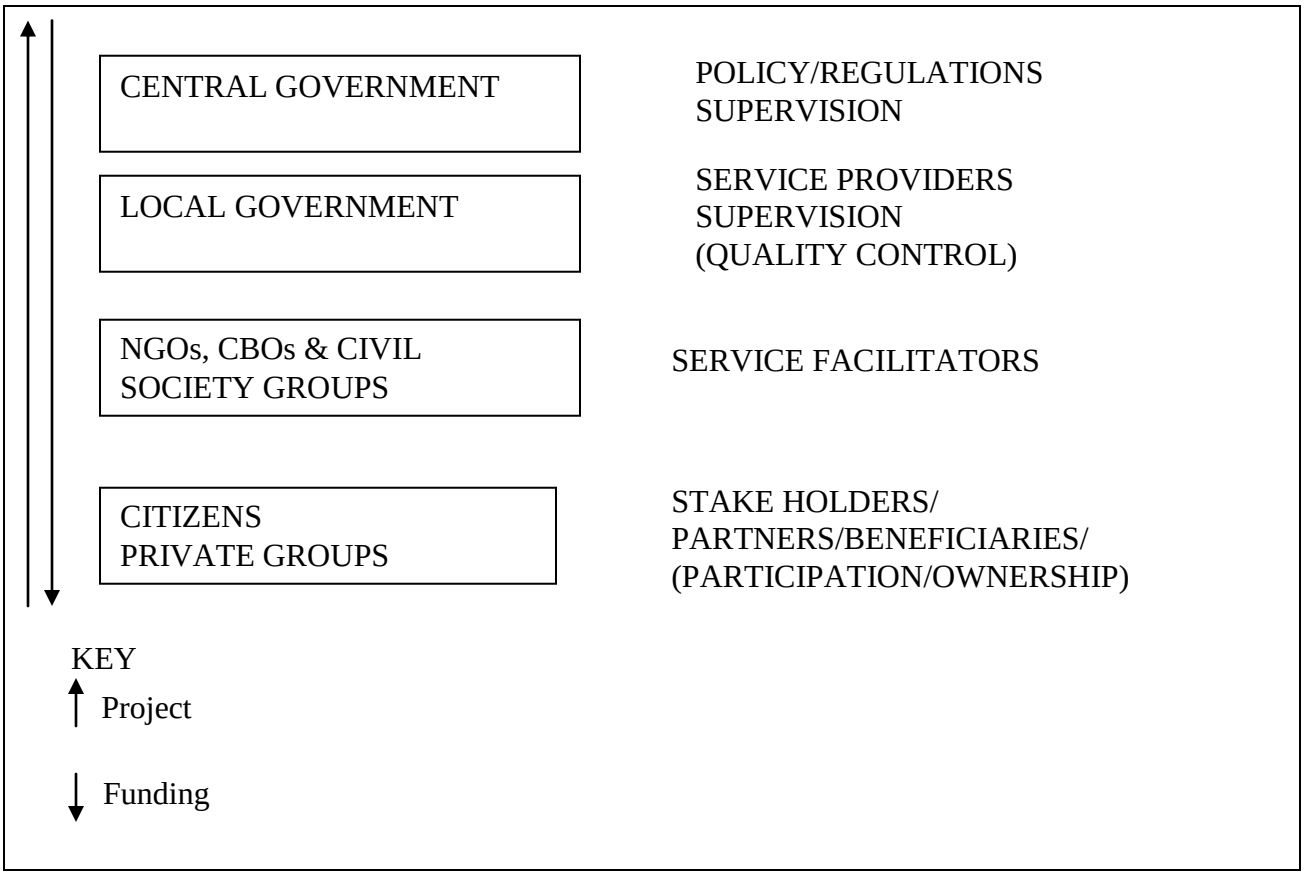


Table 12. Implementation matrix of land use development plans (Source: Ministry of Lands, 2003)

PROGRAMMES	Short-term 2-3 years	Medium-term 5-7 years	Long-term 12-30 years	COST	ACTORS
PLAN PROPOSAL 1: AGRICULTURAL DEVELOPMENT					
Agricultural production ▪ Introduction of drought resistant crops, e.g triticale and sorghum ▪ Dry land agro-forestry, beekeeping ▪ Introduction of blight-resistant crop varieties ▪ Reduce taxes on farm inputs					▪ Local community ▪ MOA ▪ KARI, ▪ CBOS ▪ KEFRI ▪ Fisheries department ▪ Local Authority ▪ Government
Produce Marketing ▪ Installation of coolers in collection centres ▪ Construction of agricultural produce processors					
Institutional Systems Supporting Agriculture ▪ Training/Capacity building					
PLAN PROPOSAL 4: NATURAL RESOUCE MANAGEMENT AND CONSERVATION					
• Appropriate tree planning programmes in gazetted catchment area • Reserve wetland areas and issuance of title deeds to community trusts • Acquisition of environmentally fragile areas, e.g hilltops and riparian reserves by trustees • Preparation of long-term environmental plan • Preparation land use guidelines • Revive national tree planting programme • Enact a law requiring a 10% tree cover on individual and public land holdings • Introduce commercial					• Ministry of environmentand natural resources • Ministry lands • NGOs • CBOs • Communities Local Authority • Ministry of Water • Kenya Water and Pipeline Corporation

forestry					

8.8.2 Methodology

The most important aspect of the methodology that should run through all the stages of the planning process is participatory approach. The process should be consultative and involve all stake holders in the analysis and decision-making stages.

It is very important that the planning process should be implementation oriented. The plans should therefore be specific in terms of proposals, responsibilities, locations, time and costs to maximize the chances of actually realizing the proposed programmes. This also reduces the danger of spending large resources on elaborate plans that have little prospects of ever being implemented. It is proposed that two districts be taken as pilot to test the propose methods.

The following are the proposed steps to be followed:

1. *consensus building*

At the onset when notification of plan preparation is being announced through print and electronic media, consensus building in support of the planning project by leaders of the district concerned is sought.

2. *Sensitization of stakeholders*

Sensitization workshops for stakeholders at the district and divisional levels should be held to inform and educate them and articulate the objectives and process of planning. These workshops focus and interpret the issues raised by stakeholders and set the vision and objectives of the plan. The vision provides a perspective of the desired economic, socio-cultural and environmental development structure. It is based on the actual possibilities of the area and the aspiration in the minds of the stakeholders. The workshop also identifies sources of required data and formation of thematic groups to participate in the plan formulation.

3. *Formation of sectoral planning teams*

Since the physical land use development plans integrate sectoral concerns, thematic groups among the stakeholders to assist in plan formulation are necessary. The groups could be organized in the following sectors:

- Natural resource base,
- Social –cultural,
- Economic,
- Infrastructure and services,
- Human settlement,
- Institutional and policy issues.

4. *Data collection, review and analysis*

This is an important step that is mainly technical and requires multi-disciplinary experts. The techniques are spelt out in Chapters 2 and 3.

5. *Consultative meeting with focused community groups*

The planning team gets the views of community groups at the divisional and grassroot levels.

6. *Plan formulation*

The planning team formulates the plan with input from the thematic groups and views from focused consultative group meeting.

7. *Review of draft plan*

The initial draft plan is presented to stakeholders for review and comments.

8. *Final plan preparation*

The final plan is produced after considering all comments from stakeholders and the different possible land use development models. The plan has to be approved by the relevant authorities such as the Ministry of Lands and Local authorities.

9. *Plan implementation*

The plan is put to action through the coordination of the DDC, local authorities and the planning team.

10. *Monitoring and review*

The planning team should be in place to monitor and review the progress of plan implementation and make modifications where necessary for ease of implementation and achievement of plan objectives

8.9 Implementation of Land suitability mapping and land use planning

The implementation matrix of the above proposed for land suitability mapping and land use planning at the district level is shown in Table 13. The implementation matrix is for all the activities required to produce land use plans based on suitability mapping. The costs and period required for each activity will vary from district to district depending on the size, number of administrative divisions and availability of data. The cost and time frames for the activities therefore, are a rough guide only, based on ongoing work on preparation of land use plans for Kisumu and Nyando districts. It assumed little data on land characteristics exists.

It is estimated that it will take about twenty months to prepare a land use plan. This time includes time for preparation stages in institutional capacity building. The total cost is estimated to be Ksh.18,500,000. The percentage of the total cost for each objective or major activity is given in the budget column to indicate comparison of estimated costs of the different objectives. It is proposed that land use plans for two districts; one in the upper catchments of the basin and the other in the lower catchments be prepared in a pilot phase. The methodologies developed and lessons learnt in the pilot phase could then be replicated in all the other districts in the basin.

Table 13. Implementation Matrix for Prepartation of Land Use Development Plans One District

	Verifiable Indicator	Verification		Frame	Ksh.
Planning team (PT) formed	Search for qualified Planning team member Evaluation of most suitable members Appointment of the team	Evaluation report Acceptance letters List of Names of team	PPD,DDC,LA	5 months	5,000,000 (27%)
Hardware and software procured	No. of specifications for hardware and software prepared No. of Tenders for Procurement advertised No. of Procurement contract awarded No. of Hardware and software installed	Advertising invoices Contract documents Facilities inventory report	PPD/LA/PT		
Planning team trained	training needs assessed Specifications for	Training needs report Specifications documents	PPD/LA/PT Consultants		

	training/course outline prepared TOR for training consultant prepared Training program implemented	TOR documents			
Legal framework strengthened	Legal task force formed TOR for task force prepared Task force report submitted to Attorney General Legal framework passed in Parliament	List of names of task force Task force report Acts of Parliament	MOL/PPD/ MLG	1 year	
Objective 2: To sensitize and build consensus on planning project					
Kenya Gazette Notice published	Notification drafted Notification approved for publication Published notification distributed to stakeholders	Kenya Gazette Distribution list	MOL/PPD	3 months	1,500,000 (8%)
Adverts in print & electronic	Adverts prepared		MOL/PPD/PT		

media made	Print and electronic media identified Adverts printed and/or broadcasted	Receipts of payments for adverts			
DDC members briefed	Dates of DDC meeting fixed in consultations with stakeholders Invitations made Meetings of DDC held	Copies of invitations Minutes of meetings	PT		
Divisional Development Committee members briefed	Dates of Divisional Development Committee meeting fixed in consultations with stakeholders Invitations made Meetings of Divisional Development Committee held	Copies of invitations Minutes of meetings	PT		
Local Authorities briefed	Dates of Local Authorities meeting		PT		

	fixed in consultations with stakeholders Invitations made Meetings of Local Authorities held	Copies of invitations Minutes of meetings			
Workshops at district level held	Stakeholders at the district level identified Notification of stakeholders No. of district level meetings held	Copies of invitations Minutes of meetings	PT Facilitators		
Workshops at divisional level held	Stakeholders at the divisional level identified Notification of stakeholders No. of divisional level meetings held	Copies of invitations Minutes of meetings	PT Facilitators		
Objective3: To establish thematic groups					
DDC meetings held to form sectoral/thematic teams	DDC meeting convened	Copies of invitations List of names	DDC/PPD/PT/LA	1 month	800,000

	Thematic teams selected	Minutes of meetings			(4.3%)
Sectoral/thematic teams trained	training needs assessed Specifications for training/course outline prepared TOR for training consultant prepared Training program implemented	Training needs report Specifications documents TOR documents	PT Consultants		
Objective 4: To collect, review and analyze data					
Existing data surveyed and catalogued	Literature search carried out Data holding institutions identified Existing data obtained from institutions	Literature review report Catalogue of data	PT consultant		
New data acquired	New data to be acquired identified Specifications for data acquisition methods prepared Data acquisition	Specification report Contract documents	PT/Consultants	6 months	7,000,000 (37.8%)

	institutions selected New data submitted to Planning Team	Catalogue of data			
Data analyzed	Data from various sources formatted in compatible forms Data quality and reliability assessed Analyzed data submitted to planning team	Quality report Catalogue of analyzed data	PT/Consultants		
Land suitability maps prepared	Overlay thematic maps prepared GIS analysis of the overlays Land suitability maps produced	Inventory of overlays Catalogue of maps	PT/Consultants		
Land suitability reports prepared	Suitability maps and other data analyzed Statistics of suitability	Suitability reports	PT/Consultants		

	prepared Reports compiled				
Objective 5: To formulate draft regional plan					
Workshops held for focused groups at divisional level	Focused groups identified Invitations made Workshops convened for each theme	List of participants Workshop reports	PT/facilitators	5 months	3,000,,000 (16.2%)
Draft plan prepared	Suitability maps, reports and other analyzed data are collated Draft Plan drawn	Draft regional plan	PT/Consultants		
Draft plan circulated to stakeholders	Mass production of draft plan Address of stake holders prepared Draft plan mailed	No. of copies produced Mailing list	PT		
Draft plan reviewed	Draft plan presented in workshops to: Thematic groups DDC Divisional	Workshop reports	PT/DDC/LA		

	development Committee Local Authorities Stakeholders workshop				
Objective 6: To prepare final regional plan					
Final plan prepared	Comments from stakeholders analyzed and compiled Comments from stakeholders incorporated Final amendments made Quality control and assessment made Plan submitted for approval Notification of New plan to public through electronic and print media	Comments/review report Final plan	PT	2 months	1,000,000 (5.4%)
Objective 7: To implement the regional plan					
Implementation team set up	Implementation team identified	List of names Minutes of appointment	PPD/PT/DDC	1 month	200,000

	Implementation team appointed	committee			(1.1%)
District Planning Liaison Committee set up	TOR for committee prepared Committee members selected Committee inaugurated	TOR document Appointment letters	PPD/PT/DDC	Continuous	
Plan monitored and reviewed	monitoring report prepared every six months Review report prepared every six months	Monitoring report Review report	PT/PPD		
TOTAL				20 months	18,500,000

References:

Abila, R. (2002) utilization and economic valuation of Yala swamp wetland, Kenya. In Gawler, M(ed) 2002. Strategies for wise use of wetlands: Best practices in participatory management. Proceedings of a workshop held at the 2nd International Conference on wetlands and Development (November 1998, Dakar, Senegal) Wetlands International INCN, WWF Publication No. 56, Wageningen, The Netherlands

Agembe S.W and Raburu P.O. (2005). Effect of point and non-point pollution sources on Fish in River Mbogo. A paper presented at the 2nd Lvemp I. National Scientific Conference, held in Kisumu, 17-19th October 2005.

Akotsi, E. and M. Gachanja, (2004). Changes in Forest cover in Kenya's Five Water Towers.

Aligula, H.M. (1987), A Land use proposal for South Nyanza district, Kenya. An Msc thesis, University of East Anglia, U.K.

Annadale, W.G. (2001). Watershed Degradation, River sediment and Reservoir Management. World Bank.

Anyango, L. (2004) Effects of flooding in the larger Nyando river basin. In proceedings of workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin. Eds D.Mungai, B.Swallow,Joseph Mburu, L.Onyango and Annah Njui pp 41-50

Awili A., Walsh M., and C. Mwito (2004) Consequences of land cover change: Land management and policy options. In proceeding of a workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin. Eds D.Mungai, B.Swallow,Joseph Mburu, L.Onyango and Annah Njui pp 30-32

Blackie J.R. (1979). The water balance of the Kericho catchments. East Agric. For J. 43,55-84; Edwards and Blackie 1981.

Bruijnzeel L.A 1982. Hydrology of moist tropical forests and effects of conversion a state of knowledge review UNESCO 1992.

Bruijnzeel L.A. and J. Proctor 1995. Hydrology and biochemistry of tropical montane cloud forests. What do we really know? In Hamilton L.S etal (eds). Springer Ecol. Studies, 110,38-78.

Busulwa, H. Mafabi, P. Malinga A, Kyambadde, R and J. Ssekane 2002, Buffering capacity studies in rural and urban wetlands in lake Victoria catchment Uganda.

Cowe, (2002). Integrated Water quality/Limnology study for Lake Victoria, Vol. II Technical Report.

Cowe, consulting Engineers and Planners, (2002). Integrated water quality / limnology study for Lake Victoria. Lake Victoria Environmental Management Project, Draft Final Report.

Dent , D. and Ridgway R.B (1986), Land use planning Handbook for Sri Lanka, FAO publication

Dent, D. and Young, A.(1981), Soil Survey and Land Evaluation. George Allen and Unwin(publishers) Ltd.

East African Community, (2002), The Economic Potential and Constraints for Developing Lake Victoria Basin as an Economic Growth Zone

East African Community, (2003). The Vision and Strategy Framework for Management and Development of Lake Victoria Basin.

Food and Agricultural Organization (FAO) 1976. A framework for land evaluation. Soil Bull. 32 Rome: FAO.

Gichuki, F.N. (1992). Utilization and conservation of wetlands: an agricultural drainage perspective. In S.A. Crafter, S.G. Njuguna and G.W> Howard (eds) wetlands of Kenya. INCN, Gland, Switzerland. Pp173-174

Gichuki, F.N. (2003). A Review of Wetland Research in Lake Victoria Basin, Kenya: Analysis and synthesis Report SIDA-SAREC, Nairobi.

Gor, S. and Okungu, J. (2005). Estimation of suspended solids loads from Kenya catchment into Lake Victoria. A paper presented at 2nd Lvemp I. National Scienetific Conference, held in Kisumu, 17-19th October 2005

Hecky, Q.E 2003. Science and the Lake Victoria Environment Management Programme (LVEMP); progress during Lvemp 1 and challenges for the future.

ICRAF, (2000). Linking Land and Lake, Research and Extension, catchment and Lake Basin. Working paper 2000-2002

ICRAF,(2000). Linking Land and Lake, Research and Extension, catchment and Lake Basin. Working paper 2000-2.

Jetzold, R and H. Schmidt, (1982). Farm Management Handbook of Kenya, Vol. II, Part II, Part A. Western Kenya. Nairobi.

LVEMP I (2005). Knowledge and Experiences gained from managing the Lake Victoria Ecosystem. The World Bank, GEF. 725 pages.

LVEMP, 2003. Lake Victoria Environmental Management Project, Kenya stock taking report, World Bank.

Mavuti, K.M (1989). Environmental Ecology of Yala Swamp, National Expedition on Genetic Resources and habitat, Kenya 1989

Ministry of Lands, (2003). Nyandarua District Regional Development Plan, 2001-2030.

Minstry of Agriculture and Land Affairs, (2001). White Paper on Spatial Planning and Land Management. July, 2001

Njuguna, H. M. (2004) Some aspects of the sediment load of the Nyando river workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin. Eds D.Mungai, B.Swallow,Joseph Mburu, L.Onyango and Annah Njui pp 34-36

Obiero Ongonga, Herrick Othieno, Kinya Munyirwa 2001. Lake Victoria 2000 and Beyond challenges and opportunities – publication by Osienala (Friends of Lake Victoria.).

Ochola, W.O. (2004), Land cover, Land use and related issues in the Lake Victoria Bain. Background paper on Environmental Assessment of

the Lake Victoria Basin as a contribution to UNEP Africa outlook (AEO) Report 2004.

Ocholla W.O, Muhia, R.N and Mwarasomba, L.I, 2000. Culture, Traditions and Society: The Challenges to Natural Resource Management and Development. A report of a socio-cultural study of the Lake Victoria Region, Kenya. National Soil and Water Conservation Programme, MOARD, Nairobi

Okedi, J. (1998), The Lake Victoria Basin, perspectives of its Environment and Natural Resources.

Okung, J. (2004) environmental degradation and water quality. In proceedings of a workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin. Eds D.Mungai, B.Swallow,Joseph Mburu, L.Onyango and Annah Njui pp.

Okungu, J. and P. Opango (2005). Pollution loads into Lake Victoria from the Kenya Catchment.

Ong C.K. and F. Orego, (2002). links between land management, sedimentation, nutrient flows and small holder irrigation in lake Victoria Basin. In 'The changing face of irrigation in Kenya: opportunities for anticipating change in Eastern and Southern Africa Eds. HC.Bank, CM Mutero H.Murray-Rust IWMI pp 135-154

Rashid A Tamatamah, Robert E. Hecky and Hamish C. Duthie (2002). Atmospheric Phosphorus loading in Lake Victoria. A Research paper.

Regional Centre for mapping of Resources for development. (2005). Mapping wetlands in the Lake Victoria basin in Kenya. 23 pages

Republic of Kenya, (2004). Regional Planning Handbook, Ministry of Lands and Settlement

Swallow B., (2004) Kenya's Nyando Basin: problems of poverty, agriculture and environment. In proceedings of a workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin. Eds D.Mungai, B.Swallow,Joseph Mburu, L.Onyango and Annah Njui pp22-26

Swallow, B.J Walsh, M. Nyautika, D. Murithi, S., Noordin, Q. Ching, O., Shephard, K., Place, F., A. Hui, M. Ochieng O, Conhen, M., Mugo, F., Oyasi, S., Omuto, C., Cohen, L. and Oknono A. (2002). Improved Land Management in the Lake Victoria Basin. Annual Technical Report. National Resource Problems, Priorities and Policies Programme Working paper 2000-2 ICRAF, Nairobi, Kenya.

Tyler Associates, Ireland, (2003) Summary of Existing Knowledge of Industrial pollution of Lake Victoria (Lvemp. Industrial pollution Report)

World Bank(2002). LVEMP 2 project: Private Sector Development PSD. Preparation and discussion paper.

World Bank, (2001). Lake Victoria Management Project – phase 2. Uganda pre – Identification mission Aide Memoire.

World Bank, (2003). Lake Victoria Environmental Management Project 2 (LVEMP 2) project concept.

APPENDIX 1 - GLOSSARY

AGROCLIMATIC REGION: An area of land that is suited to a specified range of crops, defined in terms of its temperature and rainfall regimes and, especially, its growing period.

CONSERVATION REQUIREMENTS: The conditions of land necessary or desirable to achieve conservation of natural resources under a given land-use type.

CROP REQUIREMENTS: The conditions of land necessary or desirable for the successful growth of a crop.

CURRENT LAND SUITABILITY CLASSIFICATION: a land suitability classification based on the suitability of land for a specified use in its present condition, without major land improvements

DECISION-MAKER: An executive person or group responsible for land-use policy, action and allocation of resources.

DISTRICT-LEVEL LAND-USE PLANNING: A level of land-use planning between the national and local levels, typically but not necessarily that of the administrative district. Intermediate map scales are used. Land-use development projects are often at the district level.

ECONOMIC ANALYSIS: Analysis that views the money value of a land-use system for the community as a whole.

EROSION HAZARD: The risk of soil erosion occurring under specified conditions, or in a specified area. Erosion hazard may be expressed in qualitative terms (severe, moderate, slight, etc.) or quantitative terms (as predicted soil loss in tonnes per hectare per year).

GOAL: One of the major objectives of a land-use plan, defined in generalized terms, often those of policy.

FACTOR OR VARIBALE DETERMINATION: a variable, which may be a land quality, a land characteristic or a function of several land characteristics, that has an understood influence on the output from, or the required inputs to, a specified kind of land use, and which serves as a basis for assessing the suitability of a given type of land for that use. For every diagnostic criterion there will be a critical value or set of critical values which are used to define suitability class limits.

KIND OF LAND USE: this term refers to either a major kind of land use or a land utilization type , whichever is applicable; where the meaning is clear it is abbreviated to "kind of use" or "use".

LAND: an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man.

LAND ASSESSMENT/EVALUATION: the process of assessment of land performance when used for specified purposes" involving the execution and interpretation of surveys and studies of landforms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation.

LAND CHARACTERISTIC: an attribute of land that can be measured or estimated.

LAND IMPROVEMENT: an alteration in the qualities of land which improves its potential for land use (of. major land improvement, minor land improvement).

LAND QUALITY: a complex attribute of land which acts in a manner distinct from the actions of other land qualities in its influence on the suitability of land for a specified kind of use.

LAND SUITABILITY: the fitness of a given type of land for a specified kind of land use.

LAND SUITABILITY CATEGORY: a level within a land suitability classification.

LAND SUITABILITY CLASSIFICATION: an appraisal and grouping, or the process of appraisal and grouping, of specific types of land in terms of their absolute or relative suitability for a specified kind of use.

LAND UNIT: An area of land which possesses specific land characteristics and land qualities and which can be mapped.

LAND USE: The management of land to meet human needs. This includes rural land use and also urban and industrial use.

LAND USE PLAN: A coherent set of decisions about the use of land and ways to achieve the desired use. A land-use plan includes: a definition of goals; an ordering of land and human and material resources; an explicit statement of the

methods, organization, responsibilities and schedule to be used; and agreed targets.

LAND-USE PLANNING: The systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land uses It includes participation by land users, planners and decision-makers and covers educational, legal, fiscal and financial measures.

LAND USE REQUIREMENT: Land conditions necessary or desirable for the successful and sustained practice of a given land-use type. Includes crop requirements or plant growth requirements, management requirements and conservation requirements.

LAND USERS: All people who obtain their livelihood directly, either wholly or partly, from the land, e.g. farmers, foresters, pastoralists, staff of national parks.

LAND-USE TYPE: A kind of land use described in enough detail to assess its land-use requirements and to plan the necessary inputs. The amount of detail varies with the level, scale and purposes of the survey, from generalized land-use types, such as "dairy farming" or "irrigated agriculture" in reconnaissance surveys, to detailed descriptions of plants, management, inputs, etc. in more intensive surveys.

LEVELS OF LAND-USE PLANNING: The scale and intensity of a land-use plan, which may be at the national, district or local level.

LAND UTILIZATION TYPE: a kind of land use described or defined in a degree of detail greater than that of a major kind of land use (q.v.).

LIMITATION: a land quality, or its expression as a diagnostic criterion, which adversely affects the potential of land for a specified kind of use.

MAJOR LAND IMPROVEMENT: a large non-recurrent input in land improvement which causes a substantial and reasonably permanent (i.e. lasting in excess of about 10 years) change in the suitability of the land, and which cannot normally be financed or executed by an individual farmer or other land user (cf. minor land improvement).

MAJOR KIND OF LAND USE: a major subdivision of land use, such as rainfed agriculture, irrigated agriculture, grassland, forestry, recreation.

MATCHING: the process of mutual adaptation and adjustment of the descriptions of land utilization types and the increasingly known land qualities.

OBJECTIVE: A specific aim, expressing something to be achieved as part of the goals of a land-use plan.

PLANNING: The exercise of foresight, systematically examining alternative proposals for action to attain specified goals and objectives. Includes the description of the desired future state of affairs and of the actions needed to bring about this state.

POTENTIAL LAND SUITABILITY CLASSIFICATION: a land suitability classification based on the suitability of land for a given use after specified major land improvements

QUALITATIVE LAND SUITABILITY CLASSIFICATION: a land suitability classification in which the distinctions between classes are made in terms which do not meet the requirements of a quantitative land suitability classification (q.v.).

QUANTITATIVE LAND SUITABILITY CLASSIFICATION: a land suitability classification in which the distinctions between classes are defined in common numerical terms, usually economic, which permit objective comparison between classes relating to different kinds of land use.

SOCIAL ANALYSIS: The analysis of a plan in terms of its impact of different sections of the community. Social analysis gives particular attention to the interests of minority groups, women and the poor

SUSTAINED USE: continuing use of land without severe and/or permanent deterioration in the qualities of the land.

APPENDIX 2 - EXAMPLES OF LAND QUALITIES

A. LAND QUALITIES RELATED TO PRODUCTIVITY FROM CROPS OR OTHER PLANT GROWTH

- Crop yields (a resultant of many qualities listed below)
- Moisture availability
- Nutrient availability
- Oxygen availability in the root zone
- Adequacy of foothold for roots
- Conditions for germination
- Workability of the land (ease of cultivation)
- Salinity or alkalinity
- Soil toxicity
- Resistance to soil erosion
- Pests and diseases related to the land
- Flooding hazard (including frequency, periods of inundation)
- Temperature regime
- Radiation energy and photoperiod
- Climatic hazards affecting plant growth (including wind, hail, frost)
- Air humidity as affecting plant growth
- Drying periods for ripening of crops.

B. LAND QUALITIES RELATED TO DOMESTIC ANIMAL PRODUCTIVITY

- Productivity of grazing land (a resultant of many qualities listed under A.)
- Climatic hardships affecting animals
- Endemic pests and diseases
- Nutritive value of grazing land
- Toxicity of grazing land
- Resistance to degradation of vegetation
- Resistance to soil erosion under grazing conditions
- Availability of drinking water.

C. LAND QUALITIES RELATED TO FOREST PRODUCTIVITY

The qualities listed may refer to natural forests, forestry plantations, or both.

- Mean annual increments of timber species (a resultant of many qualities listed under A.)
  - Types and quantities of indigenous timber species
  - Site factors affecting establishment of young trees
  - Pests and diseases
  - Fire hazard.

APPENDIX 3 - LIST OF STAKEHOLDERS VISITED

P-LEASE TRY TO GET THE FULL NAMES FOR THE PEOPLE CONTACTED

	Name	Organization
1	Mr. Fenner Omollo	Physical Planning Department -Kisumu
2	Dr. StepheNjoka	LVEMP I Secretariat
3	Dr. Obiero Onganga	OSIENALA
4	Dr. Enock Wakhabi	KEMFRI-LVEMP Fisheries Research Component
5	Ms. Susan Imende	Fisheries Department- LVEMP Fisheries Research Component
6	Mr. Opango	LVEMP-Water Quality component
7	Mr. Oleko	LVEMP-Water Quality component
8	Mr. Masogo	LVEMP-Water Quality component
9	Mr. Muiruri	LVEMP-Water Quality component
10	Mr. Aggrey Wanjala	Mumias Sugar Company
11	Mr. Patrick Chebos	Mumias Sugar Company
12	Mr. P.Makheti	Ministry of Agriculture-Kakamega
13	Mr. Wasike	Tzoia sugar Company
14	Mr. Zephania Nyajora	LBDA
15	Mr. S.J. Ochieng	Distric Development Office -Kisumu
16	Mr. J.Maina	LVEMP-Water and Soils Conservation component
17	Mr. Patrick Mutuo	Millennium Villages Project/ICRAF
18	Dr. Markus Walsh	ICRAF-Kisumu
19	Mr. Masinde	Physical Planning Department, Nairobi
20	Mr. Agatsiva	Department of Resource Surveys and Remote Sensing
21	Mr. Ojwang	Department of Resource Surveys and Remote Sensing
22	Dr. Patrick Wergute	Department of Resource Surveys and Remote Sensing
23	Eng. Ombogo	Lake Victoria South Water Services Board
24	Mr. Katua	NEMA/LVEMP wetlands