PAPYRUS CONSERVATION AROUND LAKE NAIVASHA

Development of alternative management schemes in Kenya

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INTERNATIONAL INSTITUTE FOR GEO-INFORMATION SCIENCE AND EARTH OBSERVATION ENSCHEDE, THE NETHERLANDS

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By

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March 2002

Thesis submitted to the International Institute for Geo-information Science and Earth Observation, ITC in partial fulfilment of the requirements for the degree of Master of Science in Natural Resource Management – Planning and Co-ordination

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Abstract

Lake Naivasha is a unique freshwater body in Kenya, world famous for its high biodiversity. In particular the wetlands around Lake Naivasha are reputable for the existing papyrus swamp, significant because these species play an important role in the hydrological regime, as habitat for wildlife, and in the local economy of the area. Due to the development pressure behind the lake's fringe, conflicts between conservation and cultivation purposes occurred. The present situation in relation to papyrus conservation is significantly alarming and the difficulties that exist to reach consensus about the appropriate management of the lake, pose serious threats to the ecosystem. Under the present conditions conservation of its resources does not seem to succeed. During the last years significant initiatives from authorities in charge have been promoted to change the situation. However, current efforts seems neither to be enough nor totally effective to avoid lake resources depletion.

This study integrates RS, GIS and MCA methods in the assessment of boundary alternatives. Analysis of economic information from previous studies helped to define criteria and indicators that allow an assessment of current and potential impacts from agricultural activities and proposed alternative boundaries.

Potential loss of the net economic return from "influenced areas" was used as indicator to estimate the potential economic impact that may take place and acted as spatial component to compare different proposed riparian limits. Superimposing these limits (overlay) with current land uses allowed eventually coming up with the establishment of matching and influenced areas between both uses.

Prioritisation of sites for conservation was done as a first step to introduce a wetland management policy. Sensitivity analysis performed on selection of preferred boundary alternative for RLD, as well as for, the prioritisation of swamp sites for conservation purposes allowed simulation of variations either in the importance weights as well as in criteria effects.

Since results did not evidence significant variation, this process contributed through obtaining the most acceptable results for all the parties involved.

Acknowledgements

This research would not have been realised without the assistance and moral support of many. I am sincerely grateful to Mr. Hernán Velásquez who advised me about the necessity to improve my professional career and to the Government of The Netherlands to give me the opportunity to pursue the Master of Science course at ITC.

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Furthermore, I am grateful to life for allowing me to dream and enjoy every moment in my own way.

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GIS	Geographic Information Systems
LNRA	Lake Naivasha Riparian Association
MCA	Multi-criteria Analysis
PWC	Pair wise Comparison
RLD	Riparian Land Definition
RLM	Riparian Land Management
RS	Remote Sensing
Shs	Stakeholders

1. Introduction

1.1. Background

The need to protect biodiversity and respect the prior claims and land use practices of people who live in and around national parks and nature reserves is one of the major challenges for natural resources managers in our days.

Planning purposes on one side consider that the success to reach this approach in drafting and implementing sustainable use of resources depends on the interaction of several factors. One of the factors is the availability of information at an appropriate scale. Second is the availability of the updated information. Lastly is to say the Information Technology and Human Resources capability to support the analysis.

According to Fischer, (1999) "*sustainable decisions on use of land should be based on comprehensive and quantified assessment of potential and development possibilities of its resources, taking into account the biophysical, environmental and socio-economic factors*". Attaining sustainability is a common problem in many parts of the world. Lake Naivasha is no exception.

Lake Naivasha is a unique freshwater body in Kenya. It is world famous for its high biodiversity specially birds (more than 350 bird species). Located in a dry region it posses a fragile ecosystem. In particular the wetlands around Lake Naivasha are reputable for the existing papyrus swamp, significant because these species play an important role in the hydrological regime, as habitat for wildlife, stabilizing climate, and in the local economy of the area.

The lake supports a diversity of activities such as floriculture under intensive production, agriculture, horticulture one of the most foreign exchange earner of the country and which support more than 250000 people, commercial fishery, geothermal energy generation which provides 15% of Kenya's electricity and tourism.

Figure 1.1 Papyrus local uses

"Papyrus swamps are buffers between terrestrial and aquatic ecosystems acting as silt traps and nutrient filters conserving the quality of the water" (Gaudet, 1980). They are natural purification system, which operates without any investment.

The papyrus ecosystem acts as habitat for important live stages of animals and plants (nesting, breeding, roosting, aestivation), there are natural hide sites for a large variety of animal species, and its biological status seems to indicate the health pulse of the lake.

"Papyrus was first used by Egyptians to make paper (more than five thousand years ago)" (Bucci, 2001). Even though the cultural uses of Cyperus papyrus have not been limited to paper manufacture, this kind of riparian vegetation has also been used by locals to make wreaths, sandals, boxes,

rope, mats, as a mean of subsistence and even as building materials and fuel. Figure 1.1 shows use of papyrus as roofs.

1.2. Problem definition

Lake Naivasha has several important resources important for the environment and the local community. Unfortunately since a long time ago, several drastic human impacts have occurred around Lake Naivasha that have influenced this important ecosystem.

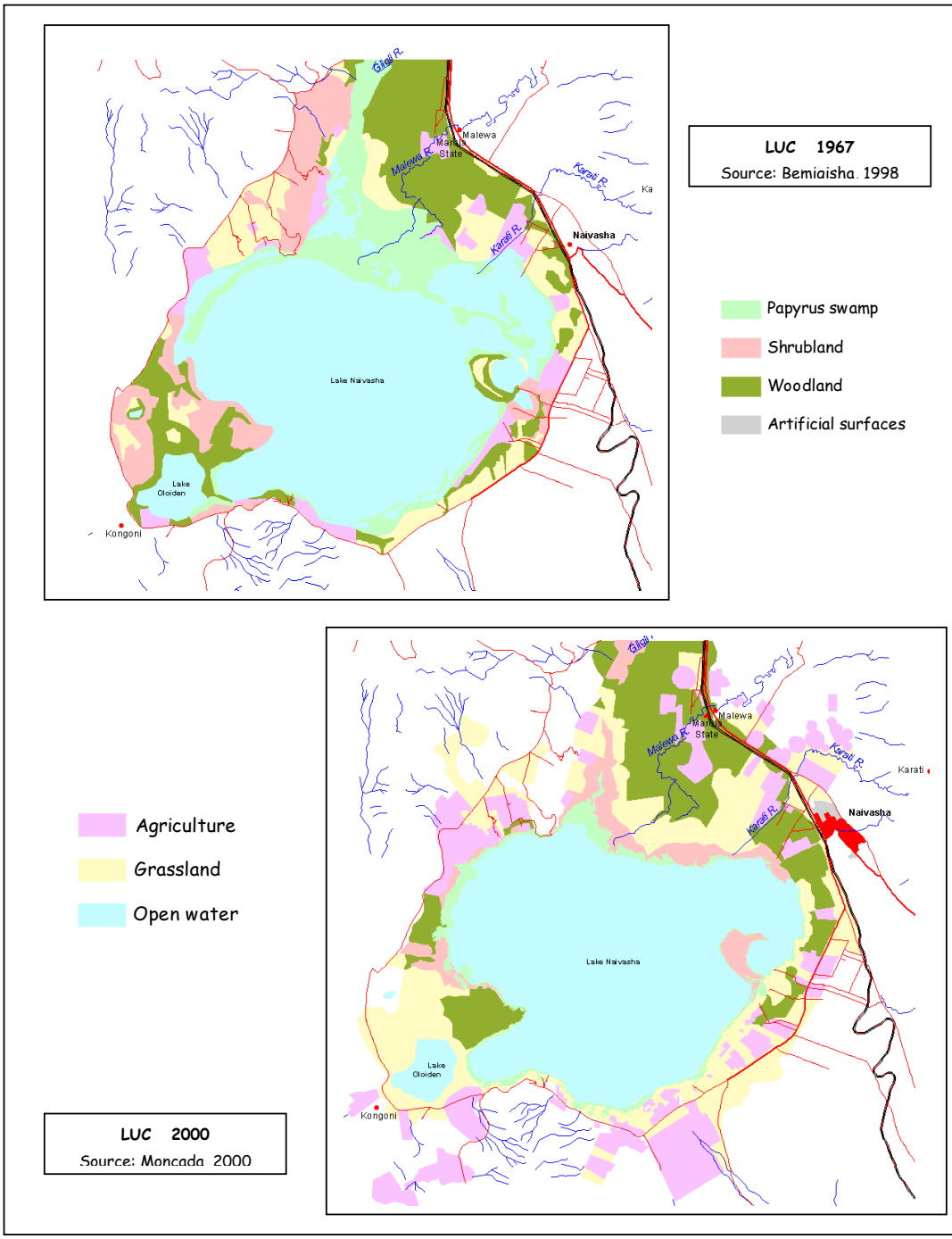


Figure 1.2 Land use cover changes from 1967 to 2000

In figure 1.2 spatial changes from 1967 to 2000 on the general land use types around the lake are shown. Significant changes at the south-western part from shrub land to grassland as well as from grassland to agriculture uses on the southern part of the lake are recognizable.

Particular changes have been registered concerning papyrus swamp area especially because it was burned to gain more land for cultivation purposes. Table 1.1 shows the changed area of papyrus swamp and the change rate from 1967 – 2000. The area of papyrus reduced from 3,652 ha in 1967 to 1,467 ha in 1984, a loss of 129 ha/year. Between 1984 and 1995 the papyrus swamp decreased with another 422 ha, a loss of 38 ha/year.

Table 1.1 Papyrus cover change between 1967 - 2000

Land cover	1967 ha	1984 ha	1995 ha	2000 ha	rate 67/84 ha/year	rate 84/95 ha/year	rate 95/00 ha/year
Papyrus swamp	3,652	1,467	1,045	1,180	-129	-38	27

Source: Bemigisha, 1998

On the contrary from 1995 to 2000 papyrus swamp increased with 135 ha, with a positive rate of change of 27 ha/year, fact that could be explained by the effect caused by El Niño phenomena occurred from November of 1997 to March of 1998 in Kenya. Nevertheless change in papyrus swamp area from 1967 to 2000 resulted in the loss of 2,472 ha, giving still a negative rate of change of 75 ha/year.

Other problems such as encroachment into unsuitable settlement locations, reduction of the water quality of the lake, land degradation due to removal of vegetation, incompatible land uses and environmental deterioration are distinguishable within the area, increasing the stressed situation. Figure 1.3 shows destruction of papyrus by clearing to give room to agricultural activities.

Figure 1.3 Papyrus swamp destruction for agricultural purposes

Management programmes for conservation areas are required when intrinsic natural resources reach significant importance, whether for its innate characteristics or because of the benefits obtained from its conservation. That is the case of Lake Naivasha, which was assigned the label "RAMSAR site[1]" in 1975 because of the international importance of their resources.

The place is influenced by particular threats and under the present conditions conservation of its resources seems not to succeed. Difficulties to reach consensus about the appropriate management of the lake, no permanent limit for riparian area exists, which leads to a progressive depletion of lake resources (including papyrus ecosystem).

In addition financial problems to solve requirements for equipment, maintenance, and monitoring and administrative duties added to the lack of qualified staff, which complicated management issues.

[1] (RAMSAR site is a wetland designated for the Ramsar list of Wetlands of International Importance especially as a Waterfowl Habitat, and also significant in terms of ecology, botany, zoology, limnology or hydrology. It is bound by the Ramsar Convention, which provides a framework for International cooperation for the conservation and sustainable/wise use of wetlands).

The following activities are considered to be inappropriate or illegal on riparian land:

- Construction of permanent structures including buildings, sewage works, septic tanks and cattle dips.
- Drainage of land for cultivation.
- Destruction of papyrus.
- Conversion of the buffer zone behind the papyrus fringe to other than its natural state.
- Intensive irrigated agriculture particularly involving the use of fertilizer or pesticides.

Fortunately during the last years some efforts have been promoted to change the situation, proposed by the Lake Naivasha Riparian Association (LNRA), a local association of people worried about the future of Lake's resources, Lake's Management Plan implementation searches to ensure that adversities can be corrected on time based on existent consensus or current legislation, long term actions undertake the establishment of regulations for papyrus conservation/restoration, and sensitive habitat areas, preserve wildlife corridors, impact of socio economic activities monitoring LNRA, (1999).

Nonetheless current efforts seems neither to be enough nor totally effective to avoid lake resources depletion.

Hence it is evident that most of the human activities around the lake have a direct connection to the quality and availability of water from the lake, which is an inherent natural function of papyrus swamp, for that reason need for Papyrus conservation is the justification of this research.

An important aim of the research will be to evaluate different boundary alternatives for riparian land, towards management of the lake resources, with particular focus on papyrus.

1.3. Aim of the Research

Under the present (2001) land use enforcement of the agreement between land private owners and authorities in charge, on the establishment of regulations for papyrus conservation/restoration, sensitive habitat areas and preserve wildlife corridors in some areas around the lake is not evident.

The aim of the research is to contribute to the protection of Lake Naivasha resources, towards the implementation of an integrated planning and environmentally sound management process. In this context, evaluation of a permanent spatial limit for Lake riparian land counts as a priority.
The Papyrus vegetation has a considerable effect on water quality, acting as a phosphate pump (McRoy et al, 1972). Therefore recommendations will be based in conservation of this resource.

In addition, development of alternatives for Riparian Land Management towards its implementation, suggests a recommendable participatory approach; consequently suggestions and recommendations will be based on stakeholders' contribution depending on legal framework limitations, constraints, organization and institutional capacities.

1.3.1. Objectives

Main Objective
To contribute to the management scheme for "P*apyrus*" ecosystem conservation.

Specific Objectives

a. To describe the structure and analyse the problems related to Papyrus around Lake Naivasha
b. To evaluate alternative boundaries for riparian land
c. To propose a management scenario for a selected alternative boundary

1.3.2. Research Questions

- What is the problem around papyrus conservation (causes and effects)?
- Who are the stakeholders and what are their concerns in the definition of the riparian zone?
- What are possible boundary alternatives for Riparian Land?
- Is there any alternative scenario that will be acceptable to all stakeholders?
- What are the criteria in the determination of possible Riparian Land alternative boundaries?
- Which areas around the lake are influenced by the proposed boundary alternatives?
- Which and where are the priority sites for riparian vegetation management within a selected alternative?
- Based on a chosen alternative boundary, what would be a possible management scenario?

1.3.3. Scope and limitation

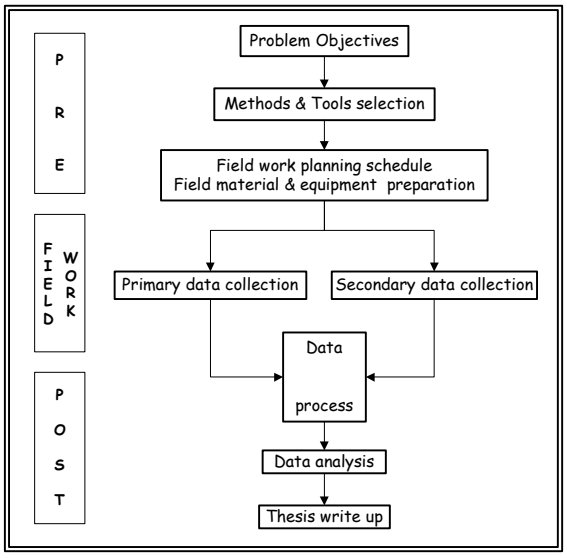


Figure 1.4 Major research phases and activities

Due to the extended scope that research on land use management might encompass and time constraints, this study had to concentrate on the conflicts between the management scheme proposed for a preferred alternative for riparian land and the Stakeholders involved in the process.

Most of the information has been generated from secondary data through literature review, expert opinions and stakeholders' interviews.

Because an updated (2001) satellite image was not available, one from May 2000 was used, even though changes in the use of the land may have occurred from one year to the other.

Due to the fact that the area of study comprised a swamp evaluation, risk of wildlife encounters and private owned lands, which in most of the cases were not directly accessible, were the main inconvenient, therefore unsupervised classification technique was selected to establish different land use types.

Illustrated in figure 1.4, the major phases and activities involved in this research encompassed problem definition and selection of techniques and tools during pre fieldwork. Fieldwork stage implied recollection of primary and secondary data towards understanding of present situation, stakeholders, priorities, concerns and attitudes towards conservation matters. Finally post field-work, covered data processing and analysis bearing in mind findings and results that may support recommendations and technical advice for current efforts displayed around papyrus ecosystem conservation.

1.3.4. Thesis outline

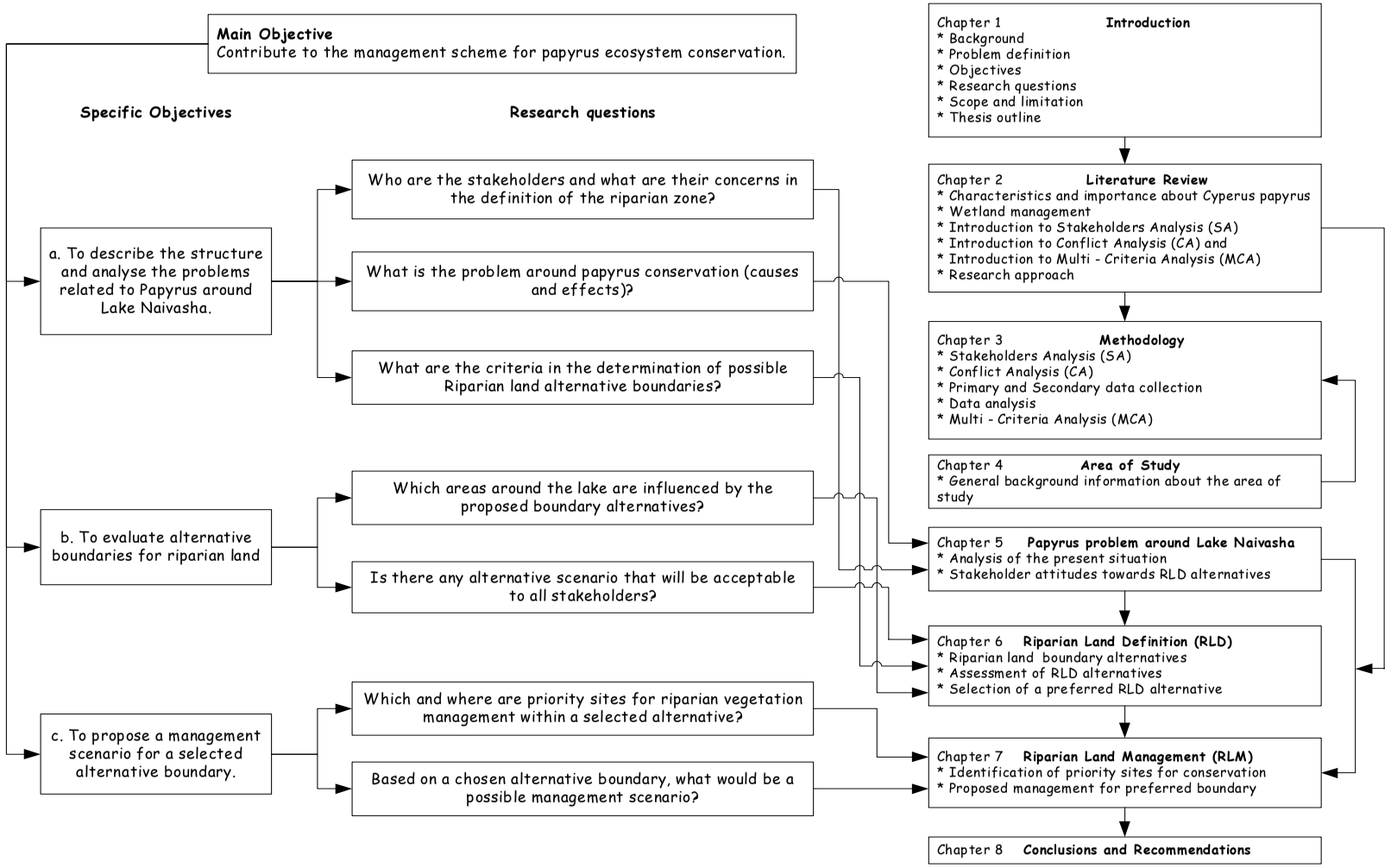


Figure 1.5 Study structure showing the relationship among objectives, research questions and chapters

2. Literature Review

This chapter will review of specialized bibliographic as well as successful management experiences from other countries in the world as guideline references for development actions focus on Cyperus papyrus swamp. Literature review tries to describe the importance of wetlands in general and papyrus characteristics in particular. Stakeholders, Conflict and Multi criteria Analyses concepts, are also discussed in this chapter, as these techniques will be used in the further analysis.

2.1. Cyperus papyrus

Particular focus on Papyrus data collection, aim for the understanding of occurrence factors and distribution of the specie for the design of RLM alternatives.

Figure 2.1 Cyperus papyrus

Characteristic	Specifications
Family	Cyperaceae (sedge family)
Common Names	Papyrus, Egyptian papyrus, bulrushes (biblical).
Location	Native to northern Africa lakes and rivers. Popular landscape plant in frost-free areas
Culture	Stems grow in great masses in shallow water and wet soils. They spread quickly and extensively. They are less enthusiastic in poorer soils and more polite about staying in bounds.
Light	More suitable in areas under sun or partial shade.
*** Moisture**	Likes wet boggy soil; they will grow in standing water.
*** Height**	Mature papyrus plants can grow to be anywhere between 3 and 15 feet tall
Width	Many are as much as 6 inches thick
Hardiness	USDA Zones 9 - 11. Papyrus is a tender perennial, but it can be grown in Zone 8. Freezing temperatures will kill the top, but the plant will recover if the roots are mulched or are under water.
Propagation	Easy to propagate by clumps division.

Source: (Floridata - Encyclopaedia of Plants and Nature, 2002)
* (Frazier. 1996)

In Lake Naivasha, *Cyperus papyrus* is one of the most common wetland plants, papyrus are relatively small areas found in some cases as floating islands around the lake, or strips of vegetation close to its shoreline. Because of the continuous fluctuation of the water lake level its presence is characterized by a not permanent location.

Importance of papyrus swamp

Particularly considering benefits on water quality, wetlands with Cyperus papyrus as the dominant vegetation stands for a "particular capacity to remove nutrients from waste water as it flows through them by either plant/microbial uptake, chemical precipitation, adsorption onto sediments, or loss into atmosphere (denitrification).

Papyrus is vital for the habitat requirements of birds and mammals. Studies shown that the highest species richness of birds in 1987 occurred in marshland, submerged macrophytes and Papyrus zones in the Lake environs (Henderson, 1988). Fish eagles as well as Hippopotamus were highest in the western and southern areas where Papyrus and natural vegetation were plenty (smart, 1998a,b) cited in (Harper, 1990)

Moreover, compared to extended conventional systems that would effectively remove nutrients, these systems are cheaper, need minimum maintenance, can be operated by non-skilled personnel and require minimum energy" (Nalubega, et al., 1995).

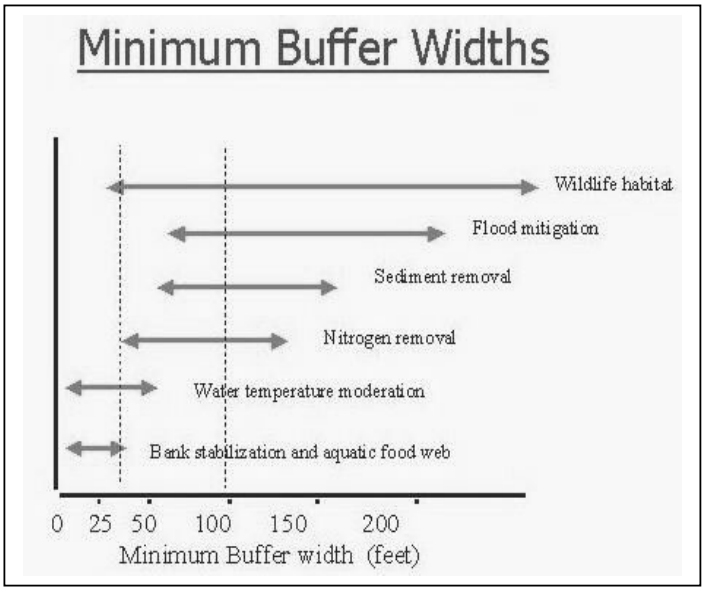
Extent literature available about wetland management issues, stressed the importance of lake swamps, among some of the most important functions and benefits that human and environment could get from *Cyperus papyrus* swamps are:

- "Conservation buffers protect soil, improve air and water quality, enhance fish and wildlife habitat, and beautify the landscape " (Conservation Technology Information Centre, 2001).
- "Wetlands slow the passage of water and encourage the deposition of nutrients and sediments carried in water.
- "Wetlands may store as much as 40% of global terrestrial carbon; peat lands and forested wetlands are particularly important carbon sinks.
- Conversion to agricultural use and destruction of wetlands will release large quantities of carbon dioxide, the gas that accounts for at least 60% of the global warming effect." (RAMSAR, 1996-2002)
- "Plants and soils in wetlands play a significant role in purifying water, removing high levels of nitrogen and phosphorous and, in some cases, removing toxic chemicals" (RAMSAR, 1996-2002)

Therefore implementation of an environmental sound management process, seems require assistance on the already stretched resources of the Lake.

2.2. Conservation Buffers

Water bodies resources management techniques includes 'Conservation buffers", which are innate measurements of nature balance sediment runoff and water quality control. This natural means located in environmentally sensitive areas can provide another line of defence to filter water both surface and shallow groundwater before it enters streams and lakes.



Conservation buffers types can be divided in: contour buffer strips, field borders, filter strips, grassed waterways, living snow fences, riparian buffers, shelterbelts/windbreaks, (grass, shrubs and trees), and wetlands.

Figure 2.2 illustrates that strategic placement of buffer strips in the landscape are able to effectively mitigate of sediment nutrients and pesticides movements within and from farm fields.

Figure 2.2 Minimum buffer widths

Benefits

Wise use of natural processes compensate disturbance to the environment. Several are repayments that conservation buffers can offer to a particular location. Benefits can be in terms of:

a. Water quality regulation

- Slow water runoff.
- Remove up to 50% or more of nutrients and pesticides in runoff.
- Remove up do 60% or more of pathogens in runoff.
- Remove up to 75% or more of sediment in runoff.
- Stabilise stream banks and reduce water temperature in stream.
- Provide a setback distance for agricultural chemical use from watercourses.
- Reduces 40% (on average) of phosphorous.
- Removes a significant amount of nitrate; stores it in plant material.
- Up to 60% of pathogens removed from runoff.

b. Water volume regulation

- Represents profitable, common sense conservation for landowners.
- Can reduce up to 80% of sediment.
- Protects soil in vulnerable areas". (Conservation Technology Information Centre, 2001)
- Reduce downstream flooding

c. Flora and fauna habitat

- Serve as a source of food, nesting cover, and shelter for wildlife.
- Establishment of natural vegetation.
- Provides a source of food, nesting cover and shelter for wildlife.
- Improves fish habitat

d. Socio-economic

- Adds visual aesthetics to the landscape.
- Improves air quality
- Reduces wind erosion.
- Often provides a source of income to local communities.
- Conservation can be use to provide tax incentives.
- Reduces crop losses from flooding.
- Reduce noise and odour.

Swamp conservation, supported in wise use of natural structures is world-wide well known, Naivasha is not the exception, papyrus swamp importance was recognised long time ago, here although papyrus protection is covered under a legal framework and even under a Governmental – Private owners' agreement its conservation had not been successful.

2.3. Stakeholder Analysis

Howard (1996) emphasises that successful development of a national policy requires that, as many stakeholders as possible of all types are able to input into what should become a consensus view. Since the interest of the present research is search for the establishment of the present situation and stakeholder attitudes towards RLD alternatives, use of several techniques in the extent set of Stake-

Stakeholder Analysis approach, seems to be an appropriate mean to evaluate the current problematic, opening the opportunity for discussion and get guidelines beyond development suggestions.

2.4. Conflict Analysis and Management

Conflicts are defined by Grimble & Wellard, (1996) as "situations of competition and potential disagreement between two or more stakeholder groups over the use of one or more scarce resources". In this context Lake Naivasha is not the exception, characterised by a variety of activities in its surroundings, by dynamic evolution of its landscape and in the last decades by continuous depletion of its resources, conflicts have been raised particularly between agricultural clearance of lake edge and ecological purposes for conservation of its resources.

Management Policy experiences in other countries also called 'strategies' which "*usually include legal and institutional arguments as well as recommendations about the treatment and the needs of research, monitoring and EIA*" (Van Bruggen, 2001), resulted in successful intents concerning resources conservation.

According to Howard, (1996) many accounts as reference events. USA has been trying to reach consensus on wetland conservation over the last two decades. Uganda has developed a National wetland policy after 5 years through discussion among governmental authority sectors and district communities' representatives, having as a goal " End existing inefficient exploitative practices in wetlands to aver to the decline in their productivity, maintain the values and functions derived from wetland resources."

A national wetland policy draft was produced in 1996 in Australia, policy goal was "The impacts of human use on those values determined as far as practicable before decisions are made, should be identified. Individual landowners and community groups should be empowered to act responsible long-term custodians of wetlands

Costa Rica has begun to develop a national strategy on wetland conservation and sustainable development. Strategy objectives pursued "generation of the appropriate tools (scientific socio-economic legal and administrative towards the adequate planning of the wetlands use and management. Tanzania is facing the opportunity to develop its own based on other experience.

Canadian Federal Government in support with the provinces territory and public have been working in order to reach " enhancement and rehabilitation of wetlands in areas where the continuing loss or degradation of wetland or their functions have reached critical levels"

Management experiences on wetland management should include legal and institutional arrangements, as well as recommendations, research monitoring and EIA. Awareness and public education about wetlands are considered essential supports to understand and appreciate wetlands values, even though first step for National wetlands policy strategy is identify those most valuable that are under threat or are likely to be under threat and take immediately action to ensure their conservation and wise management

Therefore the position of management scenarios should be aimed to working in concert with other ongoing initiatives on wetland conservation, providing practical direction, support and tools to program managers. In this context CA purpose in this research wants to assess identify priority sites for papyrus conservation as well as evaluate potential implications in the management scheme proposed for its implementation.

2.5. Multiple Criteria Analysis (MCA)

"MCA is a world of concepts, approaches and methods to help decision makers to: describe, evaluate, sort, rank, and select or reject objects" (Van den Toorn et al., 2001). MCA in this study was used to evaluated alternative boundaries for riparian land definition, as well as for prioritise sites for conservation management purposes.

Once identified and characterized the space of assessment, the next step is to know which wetlands to conserve particularly for their contents rather than what is important for conservation in general, therefore process recommendable implies selection of potential sites for management purposes.

Depending on the objective of evaluation, many may be the possibilities for site selection assessment: Cost Benefit, Explicit spatial, Implicit spatial, Non-spatial (Sharifi et al., 2001). For this research evaluation is one of the main components of the model. Evaluation of multiple criteria and indicators for site selection as well as alternatives boundaries, leads to multiple objectives interest, therefore MCA seemed to be a recommended tool for this purpose.

There are a number of methods available to define the weights and for standardizing the effect scores, which support the application of multi-criteria methods, these are: Weighted summation, Electre 2 method, Regime method, Evamix method.

2.6. Research Approach

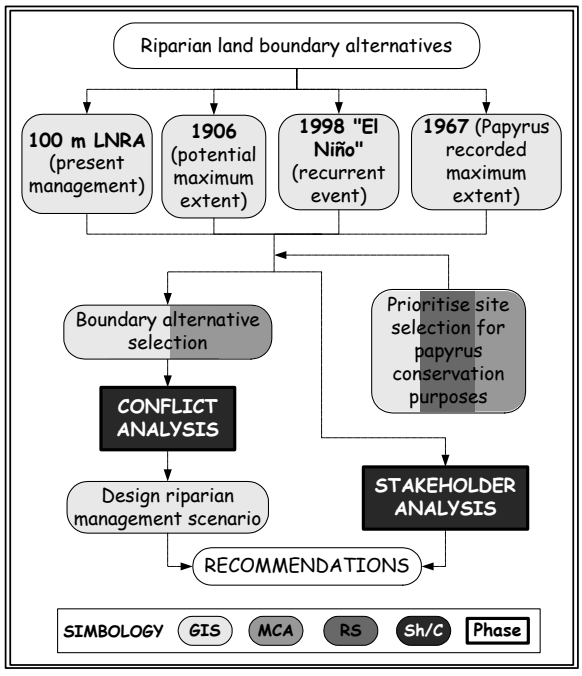


Figure 2.3 A general systematic approach on RLM

Shown in figure 2.3, the approach followed by this study is illustrated.

In this research Stakeholder and Conflict analysis as well as Remote Sensing (RS), Geographic Information Systems (GIS) and Multi-criteria Analysis (MCA) methods, were integrated, to get an entire, clear and sound understanding of the past and present uses of the land around Lake Naivasha.

Stakeholder and Conflict Analysis tools were used intending to find among four proposed limits, most suitable boundary alternative for riparian land. Possible boundaries based on stakeholders who were able to express their priorities will be evaluated according to specific criteria and indicators under two main perspectives,

In addition this study combined an approach on socio-economic and environmental criteria to develop alternative management schemes, for papyrus ecosystem conservation. Guidelines and technical advice to support further decision-making and contribution with current efforts that authorities in charge have done are expected at the end.

3. Methodologies

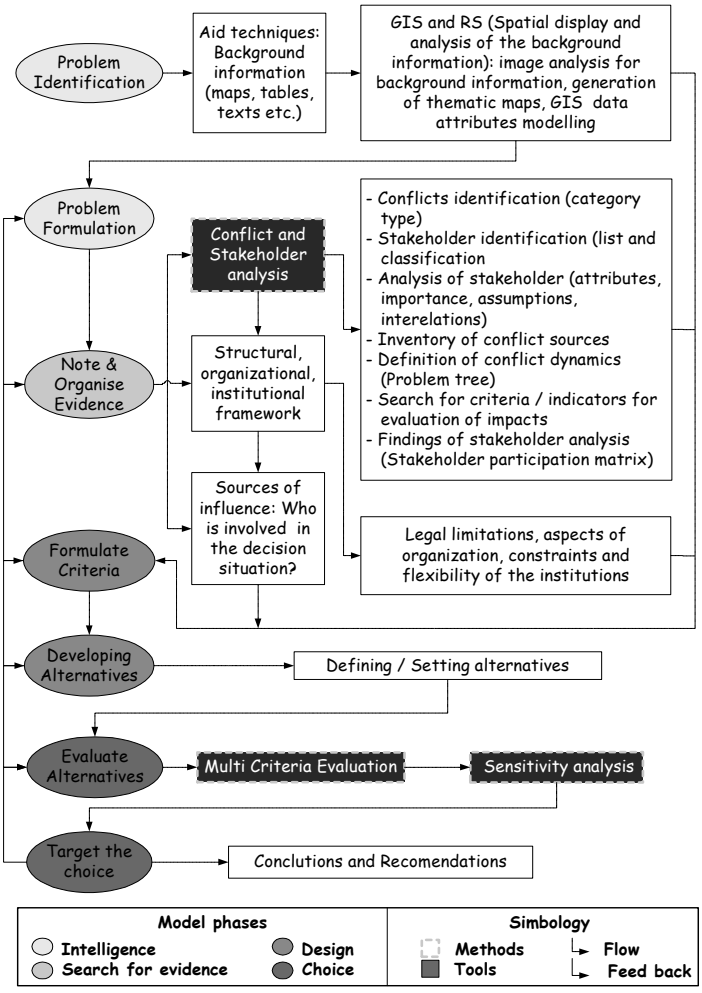


Figure 3.1 Methodology data flow
Source: adapted from (Sharifi, 2000)

Based on the problem description and the literature review around RLD, this chapter provides the study data/information requirements, methods and considerations followed by this study.

Taking into account the spatial nature of Riparian Land Management (RLM) topic, and the complexity of the relationships among the parties involved, three major categories of data requirements were identified:

- Land use cover
- Environmental considerations about RLM issue and
- Riparian Land Definition (RLD) legal and institutional framework.

Table 3.1 gives and overview of the methods, tools and requirements involved in the process

3.1. Stakeholder Analysis

Illustrated in figure 3.1, planning processes implies decision steps; since individual decisions over common interests seems not to be a big problem, when decisions have to be taken among several decision makers, potential conflicts may arise.

For that reason, on one side due to intrinsic relationships and dynamics of the issue, the role of the stakeholder is recommendable if not compulsory to be defined from the beginning. On the other hand local knowledge and particular stakeholders' position counts as important factors for further recommendations, consequently use of research techniques to acquire a real picture of the present situation, is also required.

Complexity in the identification of sources and categories of intrinsic problems and conflicts, suggests use of a combined analysis of the characteristics of the area, work meetings, and expert opin-

ion, supported on literature review, to reveal a detail analysis of the parties involved. Results on detailed stakeholder analysis are presented on chapter 5.

3.2. Conflict Analysis and Management

In planning discipline, conflict is a common phenomenon referred to in resources management often as "conflicting interests", resulting from different goals and objectives of many groups and individuals involved or influenced by their use and/or exploitation.

Lake Naivasha is not an exception, considerations about maintenance of hydrological functions, water use, storage, tenure of wetlands, bio diversity, wetland conversion, mechanism for management, inventory, awareness and public education count as essential factors to be considered.

Particular interest of this study is in understanding the conflicts present to contribute with a better control and management of the lakes' resources. In this context, since use of geo-information helps in the generation, spatial manipulation and illustration of the areas involved, combined use appears to be a powerful method for analysis of the present situation around Naivasha Lake.

3.3. Secondary data collection and processing

Description of problems related with papyrus around lake Naivasha is the first objective of this study; in order to accomplish this reason secondary data collection was the main activity regarding Pre fieldwork stage. To compile background information and set-up the spatial context of the area of study, digital information were prepared, according to:

Base information: population centres, hydrology and road network, elevation data, and administrative boundaries.

Data type	Source	Prepared by	Scale	Format
Topographic Map. Sheet Naivasha (133/2)	IPL-section ITC	Ministry of Overseas Development	1:50.000	digital
Topographic Map. Sheet Longonot (133/4)	IPL-section ITC	Ministry of Overseas Development	1:50.000	digital

Thematic information:

Data type	Source	Prepared by	Scale	Format
General LUT cover	Landsat TM 05 /2000 ITC	author	1: 250.000	digital
Semi-detailed swamp LUT cover	Landsat TM 05 /2000 ITC	author	1: 100.000	digital
Land cover map for 1967	Aerial photography 03 /1998. ITC	Bemigisha J.	1:50.000	digital
Land tenure status	02 /2000. ITC	Sayeed	1:50.000	digital

Using Arc View vs. 3.2a GIS software, basic procedures in terms of: digitising, editing and attribute linking for representation of vector data layers generated were performed.

OBJ	RESEARCH QUESTIONS	ACTIVITIES	METHOD & TOOLS	REQUIREMENTS
1	**To describe the problems related to Papyrus around Lake Naivasha.**			
	Who are the stakeholders and what are their concerns in the definition of the riparian zone?	Identify RL current users and authorities in charge	Stake Holder Analysis Literature review, expert opinion.	Personal interview
	What is the problem around papyrus conservation (causes and effects)?	Elaborate Problem Tree approach		Semi-structured research questionnaires.
	What are the criteria in the determination of possible Riparian Land boundary alternatives?	Update & verify secondary information Conduct primary information collection to specialised agencies & technical organisations	Fieldwork ground truth survey Personal interview Rapid Rural Appraisal (RRA)	Secondary & Primary data, GPS and Semi-structured research questionnaires.
		Conduct inquiring survey to official institutions in charge around RLM issues and lake users		Semi-structured research questionnaires.
2	**To evaluate riparian land alternative boundaries.**			
	Which areas around the lake are influenced by the proposed boundary alternatives?	Collect and generate: Base and Land tenancy data	GIS processing	GIS software
		Perform TM Landsat Image interpretation.	Un supervised RS image classification.	
		Perform lake swamp vegetation un supervised classification		
		Generation of RLD boundary alternatives	Digitising, cover edition, table attribute links and map production	GIS software,
		Cover overlay.	GIS process	
	What are the criteria in the determination of possible Riparian land boundary alternatives?	Establish criteria for the evaluation of RL boundary alternatives?	Literature review, RRA, (expert opinion)	Semi-structured research questionnaires.
	What are the implications in the adoption of the proposed alternatives?	Perform evaluation of boundary alternatives	Multi Criteria Analysis (MCA)	DEFINITE software GIS software,
	Is there any alternative scenario that will be acceptable to all stakeholders?	Select preferred boundary alternative	Sensitivity analysis	
3	**To propose a management scenario for selected alternative boundary**			
	Which and where are the priority sites for riparian vegetation management within a selected alternative?	Identify papyrus units	GIS process	DEFINITE software GIS software,
		Prioritise papyrus sites for habitat conservation	(MCA) Sensitivity analysis	
	Based on a chosen alternative boundary, what would be a possi-	Define policy for management scenario for selected alternative boundary	Social and Economic Appraisal (SIA) b) Environmental Impact Appraisal (EIA)	Literature review, expert opinion

Table 3.1 Overview of the methods, tools and requirements followed by this study involved in the Riparian Land Definition process

Satellite image interpretation

Combining image bands for enhancement of its features, a false colour composite combination was produced with two purposes. First supported on visual interpretation a general idea about the context of the area was established and second a more detailed overview about the land use cover of the shoreline vegetation.

a. General LUT cover identification

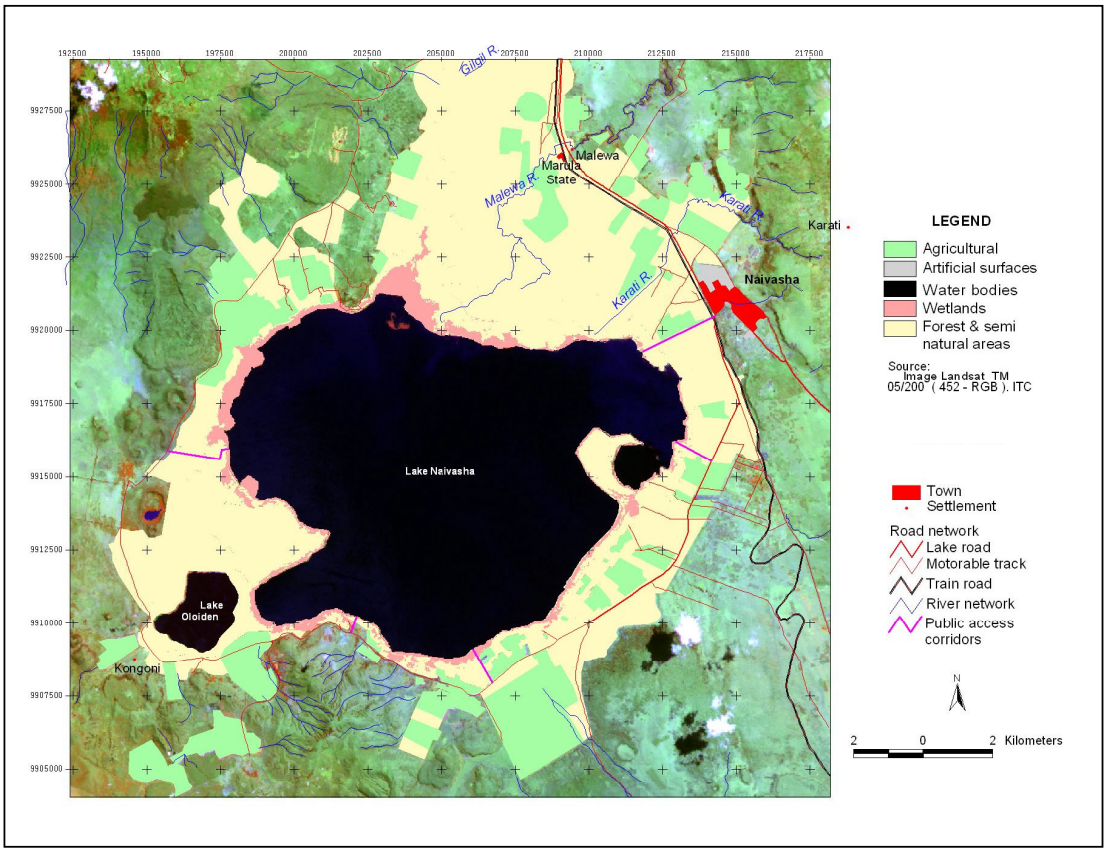


Figure 3.2 General land use cover type

452 (RGB), band combination, shown in figure 3.2, was used concerning the establishment of general land uses of the area, a tentative map was generated based on the *CORINE*[2] *land cover nomenclature,* which consider at level 1 five categories. Table 3.2 list the area and description of the LUT identified.

Table 3.2 Area and description of 2000 general land use types in Naivasha

Land use type	Area (ha)	Description
Agriculture	5,041	Includes, orchard, vegetables, alfalfa and flower crops
Artificial surfaces	2,367	Includes, residential areas
Forest & semi-natural areas	13,786	Includes, Natural areas, shavana, shrub, grass and natural grass
Water bodies	13,086	Includes, Lake Naivasha and Oloidien
Wetlands	1,180	Includes, papyrus, macrophytes

[2] Coordination of information on the environment, European Environmental Agency

Area: Area coverage per class was obtained using "raster attributes" display menu. Visual interpretation and further ground truth control supported by geographic position system (GPS) readings were used for the final legend identification.

b. Shoreline land use cover identification

Using Landsat TM, discrimination between soil and water is particular characteristic of band 7, which occupies the distant infrared portion of the electromagnetic spectrum. On the other hand use of bands in the visible fraction (bands 2, 1) allows water penetration detailing turbidity and signs of sedimentation.

For this reason histogram equalization on 721-(RGB) band combination, shown in figure 3.3, resulted to offer significant assistance on the establishment of semi-detailed land uses of the area.

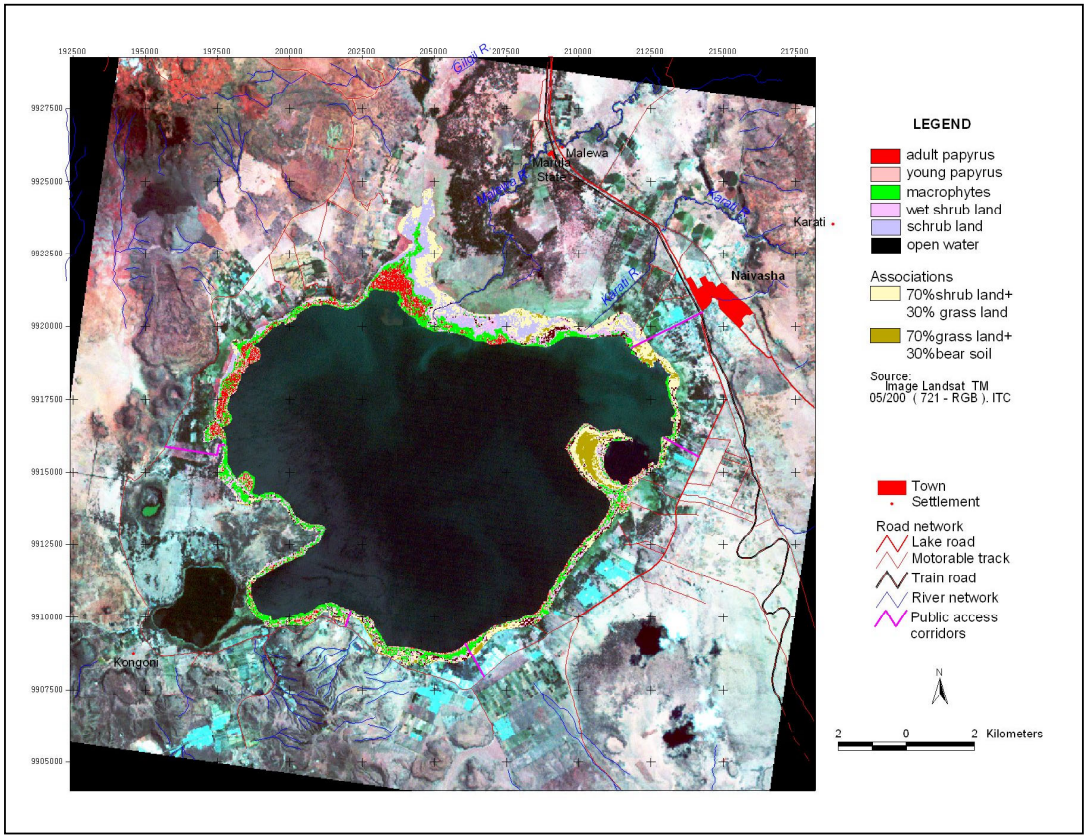


Figure 3.3 Semi-detailed swamp vegetation land use type cover

Table 3.3 Riparian vegetation cover classes

Class land cover	Area (ha)
Adult papyrus	249.7
Young papyrus	278.7
Macrophytes (Low riparian vegetation)	670.3
Wet shrub land	341.7
Shrub land	394
Open water	12613
Assoc. 70% grass land + 30% shrub land	654.7
Assoc. 30% bear soil + 70%grass	143.4

Using "Unsupervised classification (Isodata)" function under the "Classifier Module" over a TM LANDSAT satellite image of ERDAS Imagine (vs. 8.3.4), image-process run for the identification of 15 classes, using 10 iterations, resulted in 8 classes eventually defined.

Complementary field verification, which included a boat reconnaissance trip around the lake facing its shoreline, was performed for verification of physical characteristics of classes identified. Table 3.3 list the area and description of the land uses identified.

3.4. Primary data collection and processing

Purpose of primary data collection was:

- To update and verify primary information prepared, using ground truth survey,
  Supported with Global Position System (GPS) measurements, programmed field trips were executed along and around the area of study, to characterise information got from the unsupervised image classification in terms of: land use type, and ownership status.

- To conduct secondary information collection at specialised agencies and technical organisations. Local identification and personal visit to particular institutions in charge of the present management of the area was executed. Using questionnaires specially prepared for interviewing "authorities", in a Rapid Rural Appraisal (RRA), interviews were conducted to identify technical criteria and specialised advice for further considerations in the determination of RLM alternatives.

- To establish the present social, environmental and legal situation about the problem, considering stakeholder attitudes towards RLM alternatives. Semi-structured research questionnaires were designed for identify keys of explanation about three main interests: present situation, current legal status enforcement and for evidence Shs' attitudes towards RLM alternatives. (see appendix I).

Field material and equipment was organised and prepared before fieldwork phase. According to the ITC MSc program, fieldwork period took place for five weeks from 11 of September to 12 of October of 2001. Once in the field personal interviews and meeting workshops were arranged to discuss about the RLD issue. Field material such as hard copy thematic maps and points rose in the prepared questionnaires, helped interviewees to feel familiar with the topics in discussion.

Information links identified from the selected key informants were incorporated as further visits, complementary to the preliminary list scheduled.

3.5. Data analysis

Once data is available, effects of the alternatives for evaluation can be entered into the effects table. Therefore since the scores for the criteria have different units of measurement either qualitative or quantitative form. For criteria comparison purposes value normalization or standardization is required, this was done by quantitative ratio scale before the evaluation process.

a. Quantitative ratio measurement scale

In ratio scale the importance of an effect measured on a ratio scale is proportional to its value (Janssen, 2000). It takes the form:

$$\text{Standard score (i)} = \text{raw score (i)} / \text{row maximum} \qquad \text{(Eq. 3.1)}$$

Where: The standard score is the new criterion score standardized,
The raw score is the criterion score before the standardization,
The row maximum is the maximum criterion score by the same row

3.6. Multi criteria Analysis (MCA)

"MCA is a world of concepts, approaches and methods to help decision makers to: describe, evaluate, sort, rank, and select or reject objects" (Van den Toorn et al., 2001). The process at this stage involves criteria effect scores weighting and ranking for generated sites. Using DEFINITE software criteria were evaluated using the 'Weighted summation method' to define and standardise score effects.

3.6.1. Weighted Summation method

Weighted summation method allows compensation, which means low scoring of a particular indicator can be compensated by another with a better score. Compensatory decision rule searches for the best combination among all considered criteria for the final selection, this method requires standardizing all effect scores as a first step.

3.6.2. Standardization

Scores from the various effects can only be compared if the measurement units are the same. Through the standardization procedure the measurement units are made uniform, and the scores lose their dimension along with their measurement unit (Janssen et al., 2000). Since objective is to maximize the production or benefit as well as to minimize the negative impact or cost Maximum standardization was selected as standardization method.

Maximum standardization:
The scores are standardized with a linear function between 0 and the highest absolute score. For a benefit effect the absolute highest score is indicated with 1, for a cost effect this is 0 (Janssen et al., 2000). It takes the form:

Benefit effect:	$\frac{\text{score}}{\text{highest score}}$	(Eq. 3.2)
Cost effect:	$\frac{1 + \text{score}}{\text{highest score}}$	(Eq. 3.3)

3.6.3. Criteria Weighting

Criteria weighting is based on the importance attributed to each criterion. Because priorities assigned to each criterion are better reflected, through direct specification of importance among all individual criteria possibilities, Pair wise comparison was selected as weighting method.

3.6.4. Pair Wise Comparison (PWC)

Also known as the Analytical Hierarchy Process (AHP). The method converts comparisons of all pairs of effects to quantitative weights for all effects (Janssen et al., 2000). Table shows the values obtained from the comparison.

A standardized effects table, meaning a table with mutual comparable scores. An appraisal score is then calculated for each alternative by first multiplying the standardized effect scores by its appropriate weight, followed by summing the weighted scores of all effects (Janssen et al., 2000). It takes the form of:

$$R_n = \Sigma a_i b_i \quad \text{(Eq. 3.4)}$$

Where: R_n: alternative ranking
a_i: standardized effect score
b_i: criteria weight

3.6.5. Ranking of alternatives

This procedure displays the results of the multi-criteria analysis. Normally the result is presented graphically with a simple bar graph. On the X-axis are all alternatives, and on the Y-axis the value of the ranking. When a quantitative method has been applied, values are used, and when a qualitative method has been applied rank numbers are used. The bar length indicates preference for the alternative. The higher the bar, the better the alternative.

4. Study area

This chapter provides general background information about the area of study in terms of location, social and legal profile, history, and physic characteristics of Naivasha.

4.1. Location

The research area lies between 36° 14' 12.15" E and 36° 28' 05.35" E longitude, and 0° 38' 21.48" S and 0° 52' 03.72" S latitude, and covers an area of about 652 Km^2. The study area is located in the south eastern part of Lake Naivasha catchments, at an altitude of 2100 masl Kijabe Hill (2669 masl), is located to the northwest and Kikuyu Escarpment Forest to the east. Administratively the area is a part of Naivasha Division of Nakuru District in the central Rift Valley Province of Kenya.

Lake Naivasha is situated 80 km south of the Equator and 100 km northwest of Nairobi, the capital of Kenya, in the bottom of the Eastern Rift Valley and "in the middle of three major centres of geo-thermal activity" Goldson, (1993).

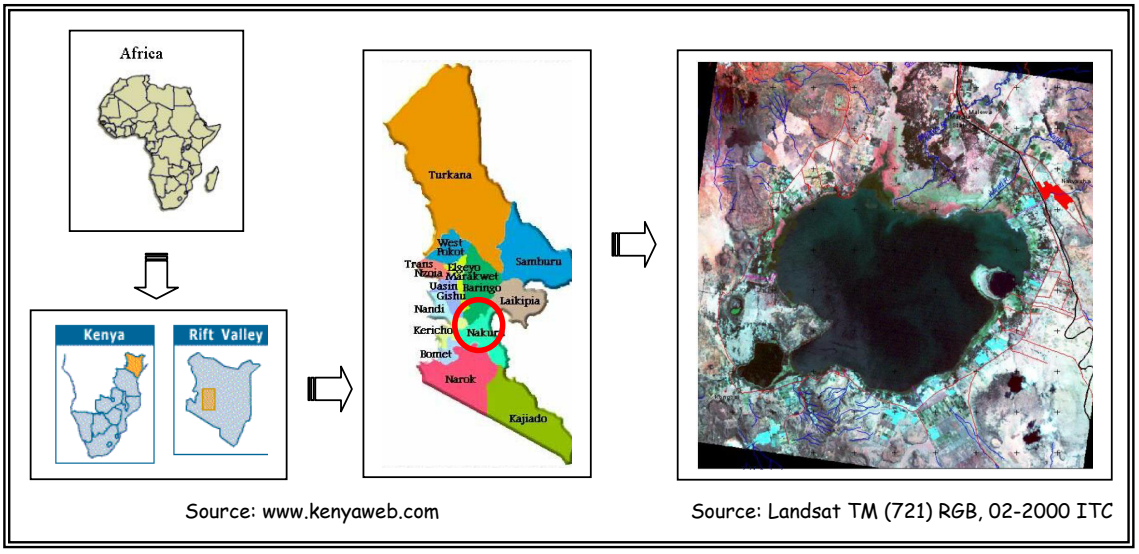


Figure 4.1 Area study location

Because of the nature of its recharge the lake is characterized for retain the highest and freshest water in an area of alkaline lakes. The lake is well known as a bird watching site. Having rivers Malewa or Morendat, Gilgil (contributes 90% flow to the lake Goldson, (1993), and Karati, as main catchment's tributaries of its basin, the lake has shown changes in depth area and volume with a general trend downwards of these two parameters (see figure 4.3)

4.2. Social Profile

Naivasha is an administrative Division of Nakuru District within Kenya. Last population Census was performed in 1999, although updated local level data is not available yet. According to 1979 source at this date, Naivasha population was under 100.000. Based on a 3.5 population growth rate population should now (2001) be around 250.000.

4.3. History of the area

Figure 4.2. Diversity LUT in the area

According with (Nilsson, 1932) "from 12000 to 9500 BC, the lake was much larger than today and Nakuru, Elementeita and Naivasha were one big lake with an area of 612 km^2. The level of the lake at that time was estimated in to be 1930 m above sea level, 130 m above the present level."

At least 10.000 years ago with an approximate area of 400 Km2, the lake size remained large, after that period the lake dried out and remained so for hundred years, since that date the lake has become progressively smaller. People have lived round the lake since that long time ago. The Maassai people migrated from the north during the 16^{th} and 17^{th} centuries increasing connections with the lake surroundings. For the coming centuries these people basically Pastoralists through nomadic trends occupied the area grazing the land and watering their stock on the lake Goldson, (1993).

Changes in land use pattern occurred due to the arrival of sedentary farming and ranching given room to intensive irrigation, land subdivisions, intensive use of agrochemicals and deforestation, in addition stressed with an increasing population growth. Figure 4.2 illustrates the surrounding agricultural landscape, with Lake Nivasha in the bottom.

4.4. Physical Lake characteristics

Table 4.1 Water bodies characteristics

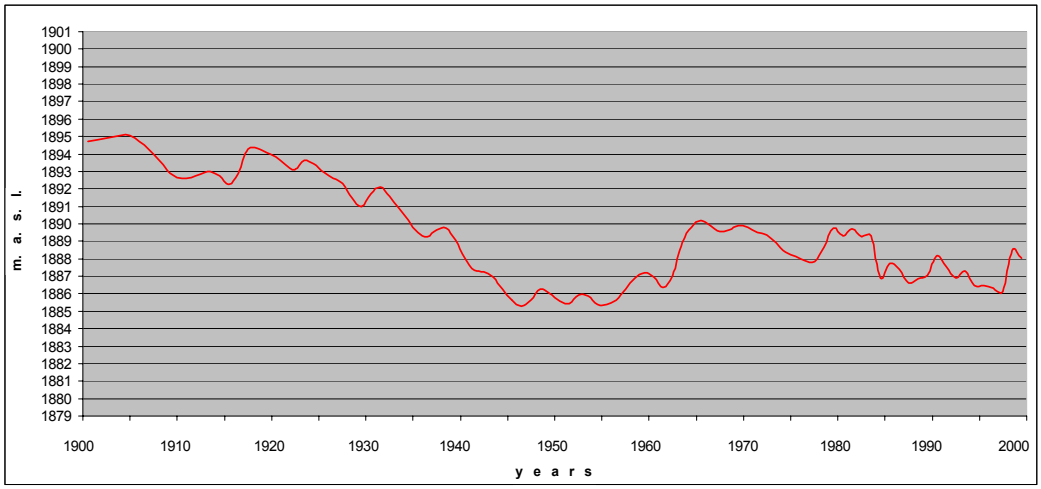
Water body	* Area (Km^2)	* Volume ($m^3 \times 10^6$)	Mean depth (m)	Maximum depth (m)
Lake Naivasha	145	680	4.7	7.3
Basin	2.1	23	11.0	17.0
Oloiden	5.5	31	5.6	6.1
Sonachi	0.6	0.62	3.8	6.1
Crescent Island				

(* Area and volume will depend on the lake level) Source: Melack (1976) cited in Goldson, (1993)

Because of a shallow slope of the lake shoreline, Naivasha presents a dynamic variation of its shoreline level, which makes more and more difficult for lake management bearing in mind conservation purposes; table 4.1 illustrates some of the characteristics of the four water bodies.

Since the past, continuous changes in Lake's surroundings had been evidenced. Figure 4.3 shows a record of water lake level fluctuations during the last century. From the figure a general decline to a low point of 1,885 masl, in the decade 1945 – 55 stands for the minimum level recorded; around 13 m at Crescent Island with an area of 100 km^2 (Harper et al., 1990). This was followed for a rapid increase in the water level until approximately 1890 masl, maintained for almost 8 years, but declined again of 2-3 m in the latest 1970s.

In 1979 the level just increased in almost a couple of meters retained for the next fourth years (1980-84), from that time onwards in general the water level dropped with few exceptions. A significant increase was recorded at the last "El Niño" phenomena, occurred from November 1997 to march of 1998 in Kenya.



Source: Copy by Becht-ITC from lake_ll.xls June 2000

Figure 4.3 Water lake level fluctuations form 1900 to 2000

Climate in general has a direct influence in most of the physical characteristics of the area. However particularly rainfall does not count as one of the major contributors of lake recharge. Average annual rainfall is about 627 mm/year (Ataya, 2000).

Due to the fact that getting permission for water abstraction either directly from the lake or from boreholes is not a difficult, Lake Naivasha freshwater resources have been used for many purposes: water supply, irrigation, industry, fishery and tourism.

Table 4.2 Area study location

Uses	Water extraction (m^3 per year)
Agricultural	35×10^6
Geothermal power	15.2×10^6
Domestic	0.6×10^6
Flood flow	21×10^6
Total	**71.8×10^6**

Source: different sources cited in Goldson, (1993)

Table 4.2 illustrates an estimation of the amount of water abstraction of the main uses around the area. (Svaren, 1969) cited in Goldson, (1993), reported by the Chief Hydrologist in the Water Development Department in 1984 indicated that the safe yield of the lake was in the region of 16.5 x 10^6 m^3 per annum", which is very far in comparison with the volume of 71.8 x 10^6 m^3 per annum reached during the last years, presented in table 4.3.

Water quality is one of the most important aspects in Lake resources management, because of most if not all of those activities around the lake take place supported in this resource. Local water treatment station has been abandoned since a long time ago, for that reason sewage water without any treatment finds its final way directly in the lake, declining the situation. Figure 4.4 shows water swage treatment plant current situation.

Figure 4.4 Naivasha water treatment station

In addition polluted water also reaches the lake through their main taking flows, whether on or under ground paths. 30 – 90% of chemicals applied to crops end up in the soil. (Harper, 1988) cited in Goldson, (1993) mentioned that the majority of growers in the area have been using acceptable chemicals, but not all growers are willing to discuss this subject.

5. Problems around Lake Naivasha related to papyrus

This chapter deals with the identification of the parties involved in riparian land definition as well as riparian land management matters. This section also describes the main problems found around this issue. Finally generation of a schematic representation of the problems is presented.

5.1. The Lake Naivasha Management Plan

Proposed by Lake Naivasha Riparian Association (LNRA), a local association of people worried about the future of Lake's resources and currently in charge of its custody, the Management Plan of the Lake was signed on May of 1995, and at the present time is in its implementation phase.

Management Plan implementation searches to ensure that adversities can be corrected on time based on existent consensus or current legislation, long term actions undertake the establishment of regulations for papyrus conservation/restoration, and sensitive habitat areas, preserve wildlife corridors, impact of socio economic activities monitoring. Monitoring programme per se seeks out information to establish reasons for changes in the Lake and environs and monitoring parameters about lake water quality and catchment's activities.

As a prime objective the Management Plan, has "to manage the existing human activities in the lake ecosystem, through voluntarily adopted sustainable wise use principles to ensure the conservation of the fresh water resource" (Goldson, 1993). Particular wetland conservation long and short-term measures include:

- Maintain and where necessary restore to a natural state minimum of 100 m (formerly 50 m) buffer zone on landside of the Papyrus edge or from the shoreline where no papyrus exists.
- To improve the standard living of the people through regional development and economic growth, while conserving biological diversity.
- Disallow the reclaiming of flooded land, intensive irrigated agriculture, and building of permanent structures below the Lake level in 1906 (1,893.3 masl).
- To restore the ecological character of the Lake and its environs where appropriate.
- "Destruction of papyrus and conversion of the buffer zone behind the papyrus fringe from other than its natural state, among others is considered inappropriate or illegal activities on riparian land" (Goldson, 1993).

To ensure Lake's ecosystem conservation and manage the existing human activities, in 1931 Kenya's Government granted the land fringing Lake Naivasha (riparian land) to the adjacent landowners for conservation, LNRA was given authority through an arbitration agreement of December 1931 to settle riparian land disputes.

Even though policies for riparian catchments' resources development and conservation are assumed common among the various organisations involved in the utilisation and management of the lake, under the present conditions this seems to be neither enough nor fully achieved.

5.2. Stakeholder Analysis (SA)

5.2.1. Stakeholders identification

During and after colonial times, agricultural interests over land were established as the main purposes of human presence around Lake Naivasha, hence land use pattern has changed over the years with the arrival of sedentary farming and ranching.

At the present time geothermal energy generation, floriculture/agriculture, commercial fishery, tourism, among other activities count as current activities in the area. Pastoral activities have given way to intensive irrigated farming, land subdivisions, intensive use of agrochemicals, deforestation and growth of Naivasha township, all of which adversely influence the ecosystem even tough their benefits in development terms are obvious. Figure 5.1 shows livestock watering one the economic activities in place.

Figure 5.1 Maassais' livestock watering

Analysis of the parties involved in the problem resulted in the identification of thirteen stakeholders concerned with the management of Lake resources.

Ministry of Environment (ME)
Is responsible for sustainable development based on guidelines for environmental conservation and management, including promotions of local communities, based management and establishment of local resource management groups. Main activities include:

- "Promotion and interpretation of environmental policies, plans, programmes and projects
- Ensuring rational utilization of the nation's natural resources on a wise use basis
- Coordinating, initiating and formulating of policies on conservation, protection and environment
- Assessing and mitigating environmental impacts of development activities
- Promoting proper land use practices
- Monitoring the nation's resource base and preparation of periodic reports on the state of the environment" (LNRA, 1999)

Kenya Wild Life Service (KWS)
KWS is one of the only active nature conservation organizations and responsible for promoting sustainable tourism in the area. Functions includes:

- Train wardens and foresters, to manage national Parks on different levels
- Managing human-animal conflicts (wild animals eat the harvest or danger of human by wild animals)

Lake Naivasha Riparian Association (LNRA),
Currently with more than 100 members, "LNRA is represented in the District Development Committee DDC, the forum for District development Focus Strategy and also in the Commissioner's Lake Naivasha Environmental Committee LNEC. Among others, its activities includes the preservation of a clean, pollution free body of water, supporting the bio-control of *Salvinia molesta*, through voluntary code of practice of its members, which comprise:

- Support for drip irrigation as opposed to overhead irrigation
- The banning of buns to push back the lake to allows the cultivation of extra land.
- The leaving at least a 50 m buffer zone of natural vegetation between the open lake and the beginning of cultivation
- The protection of papyrus" (LNRA, 1999)

ELSAMERE

ELSAMERE Conservation Centre is an active nature conservation organization. Their main activities are concerned with LNRA, (1999):

- Data collection for research and environmental education
- Witness, awareness and monitoring of health lake resources status
- Technical advice on management policies design

Kenya Marine & Fisheries Research Institute (KMFRI)

"The fisheries office falls under the ministry of Fisheries and Wildlife, their role is the commercial fishery, aquaculture and sport fishing in Nakuru district. As main objective the Institute has to conserve the fishery resources and regulate its exploitation" (LNRA, 1999). According with code of conduct of the fishery sector, they are supposed to:

- Research and designate and protect fish breeding areas in the lake,
- Continuously monitoring the fish catch and riparian shoreline
- Record and process catch stock data for yield prediction
- Issue new and renew fishing permits on annual basis
- Awareness, training and education of local community in environmental issues

"The office has full powers to arrest on their own or in conjunction with the police and Game Department" (LNRA, 1999)

Kenya Agricultural Research Institute (KARI)

Established since 1903 with support of the Deutsch Government, is part of 33 centres in Kenya, the institute focus their activities in:

- Research in agricultural issues
- Production and marketing of livestock for local consumption
- Training community support

Big, medium and small farmers

These parties involved large-scale agricultural fields occupied for floriculture production, as well as medium and small extensions for horticulture. Fruits vegetables and flowers are grown for local and export market; this activity with an irrigated extent under production over 10,000 ha employs some 30.000 people (Abiya, 1996). Other agricultural activities encompass livestock and fishery tasks.

Municipal Council

With approximately 200.000 inhabitants Naivasha town increased rapidly, with a 3.5 % population growth rate, is national 3rd in earning income for the Government of Kenya. Laszlo, (1997) Monitoring and provision of community services count as their main activities concern.

Pastoralists

There are 20.000 Pastoralists potential users of the lake in Narok and Nakuru districts. They are Maasais that still practices traditional customs and religion. During the 16th and 17th centuries the

Maassai people migrated from the north and from then on they had an increasing connection with the lake and its surroundings.

Pastoralists occupied the area from the 18th century grazing the land and watering their stock on the lake Goldson, (1993). Their main activity is animal husbandry, they keep cows, goats and sheep, and they don't stay permanently at one place but constantly move according to available green pastures.

Hotel and lodges campsites
Well structured as commercial chains, Resort concerns their main activities on marketing of tourist services (boating, bird watching, boat riding, excursion, etc) based on the pictorial and scenic value of the lake resources. Tourism activities include boating, water-skiing, sport fishing, game viewing and bird watching.

Illegal resource users
According to 200-300 poachers use the Lake, in average about 30-40 poachers catch as many fish as possible every day. Associated activities with poaching are:

- Use of undersize-nets (prohibited)
- Distributing and transporting the poached fish
- Trading in fish which is illegally obtained (poached)

The Kenya Electricity Generating Company Limited (Ken Gen)
In 1972 the East-African Power and Lighting Company (later KPC, nowadays Ken Gen) started exploiting geothermal energy by drilling, as a relatively cheap source of energy. Ken Gen pumps a great amount of water from the lake for industrial and domestic uses. "Is supposed to use environmental friendly technology, ensuring waters saving (reuse and recycling) and cutting pollution" (Laszlo, 1997). Ken Gen's code of conduct takes into account "to foster responsible and safe geothermal energy exploitation practices with due regard to the interests of the community and the environment…"(LNRA, 1998)

Lake Naivasha Growers Group (LNGG)
Formed independently from LNRA since 1995, they are big intensive flower growers, producing flowers and seeds for the world market, "although big amounts of agrochemicals and water are used, they consider serious efforts to protect the environment, due to restrict standards for production of European consumers" (Laszlo, 1997)

LNGG put especial emphasis on the pesticide policy, introducing environmentally friendly technologies (Laszlo, 1997). LNGG's aim code of conduct encompass, "to foster responsible and safe horticultural/agricultural practices with due regard for the interests of the community and the environment. Particularly to control those activities which have any detrimental effect on the integrity of the Lake and its environs" LNRA, (1999)

5.2.2. Stakeholders definition

SA was used to process and analyse data collected in fieldwork. A total of 15 interviews were completed, appendix II, lists the parties interviewed. Using a spreadsheet format data was ordered and classified (questionnaire tabulation). Preliminary identification of Shs as "users" and "authorities", allowed further interpretation.

To convert data to information, among all the interviews the most common answers were firstly identified in order to get a clear understanding of current situation and to set the background information required for establish criteria for riparian land definition (RLD) evaluation and design of alternatives for riparian land management (RLM). Data arrangement is shown in appendix III.

Table 5.1 lists Shs' definition. Among them differentiation by colour and letters permitted three ways to categorize their attributes, as follows:

- **By institution:** Based on the activities (institutional mission) of their nature association, Shs' identification by institution permitted appreciates parties involved.
- **By action type:** This means of identification evidences opinion among the parties concerned. Identification by action type (authority, user and others) was the preliminary categorization attached to Shs identified before fieldwork. From field inputs and after fieldwork inclusion of a third category "others" opinion from Consultants and Particular Organizations was incorporated.
- **By interest:** Shs' categorization by interest makes reference to main priorities, interests and objectives of the institutions that they represent (see also table 5.4).

Table 5.1 Stakeholders cluster identification

		Categorized by		
#	Occupation / Institution	Institution	Action type	Interest
1	Small farmer	A	user	A
2	Brixia farm (owner)	A	user	A
3	Loldia farm (administrator)	A	user	A
4	Marula farm (administrator)	A	user	A
5	Honourable Secretary, LNRA	B	authority	B
6	Senior Fisheries Officer, KWS, Naivasha	C	authority	B
7	ELSAMERE Conservation Centre, Biologist	D	authority	B
8	Manager Assistant, Lake Naivasha Country Club	E	user	A
9	Naivasha Municipal Council (Water Maintenance Officer)	F	user	C
10	Kenya Agricultural Research Institute (KARI)	G	user	C
11	Ministry of Environment. Water Resources Department	H	authority	B
12	Indigenous Biodiversity Environmental Conservation Assoc.	I	others	C
13	Naivasha Municipal Council (Planner Town engineer)	F	others	C
14	Chairman LNRA	B	authority	B
15	Naivasha Municipal Council (Water Project Consulter)	F	others	C
16	Kenya Marine & Fisheries Research Institute	C	authority	B
17	Environmental Officer LNRA	B	authority	B

Table 5.2 Stakeholders definition

	Clustered by	Category			
ID	Action type	Affect	Affected	Directly	Indirectly
1	user		+		X
2	user		+/-	X	
3	user		+/-	X	
4	user		+/-	X	
5	authority	+		X	
6	authority	+			X
7	authority	+			
8	user		-	X	
9	user		+		X
10	user	?			
11	authority	+			
12	others	+			
13	others	+			
14	authority	+			
15	others	+			
16	authority	+			
17	authority	+			

Considering Shs' action type, table 5.2, shows identification in three clusters: users, authorities and others Shs. It also allows categorization in terms of: "those who affect (determine) a decision or action and those affected by this decision (whether positively or negatively)" (Verplanke, 2000).

In this case, in terms of the implications that proposed management scheme will cause from and over the parties involved.

+ / - Symbology used, evidence Shs' benefits labelled with "+" or suffers identified with "-" from proposed RLM issue, respectively.

For this analysis "Impact" is defined as an action performed to produce an effect, influence or change upon. In this case the positive or negative result on the environment as a contribution for papyrus ecosystem conservation.

In this context "authorities" and "others" Shs play the role of policy decision makers around RLM issue, which could be understood as an impact.

In addition, for those who are affected either positively or negatively in terms of: "those who stand to benefit or lose" (Verplanke, 2000) is shown in Table No. 5.2

Small farmers (1) seems to be positively influenced by the RLD, but indirectly because their activities are restrict to a small extent.

Among lake's resources users, those who have their activities in direct dependence to the amount of water (2,3,4) seems to be possibly affected, since recommended restrictions in the use of this resource being introduced.

Current RLD policy stresses the importance of shoreline vegetation (papyrus), as a contributor for water purification; therefore direct positive impact in Shs (8,9) could be understood by the benefits return in terms of water quality. In this context establishment of a permanent reference limit for riparian land could be help control and avoid its destruction.

Table 5.3 Stakeholders' impact type

	Clustered by	Category		
ID	Action type	Primary	Secondary	External
1	user		X	
2	user	X		
3	user	X		
4	user	X		
5	authority		X	
6	authority		X	
7	authority		X	
8	user	X		
9	user			X
10	user			X
11	authority		X	
12	others			X
13	others			X
14	authority		X	
15	others			X
16	authority		X	
17	authority		X	

Third way of categorization considered "people as the intended beneficiaries of the policy" (Verplanke, 2000), and Shs' participation as the objective of the analysis.

In view of RLD, using the scale of impact as an evaluation factor and based on the type of action, Shs' differentiation is presented in table 5.3

Successful control in the direct water abstraction from the lake and in the contamination that inadequate use of pesticides are causing to the ecosystem, a positive impact will benefit in the long term big and medium farmers (2,3,4,8), therefore Primary category was attached to this party.

Among farmers, small ones (1) were labelled, as secondary category taking into account that their activities take place in most of the cases outside the riparian zone, therefore there is not direct influence on them.

In particular for Shs (9,10) and in general for (12,13,15) due to the no direct involvement in RLD issue but interested in the outcome of the process, Shs' category, was considered as "external". On the other side Shs (5,6,7,11,14,16,17) seems to have the decision stake in this matter.

5.2.3. Stakeholders' interest

Table 5.5 shows a summary explanation about the relative priorities concerned Shs' common interests (mission) as objective.

a. Stakeholders' specific interests

For analysis of Shs' specific interests illustrated in figure 5.4, a column "Code", was added to make handle further analysis. Considering Shs' common interests, grouping was performed, the number in parenthesis in column "Institution" (beside name) specifies the Shs' ID included in each group, for instance: Medium farmers (2,3,4) mean that the group **1b** (code) was formed including medium farmers identified as (ID) 2,3,4. Shs grouping (by colours), on this basis, resulted in four categories as follows:

Table 5.4 Stakeholders' interests

Code	Institution	Category	Particular needs & interests
1a	Big farmers, * KPC	commercial	Floric. / Agric. / Horticulture production for local consume and especially for exportation. * Industrial
1b	Medium farmers (2,3,4)	commercial	Floric. / Agric. / Horticulture production for local consume and specially for exportation
1c	Small farmers (1)	commercial	Agric / horticulture production specially for local consume
1d	Tourist Resorts (8)	commercial	Tourism, marketing
2a	LNRA (5,14,17)	environmental	Research, conservation / protection, education - training, monitoring, awareness, management - policies, data collection
2b	KWS / ME (6,16,11)	environmental	Conservation / protection, awareness, research, education - training, monitoring, management - policies, data collection
2c	ELSAMERE (7)	environmental	Research, conservation / protection, education - training, monitoring, awareness, management - policies, data collection, witness
3a	IBECA (12)	neutral	Conservation / protection, monitoring, awareness, management - policies, witness
3b	Consulters (13,15)	neutral	Technical consulter for water project
4a	Town Council (9)	special	Community service, research, monitoring
4b	KARI (10)	special	Livestock production for local marketing, research, training

Commercial: Encompass production activities with commercial purposes, based on the scale of production and place of its consumption. Differentiation between large and small scale farms were introduce, Ken Gen was assigned to this group, assuming that the amount of water extracts directly from the lake and the ecological impact of its activities fall in the range of this group mates.

Environmental: Basically consider Shs with Lake resources conservation and management interests. This category grouped almost all the institution in current charge of the lake protection.

Neutral: This category gathers particular points of view around RLD as well as RLM issue. Technical opinion from Consulters working for The Municipal Council together with a former private recent organization worried about the future lake ecology were considered as an impartial opinion about these topics.

Special: Special category was attached to some Shs because of the indirect influence role that this group have in the RLD issue. The Town Council signed special consideration for this analysis, due to its role as authority is more related with urban duties rather than with the direct establishment of riparian land boundaries. Therefore SH category was labelled as "user" of lake resources (water),

b. Stakeholders' priority interests

Using a scale from five to one, where score 5 evidence severe impacts and score 1 the least, qualitative and quantitative estimation about the level of impact of Shs' current activities are causing in place is shown in Table 5.5. Negative values are characterizing a negative impact of the activity evaluated.

Since big and medium farms operate most of the activities around the lake, their role could be considered as lake "users". Because interaction between the scale of present and potential activities and the main problems, identified as major impacts to the ecosystem (see problem tree approach in section 5.3), suggests a correspondent relationship, high environmental negative impact (-5) derived from commercial purposes (1a, b, c, d) was signed to lake's users.

Table 5.5 Stakeholders' priority interests

Code	Action type	Shs' current activities priorities	Impact	Level of impact	Relative priorities
1a	user	commercial	-	-5	1
1b	user	commercial	-	-4	1
1c	user	commercial	-	-3	2
1d	user	commercial	+	2	3
2a	authority	environmental	+	5	5
2b	authority	environmental	+	5	5
2c	authority	environmental	+	4	5
3a	others	neutral	?	1	5
3b	others	neutral	+	0	2
4a	user	special	-	-5	1
4b	user	special	+	4	3

High = 5 Low = 1

In contrast, impact to the ecosystem as a whole by proposed alternatives around RLD issue from an environmental perspective (2a, b, c) conduct by "authorities' in charge seems to have a valuable positive impact (+5) in case of success implementation. Clear legal framework and spatial reference basis for further development among others, counts as return benefits expected.

Even though currently there is harmony in direction of RLD purposes, impact influence from a "neutral" point of view (3a, b), at least for the moment looks to be low (+1, 0 respectively).

Conditioning of the lake swamp as an environmental friendly instrument for natural water purification and even for wastewater disposal outputs, accounts in the Management Plan of the lake as future plans for Naivasha town development. Then special category has been assigned to SH (4a) because official duties might be directly related with lake resources conservation, but under the present situation, lack of assistance and financial support had resulted in long period stacking of town outflows. This problem accounts as a significant source of contamination for the lake (-5).

In these context contributions to lake management efforts, current activities seem to be compulsory. Stressed use of lake resources along the last decades, leads to an urgent claim for a sound environmental management, therefore environmental priorities encourage for lake authorities (2a, b, c) at least for the near future should count as essential needs (+5, +5, +4 respectively).

In addition priority interest supported from training and recreational parties (1d, 4b) counts as public agreement (+2, +4) respectively.

c. Policy Interests

Using the same scale range for evaluation described before, qualitative and quantitative estimation about the relative priorities given to each Shs' needs, through expected management policy effects are shown in Table 5.6

Availability of high volumes of water depends on natural trends, but also on human activities influences, for this reason impacts as well as priorities should be related with conservation purposes and sustainable considerations for further development activities.

Long-term benefits, wise use and control over common resources are evident expectations from RLM, then in one-way or another a positive impact on all parties involved is expected from its potential implementation.

Table 5.6 Stakeholders' policy interest

Code	Action type	Policy interests	Type of impact	Level of impact	Relative priorities
1a	user	Enhanced amount of water	+	5	1
1b	user	Enhanced amount / quality of water	+	4	3
1c	user	Enhanced amount / quality of water	+	2	3
1d	user	Enhanced amount / quality of water	+	2	4
2a	authority	Sustainable use of Lake resources	+	5	5
2b	authority	Control on Lake resources	+	5	5
2c	authority	Room for environmental education	+	4	5
3a	others	Sustainable use of Lake resources	+	5	5
3b	others	Legal framework for further development	+	3	1
4a	user	Control on waste disposal effluents	+	4	3
4b	user	Room for agricultural training	?	2	2
				High = 5	Low = 1

5.2.4. Assessment of influence and importance of stakeholders

Code	Shs' Priority	Policy Interest	Importance	Influence
1a	commercial	Enhanced amount of water	1	5
1b	commercial	Enhanced amount / quality of water	3	3
1c	commercial	Enhanced amount / quality of water	3	0
1d	commercial	Enhanced amount / quality of water	4	3
2a	environmental	Sustainable use of Lake resources	5	3
2b	environmental	Control on Lake resources	5	3
2c	environmental	Room for environmental education	5	1
3a	neutral	Sustainable use of Lake resources	5	0
3b	neutral	Legal framework for further development	1	0
4a	special	Control on waste disposal effluents	3	2
4b	special	Room for agricultural training	2	0
			High = 5	Low = 1

Table 5.7 Stakeholders' influence and importance

Combining "priorities giving to satisfy Shs' interests already assigned in table 5.6 above and what the project is trying to achieve" (Verplanke, 2000), using the same evaluation scale, values assigned according to importance and influence attributes, are show in table 5.7.
Differentiation by colours plus the number and letter added to column "Code", specifies a group of Shs with different action type but common priority.

Importance: Indicates the priority in the project (RLM) given to satisfying Shs' needs and interests

Influence: Is defined as "the extent to which stakeholders can significantly influence, or are important to the success of the policy" (Verplanke, 2000)

5.2.5. Assumptions and risks about stakeholders

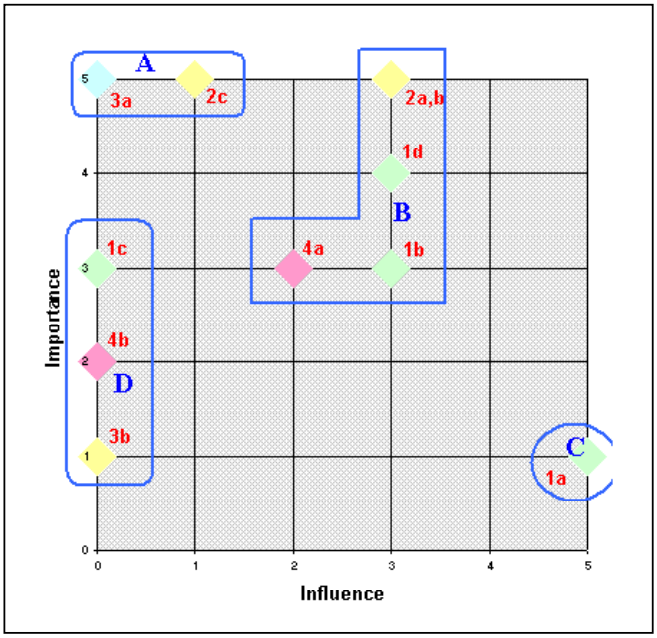


Figure 5.2 Shs' positioning risk bi-dimensional matrix diagram

Using two-dimension matrix diagram shown in figure 5.2, combination of Shs influence and importance values attributed were plotted. This was followed by Shs clustering, based in affinity of interest evidenced by their position in the diagram.

This process allowed establish the extent at which each stakeholder can significantly influence the success of RLM further activities. Through values position interpretation the following Shs' assumptions and risks were identify.

A: Because of the nature of particular interests and the potential input contributions, high importance and low influence seems to be common denominator among Shs (2c, 3a). Special treatment to fulfil their expectations is recommendable.

B: Implementation support of proposed policy through working relationships is expected from Shs (2a, 2b, 1d, 1b, 4a) who share high importance and influence. On the other side, profit from controlled use of lake resources seems to benefit Shs' (1d, b) water quality requirements.

C: Clear understanding and agreement in advance for Shs (1a) characterized by low importance and high influence is mandatory. Failure in partner building process anticipates high risk for the RLM purposes persecuted.

D: Low importance and influence positioning, belongs to Shs (1c, 4b, 3b), since neutral opinion counts over RLM issue and benefits are expected from an environmental restrict management, not special measures seems be required.

Form the diagram is possible to conclude that Hi importance and influence position seems to be occupied in balance by authorities in charge, as well as user parties. Therefore coordination for public agreement about common benefits and later enforcement of compromised decisions taken could have good results.

On the other extreme, since decision-makers in the matter had evidenced clear awareness about socio economic concerns, parties at low importance and influence position suggests to have enough chance to get support for their claims and interests

5.2.6. Stakeholders' Policy participation matrix

Considerations about which stakeholder interests should be allowed in proposed RLM activities, during which stages and in what ways are shown in table 5.8.

Identification stage, considered target groups as direct beneficiaries of proposed activities. For Planning purposed awareness about the objectives persecuted by proposed actions took into account all the identified parties involved. Aspects about technical matters were reserved for local authorities as well as those users in agreement with the present management plan scheme. In addition identification of possible support among parties with common interests (partnership) and missions (control) were recognized.

Since local society constitutes direct receiver, responsible and custodian of lake resources, implementation stage reserved room for all parties involve considering contributions in different requirements.

Table 5.8 Stakeholders' Policy participation matrix

	Inform	Consult	Partnership	Control
Identification	Big farmers			
	Medium farmers (2,3,4)			
	Small farmers (5)			
Planning	Big farmers	Big farmers	LNRA (6,13,17)	LNRA (6,13,17)
	Medium farmers (2,3,4)	Medium farmers (2,3,4)	KWS/ ME (6,16,11)	KWS/ ME (6,16,11)
	Small farmers (5)	Small farmers (5)	ELSAMERE (24)	ELSAMERE (24)
	LNRA (6,13,17)	LNRA (6,13,17)		Consulters (13,15)
	KWS/ ME (6,16,11)	KWS/ ME (6,16,11)		Town Council (9)
	ELSAMERE (24)	ELSAMERE (24)		
	Consulters (13,15)	Consulters (13,15)		
	Town Council (9)	Town Council (9)		
	KARI (10)			
Implementation	Big farmers		LNRA (6,13,17)	LNRA (6,13,17)
	Medium farmers (2,3,4)		KWS/ ME (6,16,11)	KWS/ ME (6,16,11)
	Small farmers (5)		ELSAMERE (24)	ELSAMERE (24)
				Consulters (13,15)
				Town Council (9)
Monitoring & Evaluation			LNRA (6,13,17)	LNRA (6,13,17)
			KWS/ ME (6,16,11)	KWS/ ME (6,16,11)
			ELSAMERE (24)	ELSAMERE (24)
				Town Council (9)

Monitoring and evaluation towards conservation of lake resources phase relayed under authorities concern, since by law and local agreement this party have the power to deal with land issues.

5.3. Need for a permanent reference boundary

The future of the lake is under threat from unsustainable development practices. Several environmental impacts from current activities are recorded. From an ecological perspective Lake Naivasha seems to be the expression of nature. A rapid increase in human activities characterized by a startling trend change from natural vegetation to agricultural practices and uncontrolled access to the lake through public corridors; added to lack of trained staff for monitoring and financial support, leads to an inefficient control of Lake Resources. Figure 5.3, for example shows livestock grazing within papyrus swamp

Existent legislation that encompasses environmental issues towards conservation of natural resources is: Water Act. Cap 372. Agriculture Act. Cap 318. Forest Act. Cap 385. Land Planning Act. Cap 303, and Public Health Act. Cap 242 (Abiya, 1996). Nevertheless some incompatibilities in the statements that they contain, leaves room for confusion and infraction.

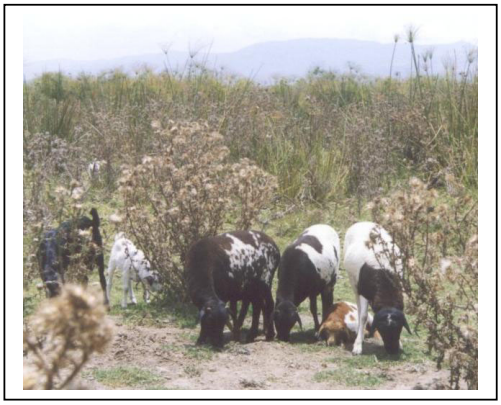


Figure 5.3 Livestock grazing within Papyrus swamp

Consequently, multi purpose water abstraction with no strict enforcement of current environmental restrictions plus unsuitable activities and inappropriate use land practices that take place in the upper catchments of the basin result in downstream effects. Therefore unless there is harmonization between all the related acts in terms of environmental laws these problems will continue.

These facts account as factors that have contributed enormously to the down going trend of the lake water level. Goldson, (1993) argued that variation in the Lake level reached the order of 15 m over the last century.

In addition, no harmonized statements in the contents of the legal act on resources administration, particularly, between Land and Water ones, seem to allow confusion and to present legal room for discussion.

Figure 5.4 Lake's fauna diversity

The swamp ecosystem as a whole supports the development of a variety of forms of life. As an important source of income in a place struggling for progress, particularly importance relays on the water quality and its contribution to tourism management.

An inefficient establishment of a permanent geographical reference has caused loss in valuable environmental resources (fauna, flora) and even private resources (water pumps, agriculture land) from time to time.

Far from the assumption of enforcement of sustainable practices, these events, lead to the fact that present buffer zone management for the Lake, does not work properly. It seems that present management practices are not enough to reach sustainable use of its resources and to satisfy a sound balance of nature.

Based on cause effect relationships of the identified problems following a 'problem tree approach' (figure 5.5) can be illustrated the present situation around riparian land definition and management and the most significant factors affecting papyrus conservation and its interrelationships. Distinction in the used symbology (shape and line pattern), allowed identification of lake's users and authorities opinion.

Evidenced in the problem tree, swamp ecosystem destruction was found as the 'Core problem' of the identified problems. In the low part of the diagram, in green, main causes and derived consequences are listed. In the upper part of the diagram, in red, the effects from these causes are illustrated. Arrows represent the various links among the factors listed.

Among the causes of severe ecosystem destruction are: population increase in the last decades, unclear legal framework concerning environmental matters, added to personal interests over common "goods", as well as individualism, understood as no common concern about depletion of common resources, account as starting point of consequent impacts. The main causes related with papyrus depletion in Naivasha identified were: Papyrus cutting and burning, water contamination and insufficient amount of water, all contributing with swamp ecosystem destruction.

Regarding swamp ecosystem destruction, the main effects identified were: incompatible land uses and increased un-controlled access to the Lake. This resulted in decreased quality of life and loss of biodiversity, both leading to an imbalanced carrying capacity of the lake resources.

Consequently proposed RLM should be based on concepts to target resources reclamation, rehabilitation and re-creation schemes and supported in efforts to regulate human development as recommendable inputs for Lake Management.

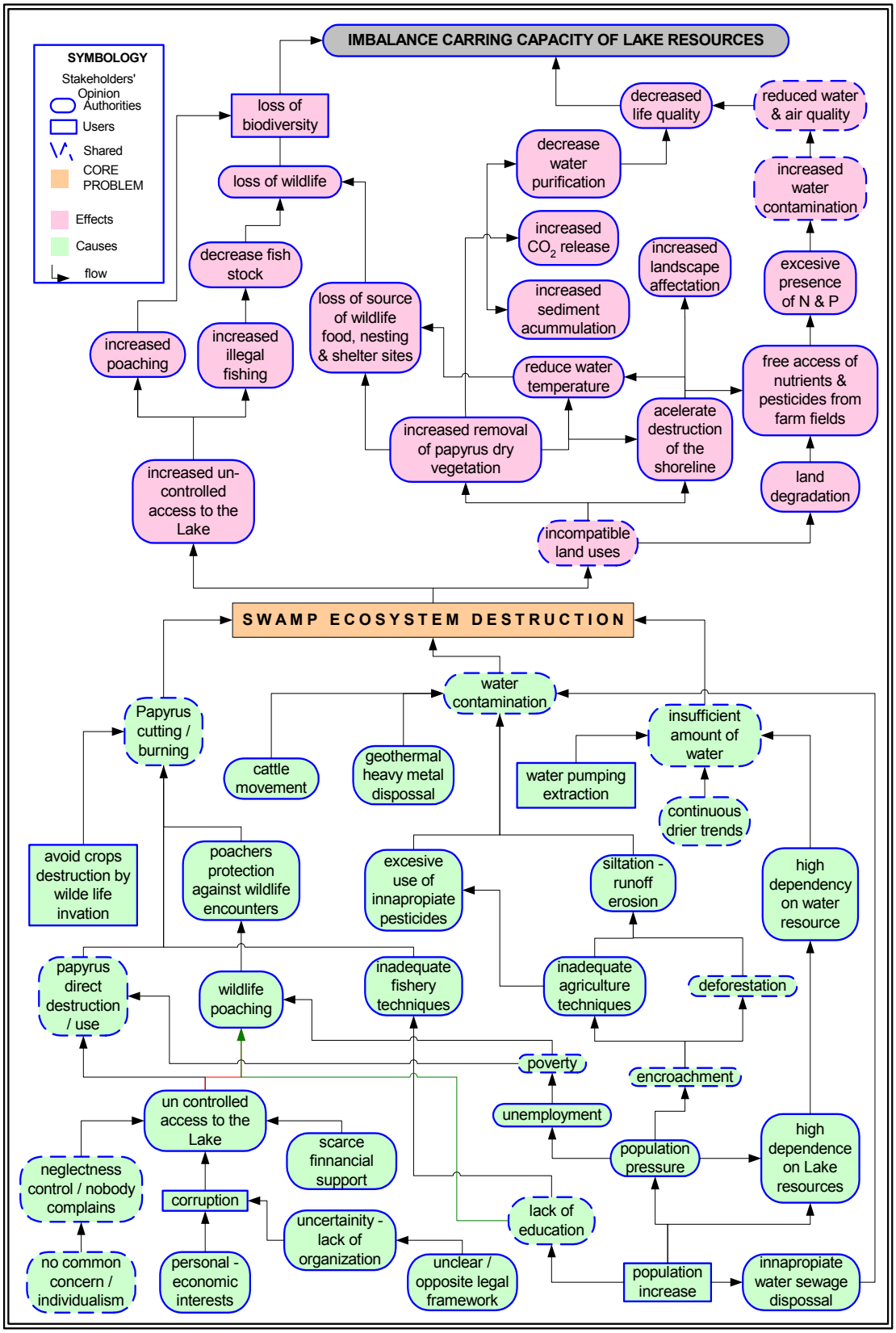


Figure 5.5 Problem tree approach for problem related with papyrus conservation in Lake Naivasha

6. Riparian Land Definition (RLD)

Once identification of potential alternatives is done, estimation of current and potential impact that proposed alternative boundaries over influenced areas is presented. Finally inquiring about any position that will be acceptable for the parties involved is evaluated.

6.1. Riparian Land boundary alternatives

Establishment of proposed permanent boundary alternatives for further riparian zone management, considered inputs from:

a. Temporal and biophysical factors derived from previous fieldwork inputs

Existent legal framework that rules the use of lake resources in the area, which encompass: On November 19th 1931, LNRA signed an undertaking with the Government in which it was agreed that:

> "All the land that was formerly part of the Lake Naivasha (all the land below the 1906 lake level of 6210 feet (1893.3 m above sea level) was to be utilised by the Riparian Land owners as they saw fit. Providing that no permanent structures were erected and no claims against Government made, should the water rise above land developments" (LNRA, 1999).

b. Natural dynamics of the Lake

Along the time in natural conditions areas with dying papyrus can be taken over by scrublands and grassland and finally woodland, making it possible to reverse the process, if the area is inundated again Bemigisha, (1998).

In this context, the following four boundary alternatives were designed:

6.1.1. LNRA, 100 meters Papyrus buffer protection (present management)

As one of the environmental considerations proposed by LNRA in the Lake's Management Plan former version (originally 50 meters) and re-consider in the final one, this limit constitutes the present management scheme for riparian land. Idealized to permit vegetation conservation, this limit implies leaving at least 100 m between the owned land and the backside of the existent riparian vegetation fringe.

6.1.2. 1906 Lake water limit level (potential maximum extent)

Over the last decades there was a down going trend in the lake's water level. As a consequence 1906 lake level seems to be difficult to be reached again, unless the process is reverted. Nevertheless this alternative boundary resulted important for evaluation because it constitutes the original reference limit established between private owned and riparian land.

6.1.3. "El Niño[3]" water level (recurrent event)

This boundary alternative was based on the highest water level lake occupied during the last "El Niño" phenomena, occurred from November 1997 to March 1998.

6.1.4. 1967 Closest past Papyrus occurrence (papyrus recorded maximum extent)

Because of the particular focus in Papyrus conservation, the setting of this boundary limit is proposed by the present study as another alternative for riparian land definition. This boundary alternative considers the maximum spatial documented reference extent suitable for papyrus vegetation under natural conditions. This alternative was based on the land cover map for 1967 prepared by Bemigisha, (1998), closest historic source available for the area.

A general assumption adopted for this alternative is that past papyrus area occurrence should be different for the open water, papyrus, agriculture fields, or build up areas in the current use (2001).

6.2. Criteria and underlying assumptions for RL boundary alternatives

A preliminary set of criteria and indicators were identified and developed to evaluate if there any position that will be acceptable to all parties involved. Criteria selection was based on stakeholders' analysis as well as on data availability. Table 6.1, shows the criteria and indicators selected for the assessment.

Table 6.1 Criteria for Riparian Land boundary alternative selection

ASPECT	CRITERIA	INDICATORS	DEFINITION
ENVIRON-MENTAL	Area	ha	Total area of boundary alternative
	Reduced water abstraction	m^3/year	Total volume of water required for irrigation in influenced areas.
	Swamp presence	ha	Total area of current (2000) swamp included per boundary alternative
	Reduced contamination by use of pesticides	ton/year	Total amount of pesticides required per crop in influenced areas
SOCIO ECONOMIC	Farm income loss	US $/year	Total of loss on production caused by potential farm area reduction in influenced areas
	Farm affected areas	ha	Total extent of area influenced
	Employment displacement	people	Total labour potentially displaced from influenced areas

a. Area

- Set up the most potential lake levels, in which space occupied by water could leave room for free vegetation expansion under natural conditions is one of the purposes behind RLM, hence the more extent the area the more suitable.
- Implies estimation of total boundary alternative area without consider in water bodies.

[3] ENSO
"Stands for El Niño - Southern Oscillation. ENSO refers to an irregular cycle of warming and cooling of the sea surface temperatures of tropical Pacific Ocean. The cycle has a length of about 4 years, and is a natural part of the Earth's climate system. The oceanic warming and cooling is accompanied by changes in air pressure above the Pacific Ocean (the "Southern Oscillation"). These changes in the Pacific Ocean's temperatures and the atmosphere above it affect the global climate system, and therefore can affect the climate in regions far away from the Pacific (like Africa)." International Research Institute for Climate Prediction, (2002).

- Total alternative area size (TA-ar_sz) in hectares was calculated for each of the alternatives identified, using "summarize" table tool in Arc View

b. Reduced water abstraction

- Minimize and regulate the use of water extracted from the lake is the goal of this criterion, so the less amount of water abstracted the better.
- The indicator gives the volume of water saved due to reduction of the farm area
- Total water abstraction (TA-wt_at) for the year for each boundary alternative is estimated by aggregating C-wt_at in m^3/ha/year per crop.
- TA-wt_at (m^3/ha/year) = $\sum$ C-wt_at (m3//ha/year)

c. Swamp presence

- Swamp vegetation considered current areas occupied by adult and young papyrus as well as low riparian vegetation (macrophytes) LUT identified classes, where adult ones.
- Considering all the benefits to the environment getting from papyrus, mature ones has relative advantage compared with the young ones, then adult papyrus are more suitable, than young ones.
- Total alternative swamp area (TA-sw_ar) in hectares was calculated for each of the alternatives identified, using "summarize" table tool in Arc View

d. Reduced contamination by use of pesticides

- Reduced contamination by use of pesticides is what this criterion looks for, so the less contamination the better
- What is measured is the amount of pesticides reduced due to reduction of the farm area
- Total impact by contamination (TA-ptc_ct) for the year for each boundary alternative is estimated by aggregating C-ptc_ct in Tons/ha/year per crop.
- TA-ptc_ct (Ton/ha) = $\sum$ C-ptc_ct (ton//ha)

e. Farm income loss

- The less economic loss for an alternative ranks it as more suitable.
- What is calculated is the loss of income due to the loss in farm land
- Total income loss (TA-ic_ls_opv) for the year for each boundary alternative is estimated by aggregating C-net profit per hectare per crop.
- TA-C-lc_ls_opv (US $/ha/year) = $\sum$ C-lc_ls_opv (US. $//ha/year)

f. Farm influenced areas

- Criteria 'income loss', 'employment displacement', 'impact by contamination' and 'reduced water abstraction' were effects calculated based on this criterion.
- Influenced areas are considered those within the proposed boundary for the riparian zone definition and in the present occupied by any land use different from natural vegetation or open water.
- Total alternative influenced area size (TA-C_aa_sz) in hectares was calculated for each of the alternatives identified, using "summarize" table tool in Arc View

g. Employment displacement

- The less potential employment displacement stands for a better selection.
- What is measured is the loss of employment due to the reduction in farm land

- Total employment displacement (TA-em_dlm) for the year for each boundary alternative is estimated by aggregating C-em_dlm in number of persons required per hectare per crop.
- TA-em_dlm (persons/ha) = ∑ C-em_dlm (persons/ha)

h. Assessment of current and potential impacts

Analysis of economic information from previous studies was used for calculations and assessment of current and potential impact from present agricultural activities and proposed alternative boundaries may cause in place. Computation was made for: flowers in green houses (GH) and indoor, vegetables, wheat, fodder, and grass current crop types in the area.

Prepared by Sayeed - ITC, (2001), table 6.2 shows the "Regional Constants" used for the impact assessment. Regional constants are in terms of requirements of water for irrigation purposes (potential flow contribution to lake's water level volume), amount of pesticides required per the different crops (potential source of pollution for lakes resources), and labour required per type crop (potentially employment displaced per farm), per each of the crop types present in the area.

Table 6.2 Regional constant rates for impact assessment estimation

Crop type	Irrigation water requirement m^3/ha/year	Pesticide ton/ha/year	Employment person/ha	Net crop profit US $/ha/year
Flowers (GH)	6570	0.2	19	28824
Flowers (indoors)	6695	0.2	19	28824
Vegetables	2070	0.0	6	9054
Wheat	4219	0.0	4	613
Fodder	4073	0.0	3	83
Grass	4073	0.0	5	219

Source: Saveed - ITC.

Complementary the economic impact in terms of potential loss of the net economic return from "influenced areas" was also assessed. Impact evaluation criteria and indicators are shown in appendix IV. All data calculations were performed using Excel worksheet. Results are presented beside each boundary alternative.

In addition, comparison of different proposed riparian limits (overlay) with current land uses allowed coming up with the establishment of congruence and influenced areas between both uses.

'**Influenced area**' for this case study is considered an area within the proposed alternative boundary for riparian zone definition and presently occupied by any land use different from natural vegetation or open water.

6.3. Evaluation of riparian land boundary alternatives

For each of the different crop types identified in Naivasha (2000) and for each RLD boundary alternative proposed, data table adjacent shows the impact on influenced areas (farms) in terms of: volume of water required for irrigation and the amount of pesticides required by as well as the impacts on potential employment displacement and income loss.

6.3.1. LNRA 100 meters Papyrus buffer protection

Illustrated in figure 6.1, in the present situation the boundary occupies an area of 1,598 ha (without considering water bodies). In case this alternative will be selected as a preferred one, under restrict environmental scheme 10 farms with a total area of 23 ha have to be removed.

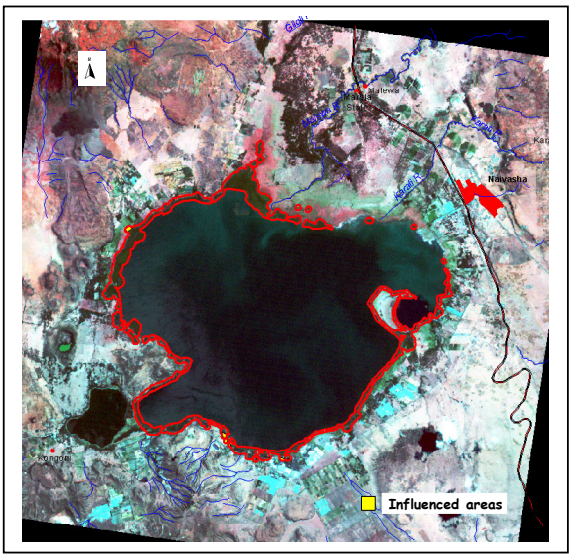


Figure 6.1 LNRA boundary alternative and influenced areas

Shown in table 6.3, for this alternative, areas cultivated with flowers in green houses (GH), flowers indoor, fodder and vegetables. Indoor flowers have the largest area at 8 hectares, followed by flowers GH (4 ha) and fodder (4 ha).

Since these three crops account for the largest area cultivated, they also required the highest volume of water for irrigation, respectively among the crops.

The indoor flowers accounted for the highest requirement of pesticides among these three crops, at 1 ton/ha. Fodder and vegetables required the least amount pesticides.

Correspondingly, potential employment displacement and income loss were the greatest for indoor flowers, with a potential displacement of 148 persons and potential income loss of USD $ 227,637 per year, this was followed by flowers GH.

Table 6.3 "LNRA" alternative characteristics and potential economic impact

Crop type	Cultivated has	Volume of water used fro irrigation m^3/ha/year	Pesticide requirements ton/ha/year	Labour required person/ha	Net profit U.S. $/year
Flowers (GH)	4	28,611	1	82	125,522
Flowers (indoors)	8	52,874	1	148	227,637
Vegetables	2	3,481	0	11	15,220
Wheat	0	0	0	0	0
Fodder	4	15,898	0	11	325
Grass	0	0	0	0	0
Total	**18**	**100,863**	**2**	**251**	**368,704**

Vegetables and fodder had the least effect on potential employment loss, with a loss of only 11 persons both but USD $ 15,220 per year and USD $ 325 per year respectively.

6.3.2. 1906 Lake water limit level

Illustrated in figure 6.2, in this boundary limit, flowers in green houses (GH), flowers indoor, fodder, wheat, vegetables and grass are the crops that could be influenced. Table 6.4 shows that fodder had the largest area at 1,91 hectares, followed by vegetables (176 ha) and grass (104 ha). Even though these three crops account for the highest area cultivated, not all of them are the ones, which required the highest volume of water for irrigation and use of pesticides among all the crops.
Only fodder accounted for the highest volume of water with 778,745 m^3/ha/year and 4 ton/ha of pesticides required.

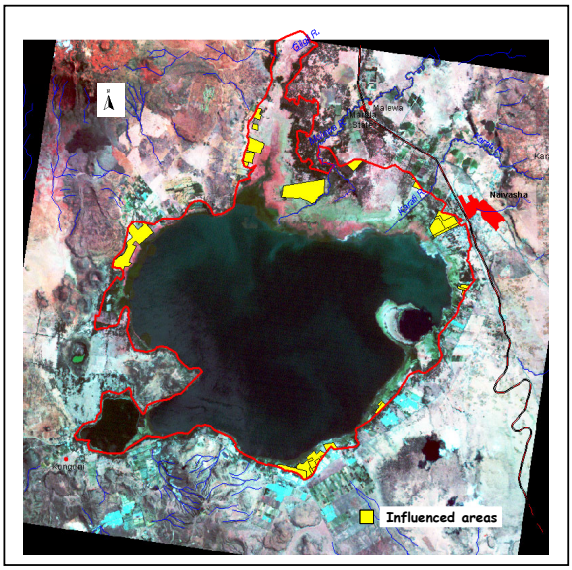


Figure 6.2 1906 boundary alternative and influenced areas

Even though flower indoor with a bit less volume of water at 671,314 m^3/ha/year, a higher requirement of pesticides at 16.7 ton/ha is needed. Wheat and wheat required the least amount pesticides.

Correspondingly, potential employment displacement and income loss were the greatest for indoor flowers, with a potential displacement of 1880 persons and income loss of USD $ 2,890, 217 per year, this was followed by flowers GH and vegetables. Wheat had the least effect on potential employment displacement, with a requirement loss of only 59 persons and USD $ 9,969 per year.

Table 6.4 "1906" alternative characteristics and potential economic impact

Crop type	Cultivated has	Volume of water used fro irrigation m^3/ha/year	Pesticide requirements ton/ha/year	Labour required person/ha	Net profit U.S. $/year
Flowers (GH)	81	533,770	14	1,523	2,341,771
Flowers (indoors)	100	671,314	17	1,880	2,890,217
Vegetables	176	363,850	7	1,098	1,591,095
Wheat	16	68,669	0	59	9,969
Fodder	191	778,745	4	535	15,900
Grass	104	0	1	552	22,849
Total	**669**	**2,416,349**	**42**	**5,648**	**6,871,801**

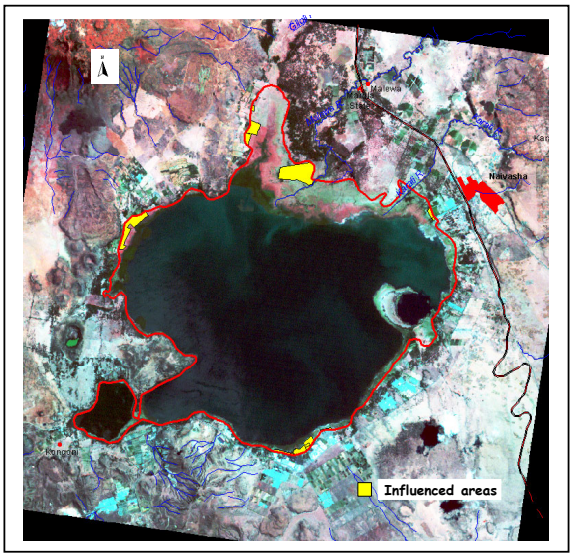
6.3.3. "El Niño" water level

Shown in table 6.5, flowers in green houses (GH), flowers indoor, fodder, wheat and vegetables, are the crops that are most affected in this boundary alternative. Fodder registered the largest extent at 97 hectares, followed by grass (73 ha) and vegetables (64 ha).

Although these three crops account for the highest area cultivated, not all of them are the ones, which required the highest volume of water for irrigation and use of pesticides among all the crops.

Only fodder accounted for a high volume of water with 393,617 m^3/ha/year followed by flower indoors at 235,838. Wheat required the least volume of water.

Flower indoor even though has less area cultivated (35 ha), stands for a higher requirement of pesticides at 6 ton/ha, followed by flowers GH at 3 ton/ha. Grass and wheat required the least amount pesticides.



Employment displacement and income loss were the greatest for indoor flowers, with a displacement of 661 persons and income loss of USD $ 1,015, 357 per year, this was followed by Vegetables and flowers GH.

Wheat had the least effect on employment, with a loss of only 47 persons and USD $ 7,942 per year.

Figure 6.3 El Niño boundary alternative and influenced areas

Table 6.5 "El Niño" alternative characteristics and potential economic impact

Crop type	Cultivated has	Volume of water used fro irrigation m^3/ha/year	Pesticide requirements ton/ha/year	Labour required person/ha	Net profit U.S. $/year
Flowers (GH)	19	122,366	3	349	536,848
Flowers (indoors)	35	235,838	6	660	1,015,357
Vegetables	64	132,531	3	400	579,548
Wheat	13	54,706	0	47	7,942
Fodder	97	393,617	2	271	8,037
Grass	73	0	0	386	15,950
Total	**300**	**939,059**	**14**	**2,113**	**2,163,682**

6.3.4. 1967 Closest past Papyrus occurrence

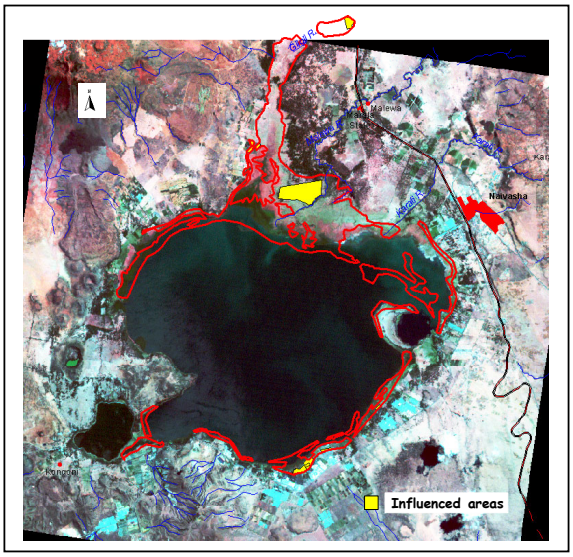


Figure 6.4 1967 boundary alternative and influenced areas

Illustrated in figure 6.4, in this boundary limit flowers at green houses (GH), flowers indoor, fodder, vegetables, and wheat are the crops in potential risk. Table 6.6 shows that grass may occupy the largest area at 101 hectares, followed by fodder (62 ha) and flowers indoor (29 ha).

Although these three crops account for the highest area cultivated, not all of them are the ones, which required the highest volume of water for irrigation and use of pesticides among all the crops.

Only fodder accounted for the highest volume of water with 253,811 m^3/ha/year followed by flower indoors at 190,477. Vegetables required the least volume of water.
Flower indoor even though has less area culti-

vated (29 ha), this crop stands for a higher requirement of pesticides at 5 ton/ha, followed by flowers GH at 2 ton/ha.

Grass and wheat required the least amount pesticides. This crop had the greatest effect on potential employment loss, with a potential displacement of 537 persons/ha, followed by flower indoors (533 persons/ha) and flowers GH (219 persons/ha).

Potential income loss was the greatest for flowers indoor, with a potential loss of USD $ 820,065 per year, followed by flower GH at USD $ 336,790 per year, the least loss was registered by fodder (USD $ 5,182 per year).

Table 6.6 "1967" alternative characteristics and potential economic impact

Crop type	Cultivated has	Volume of water used fro irrigation m^3/ha/year	Pesticide requirements ton/ha/year	Labour required person/ha	Net profit U.S. $/year
Flowers (GH)	12	76,766	2	219	336,789
Flowers (indoors)	28	190,477	5	533	820,065
Vegetables	21	42,459	1	128	185,672
Wheat	18	76,206	0	65	11,063
Fodder	62	253,811	1	174	5,182
Grass	101	0	1	537	22,218
Total	**244**	**639,719**	**10**	**1,657**	**1,380,989**

6.4. Selection of preferred RLD boundary alternative

Riparian Land Management (RLM), concerned the establishment of a preferred alternative boundary for RLD, considering two different perspectives using Multi-criteria Analysis (MCA) evaluation of alternatives was performed.

Because priorities assigned to each criterion are better reflected, through direct specification of importance among all individual criteria possibilities, "Pair Wise Comparison", also known as the "Analytical Hierarchy Process (AHP)", was selected as weighting method. This method converts comparisons of all pairs of effects to quantitative weights for all effects Janssen, (2000). Appendix V, table a, b, shows the values obtained from the comparison.

6.4.1. RLD boundary alternative Scoring

Table 6.7 Riparian Land boundary alternative effects matrix

	C/B	Unit	1906	LNRA	El Niño	1967
Environmental						
Alternative total area	+	ha	7,593	1,598	4,101	3,653
Reduced water abstraction	+	m^3/year	2,416,349	100,863	939,059	639,719
Reduced pesticide contamination	+	ton/year	42	2	14	10
Swamp presence	+	ha	1,039	1,031	1,016	505
Socio-economic						
Employment displacement	-	person	5,648	251	2,113	1,657
Farm influenced areas	-	ha	714	23	302	243
Income loss (owner point of view)	-	U.S. $/year	6,871,801	368,704	2,163,682	1,380,989

Aggregation of the effects obtained from all four alternatives resulted in a total impact effect score as shown in table 6.7.

Among the alternatives evaluated, under environmental perspective, boundary "1906: accounts for the major extent at 7,593 ha, followed by "El Niño" at 4,101 ha and "1967" at 3.653 "LNRA" presents the smallest extent at 1,598 ha. Since alternative "1906" accounts for the biggest extent, and "LNRA" for the smallest; they also impact the lake ecosystem following the same trend.

With respect to requirements of water for irrigation this varies between 2,416,349 m^3/year for "1906" to 100,863 m^3/year for "LNRA". In terms of pesticides requirements, effects could reach from 43 ton/ha to 2 ton/ha respectively. Alternatives "El Niño" as well as "1967" seems to have intermediate effects.

From a socio economic point of view, "LNRA" boundary alternative, as current management scheme for the lake and occupying the smallest extent has opposite effects compared to "1906" proposed limit.

"LNRA" boundary is influencing a total extent 23 ha cultivated. Therefore potential loss of labour affects 251 persons, and a net profit from production of US. 368,704 $/year, is lost.

"1906" boundary, is influencing a total area of 714 ha. Potential impact in loss of labour could be around 5,648 persons, and income loss would stand for US. 6,871,801 $/year

Boundary alternative "El Niño", having the second major area extent, may require water for irrigation at 939,059 m^3/year. Pesticides requirements could reach 14 ton/ha. In addition, influence over a total area of 714 ha, may cause a potential impact in loss of labour around 2,113 persons, and an income loss of US. 2,163,682 $/year

For "1967" alternative, requirements of water for irrigation purposes would be at 639,719 m^3/year, and required pesticides could reach 10 ton/ha. Influencing a total area of 243 ha, this boundary could cause an impact in loss of labour on 1,657 persons, and an income loss of US. 1,360,969 $/year

For boundaries " El Niño" and "LNRA", estimation of papyrus extent was done based on current area, for alternatives "1967" and "1906" spatial distribution at 1967 was used as reference. This approach resulted in a major extent at 2,889 ha registered for "1967" alternative followed by "1906" at 2,712 ha and "LNRA" at 1,031 ha. With little difference at 1,016 ha, alternative "El Niño" stands for the minor extent of this vegetation.

6.4.2. Criteria weighting

Effects represent the objectives of the problem; to discern which criterion should be treated as 'Cost' or 'Benefit' is required to proceed with the evaluation. Considering management policy's interest and a recommendable restrict use (wise use) of lake resources, four criteria out of seven were identified as benefits, which means that interests is on the higher value of the criterion, then "the higher the better." At the other side three criteria were handled as costs, meaning that "the lower the better'. Table 6.7, shows the effects matrix data arrangement.

Outputs from Stakeholders' Analysis presented in section 5.3, fieldwork inputs and selected literature reviewed, allowed the author to attribute criteria importance based on stakeholders' preferences as following. Table 6.8, shows the criteria selected as well as the value function and level of importance attributed, where 1 = the most important, 5 = the least important, to each criterion for the assessment.

Lake's Users:
A diversity of economic activities characterizes Lake Naivasha surroundings. Over the time, imbalanced use of lakes resources have resulted in a significant level of depletion. Economic revenue from large and medium scale agricultural activities, as well as direct benefits from lake's resources such as fishery and poaching is a common interest among users.

According to this context a general importance level was allocated, giving a significant priority to Socio-economic factors at (82.5%) compare with Environmental ones less important, which were set up at (12.5%).

Within Socio-economic aspects criterion "income loss" seems to have first priority of importance for lake user's group. Since priority had been identified by direct influence over land and expressed in economic terms, criterion 'farm influenced area' as a resultant received the second level of importance was ascribed to this criterion.

Potential removal of areas influenced by implementation of a boundary alternative as a consequence will cause labour reduction. So "employment displacement' received the third level of importance for evaluation within the socio-economic aspect.

With respect to Environmental aspect, criterion "total area size", has a direct relation with the impact caused by the rest of criteria within this aspect, hence a first importance level corresponds to this criterion.

Fortunately over the last decades serious efforts show evidences of the miss use of potential sources of benefit have done. Catching the conscience of owners around the lake, local initiatives about the use of ecological pesticides either in quantity or in quality have been reported. Some farmers have found as a profitable resource the conservation of wildlife within their properties, for instance as eco-tourism purposes, contributing somehow with the balance capacity of lake's environment.

In addition although in some cases in un-sustainable way, local lake's users, process swamp resources as means of self-subsistence. Therefore criteria 'swamp presence current size' was identified as second level of importance for this group of stakeholders.

Since unrestricted use of water and uncontrolled use of pesticides have been maintained in Naivasha since a long time ago, less importance seems to be attributed for potential save in water quantity and quality. Hence criterion "reduced water abstraction", as well as "reduced pesticide contamination", were attributed an importance of third and fourth level respectively.

Table 6.8 Riparian Land Definition value function and criteria's importance attributed

ASPECT	CRITERIA	C / B	ATTRIBUTED IMPORTANCE	
			Lake Users	Lake Authorities
ENVIRONMENTAL	Alternative total area	B	1	4
	Reduced water abstraction	B	2	1
	Swamp presence	B	3	3
	Reduced pesticide contamination	B	4	2
SOCIO-ECONOMIC	Income loss (owner point of view)	C	1	3
	Farm influenced areas	C	2	2
	Employment displacement	C	3	1

Lake's Authorities:
Since compiled Lake's Authorities interest search for environmental conservation and management of lake's habitat, importance to environmental and socio-economic aspects seems to be equivalent. For this reason general importance level at aspect stage was distributed, giving a comparable priority to Environmental (50%) as well as Socio-economic (50%) factors.

Shown in table 6.8, considering consequences from lack of control and the large-scale impact on the environment, first priority for this group was given to 'reduced water abstraction'. Consequently with water level dropping, minerals carried by the water from the surroundings more concentrate in the remaining water volume, so pesticide contamination by use of pesticides', signed for the second priority.

Within environmental aspect in the present management scheme Lake's resources are under threat of many factors, nevertheless take care of current resources is required, therefore third preference was attached to 'total area of current swamp'.

Possible natural factors, which rules lake level fluctuations, could give or not room for an extent or limited area, therefore particular focus was given to papyrus habitat conservation. Hence importance seems to relay on 'total boundary alternative area' as fourth significant criteria.

Even though there is an implicit claim to protect environmental resources, as source of further benefits, authorities interest also covers local community demands, worries about potential employment loss, through criteria 'employment displacement' stands as first priority among the socio-economic aspect.

Since under current management plan change in the extent of landowners is under own risk, and often extent increasing obey to economic purposes, in complete opposition with lake users, for authorities party criterion 'total extent of farm influenced area', signed for the second priority.

Even so particular focus was on local farm activities because large and medium farm activities contribute with the economic development of Kenya's society. Hence bearing in mind necessary adoption of wise use of current resources as a development alternative, considerations about human society (criterion 'Income loss owner point of view') as custodians of Lake's future was given a third level of importance.

6.5. Multi criteria analysis (MCA)

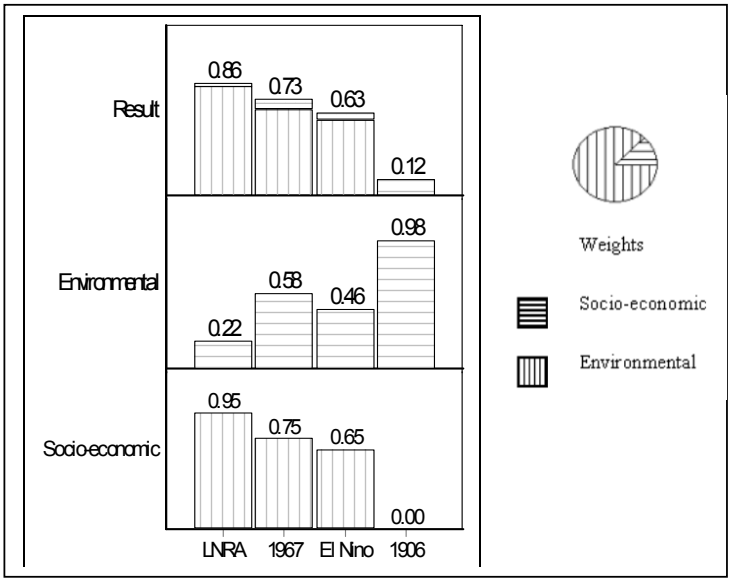
Under this setting, for each boundary alternative identified and for perspectives, aspect, criteria, its respective measurement units and score were introduced in an "Effects matrix". All data calculation was performed using Excel worksheet.

6.5.1. RLD boundary alternative ranking 'Users' Perspective'

This procedure displays the results of the multi-criteria analysis. The result is presented graphically with a simple bar graph. On the X-axis are all alternatives, and on the Y-axis the value of the ranking.

A quantitative method has been applied values are used. The bar length indicates preference for the alternative. The higher the bar, the better the alternative.

MCA under the present evaluation settings resulted in: for Lake's Users, 'LNRA' boundary alternative, with the highest rank (0.86), followed by '1967' (0.73) and 'El Niño' (0.63) alternatives respectively.



At the other hand '1906' boundary, seemed to be the one with lowest ranking (0.12). Figure 6.5 illustrates the output site arrangement.

Figure 6.5 Alternative ranking graphic output

a. Effect score and weight uncertainty

The uncertainty attribution procedure assesses the sensitivity of a ranking obtained by one of the available multi-criteria methods for uncertainty in the scores of all effects, in the weights of the effects, or both. The calculated rankings can also be compared with each other. Janssen, (2000).

The contribution of this analysis in the evaluation of the robustness of the ranking is that is shows how steady are the alternatives in the ranking, depending on the expected deviations of the values of the effects.

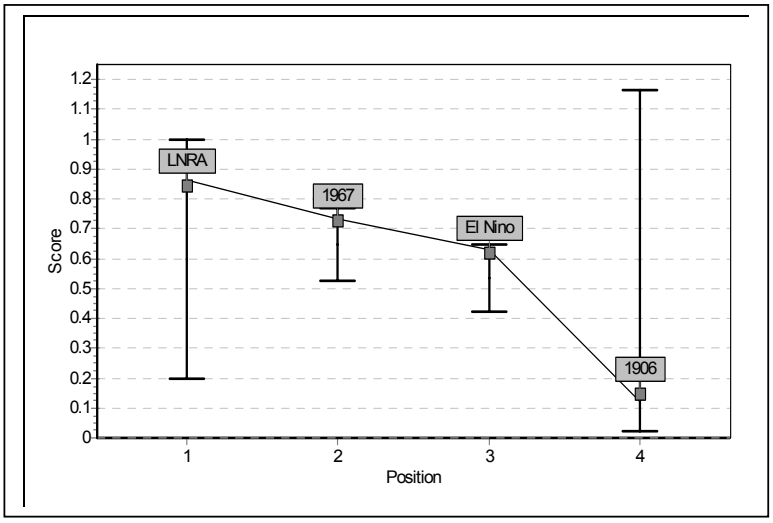


Figure 6.6 Ranking at 15% weight and score uncertainty

A 15% and 10% uncertainty of error was attributed to weight and score level respectively, as data estimated errors, due to external factors (stakeholders confidence, time constraints, sample size, etc). Even so the data resulted in the same boundary alternative ranking output.

As shown in figure 6.6, because of the range variability alternatives "LNRA" as well as "1906" ranked first and fourth in the evaluation process, seems to be very un-stables.

The opposite case happened between '1967' and 'El Niño' alternatives second and third ranking respectively. These alternatives with a low level of variability look very stable.

b. Sensitivity Analysis (SA)

Because of effect scores and weights assigned in the Problem definition and MCA steps are hardly ever totally certain, Sensitivity Analysis for MCA, contains procedures oriented on analysing the influence of these uncertainties on the calculated rankings. SA is a procedure considered for analyse how sensitive criteria and indicators are with respect to their objectives.

In general, the reversal point helps in determining at what point, depending on the criterion being tested, the alternative ranked at number 1 can be beaten by another alternative or the point in which improvement is not the best alternative any more Janssen, (2000).

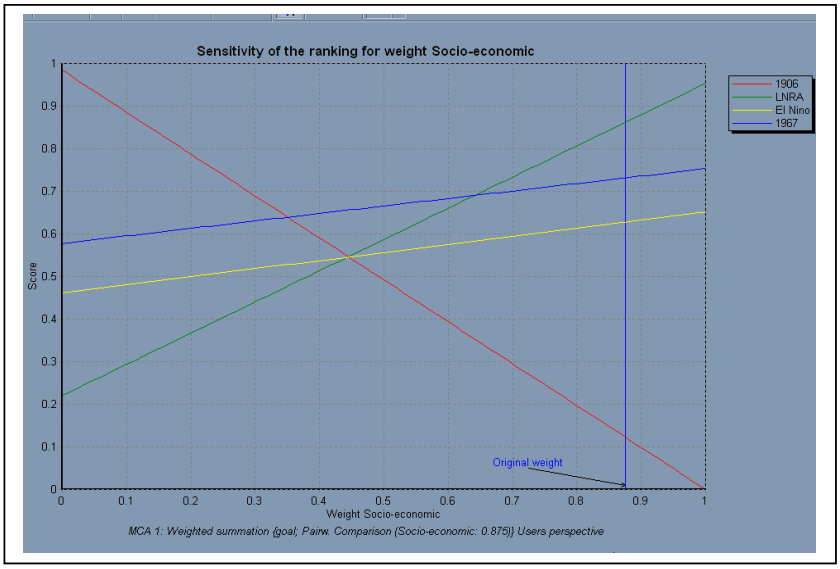


Figure 6.7 SA for more important weight (socio-economic)

In this research, Stakeholder Analysis was used to analyse how the selected criteria perform importance in establishment of priority sites for conservation purposes as well as RLD alternatives boundaries.

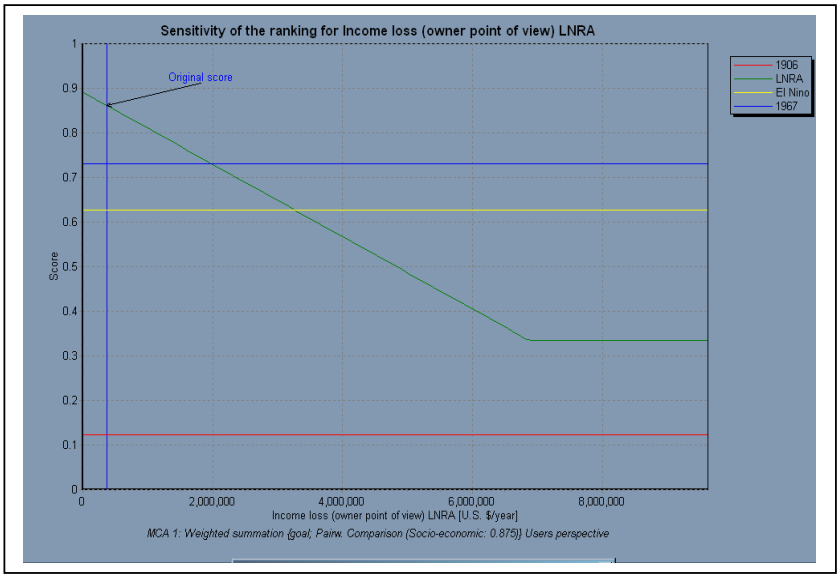


Figure 6.8 SA for more important criterion (income loss)

For Lake's users, socio economic factor evidenced priority over environmental interests. In figure 6.7, consequent from the same uncertainty error introduced, Stakeholder Analysis for the weight socio economic between 'LNRA' and '1967' limits shows that alternative "LNRA", still ranked as the best alternative.

Nevertheless, given the original weight of 0.9 the most suitable alternative "LNRA" ranks reversal with the second best alternative, boundary "1967" at 0.6 which is not a big interval from the original score.

Shown in figure 6.8, SA on highest valued criterion for this group 'income loss' between 'LNRA' and '1967' resulted reversal ranked at US. 1,971,936 $/year, this means that, if income loss reaches a value more than US. 1,971,936 $/year, then '1967' alternative becomes first.

Therefore as general conclusion is to say that, even though alternative "LNRA" for user perspective seems to be the most suitable, alternative's ranked position is moderately stable. If disagreement may arise slight differences with alternative "1967" ranked in second position suggest room for potential agreements.

6.5.2. RLD boundary alternative ranking 'Authorities Perspective'

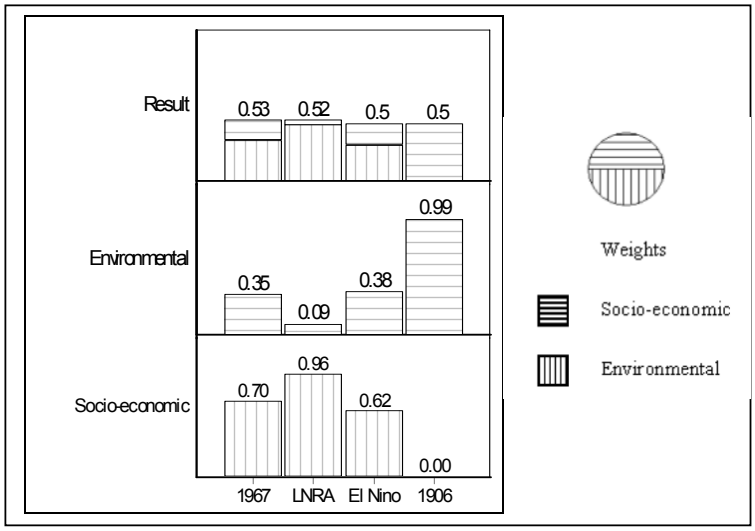


Figure 6.9 Alternative ranking graphic outputs

For Lake's authorities perspective, 'El Niño' boundary resulted with the highest rank (0.53), this was followed by 'LNRA' (0.52) and '1967' (0.5) alternatives second and third positions respectively.

At the other hand '1906' boundary, seemed to be the one with lowest ranking. Figure 6.9 illustrates the output rank arrangement.

a. Effect score and weight uncertainty

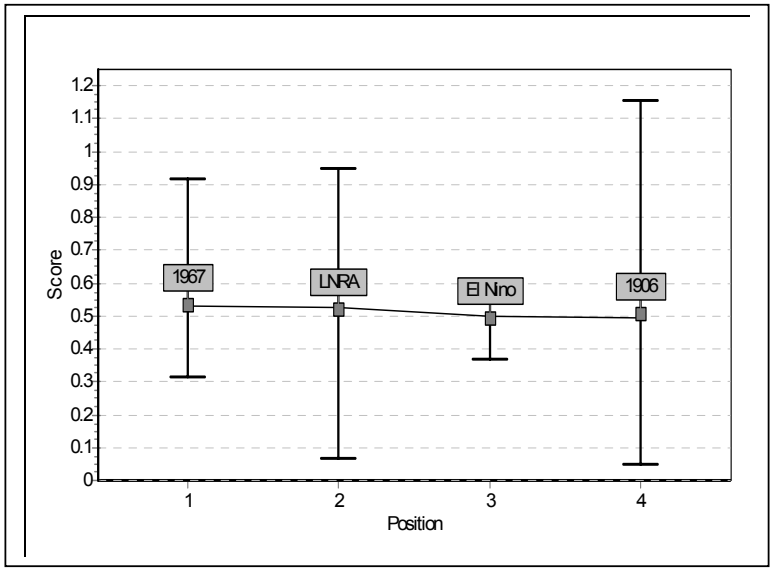


Figure 6.10 Ranking with 15% weight and score uncertainty

Also in this case a 15% and 10% of uncertainty was given at weight and score levels respectively. Even so, shown in figure 6.10, data resulted in alternative "1967" still at first position.

Under this conditions, for this point of view data arrangement, evidenced high variability for all the alternatives except for "El Niño' one.

b. Sensitivity analysis (SA)

Balanced priorities over lake's development were detected for authorities perspective. Therefore for this group an equivalent aspect weight was attached for both Environmental vs. Socio-economic evaluation aspects

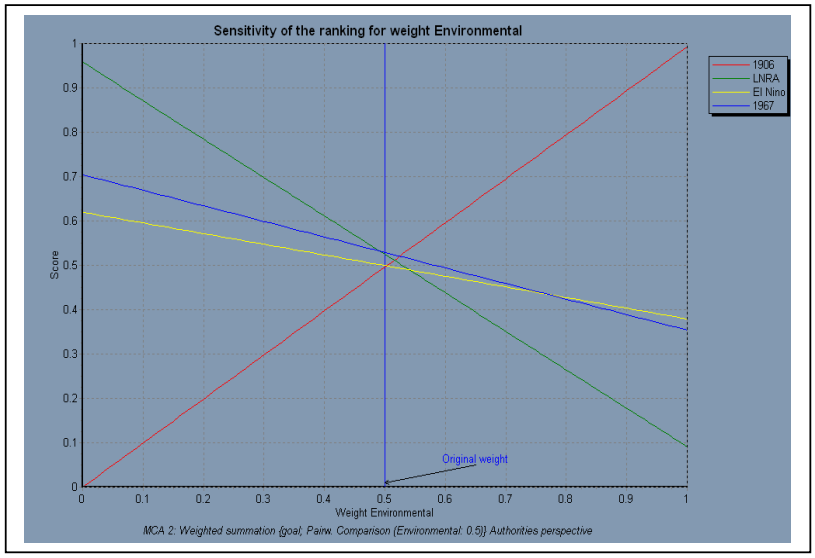


Figure 6.11 SA for more important weight (Socio-economic /Environmental.)

Shown in figure 6.11, between '1967' vs. 'LNRA' alternatives, reversal point was found at 0.52. Even though it occurs at a very close point from the original value at (0.5), its occurrence is still at a medium significant weight value.

Shown in figure 6.11a For Lake's Authorities point of view, criterion 'Reduced water abstraction" within 'Environmental' aspect was found as the most important.

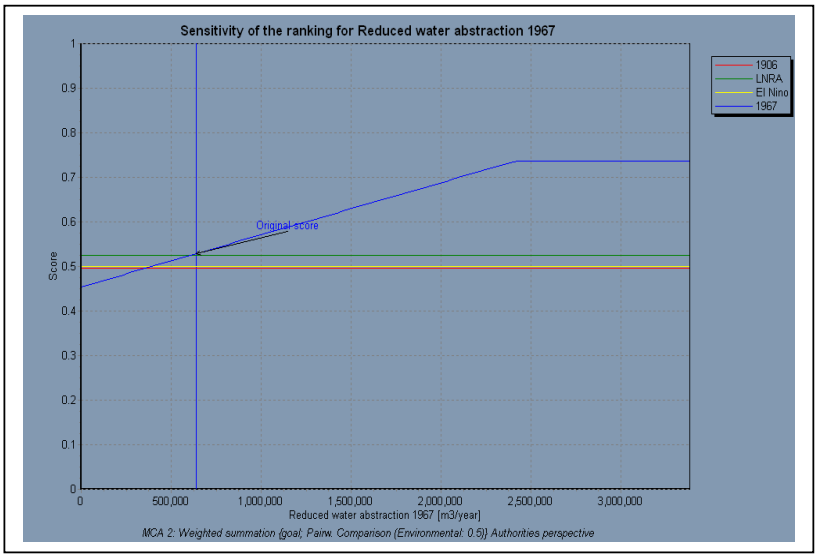


Figure 6.11a SA for most important criterion (water abstraction)

Between '1967' vs. 'LNRA' alternatives this criterion was found to rank reversal at 600,903 m^3/year. This means that if reduced water abstraction reaches a value more than 600,903 m^3/year, then 'LNRA' alternative becomes first

The rest of the alternatives seemed to be very stable respect to this criterion.

Then, it is possible to conclude that respective of weight and score effects, slight differences in weight may result in alternative position changes. Then '1967' alternative ranks at first position but with slight stability, as well as the rest alternatives 'LNRA', 'El Niño' and '1906', at second, third and fourth priorities respectively.

6.5.3. Preferred RLD boundary alternative selection

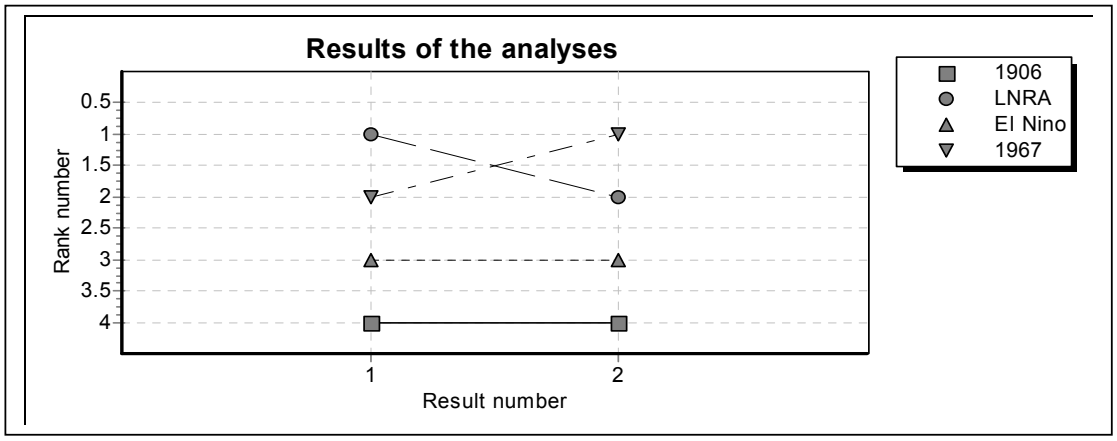


Figure 6.12 SA of the ranking for Environmental weight aspect

Figure 6.12 shows that from the evaluation performed, for 'Lake's users" perspective "LNRA" boundary alternative resulted as the most suitable. This was followed by "1967" limit. On the contrary for the Lake's "Authorities" point of view alternative preference s are in the other way around.

There is an evident conflict of interest between lakes' users and authorities. Different importance (weights) attributed to criteria in evaluation, resulted in selection of two different boundary alternatives for riparian land definition. Since benefits in the long term are common to all parties involve, significant distinction in the importance attributed to environmental aspects, from "users" perspective, suggests a strong necessity specialized programs about environmental education, and wise use of resources.

Even so a not so significant difference of 0.20 in the general scores acquired by "LNRA" limit respect to "1967" boundary alternative (0.73 for users and 0.53 for authorities), suggests significant room for positive agreement negotiations.

From users selection is possible to deduct that when decision was made:

- Shared interest between lake's users and authorities in charge achieved a significant level of agreement.
- There is enough support signing this choice from both sides.
- Primary interest from all parties involved were effectively considered
- The objectives of the Management Plan were taken into account
- Local efforts towards lake resources conservation are in the right direction.

These facts may explain stake holder's acceptance and support, to "LNRA' alternative which, constitute current Lake's management scheme adopted since 1993.

The "LNRA" boundary selected as preferred alternative for RLD was very suitable to permit vegetation conservation, leaving at least 100 meters between the owned land and the landside of the existent riparian vegetation fringe. Therefore, due to the ecological connotation attached to this boundary, current threats affecting lake's resources seems to be a cause of the management rather than the decision itself. Therefore emphasis on management implementation conceived two schemes:

Since, an agreement seemed to exist between the stakeholders on the policies that have been governing the "LNRA" alternative. Because the "LNRA" alternative was the second preference for authorities perspective and because "1967" boundary alternative was presented by this research as another possible boundary not still fully known by all parties involved and not consider in previous judgments.

For this study "LNRA" alternative was selected as preferred choice for RLD purposes and further management contemplations to be elaborated in the next chapter.

7. Riparian Land Management (RLM)

National Wetlands Policy strategies "usually include legal and institutional arguments as well as recommendations about the treatment and the needs of research, monitoring and EIA (Howard, 1996). Since the first step for development of a National wetlands policy strategy is identifying those most valuable that are under threat or are likely to be under threat and take immediately action to ensure their conservation and wise management. The aim of this section is to recognize priority sites providing practical direction to support conservation purposes as well as recommend management schemes for its implementation.

Considering "LNRA" alternative as preferred choice for RLD purposes, third objective of the study is to propose a management scheme. Three main questions seemed to require detailed answers: Which and where are priority sites for riparian vegetation management within a selected alternative? And How to implement the preferred alternative?

So in this chapter priority sites (riparian vegetation units) for conservation purposes are identified, and the current efforts around the management by local authorities in charge of lake's resources, are discussed.

7.1. Identification of priority sites for conservation purposes

7.1.1. Criteria and underlying assumptions for site selection

A main element of the proposed alternative "LNRA" is the protection of the Papyrus ecosystem. Based on review of specialized literature and expert and stakeholders' opinion, criteria to prioritise potential habitat sites (riparian vegetation units) suitable for conservation purposes were selected as follows.

- From the shoreline semi-detailed land use cover, papyrus (adult and young) classes were extracted using a "select Query" tool function in Arc View, resulting in the isolation of papyrus vegetation cover.
- According to College of Agriculture & Natural Resources. Maryland University, (2001), recommendable buffer width for conservation purposes fluctuates between (25 to 250 feet) 8 to 75 meters approximately, then around the unit edges of both classes selected, a buffer of at least 50 meters was generated using 'buffer' tools in Arc View, resulting in 43 sites.
- Elimination of units with an area less than 1 pixel (30 meters) minimum resolution of the source used was performed. Then each identified unit was given an individual identifier per polygon. (Appendix VI, show the list and characteristics of the sites identified)

Although environmental organizations abroad are interested in Lake Naivasha, its management with a lack of funds is a problem. Therefore a prioritisation of sites for conservation purposes should be based on the potential scale of impact result under natural conditions or at least under minimum economic inversion.

According with Bemigisha, (1998), dying papyrus can be taken over scrublands and grassland and finally woodland under natural conditions along the time, but this process could be reverted if the area is inundated again, thus presence of water controls occurrence of riparian vegetation, for that reason

criterion 'current size' of potential habitat conservation sites embody prevalent importance with respect to the lake ecosystem as a whole.

Considering all the benefits to the environment that papyrus can provide, mature ones have relative advantage compare with the young ones. Subsequently if water level increases, then adjacent vegetation units will form a continuous fringe, increasing the size of papyrus units and with that potential contribution to its conservation. In other words papyrus vegetation will expand itself according to water level.

Under the present conditions, papyrus have been suffering by many threats, so public access criterion seems to attach equivalent importance as the potential possibility of the threats to be increased. In this context criteria importance were assigned by the author where 1 = the most important, 5 = the least important. Specific measurements were designed for each criterion, although some measurements can be expected to have more than one effect. Table 7.1 shows the particular proximity influence factors and cause effect indicators elected. Scores are presented in appendix VI.

Table 7.1 Criteria for site selection

CRITERIA	IMPORTANCE	INDICATORS	C / B	DEFINITION
Papyrus status	2	ha	B	Maturity of existing papyrus habitat
Distance to existing adjacent habitat	3	m	C	Proximity to closest existing habitat, potential for target resources to utilize other habitats with connection to the potential conservation site
Distance to disturbance by human activities	3	m	B	Distance to nearby public access. (noise, clearing, burning, populated areas) which may reduce habitat value utilization
Site size	1	ha	B	Extent of potential habitat area for conservation

a. Papyrus status

- Papyrus vegetation discern between two stages: adult and young.
- Papyrus mature vegetation is more suitable than young vegetation
- Area in hectares was calculated for each of the classes identified above (papyrus vegetation cover), using "summarize" table tool in Arc View.

b. Distance to existing adjacent habitat

- The smaller the distance the bigger the possibility to form a continuous unit.
- Around the sites previously generated, multiple interval width buffers (50 meters) using 'buffer' tools in Arc View were generated.
- Distance estimation in meters, using "Measure' tool in Arc View between boundaries of adjacent polygons respectively was performed.

c. Disturbance by human activities

- The closer the access to lake's resources the bigger the possibility of destruction.
- Using the same procedure, distance estimation in meters from each site to public access (corridors) identified in the field was calculated.

d. Site size

- The bigger the area the more suitable for habitat rehabilitation purposes.
- Area in hectares was calculated for each of the sites identified above, using "summarize" table tool in Arc View.

7.1.2. Site Scoring

For the present evaluation, three criteria out of four were identified as benefits, and one was handled as cost (see table 7.1). For each site identified, criteria, its respective measurement units and score were introduced in an "Effects matrix". Appendix VI shows the effect matrix data arrangement.

7.1.3. Pair Wise Comparison and Criteria Weighting

Criteria weighting was based on the importance attribute to each criterion in table 7.1. Table 7.2 illustrates effect values after weighted summation procedure.

Table 7.2 Weighted summation scores and Pair wise effects settings

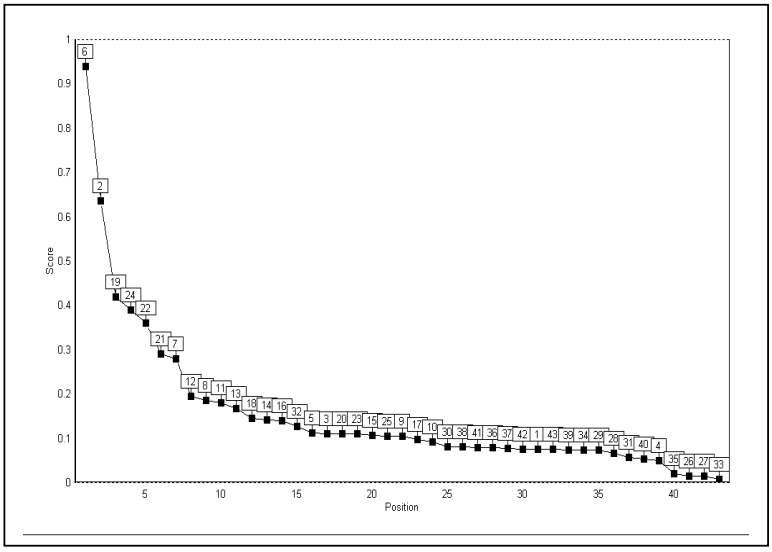
=		C/B	Unit	Standardization method	Minimum Range	Maximum Range	Weight level 1	Weight level 2	Weight
	Site size	+	has	maximum	0.00	3165463.67	0.560		**0.560**
-	**Papyrus**						0.249		
	Adult papyrus	+	has	maximum	0.00	990000.00		0.750	**0.187**
	Young papyrus	+	has	maximum	0.00	787500.00		0.250	**0.062**
	Distance to existing habitat	●	mts	maximum	0.00	400.00	0.095		**0.095**
	Distance to disturbance by H.A.	+	mts	maximum	0.00	1000.00	0.095		**0.095**

7.2. Results from site selection

7.2.1. Site Ranking

Under the evaluation setting above described, site number six (0.86), resulted with the highest priority for conservation purposes, followed by site number two (0.77).

7.2.2. Weight and Effect score uncertainty



Because decision about criteria evaluation importance relayed directly on author opinion, a 5% level of weight uncertainty was introduced.

On the contrary, because data at effect level came from a not totally confident source (unsupervised classification) a 25% uncertainty error level was attached.

Figure 7.1 Site ranking under 5% and 25% of error uncertainty

Nevertheless data processed in this setting resulted in the same site ranking output.

From figure 7.1 is possible to see that due to the range of variability of first 12 sites, those alternatives have no chance at all of beating each other and switch positions. They are very stable, and will remain as first (1st) to twelfth (12th) position, irrespectively of the mentioned percentage of uncertainty introduced. From here onwards sites have slightly chances to switch positions. Figure 7.2 illustrates the spatial locations of sites identified.

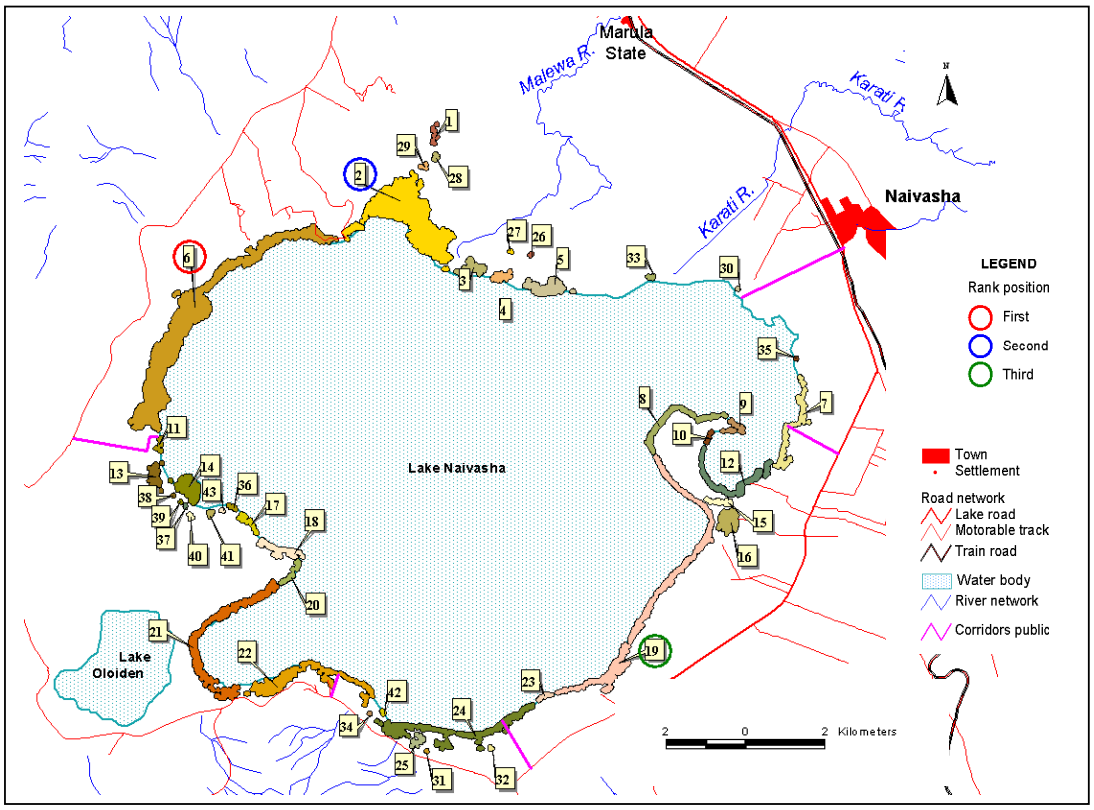


Figure 7.2 Spatial locations of identified sites for papyrus conservation

7.2.3. Sensitivity analysis (SA)

Reversal point at weight level between site six vs. site two and at criterion level, over criterion 'total site size', which is the one with the most weight, was not found.

This means that irrespective of weight variations in the criteria used the alternative 6 and 2 will remain as first and second priority respectively. The rest of the alternatives might rank reversal.

From the analysis above, is possible to conclude that alternative 6 and 2 have the first and second priority respectively for management purposes.

7.3. Management scenarios

Along the Lake's shoreline there is a high diversity of life forms. The riparian vegetation acts as a habitat for these valuable resources. Due to the development pressure behind lake's fringe, conflicts between conservation and cultivation purposes occurred. After identification of priority sites for

conservation purposes, occurrence frequencies of ranked score outputs obtained through site selection process, were plotted in a two axes diagram.

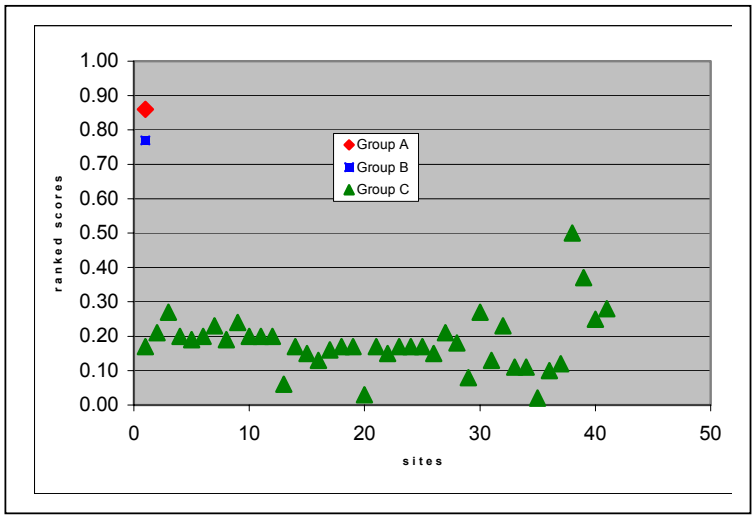


Figure 7.3 Frequency of site ranked score occurrences

Illustrated in figure 7.3, according to the frequency intervals of ranked scores, which revealed characteristic similarities, three clear different data strata could be identified. This process allowed separation of them into different management groups, to set up further management recommendations.

Complementary spatial locations of groups identified were linked with papyrus sites cover. Figure 7.4, illustrates spatial location of clustered sites.

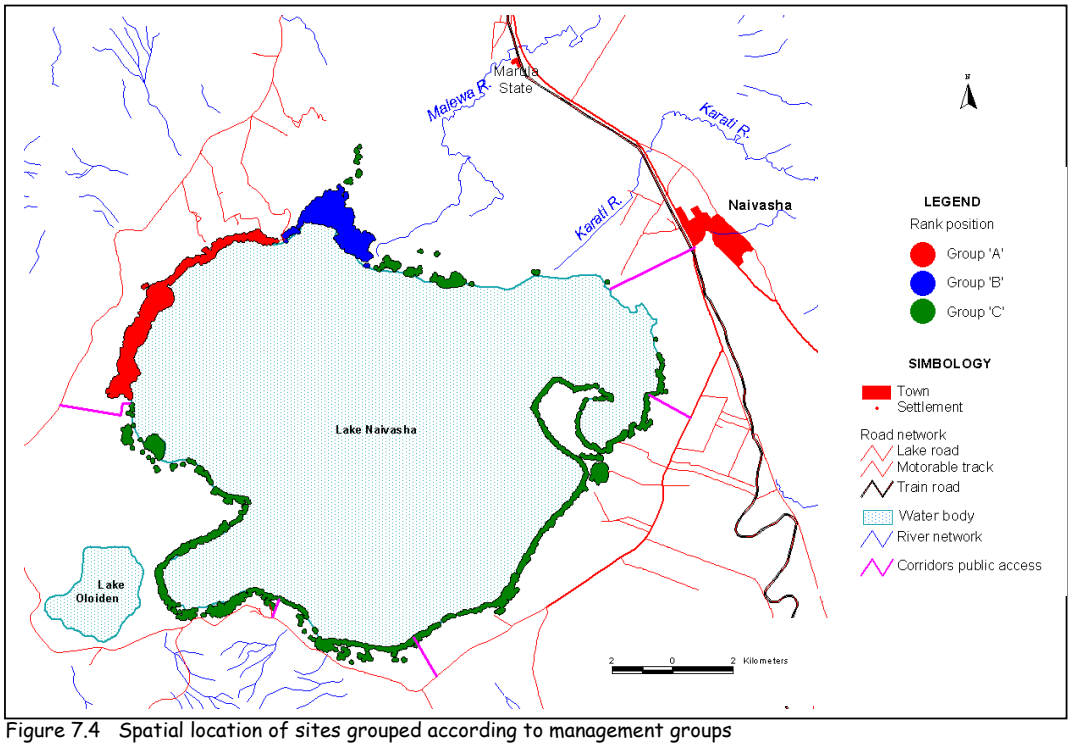


Figure 7.4 Spatial location of sites grouped according to management groups

Factors, suggestions and recommendations for implementation of the preferred alternative identified are presented as follows:

Group "A": Constitute the first ranked alternative, which obtained a ranked score of 0.86; this site located in the north-western part of the lake, with 317 hectares is the largest in area. Even though it has a close public access at about 150 meters, the second major population of adult papyrus approxi-

mately at 87 ha and the first of young ones (79 ha) are currently concentrated in this unit. In addition a close proximity of about 100 meters to alternative site two, ranked at second position, are characteristics that strongly differentiate this site among the others.

Group "B": Situated in the north shoreline of the lake, with a ranked score of 0.77, represents the second ranked alternative; this site encompass an area of 225 hectares, this unit possesses the major population of adult papyrus at 99 ha and the second of young ones (86 ha). Proximity with closest alternative site is about 100. Distance to any registered public access, is more than 1,000 meters.

Group "C": Sites within group C, surrounded all the south-east and west lakes' fringe, as well as a little portion on its north side, because of the similarities found among sites ranked between 0.17 – 0.28 score, this group gather all sites within this range. General characteristics of these sites are: A total area of 870 hectares, with site sizes below 150 hectares and a total population of adult papyrus of 58 hectares, with site sizes less than 11 hectares.

Prioritisation of sites for conservation was done as a first step to introduce a wetland management policy. Even so a more specific management schemes for each of the identified units is required. Time constraints on the elaborated extent required for this input makes impossible to include it in this study.

Even so a broad management implementation for identified groups, were conceived under the managing schemes. Illustrated in figure 7.10, figure shows the management approach proposed for current land uses for "LNRA" as preferred alternative elected.

"To do nothing" scenario, represents the current situation as explained in chapter five. In addition two different views were designed, as follows:

Under proposed "Restricted use", having different land uses around the lake, since a new boundary for riparian land definition comes out, mentioned uses are not consider at all within the proposed limit.

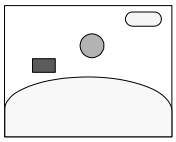
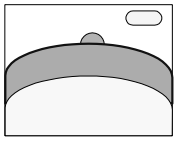
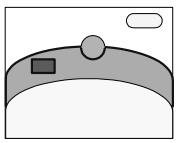
Management scenarios	Description
1. To do nothing 	This scenario reflects the current situation and status around the social, economic, spatial and legal issue in Lake Naivasha.
2. Restricted use 	This scenario implies a strict ecological management of the area, considers the proposed boundary as the major permit limit expansion for potential activities.
3. Wise use 	This scenario allows commercial management but only of sustainable current (2001) land uses within the proposed boundary.
proposed boundary limit	other land uses / current limit

Figure 7.5 Management approach for preferred RLD alternative selected

On the contrary "Wise use" approach permits appearance of new or current development activities, but only of those which are conceived as "sustainable activities".
The boundaries of mentioned sustainable uses constitute the new riparian limit.

In this context, sites classified within group 'A' and 'B' evidence much more relevance for papyrus conservation, therefore "Restricted use" scenario were elected for its management.

On the other hand, because the different characteristics of sites under group 'C', its management relayed under "Wise use" development scheme.

Considering the "LNRA" limit as the preferred boundary alternative and having in mind priority for papyrus conservation, "Restricted" management scheme designed implies that approximately

38% of the present papyrus swamp may come under priority management for conservation. Remaining 62% may be under "Wise use".

Recommended components to be considered based on public and voluntary agreement along the implementation process of the Management Plan of the Lake are:

- Emphasis in adoption of the most adequate way to regulate and control access to the identified priority areas for conservation purposes may be a responsibility shared between LNRA in the coordination and KWS in the execution as present authorities in charge.

- Considering the role in the issue, KARI may assist in appropriate techniques for cultivation upstream and control the expansion of agricultural and commercial activities relaying on the lake

- Considering particular interest and common benefits on the long term, once conservation of priority sites is implemented, swamp restoration in those areas where vegetation has disappeared, especially near sources of contamination (like wastewater discharges from town) may be duties shared between The Town Council and the communities around.

- An environmental education program based on alternatives for sustainable use for Lake Resources and awareness of present situation may change local people's attitudes and finally get their willing action.

- Searching for utilities from conservation of still available resources, promotion of ecotourism as sources of income that could attend some of the required activities for lake conservation (control, monitoring, maintenance) is suggested.

- Livestock management among Maassai people requires for special attention, due to the traditional cultural connotation of the fact, alternative sites for cattle drinking with preferable alternative sources of water, accounts as priority.

- Enforcement and improvement of existing of Lake management policies, which include licensing, banning, poaching control, use of appropriate fertilizers and pesticides, should be concern of every body.

- In addition find ways to disseminate and discussion of the recommendations and suggestions from research activities is also recommendable.

8. Conclusions and Recommendations

8.1. Conclusions

This research proposed a suitable boundary alternative for the riparian land around lake Naivasha. It also proposed a management scenario for the papyrus swamp within these riparian lands. Multi-criteria analysis (MCA), Geographic Information Systems (GIS) and Remote Sensing (RS) methods, supported by stakeholder analysis and conflict management tools, were used to identify various alternatives, which were further evaluated on the basis of a number of criteria and indicators.

Lake Naivasha is a unique freshwater body in Kenya. It is world famous for its high biodiversity. Located in a dry region it posses a fragile ecosystem. In particular the wetlands around Lake Naivasha are reputable for the existing papyrus swamp, significant because these species play an important role in the hydrological regime, as habitat for wildlife, stabilizing climate, and in the local economy of the area.

The lake supports a diversity of activities such as floriculture under intensive production, agriculture, commercial fishery, geothermal energy generation, and tourism. Even so considering the identification of common interests towards management of the lake resources, the main stakeholders were classified in two main categories, as lake "Users" and "Authorities".

Major causes for papyrus destruction that were identified were: encroachment into unsuitable settlement locations, reduction of the water quality of the lake, land degradation due to removal of vegetation, incompatible land uses and environmental deterioration. Difficulties exist to reach consensus about the appropriate management of the lake, pose serious threats to the ecosystem, and leads to a progressive depletion of lake resources (including papyrus ecosystem). Under the present conditions conservation of its resources does not seem to succeed.

During the last years some efforts have been promoted to change the situation. The Lake Naivasha Riparian Association (LNRA), a local association of people worried about the future of Lake's resources, was given authority to settle riparian land disputes. Together with the Kenya Wild Life Service (KWS); they concerned with managing human-animal conflicts are in charge and custodies of lake's resources. However, current efforts seems neither to be enough nor totally effective to avoid lake resources depletion.

The present situation in relation to papyrus conservation is significantly alarming. An uncontrolled and progressive destruction of the ecosystem was found as the core problem affecting the Lake's environment. Specific factors as for instance, population increase, unclear and some times opposite legal framework, personal and economic interests, as well as individualism understood as no common concern, were found as starting points for further effects. From these problems papyrus cutting and burning, water contamination and insufficient amount of water, accounted as main causes, all contributing with swamp ecosystem depletion.

Regarding swamp ecosystem destruction incompatible land uses and increased un-controlled access to the Lake, were found as main effects. This resulted in decreased quality of life and loss of biodiversity, both leading to an imbalanced carrying capacity of the lake resources.

Current efforts to manage the situation around the lake have been incorporated in this study, a ban on fishing from February to August of 2001, has had a favourable effect on the ecosystem that had been under stress since the 1998 "el Niño" flooding. A significant increase in the extent of the swamp area has resulted in re-appearance of aquatic species (water lilies) once thought lost forever. Large mammals seem to be relaxed with the absence of disturbance (hippopotamus). Increase in fish stock and for sure not yet recognised long-term benefits, accounts as evident successful results from this fact.

But at least just at this moment more time is still required. For instance the Papyrus swamp needs to maintain a certain presence to contribute with its benefits to the ecosystem. Also for fish species time is required to reach the size and maturity stage with the age to able to breed and reproduce another generation and to be caught.

There is existent legislation that encompasses environmental issues towards conservation of natural resources. Nevertheless some incompatibilities in the statements that they contain, leaves room for confusion and infraction. Therefore unless there is harmonization between all the related acts in terms of environmental laws these problems will continue.

Analysis of economic information from previous studies helped to define criteria and indicators that allow an assessment of current and potential impacts from agricultural activities and proposed alternative boundaries in terms of potential reduced flow to lake's water level volume, volume of potential source of pollution for lakes resources, and potential employment displaced per farm, per each of the crop types present in the area.

Potential loss of the net economic return from "influenced areas" was used as indicator to estimate the potential economic impact that may take place and acted as spatial component to compare different proposed riparian limits. Superimposing these limits (overlay) with current land uses allowed eventually coming up with the establishment of matching and influenced areas between both uses.

The evaluation of the four different boundary alternatives for riparian land definition proposed resulted in the "LNRA" (present lake's management scheme) boundary as the most suitable alternative from the lake's "Users" point of view. On the contrary for the "Authorities" perspective, alternative "1967" (papyrus recorded maximum extent) resulted as the best option.

There is an evident conflict of interest between lakes' users and authorities. Different importance (weights) attributed to criteria in evaluation, resulted in selection of two different boundary alternatives for riparian land definition. Since benefits in the long term are common to all parties involve, significant distinction in the importance attributed to environmental aspects, from "users" perspective, suggests a strong necessity of specialized programs about environmental education, and wise use of resources. Even so a not so significant difference in the general scores acquired by "LNRA" limit respect to "1967" boundary alternative, suggests room for positive agreement negotiations, towards considerations about RLD issues.

- Shared interest between lake's users and authorities in charge achieved a significant level of agreement.
- There is enough support signed this choice from both sides.
- Primary interest from all parties involved were effectively considered
- The objectives of the Management Plan were taken into account
- Local efforts towards lake resources conservation are in the right direction.

These facts may explain stake holder's acceptance and support, to "LNRA' alternative which, constitute current Lake's management scheme adopted since 1993.

The "LNRA" boundary selected as preferred alternative for RLD was very suitable to permit vegetation conservation, leaving at least 100 meters between the owned land and the landside of the existent riparian vegetation fringe. Therefore, due to the ecological connotation attached to this boundary, current threats affecting lake's resources seems to be a cause of the management rather than the decision itself. Therefore emphasis on management implementation conceived two schemes:

Since, an agreement seemed to exist between the stakeholders on the policies that have been governing the "LNRA" alternative. Because the "LNRA" alternative was the second preference for authorities perspective and because "1967" boundary alternative was presented by this research as another possible boundary not still fully known by all parties involved and not consider in previous judgments. For this study "LNRA" alternative was selected as preferred choice for RLD purposes and further management contemplations.

Along the Lake's shoreline there is a high diversity of life forms. The riparian vegetation acts as a habitat for these valuable resources. Due to the development pressure behind the lake's fringe, conflicts between conservation and cultivation purposes occurred. Therefore identification of priority sites for conservation purposes was recommendable.

Considering similarities, among identified vegetation units separation into different management groups, that allowed setting up of further management recommendations was introduced. Prioritisation of sites for conservation was done as a first step to introduce a wetland management policy. Even so a more specific management schemes for each of the identified units is required. Time constraints made it impossible to included it in this study.

Nevertheless, considering the "LNRA" limit as the preferred boundary alternative and having in mind priority for papyrus conservation, two "Restricted and Wise use" broad management schemes were designed. Under these schemes approximately more than a quarter of the present papyrus swamp may come under priority management for conservation.

Finally it can be said that integration of RS, GIS and MCA used in the assessment of the proposed boundary alternatives was a powerful tool in running the estimation of alternative impact effects, boundary selection, prioritisation of swamp sites for conservation purposes and visualizing the results.

Complementary sensitivity analysis performed on selection of preferred boundary alternative for RLD, as well as for, the prioritisation of swamp sites for conservation purposes allowed simulation of variations either in the importance weights as well as in criteria effects. Since results did not evidence significant variation, this process contributed through obtaining the most acceptable results for all the parties involved.

8.2. Recommendations

8.2.1. Actions by specific stakeholders

Recommended components to be considered based on public and voluntary agreement along the implementation process of the Management Plan of the Lake are:

- Emphasis in adoption of the most adequate way to regulate and control access to the identified priority areas for conservation purposes may be a responsibility shared between LNRA in the coordination and KWS in the execution as present authorities in charge.
- Considering the role in the issue, KARI may assist in appropriate techniques for cultivation upstream and control the expansion of agricultural and commercial activities relaying on the lake
- Considering particular interest and common benefits on the long term, once conservation of priority sites is implemented, swamp restoration in those areas where vegetation has disappeared, especially near sources of contamination (like wastewater discharges from town) may be duties shared between The Town Council and the communities around.
- An environmental education program based on alternatives for sustainable use for Lake Resources and awareness of present situation may change local people's attitudes and finally get their willing action.
- Searching for utilities from conservation of still available resources, promotion of ecotourism as sources of income that could attend some of the required activities for lake conservation (control, monitoring, maintenance) is suggested.
- Livestock management among Maassai people requires special attention, due to the traditional cultural connotation of the fact, alternative sites for cattle drinking with preferable alternative sources of water, accounts as priority.
- Finally enforcement and improvement of existing of Lake management policies, which include licensing, banning, poaching control, use of appropriate fertilizers and pesticides, should be concern of every body.
- In addition find ways to disseminate and discussion of the recommendations and suggestions from research activities is also recommendable.

8.2.2. About this study

- Since a Landsat TM image was used for shoreline cover classification, scale factor was a significant limitation; therefore data integration with another more suitable source of data such as aerial photography, which allows more detailed shoreline vegetation identification, is recommended.
- Based on the availability of spatial information level of analysis was selected, as mentioned before resolution of the source used do not allow desired truthfulness, Hence inclusion of more specific criteria and indicators for prioritisation of swamp vegetation units for conservation purposes.
- Once prioritisation of sites for conservation was done as first step for introduce a wetland management policy, more specific management schemes for identified units is required.
- Criteria elements of the research might need further discussion with and feedback from the stakeholders involved: as the proposal boundary alternatives and the identified restoration sites.

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Appendix I. Fieldwork Questionnaires

LAKE NAIVASHA PERCEPTIONS TOWARDS PAPYRUS CONSERVATION (Authorities questionnaire)

Stakeholder interview details
Name: Date: Representative of: Cod:
Characterization
1. What are the **main activities** of the institution/organization you represent?
2. What are the **main achievements** of the institution/organization you represent?
3. What are **common problems** (to fulfil your responsibilities) in to the organization?
3.a. Since when?
3.b. Why?
Attitudes towards papyrus conservation
4. What are the main **problems** with the present use of the lake?
5. What do you see as the main **causes**?
6. Is there any **evidence** of un-enforcement of the current law regulations?
6.a. If yes, specify which ones?
7. Are you **aware** about the 50 m **buffer zone regulation** for papyrus protection?
8. What is your **opinion** about this regulation/proposal (pros-cons)?
9. Does your organization do anything in relation to papyrus **conservation** around the lake?
Then, we have fertile soils vs. Papyrus bio - diversity retaining….
Attitudes towards riparian land management
10. Do you think that **Riparian** zone should be used only for conservation rather than for **other** purposes?
10.a. If no, specify which others?
11. What do you think is an **alternative solution** for **riparian land management?**
12. From your position do you **see consequent problems** in this possibility?
12.a. If yes, specify which ones?
13. Why?

LAKE NAIVASHA PERCEPTIONS TOWARDS PAPYRUS CONSERVATION (Users questionnaire)

Interview details
Name: Date: Membership: Farm/LUT: Coords: x: y:
Stakeholder definition
1. What are your main **activities and/or interests** in this area?
2. Since when you occupy this place?
Existing land use and constraints
3. Are there any **problems** you have seen to achieve your interests?
4. Are you **satisfied** with your cropping situation?
4.a. If not, why?
5. Do you thing there is any **possibility to increase** the size of your farm?
5.a. If not, why?
6. Have you or your membership **try to solve** this problem?
6.a. How?
7. What else do you think must be done to solve your problems?
7.a. By whom?
Attitudes towards papyrus conservation
8. What are the main **problems** with the present use of the **lake?**
9. What do you see as the main **causes?**
10. Do you think that **papyrus existence benefit people** around the lake?
10.a. If yes, specify how?
11. There is a law **regulation of 50m** zones for **papyrus protection**.
12. What is your **opinion** about this regulation/proposal (pros-cons)?
Then, we have fertile soils vs. Papyrus bio - diversity retaining….
Attitudes towards riparian land management
13. Do you think that **Riparian** zone should be used only for conservation rather than for **other purposes?**
13.a. If no, specify which others?
14. From your position do you see **consequent problems** in this possibility?
14.a. If yes, specify which ones?
15. What do you think is **alternative solution riparian land management?**

Appendix II. List of Stakeholders interviewed

Lake Users

Code	Name	Institution
5	Mr. Simon Ndungu	Small farmer
6	Mrs. Rafaela la Vila	Brixia farm (owner)
7	Mr. John Kariuki	Loldia farm (administrator)
8	Mr. Francisco Natta	Marula farm (administrator)

Lake Authorities

Code	Name	Institution
10	Mrs. Sarah Higgins	Honourable Secretary, LNRA
12	Mr. Roderick Kundu	Senior Fisheries Officer KWS, Naivasha
20	Mr. Nickson Othieno	Elsamere Conservation Centre, Biologist
21	Mr. James Whararer	Manager Assistant, Lake Naivasha Country Club
28	Mr. Paul Kiligori	Naivasha Municipal Council (Water Maintenance Officer)
29	Mr. Samuel Siamba	Kenya Agricultural Research Institute (KARI)
30	Mr. Dominik Wambua	Ministry of Environment. Water Resources Department
31	Mr. James Kahora	Indigenous Biodiversity Environmental Conservation Asc.
32	Mrs. Ruth Ruigimoeller	Naivasha Municipal Council (Planner Town engineer)
33	Mr. Andrew Lord Enniskillen	Chairman LNRA
34	Mr. Hans Jurgen Scholl	Naivasha Municipal Council (Water Project Consultant)
35	Mr. George Morara	Kenya Marine & Fisheries Research Institute
36	Mr. Sammuel Githai	Environmental Officer LNRA

Appendix III. Questionnaires tabulation (Users)

Lake Naivasha Users Questionnaire								
DATE			9/26/2001	9/26/2001	27/09/2001	9/28/2001	9/18/2001	9/26/2001
CODE			6	7	8	R - 5	R-21	29
IN PLACE/SERVICE			50	15	5	15	6,15	15
MEMBERSHIP			LNRA	LNRA	LNRA	3 mem. Assoc.	Block Resorts	33 Centres
LUT			be,ca,ma,po	3",we,lu,to	lu,ma,ba,we, root grs,	ma,be,ca,to,sp		cattle, lamb
Z			1938	1989	1952			1903
tape						3a	3b	
#	Question	Answer						
1	Main activities and / or interests	agric / horticulture production for exportation		X				
		research						X
		tourism		X			X	
		marketing					X	X
		community support						X
		agric / horticulture production for local consume	X	X	X	X		
		training						X
		livestock production for local consume						X
2	Since when?		12/16/1963	1958	1995	1985	1927	1985
3	Problems to achieve your interests	legal framework						X
		monetary		X		X		X
		cooperation - support					X	X
		personal		X				
		infrastructure		X		X	X	
		time to succeed						X
		insecurity	X					
		water scarcity		X	X	X	X	X
4	Satisfied with cropping situation	Y	X	X	X	X	X	X
		N						
4.a.	If not, why?	legislation						
		financial					X	
		personal						
		equipment						

Appendix III. Questionnaires tabulation (Users cont…)

CODE			6	7	8	R - 5	R-21	29
#	Question	Answer						
5	Possibility to increase your farm	Y		X	X	X		
		N	X				X	X
5.a.	If not, why?	legislation						
		financial						X
		personal						
		equipment						
		expectations fulfilled	X				X	X
		age	X					
6	Have you try to solve this problem?	Y	X			X	X	X
		N						
6.a.	How ?	by law	X					
		using force						
		by own investment	X			X	X	
		international cooperation						X
7	What else to do?	water service provision	X	X		X	X	X
		support				X		X
7.a.	By whom?	government	X	X		X	X	X
		LNROA						
		KWS						
8	Problems with present lake use	losses for land degradation	X	X	X	X		X
		reduction of the water amount			X	X	X	X
		reduction of water quality / contamination			X	X	X	X
		removal of dry papyrus vegetation	X	X				X
		loss of fauna	X	X	X		X	X
		cutting / burning						

Appendix III. Questionnaires tabulation (Users cont…)

CODE			6	7	8	R - 5	R-21	29
#	Question	Answer						
9	**Main causes**	human induced factors (encroachment, destruction)						
		external natural factors (drier trends)	X	X	X	X		
		papyrus direct	X	X				X
		water contamination (pesticides)			X		X	
		water pumping extraction	X		X		X	
		incompatible land uses						X
		avoid wild life invasion	X	X				
		deforestation				X		
		poverty				X		
		ignorance				X		
		corruption				X		
		no enough control				X		
		no community concern / individualism				X		
10	**Papyrus existence benefit people**	**Y**	X	X	X	X	X	X
		N						
10.a	**If yes, specify how?**	tourism		X	X		X	
		water quality				X		
		biodiversity	X	X	X		X	X
11	**50 m regulation for papyrus protec-**	not known				X	X	X
		agree		X				
		disagree	X		X			
12	**What is your opinion?**	**pros**						
		wildlife habitat	X		X		X	X
		protection against wildlife invasion	X	X				
		cons						
		tourism attraction	X					
		not enough - 100 or +	X	X	X			

Appendix III. Questionnaires tabulation (Users cont…)

CODE			6	7	8	R - 5	R-21	29
#	Question	Answer						
13	Only conservation use for Riparian zone	y			X		X	X
		N	X			X		
13.a.	If no, specify which others	survival +				X	X	
14	Consequent problems	y	X			X	X	
		N		X	X			X
14.a.	If yes, specify which ones	increase of mentioned problems				X	X	
		people attraction	X					
		corridors for public access	X					
15	Alternative solutions for riparian land management	increase buffer zone	X		X			
		enforcement of 500 mts, central equilibrium	X					
		help in enforcement of law (catch illegal)		X				
		enforcement of current law				X		X
		community education				X		
	other		gully	gully				
			fence	fence			permanent	
				channel			infrastructure	

# of responses out of 6 **4 - 5** **6**

Appendix III. Questionnaires tabulation. (Authorities)

Lake Naivasha Authorities Questionnaire												
DATE			9/19/2001	11/10/2001	9/13/2001	28/09/2001	1/10/2001	9/10/2001	2/10/2001	9/18/2001	2/10/2001	9/17/2001
CODE			R - 12	R - 35	R - 30	R - 10	32	R - 36	R - 24	R - 31	33 - R-34	28
tape #			3a	9a	1+2a	5b - 6a		7b	7a	2	5a	
#	Question	Answer										
1	Personal / Organ.	Conservation/protection	X	X	X	X	X	X		X		
		research	X	X	X	X	X	X	X			
		tourism - recreation				X						
		education - training	X	X	X	X	X	X	X			
		awareness	X	X		X	X	X	X	X	X	
		monitoring	X	X	X	X	X	X	X		X	X
		data collection		X	X	X	X	X	X		X	
		witness					X		X	X		
		management - policies	X	X		X	X	X	X		X	
		consultant									X	
		community service										X
2	Personal / Organ. main achievements	conservation	X	X		X	X	X	X			
		protection		X		X	X	X	X			
		protection through coopera-tion					X			X		X
		research		X	X		X		X			
		education	X			X	X	X	X			
		services provide	X	X		X	X	X	X		X	X
		public - community support		X		X	X	X	X	X		
		international support				X	X					

Appendix III. Questionnaires tabulation. (Authorities cont…)

CODE			R - 12	R - 35	R - 30	R - 10	32	R - 36	R - 24	R - 31	33 - R-34	28
#	Question	Answer										
3a	Since when?		7/1/1969	1996	10/2/2000	1997	27 - 84	1999	11 - 1	5/9/2001	1999 / 2001	86
3b	Why?	transfer			X							
		by own								X		
		support	X	X		X	X	X	X		X	X
4	Problems with present lake use	loss of agricultural lands									X	
		reduction of water quality / contamination	X	X	X			X	X	X	X	X
		land degradation	X		X			X		X	X	
		removal of papyrus dry vegetation	X	X	X			X		X	X	X
		destruction of the shoreline	X	X				X				
		fish stock decreasing		X	X							
		loss of fauna by poachers	X	X	X		X			X		X
		reduction of amount of water			X		X	X		X	X	
		sewage water disposal			X		X				X	
		cutting / burning								X		
		illegal poaching	X		X							
5	Main causes	human induced factors (encroachment)	X		X			X	X	X	X	X
		external natural factors (drier trends)	X	X			X	X			X	X
		papyrus direct destruction / use	X	X	X			X	X	X	X	X
		population increase	X	X	X		X		X		X	X
		incompatible land uses	X	X			X	X	X	X		X
		water contamination (pesticides)	X	X	X			X	X	X	X	X
		unclear definition of riparian land	X		X			X		X		
		water pumping extraction	X		X					X		X
		pests introduction										X
		personal - economic interests		X	X					X		
		lack of education	X	X	X				X		X	
		unclear / opposite legal framework	X	X	X			X		X		X
		neglect ness control / nobody complains								X		

Appendix III. Questionnaires tabulation. (Authorities cont…)

		government is no keen (support)									X		X	
		uncertainty - lack of organization						X			X			
		inadequate fishery techniques	X	X							X			
		poverty					X							
		illegal fishing	X		X									
		protection against wildlife encounters	X	X										
		deforestation						X		X				
		siltation - runoff - erosion			X			X		X				
		inappropriate water sewage disposal			X					X				
		geothermal heavy metal disposal								X				
		inadequate agriculture techniques								X				
		politics involvement				X								
		cattle movement				X								
		no common concern / individualism			X						X			

CODE			R - 12	R - 35	R - 30	R - 10	32	R - 36	R - 24	R - 31	33 - R-	28
#	Question	Answer										
6	Is there any evidence of law un enforcement	y	X	X	X	X		X	X		X	X
		N										
6.a.	Which evidences?	farms limits increase			X	X				X		X
		new farms presence			X			X	X			
		papyrus destruction	X	X		X		X	X	X	X	
		permanent buildings presence						X		X		
		destruction by hidden walls	X									
		creation of channels for fishing	X									
		destruction of the shoreline	X	X		X						
		decrease in water quality (transparency)				X			X			
		illegal poaching			X						X	
7	50 m buffer zone reaulation	not known									X	
		agree										
		disagree	X	X	X			X	X	X	X	X

Appendix III. Questionnaires tabulation. (Authorities cont…)

CODE			R - 12	R - 35	R - 30	R - 10	32	R - 36	R - 24	R - 31	33 - R-	28
#	Question	Answer										
8	What is your opinion?	**pros**										
		papyrus regeneration chance	X	X	X			X			X	
		avoid shoreline interference	X	X					X	X		
		increase water quality		X				X	X		X	
		breeding place	X	X	X			X	X			
		feeding place	X	X	X			X	X			
		refuge / shelter place	X	X				X	X			
		reproduction place	X	X	X			X	X			
		nesting place		X					X			
		cons										
		not enough - 100 or +	X	X	X			X	X	X	X	X
		farmers complains	X		X					X		X
		farmers willingness			X						X	
9	Org. actvts. payrus conserva-	restoration		X							X *	
		able restoration	X	X			X				X *	
		monitoring	X	X	X		X	X	X		X *	
		protection	X	X			X				X *	
		education	X	X			X	X	X		X *	
		capture transgressor for prison	X				X					
		**** in the future***										
10	**Only conservation use for Ri-parian zone**	y	X	X					X	X	X	
		N			X		X					X
		sustainable / wise use			X	X	X	X			X	
10.a.	**If no, specify which others**	obtain profits	X		X	X	X					X
		conservation	X	X	X	X	X	X			X	
		public corridors (Maassai)			X					X	X	
		offer job opportunities					X				X	
		waste water disposal treatment									X	
		improvement of water quality	X	X	X			X		X	X	
		eco-tourism									X	
		bird watching						X				

Appendix III. Questionnaires tabulation. (Authorities cont…)

CODE			R - 12	R - 35	R - 30	R - 10	32	R - 36	R - 24	R - 31	33 - R-	28
#	Question	Answer										
11	**Alternative solutions for riparian land management**	temporary close	X	X		X		X				
		ban application	X	X		X		X				
		permanent marks for R. L. delimitation			X	X	X	X		X		
		strict control of proposed activities		X		X	X	X	X	X	X	
		change land ownership										
		new environmental law			X	X		X				
		new sources of water									X	X
		law review		X		X	X	X				X
		law enforcement				X	X	X	X	X	X	
		patrol guard creation								X		
		monitoring			X	X	X	X	X			
		community environmental education	X	X	X	X	X	X	X		X	
		situation awareness	X	X	X	X	X	X	X		X	
		taking to court								X		
		fee or taxes collection								X		
		forced works for conservation lake	X									
		impost strict monetary fines	X									
		imprisonment	X									
		control selected access to the lake	X			X					X	
		establish a user code of conduct	X									
		ecological decisions through consensus		X		X		X				
		assist agriculture techniques up stream				X			X			
		promote eco-tourism				X			X		X	
		increment size buffer papyrus protection							X			
12	**Consequent problems**	Y		X			X		X			X
		N				X					X	

Appendix III. Questionnaires tabulation. (Authorities cont…)

CODE			R - 12	R - 35	R - 30	R - 10	32	R - 36	R - 24	R - 31	33 - R-34	28
#	Question	Answer										
12.a.	If yes, specify which ones	farmers willingness					X		X	X		X
		community support		X					X			
		loss compensations		X								
13	Why?	law contradiction		X	X			X				
		overload demand	X	X		X	X	X			X	X
		unclear legal framework			X			X		X		X
		corruption			X							
		colonial permission reference						X		X		
		C- because land compensation	X	X						X		
		fauna & flora restoration required	X	X		X			X		X	
		resources of the lake are not endless	X			X	X	X				

# of responses out of 10 **6 - 8** **9 - 10**

Appendix IV. Criteria and underlying assumptions impact assessment at farm level

CRITERIA	SUB-CRITERIA	INDICATORS	DEFINITION
ENVIRONMENTAL	Water abstraction	m^3/ha/year	Volume of water required per crop for irrigation in influenced areas.
	Area	ha	Size of area influenced
	Contamination by pesticides use	ton/ha/year	Amount of pesticides required per crop in influenced areas
SOCIO ECONOMIC	Income loss (owner point of view)	US $/ha/year	Loss on production caused by potential farm area reduction in influenced areas
	Employment displacement	Number of people/ha	Labours potentially displaced per farm

a. Area

- Cover "Overlay" between the different proposed boundary alternatives and current land uses allowed coming up with the establishment of influenced areas.
- Influenced area size (C-aa_sz) in hectares was calculated for each of the influenced areas (farms) identified, using "summarize" table tool in Arc View for each of the alternatives boundaries

b. Water abstraction

- Irrigation requirements for each of the enlisted crops have been calculated for the study area (Sayeed 2001). Water abstraction in influenced areas (C-wt_at) for the year for each crop is estimated by multiplying influenced area size in ha by the required number of m^3 for irrigation per hectare.
- C-wt_at (m^3/ha/year) = C-aa_sz (ha) * Irr.Req. (m3//ha/year)

c. Contamination by pesticides use

- Use of pesticides for each of the enlisted crops has been calculated for the study area (Sayeed 2001). Contamination by pesticides use in influenced areas (C-ptc_ct) for each crop is estimated by multiplying Area size in ha by the required pesticide weight in tons for cultivation per hectare.
- C-ptc_ct (Ton/ha) = C-aa_sz (ha) * Ptc.req. (ton//ha)

d. Employment displacement

- Employment requirements for each of the enlisted crops have been calculated for the study area (Sayeed 2001). Employment displacement in influenced areas (C-em_dlm) for the year for each crop is estimated by multiplying Area size in ha by the required number of persons per hectare.
- C-em_dlm (persons/ha) = C-aa_sz (ha) * Perosns.Req. (persons/ha)

e. Income loss (owner point of view)

- Net profit for each of the enlisted crops has been calculated for the study area (Sayeed 2001). Income loss in influenced areas (C-lc_ls_opv) for the year for each crop is estimated by multiplying Area size in ha by the net profit per hectare.
- C-lc_ls_opv (US $/ha/year) = C-aa_sz (ha) * Net profit (US. $//ha/year)

Appendix V. Pair wise comparison out put

Lake's Users perspective

=		C/B	Unit	Standardization method	Minimum Range	Maximum Range	Weight level 1	Weight level 2	Weight
-	**Environmental**						0.125		
	Alternative total area	+	has	goal	0.0	7592.7		0.565	**0.071**
	Reduced water abstraction	+	m3/year	goal	0.0	2416348.9		0.118	**0.015**
	Reduced pesticide contamination	+	tons/year	goal	0.0	42.5		0.055	**0.007**
	Swamp presence	+	has	goal	0.0	2888.7		0.262	**0.033**
-	**Socio-economic**						0.875		
	Employment displacement	●	persons	goal	0	5648		0.105	**0.092**
	Farm influenced areas	●	has	goal	0.0	714.0		0.258	**0.226**
	Income loss (owner point of view)	●	U.S. $/year	goal	0.0	6871801.3		0.637	**0.557**

Tables Va. Criteria Pair wise comparison

Lake's Authorities perspective

=		C/B	Unit	Standardization method	Minimum Range	Maximum Range	Weight level 1	Weight level 2	Weight
-	**Environmental**						0.500		
	Alternative total area	+	has	goal	0.0	7592.7		0.055	**0.028**
	Reduced water abstraction	+	m3/year	goal	0.0	2416348.9		0.565	**0.282**
	Reduced pesticide contamination	+	tons/year	goal	0.0	42.5		0.262	**0.131**
	Swamp presence	+	has	goal	0.0	2888.7		0.118	**0.059**
-	**Socio-economic**						0.500		
	Employment displacement	●	persons	goal	0	5648		0.637	**0.318**
	Farm influenced areas	●	has	goal	0.0	714.0		0.258	**0.129**
	Income loss (owner point of view)	●	U.S. $/year	goal	0.0	6871801.3		0.105	**0.052**

Tables Vb Criteria Pair wise comparison

Appendix VI. Effect matrix (Papyrus conservation site selection)

	Site size	Papyrus status		Distance to existing adjacent habitat	Distance to disturbance by human activities
Site	Area total	Area adult	Area young	Distance	Distance
code	ha	ha	ha	m	m
1	8.6	0.5	0.4	150	+ 1000
2	224.8	99.0	34.1	150	+ 1000
3	19.6	2.7	2.4	110	+ 1000
4	12.5	1.4	1.4	300	+ 1000
5	34.6	8.2	6.9	275	+ 1000
6	316.5	87.5	78.8	150	100
7	47.6	0.6	10.3	50	0
8	41.9	1.3	10.8	10	+ 1000
9	13.1	0.2	2.1	75	+ 1000
10	4.8	0.0	0.5	50	+ 1000
11	6.6	0.2	0.5	100	0
12	47.6	3.2	9.6	50	925
13	19.7	0.9	4.1	150	325
14	33.1	5.8	10.4	150	+ 1000
15	11.0	0.5	1.4	50	+ 1000
16	28.0	3.8	8.4	100	+ 1000
17	11.9	0.1	1.4	90	+ 1000
18	25.4	0.4	4.5	10	+ 1000
19	149.0	10.9	30.3	10	+ 1000
20	12.1	0.1	1.5	40	+ 1000
21	100.6	6.2	20.7	100	+ 1000
22	87.6	5.5	19.4	100	0
23	6.0	0.2	0.8	10	950
24	96.9	4.6	20.3	40	0
25	10.0	0.0	1.3	40	+ 1000
26	2.0	0.1	0.1	350	+ 1000
27	1.7	0.0	0.2	350	+ 1000
28	3.8	0.3	0.3	150	+ 1000
29	3.9	0.1	0.2	125	+ 1000
30	1.4	0.0	0.1	+ 400	175
31	1.4	0.0	0.1	175	+ 1000
32	2.1	0.1	0.2	75	525
33	3.5	0.2	0.4	+ 400	+ 1000
34	1.4	0.0	0.1	110	975
35	1.4	0.0	0.1	325	+ 1000
36	4.0	0.1	0.4	100	+ 1000
37	1.7	0.1	0.1	90	+ 1000
38	1.4	0.0	0.1	75	+ 1000
39	1.4	0.1	0.0	100	+ 1000
40	3.2	0.0	0.5	200	+ 1000
41	3.6	0.2	0.7	100	+ 1000
42	2.3	0.0	0.3	100	+ 1000
43	1.7	0.0	0.2	100	+ 1000

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Design and Performance of Experimental Constructed Wetlands in Uganda, Planted with Cyperus Papyrus and Phragmites Mauritianus

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