Lake Naivasha Riparian Owners Association

A THREE PHASE ENVIRONMENTAL IMPACT STUDY OF RECENT DEVELOPMENTS AROUND LAKE NAIVASHA

Phase I

An assessment of current information on the lake, relevant to a management plan, and recommendations for phase II of the study.

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EXECUTIVE SUMMARY

1. Introduction

1.1 The Lake Naivasha Riparian Owners Association (LNROA), mindful of its main objective of caring for the environment of Lake Naivasha and its surroundings; concerned that the lake is under intense pressure, and aware that many conflicting opinions and conclusions are held by its members who represent diverse activities; resolved to commission an independent three phase environmental impact study of the lake. This study would lead to management of the ecosystem to ensure sustainable use of the resource in the future.

1.2. Being determined to involve all concerned in the programme, and to fairly evaluate all relevant opinions; a seminar was held on September 16th 1993 which was attended by members and invited guests with concern for the lake. The seventy persons present unanimously gave the LNROA a mandate to proceed at once with the study and to solicit funds from the membership to pay for it.

1.3. This first phase is designed to collect all available information on the lake, and to write a review of the state of knowledge on the lake; particularly of information that is relevant to the preparation of a management plan for the area. Recommendations will also be given for the work of phase II of the study.

1.4 Phase II will write a Management Plan for the Lake ecosystem including the catchment areas that will allow for sustainable development of the Town, the Horticultural industry, and the Geothermal Power station; maintain the quantity and quality of lake water, and preserve its natural beauty and diversity of plant, animal and bird species. Gaps in existing knowledge relevant to the writing of the plan will be identified and filled. A monitoring unit will be established to collect data on the parameters of the lake, and subsequently advise the management authority on departures from the plan. A campaign will be undertaken to inform all concerned so that once complete, the plan is understood and accepted by all.

1.5 Phase III will implement the management plan, and consolidate the monitoring unit. Action will be taken to revise and update the plan on an on-going basis. During the early part of Phase III, it is hoped that Lake Naivasha would become Kenya's second Ramsar site.

1.6. Much research work has been done in and around the lake; the attractions being its unique wate freshness in an area of alkaline lakes, its diversity of wildlife, its constantly changing ecosystem, and **the mystery of its water recharge.**

1.7 **The lake is fed by only two major rivers, the flow of which is insufficient to maintain the level of the lake given existing abstractions.**

1.8 The lake is geologically very young, and is the remains of a once large lake that included lakes Naivasha, Nakuru and Elmenteita. Only 150 years ago the lake was almost dry.

1.9 The lake ecosystem is composed of four water bodies, all of which have different physical and chemical characteristics.

2. Main Findings

2.1. The lake ecosystem is an area of natural beauty and diversity, and supports many industries reliant on its water. The main lake is subject to considerable variation in water level, area and volume. At the moment the lake is in a falling phase

2.2 Lake levels appear not to be related to local general weather patterns, but to rainfall in the surrounding mountains over 2000m above sea level.

2.3. Although there are annual fluctuations in levels of the lake, the general trend since recording first started in 1908 is downwards. Unless there is a major change in weather patterns, it appears that the lake is heading towards another drying up phase in the foreseeable future. In the long term there is probably nothing that man can do about this, although his actions could hasten the current trend dramatically.

2.4 Because of its shallow nature, relatively small drops in level can result in large changes in area and volume. As the lake decreases in volume, the water becomes more alkaline, and even relatively small amounts of pollution gain in significance.

2.5 The catchment areas are becoming increasingly populated, and the land is more intensively cultivated. This will almost certainly have far reaching effects on the lake in terms of runoff, silting and the build up of nutrients and chemical residues.

2.6 Rainfall-on the lake is approximately one third of its annual evaporation. Evaporation/transpiration represents the biggest loss of water from the lake. (172×10^6 m³ per annum). **Approximately 2 metres of water are evaporated annually from the water surface.**

2.7 River flows into the lake are variable from year to year and in a dry year are less than half the water evaporated, and in a wet year are double the amount (60 to 350×10^6 m³).

2.8. It has been established that there is a *flow* of underground water into and out of the lake. Although insufficient work has been done to show the variation in volume of flows from year to year, **it appears that the volumes in and out are roughly in balance and of the order of 50×10^6 m³ per annum**

2.9 The biggest abstractions by man are for irrigated horticulture and Geothermal power production. Between them they abstract $50\text{-}60 \times 10^6$ m³ per annum direct from the lake, which are equal to the total river inflow in a dry year or perhaps 30% of the amount lost through evapotranspiration annually. This does not include water pumping from wells and bore-holes around the lake. It is not clear what effect this latter water abstraction has on lake levels.

2.10 A very rough balance calculated in this paper shows excess usage and loss of lake water over inputs, a situation that is confirmed in practice with the fall in the lake level.

2.11 Local experience has it that three years of abnormally high rainfall in Kenya will recharge the lake and give a return to higher levels.

2.12 **The review of research and knowledge of the lake covers the fields of water quality, phytoplankton, zooplankton, vegetation, invertebrates, animals and birds. Much of the research has been basic in nature, and not totally relevant to the writing of a management plan.** However this does not detract from its scientific and basic interest and value. Enough is known about the lake to write a management plan, which can be updated as more knowledge becomes available.

2.13 All sectors of the lake ecology show a changing pattern, brought about by the changing lake levels, and affected by the inte n. tional and unintentional introductions of flora and fauna by man.

2.14 Plant introductions have, and still represent potential disasters for the lake. Salvinia which almost choked the lake in the 1970s and 1980s was eventually brought under control by biological control methods. Water Hyacinth is present but has never 'exploded'. This could still happen if the nutrient level and temperature of the lake rises.

2.15 The presence of a fringe of Papyrus around the lake, and the maintainence of the Malewa Papyrus swamp is essential to the continued well being of the lake, particularly the freshness of the water.

2.16 The small fish industry of the lake is totally based on introduced species. The original fish species of the lake has long since disappeared.

2.17 There is potential to increase the fishing industry on the lake, by increasing the number of fish species, in order to make use of presently under-utilised fish food sources. However poaching and illegal net sizes need control and more landing groundsare needed.

2.18 Water, flora and fauna are in a continuing flux, and it is important that research and monitoring continues on the lake in order that the ecosystem is fully understood, so that management interventions, where possible can be formulated.

2.19 Pollution of the water resulting from the greater use of fertilisers and chemicals around the lake, and in the catchment is a potential danger; but all results at the moment show that although some dangerous chemicals are present in the water in extremely small amounts, there is as yet, no threat to human, animal, or plant life. However as water volume falls, extremely small amounts become correspondingly more significant.

2.20 The use and disposal of plastic sheeting, and human waste disposal from the developing labour camps, and Naivasha itself; the latter with inadequate sewage disposal; appear to be as great if not greater threats of pollution.

2.21 Currently wildlife, including game and birds, appear to be coping with the changing ecosystem in and around the lake, and there is no danger at the moment to their continued presence on the lake. The situation however needs to be carefully monitored.

2.22 Agricultural development around the lake has exploded over the last 10-15 years. It is unlikely that the lake as a source of water can sustain such a continued rate of development, unless there is a great improvement in general rainfall levels in Kenya. Presently this does not seem to be likely.

2.23 **Geothermal power generation probably presents the biggest single threat to the lake, if development plans for the continued expansion of the steam field is implemented. Olkaria is already the single biggest user of water on the lake, and when the new field is commissioned could be using more water than all irrigation in total.**

2.24 **In the rough calculations done on the water balance it is shown that the present extraction of water from the Malewa/Turasha river systems, if returned to the Lake, would swing the balance into a positive situation.** The implementation of Phase II of the Greater Nakuru Water Supply Project based on the Malewa would spell disaster for Lake Naivasha, and must be opposed at all costs.

2.25 The conditions exist which favour Lake Naivasha being declared as a Ramsar site which would be beneficial to the long term survival of the ecosystem without necessarily compromising any existing commercial interests.

3. Information Gaps

3.1. **It is not possible to work out an accurate water balance for the lake as basic data such as river flows, lake levels, evaporation, areas irrigated and water extraction are not being recorded regularly. There is a need to renew this monitoring so that accurate balances can be calculated, and to enforce water metering as a condition of abstraction.**

3.2. There is no safe extraction limit calculated at present. It appears that permit applications for extraction are not turned down, neither are they checked against a limit.

3.3. It is essential that an accurate water balance is calculated as soon as data allows, and is continued to be calculated at regular intervals and published. Water abstraction permits would need to be considered appropriately, depending on the results of the balance.

3.4. In the meantime all should be done to encourage the proper use of water for irrigation, including the introduction of drip irrigation where possible. If it is found from the balance that use continues to outweigh supply then more definite action has to be taken including a stoppage on fur her permits to extract water direct from the lake.

3.5. **There is a need to bring all the data on the lake together at one centre where it can be utilised by all with a genuine interest in the lake environment.**

3.6 There are three requirements for future research on the lake.

(a) The most important is to initiate as soon as possible a monitoring exercise on the lake. The first requirement is to collect data which will enable an accurate water balance to be calculated at regular intervals.

(b) Within this general monitoring programme, pollution, should receive particular attention including control of irrigation run off, Papyrus maintainance, and pesticide and plastic use and disposal.

(c) Regular monitoring of crucial parameters in water, vegetation, flora and fauna should be started so that an overall picture of the lake and its surroundings over time, can be built up. The monitoring should be designed with the needs of a management plan and management body in mind.

3.7 Research should as far as possible be directed towards management needs. The main areas include more work on the chemical qualities of water and the calculation of a nutrient balance; further studies of aquatic vegetation, invertebrates, and their interaction particularly with fish.

4. Recommendations

4.1 The report recommends that the future of the lake rests on a three point plan - a monitoring programme, a management plan, and an effective management body to implement that plan on an on-going basis.

4.2. It is considered that Naivasha presents an ideal and potential situation where community based management of the lake and its basin could be developed and made to work

4.3 To be effective management of the Lake Ecosystem must include direct involvement in the management of the catchment areas also.

4.4. Such an approach would be an attractive subject for donor aid, where the emphasis appears to be away from Government to Government assistance, and more towards help through NGOs and other organisations. Already this LNROA three Phase plan has attracted firm commitments from major donors for assistance in Phase II and III of the project.

4.5 It is considered that in the present times when Government is looking to change the whole face of its public services; there is an opportunity here in Naivasha to show that Community based management of natural resources can work. A successful project would be a model to Kenya and the rest of Africa.

4.6 Recommendations for Phase II are given in Section 21 of the report and amount to the planning and implementation of a monitoring programme; the writing of a management plan for the lake, and the establishment of a management body under the auspices of LNROA to implement the management plan.

4.7 It is considered that the need has been established, the time is appropriate and the groundwork prepared; therefore the LNROA should proceed as fast as possible with Phase II and III of the plan including the securing of donor funding and support for the same. In addition support should be sought for the establishment of Lake Naivasha as a Ramsar site.

Lake Naivasha is one of the great assets of the Highlands. There, Africa is painted in colours superb beyond description. Aesthetically the loss of the lake would be a grievous tragedy. Naturally it would cause serious economic loss, and it might exercise a deleterious influence on the climate of a great part of the Rift Valley and beyond.

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ABBREVIATIONS AND ACRONYMS

BDDEA	British Development Division in Eastern Africa
BP	Before the Present
DC	District Commissioner
DDC	District Development Committee
EPAT	The Environmental and Natural Resources Training Project of USAID
GOK	Government of Kenya
HCDA	Horticultural Crops Development Authority
IUCN	World Conservation Union
KCC	Kenya Co-operative Creameries
KPC	Kenya Power Company
KPL	Kenya Power and Lighting Company
KWS	Kenya Wildlife Service
LNEC	Lake Naivasha Environment Committee
LNROA	Lake Naivasha Riparian Owners Association
MALDM	Ministry of Agriculture, Livestock Development and Marketing
MLRRWD	Ministry of Land Reclamation, Regional and Water Development
NGO	Non Governmental Organisation
NWCPB	National Water Conservation and Pipeline Board
ODA	Overseas Development Administration
WCPB	Water Conservation and Pipeline Board
USAID	United States Agency for International Development

1. INTRODUCTION

Lake Naivasha is one of the important lakes of Africa.

Situated in a shallow depression on volcanic deposits in the Rift Valley in Kenya, it is a fresh water lake surrounded by the alkaline lakes of Elmenteita, Nakuru, Magadi and Bogoria. It is in a closed drainage basin and has no visible outlet, and this fact alone has fascinated scientists over the last century.

More recently the lake has become a centre for sport and recreation, and with its natural diversity and beauty and being only 100 km from the capital, presents an ideal tourist centre. The birds of the lake are world famous, and it plays host to over 350 species.

Over the last ten to fifteen years there has been tremendous agricultural and geothermal power development based on extraction of water from the lake, with the cultivation of flowers and vegetables for the export markets in Europe. This is big business and of vital importance to the Kenyan economy through the foreign exchange it generates, and the number of people it employs. Something like 40 freight flights a week leave Nairobi bound for Europe loaded with fresh Kenya produce, a major portion of this from Naivasha. Geothermal power generation in the hills to the south of the lake now provides 45MW or 15% of Kenya's electricity requirements

Not surprisingly the lake is under pressure from a variety of interests, some of them conflicting. There is no management plan for the lake, and no management of the resource.

Based on past history it is known that the lake is quite resilient to man's interference, but there are limits. The Lake Naivasha Riparian Owners Association (LNROA) is taking a leading role in attempts to implement a management plan and a management authority for the lake, so that the quantity and quality of the water can be maintained for as long as possible for future generations.

This assignment is the first phase of a major Environmental Impact Study of recent developments around Lake Naivasha, leading to a management plan, commissioned by the Association.

2. TERMS OF REFERENCE FOR THE STUDY

Terms of reference for the study are given in Appendix I.

The major task was to write a review of research work that has been completed in and around the lake, and to generally review the state of knowledge on the lake, relevant to a management plan.

From this review it was expected to find that there were substantial gaps in the knowledge of the lake, and the consultants were charged with the responsibility of determining what should be done in the future, how and by whom.

Terms of reference for Phase II were to be suggested.

3. METHODOLOGY AND TIME TABLE

With the review of research and present knowledge on the lake and its environs, the consultancy was very much helped by the presence of the Mennel collection of papers held at the Elsamere Centre on Lake Naivasha.

The Late Roger Mennel lived on the lake for nearly thirty years and during that time took a close interest in the science of the lake, giving much assistance to scientific teams working there; taking part in their work, and often continuing routine observations for them after they had left. For a long period, he was secretary to the LNROA. During this period on the lake he built up an excellent collection of scientific papers to which he added his own contributions and notes. This collection provided probably [illegible] the total bibliography given at the end of this report.

In addition access to the personal files of the late Mrs Jean Hayes, and the late Mr Wilfred Hopcraft, a past Chairman of the LNROA; and the files of The Earl of Enniskillen, the present Chairman of LNROA since 1983, was made possible. From these papers it was possible to follow up further references in the Ministries of Agriculture, Livestock Development and Marketing (MALDM) and the Ministry of Land Reclamation, Regional and Water Development. (MLRRWD).

Interviews with residents and project owners and managers around the lake resulted in access to other papers, information and data.

The list of resource persons met during the course of the work is given in Appendix II, and the time table for the assignment in Appendix III.

4. THE LAKE NAIVASHA RIPARIAN OWNERS ASSOCIATION

The LNROA was started by a general meeting in June 1929, when the objectives, rules and constitution were set out. These rules were revised in 1988. The general objective is now to maintain and conserve the lake and its environment as described in the Guidelines in amplification of the objects of the association dated January 1988. On November 19th 1931 LNROA signed an undertaking with the Government in which it was agreed that all the land that was formerly part of the bed of Lake Naivasha (all of the land below the 1906 lake level of 6210 feet (1893.3M) above sea level) was to be utilised by the Riparian Land-owners as they saw fit, providing that no permanent structure was erected and no claims against Government made, should the water rise above land developments.

The LNROA is constituted under the Societies Act by the Registrar of Societies and is open to membership from all those who own land contiguous to the lake. It charges a membership fee of shs 100/= per annum and operates on a voluntary and non profit making basis.

The Association was given authority through an arbitration agreement of December 1931 to settle riparian land disputes, and an extraordinary general meeting on May 25th 1956 created a centre point of the lake, and in general lines can be drawn from land owners' 1906 beacons to the centre point to mark boundaries. Bays and lagoons present special problems.

Activities of the LNROA over the last few years have included the preservation of a clean, pollution-free body of water, supporting the biocontrol of *Salvinia* and briefing the Minister of Environment and Natural Resources and urging him to see the *Salvinia* problem at first hand in 1990. The Association was also vocal in its concern at the Malewa water scheme and lobbied Government hard to have the scheme shelved. In addition the oil pipeline which passes through Naivasha was monitored during its installation, and help and support has been given to Government authority over fish poachers, and general security matters.

LNROA is represented on the District Development Committee (DDC) meetings, the forum for District development in the District Focus Strategy, and also supplies two members to sit on the District

Commissioner's Lake Naivasha Environmental Committee (LNEC), the Chairman and Secretary of this committee are the Chairman and secretary of LNROA. Both the Local Member of Parliament and the District Officer are members of LNROA by invitation.

In its endeavour to protect the environment of the lake the Association has through its members adopted a voluntary code of practice including:-

(i) Support for drip irrigation as opposed to overhead irrigation

(ii) The banning of bunds to push back the lake to allow the cultivation of extra land.

(iv) The leaving of at least a 50M buffer zone of natural vegetation between the open lake and the beginning of cultivation

(v) The protection of papyrus

The Association is unique in Kenya, being the only body that has legal responsibility for land disputes on the lake riparian land.

The Environmental Impact study which is the subject of this report has been brought to fruition solely by the efforts of the Association. Currently the Association has 97 members.

5. AN ASSESSMENT OF CURRENT KNOWLEDGE ON LAKE NAIVASHA

5.1 Introduction

Lake Naivasha must be one of the most researched lakes in Africa, if not in the world. Its location in the Great Rift Valley of Kenya, and its continuing freshness in an area of alkaline lakes, not to mention the mystery of its recharge; together with its fame as a centre for recreation and birdwatching, and its close proximity to Nairobi; have all made it a popular site for natural resources research.

This review deals with over 250 published and unpublished papers, and even then some may have been missed. Future revisions of this review will include these, together with papers that will undoubtedly be published in the future.

This review has been written in terms that will be understood by the layman; as well as being useful for the research scientist working on the lake for the first time. One of the problems about Naivasha, and its future, is that the average person knows little about the basic facts of this continually changing ecosystem. It is hoped that this paper will help to inform people of the problems, the successes, and the potential of the lake; and enable some plan and management body to be formed, which will safeguard the lake and its environs for future generations.

Because there is so much information available on the ecology of the lake, the reference list has in general, been confined to direct references to work on the lake. Secondary references referring to similar work elsewhere, or confirming results, methods and findings of Naivasha have not been included, but can be traced and followed up from the primary references.

6. LOCATION AND AREA.3

6.1 The Lake

The Lake is situated in the south-west of Kenya, map reference 0°45' S and 36°20' E. 80 kms south of the equator and 100 kms north-west of Nairobi the capital of Kenya. Figure 1 indicates its position relative to the rest of Kenya.

Lake Naivasha is situated in the bottom of the Eastern or Gregory Rift Valley, in the middle of three major centres of geothermal activity - the Eburru hills to the north-west, Mount Longonot to the south-east, and Olkaria to the south. The latter being the site of Kenya's only commercial power generating Geothermal field, and destined to play an increasing role in power generation in Kenya. Mount Longonot (2777m) is the most recent, volcanically, and has been active in the last 100 years (Thompson and Dodson 1958). Hot springs and fumaroles can still be seen on its slopes, as well as on Eburru. According to Maasai legend the last minor eruption of Longonot took place in the 1850s. The last major eruption was 3000 to 6000 years ago.

The lake is the highest and freshest of all the Rift Valley Lakes in eastern Africa. Harper (1984) gives an excellent introduction to and history of the lake.

Administratively the lake and its immediate environs are situated in the Naivasha Division of Nakuru District in the Rift Valley Province of Kenya.

In its more recent history the lake has shown tremendous changes in depth, area and volume. From 1909 to 1969 the lake's area has varied from 88.06 to 216.27 km², and the capacity from 148.02 x 10^6 to 1702.23 x 10^6 cubic metres. In all a fluctuation in area of 245% and in volume of 1150%. However, the general trend for both parameters is downwards.

6.2 The catchment area and rivers

Figures for the total catchment of the lake basin vary from 2874 to 3401 km². Details are given in table 1.

Table 1. Estimates of catchment area. (Km²)

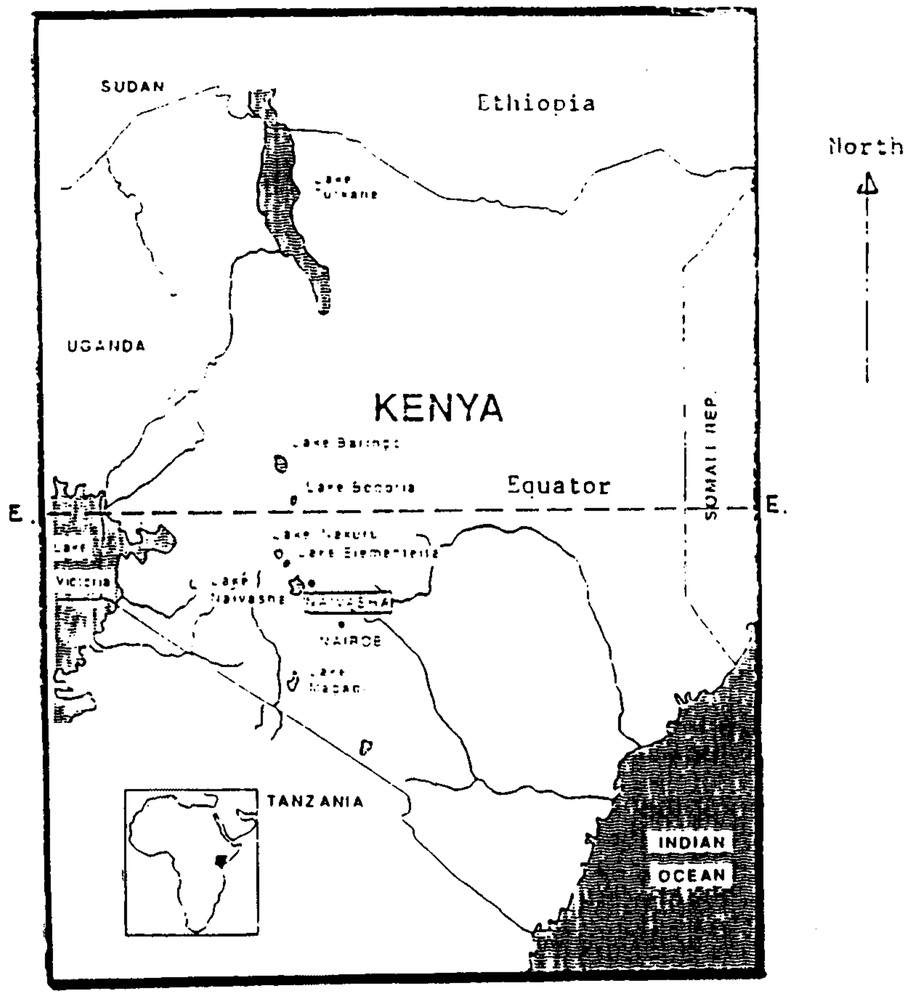
	JICA (1990)	Watson and Parker (1970)	Verschuren (1989)
Malewa river	1653	987	1730
Gilgil river	511	417	420
Karati river			134
Lake and areas to SE and W	1237	1058	590
Turasha		743	
Totals	3401	3205	2874

The discharge from the catchment surface is wholly internal and gravitates from the higher altitudes. The Eburru hills separate the lake basin from the adjoining Elmenteita catchment.

There are a number of rivers around the Lake but only two of these have a substantial flow into the Lake These are the Malewa or Morendat River, which is by far the most important, and the Gilgil, which together account for 90% of the river flows to the lake.

Figure 1.

Lake Naivasha in relation to the rest of Kenya.



Approximate scale 1cm = 90 kilometres

Malewa. The river rises on the western slopes of the Nyandarua range (Aberdares) at an altitude of 3-4,000m. The small streams flow westwards and develop into four main tributaries - the Mugutyu, the Turasha, Kitiri and Makungi. All four flow north-south before turning west and joining the Malewa. The Turasha, by far the most important tributary, joins the Malewa about 8 kms east of Gilgil town

Gilgil. The headwaters of this river are situated in the Bahati forest where it drains a long narrow basin The river rises at 2740m in an area where rainfall is high at 1300mm per annum. There are few tributaries

Karati The Karati river also flows from the north and rises on the Kinangop plateau at an altitude of 2620m where there is a mean annual rainfall of 800mm. However little water reaches the lake and the river flows for a few months per annum at the most. Its contribution to lake water is normally ignored. Most of the flow of water is lost into the porous soils and permeable strata of the area.

Marmonet. This river originates in the Mau escarpment to the south west of the Lake and descends towards the lake through Ndabibi Estate. The flow never reaches the lake but disappears underground and charges the alluvium of the Ndabibi plains.

The flows of these rivers will be discussed in section 11.1.2 which deals with the water balance of the lake. The catchment area and the streams and rivers mentioned above, together with the sites of their principal gauging stations are shown in Figure 2.

7. HISTORY OF THE LAKE AREA

7.1 Geology of the area

Good accounts of the general geology of the Lake Naivasha area and its catchment can be found in the papers of Thompson and Dodson (1963), Clark et alia (1990), and McCall (1967). Leakey (1931) and Nilsson (1937) have reported on the evidence of lake levels prior to this century.

Lake Naivasha is situated in the Eastern or Gregory Rift, part of the Great Rift Valley which stretches from Jordon in the Middle East to Mozambique in south east Africa. The Rift Valley was formed through many episodes of faulting and volcanism some 30M years ago. Geologically the area is young, and there is still much evidence of volcanic activity.

Naivasha is at the highest part of the Rift in Kenya (1890m), and the Rift falls both to the north (Lake Bogoria 990m) and south (Lake Magadi 600m).

Sediments cover much of the Rift valley floor. These are Pleistocene in age; Quaternary era some 1.5 to 2.0 million years ago; and were laid down in lacustrine (lake) environments. The bulk of faults, scarps and fissures are linked with the Pleistocene movements. The volcanic rocks are a mixture of acid and basic larvas such as Tephrites, Rhyolites, and sodic Rhyolites, the latter which are common are found exposed in the cliffs at Njorowa gorge. Obsidian, a black shining volcanic glass formed by rapid cooling of an acid magma, occurs in outcrops on Eburru and elsewhere.

The Kinangop plateau is situated between the valley floor and the Aberdares. The plateau is down faulted in a series of slips and the rivers cut deep into the plateau.

The upper Pleistocene Gamblian sediments of the Naivasha area have yielded a history of rich fauna and artifacts. The Gamblian deposits are indicative of a larger lake and a wet episode (pluvial) in the histor of the region. At that time, Lakes Nakuru, Elmenteita and Naivasha were one with an outflow in a southerly direction through the Njorowa Gorge Cole (1950) has discovered Pleistocene terraces in the Malewa Gorge NEED end of the Lake.

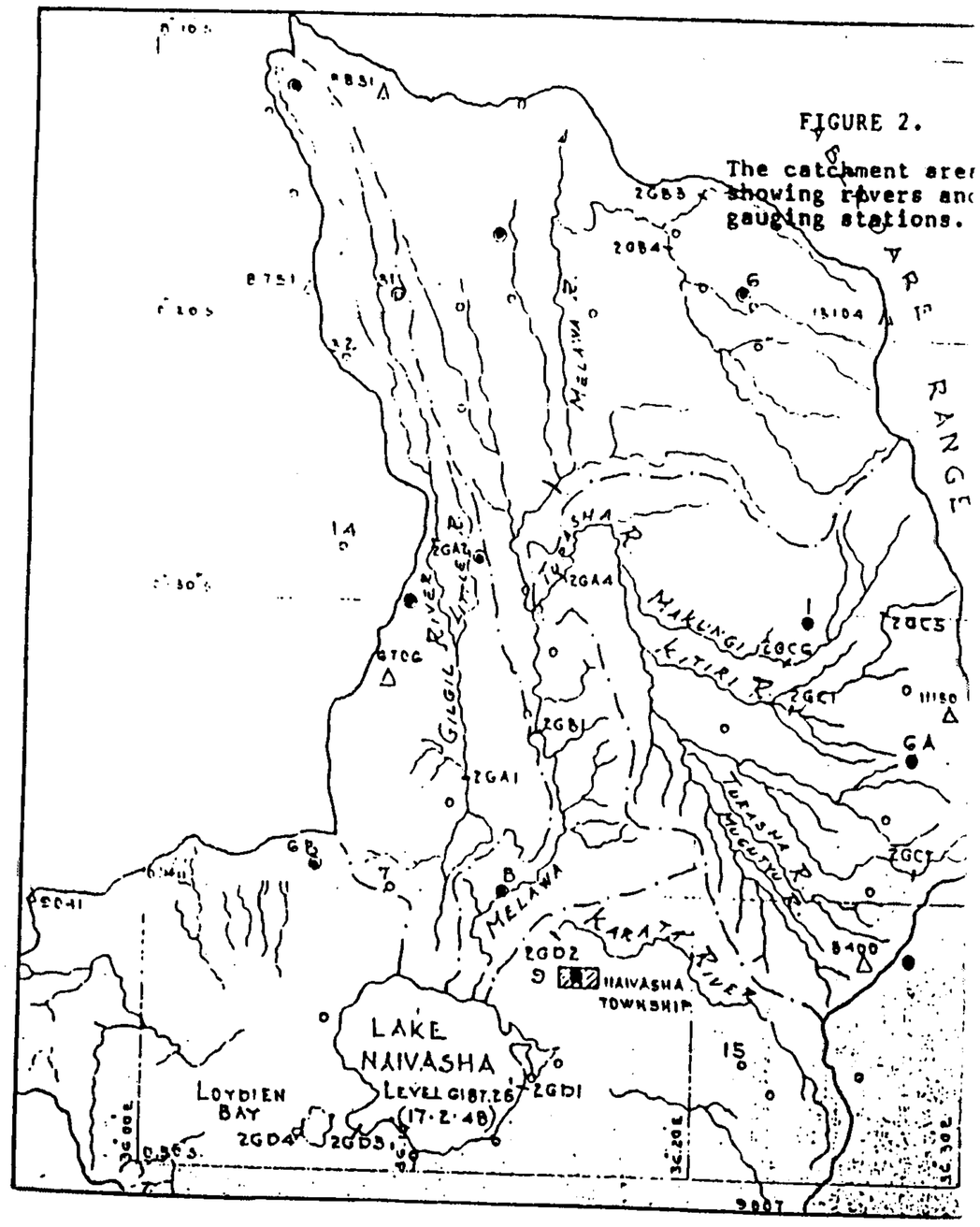


FIGURE 2.
The catchment arer
showing rivers anc
gauging stations.

The geology of the immediate lake area is shown in figure 3 and the approximate area of the Gamblian lake in Figure 4.

7.2 Contemporary history of the Lake

People have lived round the lake for the last 10,000 years.

From 12000 to 9200 BP the lake was much larger than today and Nakuru, Elmenteita and Naivasha were one big lake with an area of 612 km² with an outlet through the Njorowa Gorge. The level of the lake at that time was estimated to be 1930m above sea level; 130m above its present level (Nilsson 1932)

The Lake remained large, with an approximate area of 400 km² up until 5700 BP. At 3000 BP the lake dried out, and remained so for an hundred years. Since that date the lake has become progressively smaller, and according to Maasai lore the lake was again dry in the middle nineteenth century just before the arrival of the early European explorers.

Richardson and Richardson (1972) have given a diagrammatic representation of the history of the lake in Figure 5.

7.3 Man's history in the area

Based on evidence from archaeological finds, an early pastoralist group lived near the lake two thousand years ago; used stone bowls and herded cattle. There was an extensive Neolithic settlement 6-10,000 years BP on Crescent Island. They also buried their dead under stone cairns, the remains of which have been found on the Island. More evidence was found in the caves at Ndabibi and the rockshelter exposed during the construction of the railway along the cliffs just outside Naivasha. (Washbourne-Kamau 1971, Cole 1954, Bower et alia 1971).

During the 16th and 17th centuries the Maasai people migrated from the north, and from then on they had an increasing connection with the lake and its surroundings. Their names for various places around the lake are still used. E-na-ipasha for Naivasha - 'that which is heaving or that which flows to and fro'; a-serian -' to be well, to be at peace, or to be safe; en-dapipip -'where the clover grows.'

In the 1880s the first European explorers arrived and there was much competition between Thompson, sponsored by the Royal Geographical Society of England; and Fischer of The Hamburg Geographical Society to explore the area. The latter appeared to have the worst time with the Maasai, and the Fischer tower in Hell's Gate park stands as a memorial to him, as being the place that he eventually turned back to the coast.

Thompson described the lake as being twelve by nine miles in size; shallow, Papyrus fringed, with no fish, but lots of duck and Hippopotami, and supplied by the Guaso Gigili and the Morendat streams. He explained the freshness of the water by the lake being either very recent in origin, or having an underground channel - an astute observation considering he had only just found the lake.

At that time the lake was used extensively by the Maasai, and Sikes (1936) quotes Maasai legend that the lake was dry or nearly so; at least marshy, just before the arrival of the Europeans.

In 1898, Sir Frederick Jackson described the lake as 'thickly dotted with coots, thousands of them; and the narrow strip of sandy foreshore was packed with Egyptian Geese, ... Yellow Billed ducks, Pochards, Pink billed teal, Flamingos and Pelicans'.

In 1890 Naivasha was the headquarters of the Eastern Province of Uganda, but the area was taken back into Kenya in 1905.

Figure 3
Geology of the immediate area surrounding the lake.

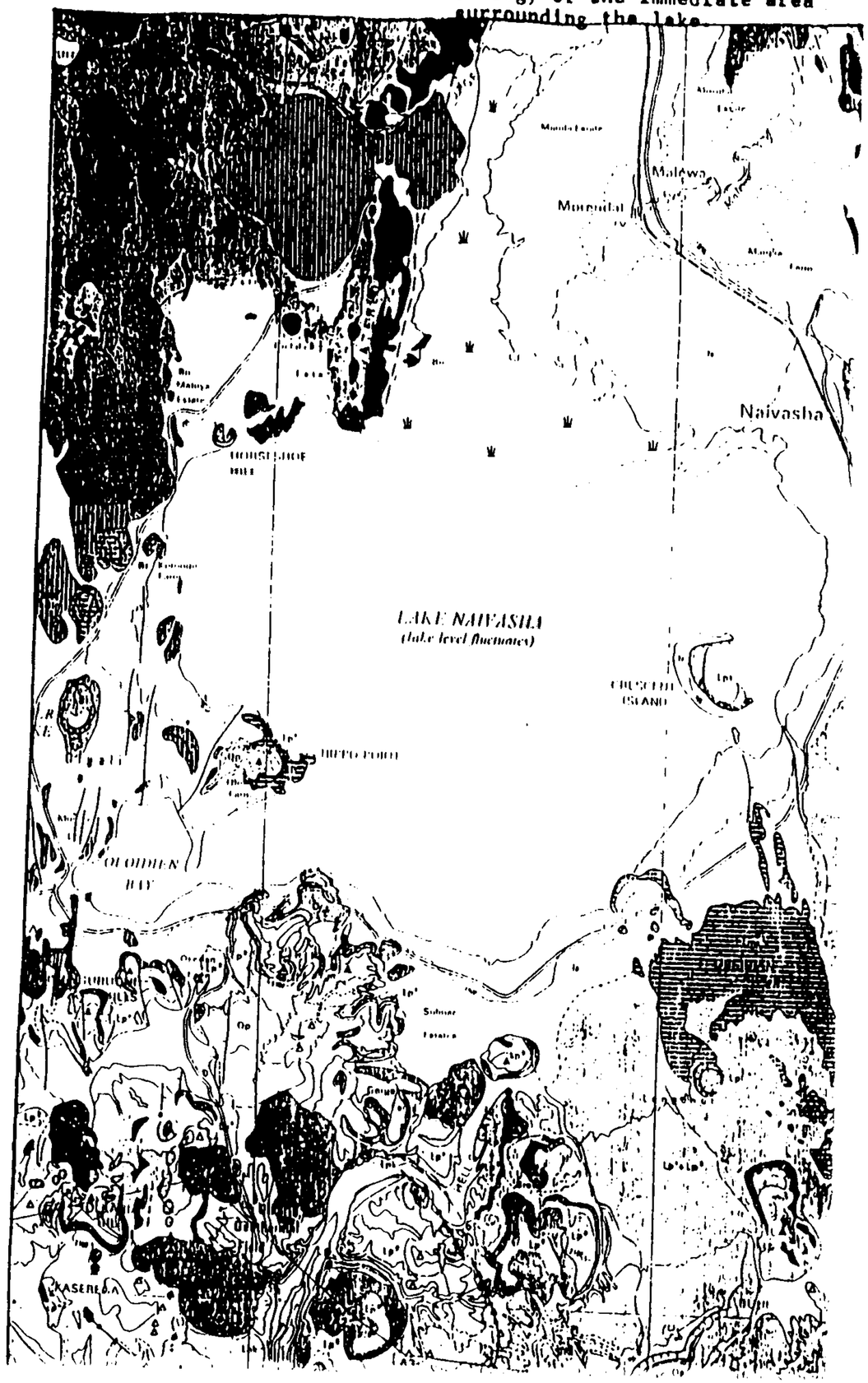
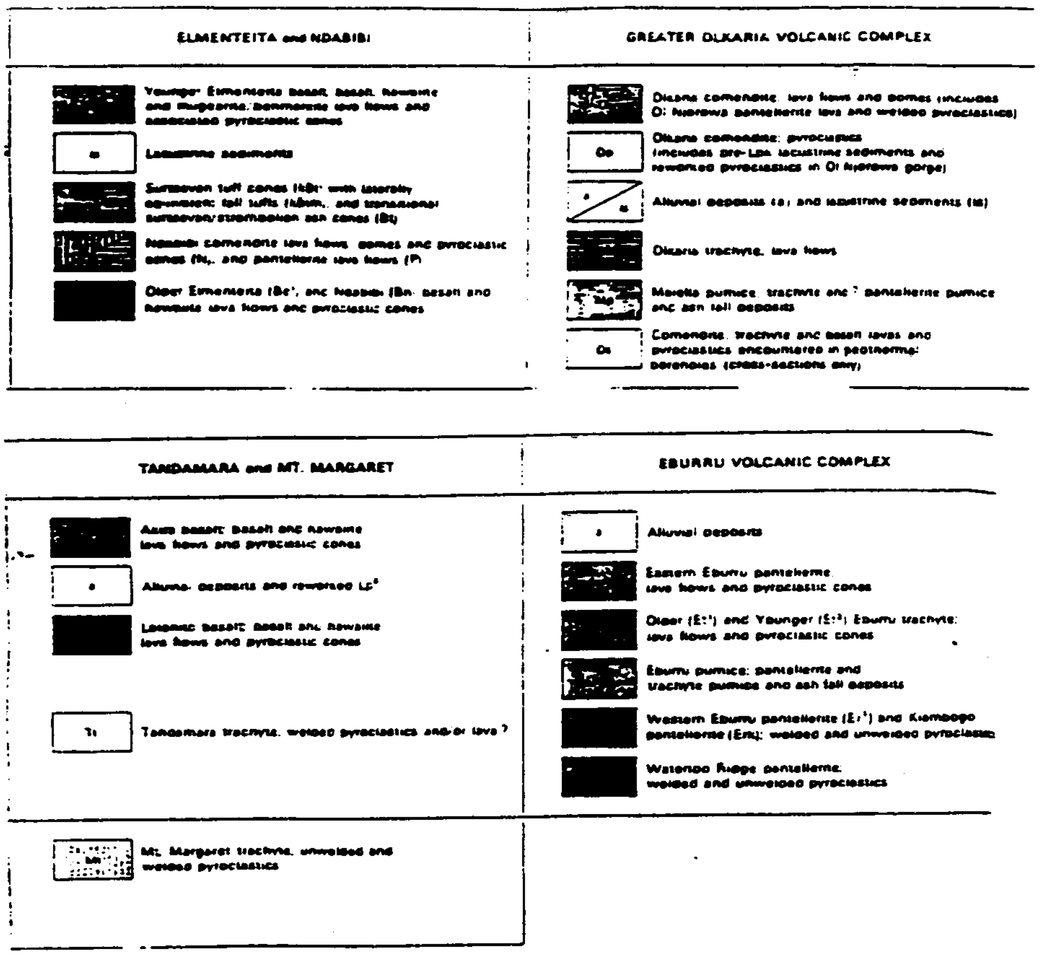


Figure 4.

Map showing the extent of
The Gamblian lake 9200 BP.

(Source: Ase et alia 1986)



(Source: Clark et alia 1990)

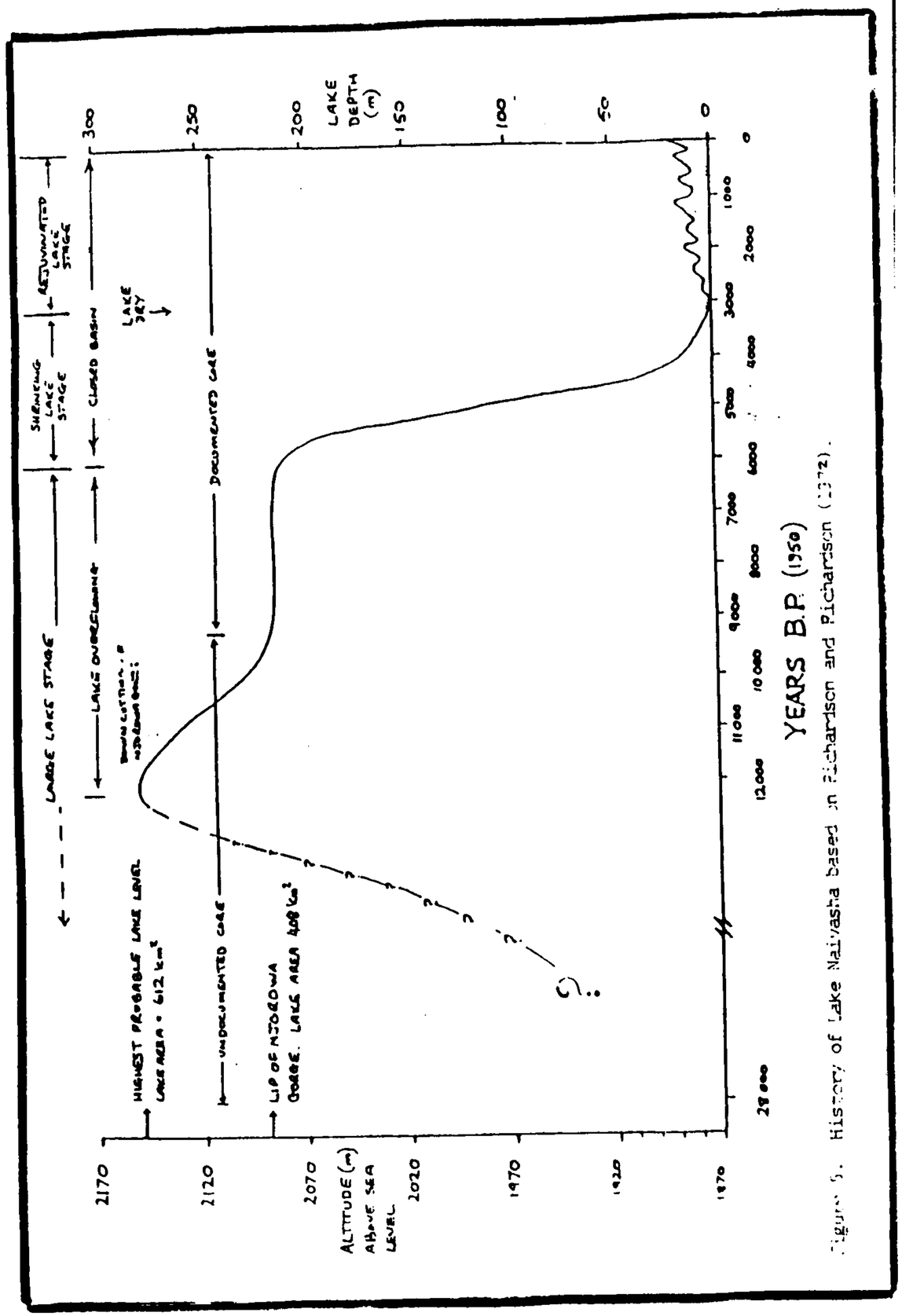


Figure 5. History of Lake Naivasha based on Richardson and Richardson (1972).

In the second treaty of 1906, the Maasai were moved from the area south of the railway line, to the top of the Mau range and beyond, leaving the lake area open to settler farms.

Following this, Robert Bryce Wills bought most of the land along the present South Lake Road, including Sanctuary farm; a history of which has been given by Hayes (1980). In 1906 the individual farms were demarcated, and the water line of the lake was surveyed; to be used later as the riparian land mark encorporated in the Riparian owners charter.

In 1904 the Government Experimental Stock farm was opened on the present Research station site, and a series of experiments were started crossing local stock with imported bulls of the Ayrshire, Hereford, Shorthorn and Guernsey breeds. There were also experimental flocks of Merino sheep and trial plots of sweet potatoes, maize and lucerne.

In 1956 a canal was dug across the narrow strip of land dividing the main lake from Oloidien (Lind 1965) The canal was dug to even up the levels of the two lakes as Oloidien at that time was lower by a few feet It was hoped also, that addition of fresher water to Oloidien would make it useful for irrigation.

By the late 1950's lucerne was by far the biggest crop around the lake and was valued at £3M per annum At that time there was little irrigation and the crop was grown on the exposed bed of the lake during the low water levels.

Over head sprinkler irrigation started around the lake in the early 1970s, but the modern development of horticultural production for export has largely developed over the last 10-15 years.

There are many farms growing green vegetables and cut flowers for export around the lake. The Oserian Development Company and Sulmac, the latter a Division of Brooke Bond, dominate the cut flower industry. Sulmac is the biggest Carnation farm in the world, and is still expanding its production.

8. PHYSICAL CHARACTERS OF THE LAKE

Although Lake Naivasha is generally refered to as one lake, it has been general practice in the scientific literature to distinguish between four components.

8.1 Lake components and their characters

The four bodies of water and their main physical characters as given by Melack (1976) are shown in table 2.

Table 2. Physical characters of the four water bodies

	Area* (km²)	Volume ($m^3 \times 10^6$)	Mean Depth (m)	Maximum depth (m)
Lake Naivasha	145	680	4.7	7.3
Crescent Island				
Basin	2.1	23	11.0	17.0
Oloidien	5.5	31	5.6	6.1
Sonachi	0.6	0.62	3.8	6.1

(*Obviously area and volume will depend on the level of the lake)

The boundaries of the four bodies have been formed by the tectonic faulting and volcanic activity associated with the formation of the Rift Valley (Richardson and Richardson 1972)

Sonachi is a flooded volcanic vent formed by an agglomerate (Thompson and Dodson 1963). The crater has no inlet and is a soda lake, with an alkalinity 15 times that of the main lake and 5 times that of Oloidien. The surrounding rim is between 50 and 115m above the lake level. The water is basically a solution of sodium carbonate and its derivatives. There are no streams into the lake and recharge is from the crater area of 84 ha. Lack of dramatic level variation even in prolonged dry periods, suggest that this lake has underground water flows. The shore line fringe is *Acacia xanthophloea*, and the inside slopes are vegetated with thick bush including *Tarchonanthus camphoratus* on the drier parts, and *Rhus natalensis* and *Pruchea ovalis* near the lake. In 1973 to 1974 the lake decreased in size from 16.1 to 14.7 ha and depth decreased from 6.5 to 5.5m. However the lake level is generally quite stable.

The name of the lake is derived from Maasai, and describes an unfruitful or unproductive bull. The waters do seem to have some therapeutic value with livestock; the Maasai are known to collect samples of the water to treat sick animals. The lake is full of blue green algae and is reputed to have one of the highest photosynthetic production rates in the world. There has been speculation that the lake might be harvested commercially for its algal content which is high in protein and B12 vitamins.

Oloidien, another old crater, has three times the salinity of the main lake, such that Papyrus and Salvinia cannot grow there. Because of this the submerged vegetation of the lake has been fairly constant and stable. The lake is full of blue green algae. There are fish but the water is unsuitable for irrigation. A channel connecting Oloidien and Naivasha was dug in 1956 at a level of 1888.5m above sea level, and when the water rises above this level, the two lakes are joined, although their chemistry, flora, and fauna remain different.

Crescent Island Basin is the remains of an old volcanic crater, and represents the deepest part of all the water bodies. Crescent Island is what remains of the crater rim. The water in the crater has a different chemistry and ecology than the rest of the lake, and is therefore generally reported on separately.

A diagrammatic map of the lake bodies is given in figure 6.

8.2 Lake Area and Volume

These two parameters obviously vary with the level of the lake at any one time. Ase (1987) has graphed the relationship of lake-level with surface area and volume of water, and this information is shown in figure 7.

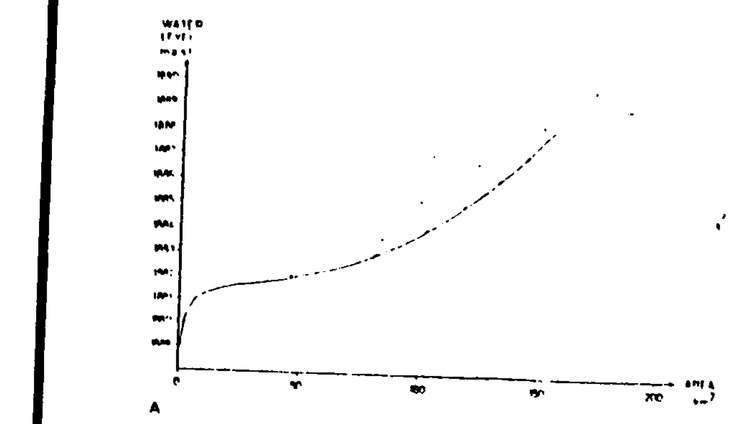
The lake can show dramatic changes in size, level, and volume over very short periods. Tetley (1948) reported a fall of 37 feet (11.3m) from 1917 to 1946, with a reduction in area from 86 to 35 square miles and a loss of 15/16 of its volume. During this low period, fish actually died in the lake. Between 1980 and 1987 the lake went down by 4m and exposed 60-65 km² of soils and reduced its volume of water by 550 x 10^6 m³. As a result the conductivity doubled and the algal biomass multiplied by three. The problem is that when the lake level goes down quickly and the Papyrus is left high and dry, the buffering effect of this plant is lost, and dissolved salts and algae build up rapidly.

At high levels of the water, a small drop can result in a large fall in the area of the lake. This is due to the shallow sloping nature of the littoral area. A level change of 0.5m can cause an area change of several square kilometres particularly along the north-east and north-west shores which are gently sloping. In 1917, during a high water phase of the lake, the area was estimated at 217 km². In 1972 the area was 158 km² and in 1953 the area was at an all time low for the century, of 93 km².

Figure 7.

Relationship of Lake levels with area and volume of the lake.

(Ase et alia 1986)



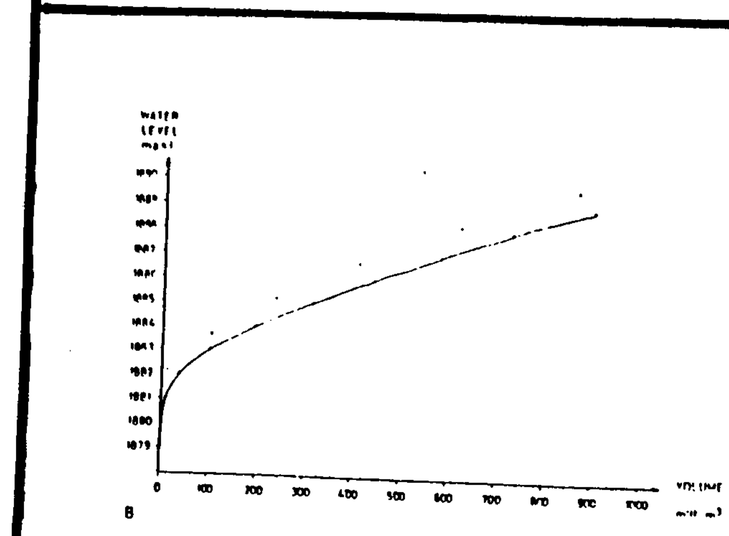
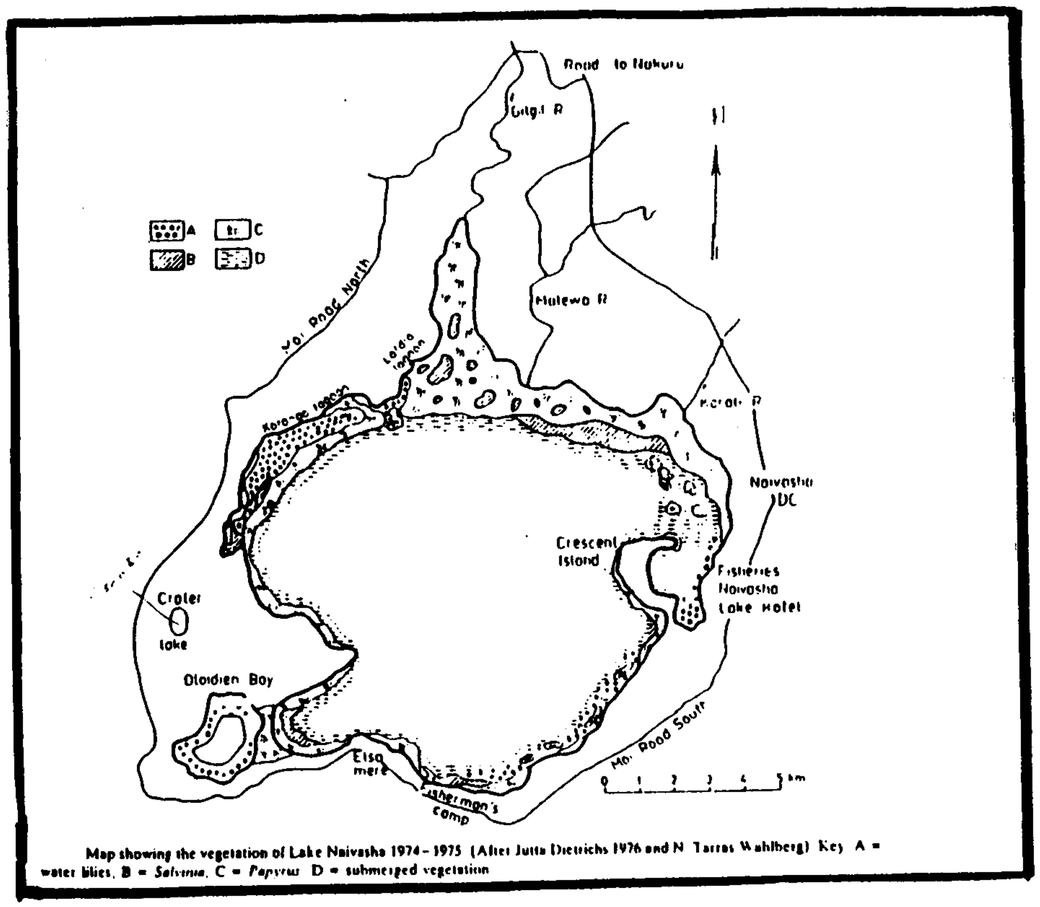


Figure 5.

Diagramatic sketch of Lake Naivasha showing main features.P



Map showing the vegetation of Lake Naivasha 1974–1975 (After Jutta Dietrichs 1976 and N Tarras Wahlberg) Key A = water lilies, B = *Salvinia*, C = *Papyrus* D = submerged vegetation

Brind (1957) suggested that the capacity of the lake was being reduced at all levels due to silting. Sediment is certainly carried down in the rivers, particularly the Malewa but surprisingly there is no evidence, as yet, of a serious problem.

The comparatively shallow depth of the water, and the big area means that the water body has little capacity to buffer the effects of temperature and wind that affect the ecosystem. This can have far reaching effects on the ecology of the littoral area, and the flora and fauna that live there. For example the oxygen level in water can go from anaerobic to supersaturated conditions within a few hours.

8.3 Lake Levels

At present there is no official record of lake levels being kept. The lake level as measured on December 31st 1993 against the **Laws and Flintoft survey benchmark system was 1886.54** metres above sea level. (Vaughan, Pers. Comm.)

There are considerable data on the level of the lake since official recording began in 1908. However **Ase et alia (1985) have raised caution on some figures as different bench marks have been used for some record points.** They recommend the bench mark to be used as that one, 1 km south-south-east of Naivasha railway station which when used in October 1985 to measure the lake gave a reading of **1884.7m** above sea level.

Ase (1987) has constructed a graph of levels from 1880 to 1988 in Figure 8. More recent data is available (Burch Pers Comm.), but it is not known to which level this is zeroed. There are two official gauging stations on the lake at Kongoni Estate (for Oloidien) and at Lake Naivasha Country Club (main lake). These should be recorded by MLRRWD but no data has been collected for a number of years, and the Naivasha gauge (2GD1) stands on dry land.

The variation in levels over the last century has been of the order of 15m. Some impressive rises have been recorded over a short period, for example the 3m rise recorded after the heavy long rains recorded in 1977. See Figure 8. High phases in the lake level have been recorded in 1893, 1905, 1917, 1923, 1931, 1937, 1947, 1952, 1964, 1972, 1980, and 1988. Lows have been recorded in 1882, 1900, 1910, 1916, 1929, 1930-40, 1945, 1953, 1977, 1987 and 1993. There appears to be a pattern of high, and low water levels every seven years.

Following the drying of the lake in the mid 1850s there was a low period up to 1882, but from then up to 1895 the lake rose a total of 10.6m and thereafter remained high until 1917, when it began to go down again. In 1884 when Hobley visited the lake he had to climb up over the cliffs near the present Naivasha railway line in order to get into Naivasha, as at that time the Lake was lapping at the base of those rocks. The lake at that time was 8.5m higher than it is today. It should be remembered that when the lake last dried in 1850, there was no irrigation, agriculture nor geothermal power; although the Maasai did use the lake as a watering place for their cattle. Hardly the reason for the lake drying up.

There is some variation in lake levels throughout the year, see Figure 9. A low level in February to April being followed by a general rise to a maximum in September. Attempts have been made to correlate lake level with various climatic factors in the basin. The only significant correlation that has been found is quoted by Vincent et alia (1979) who found that rainfall levels over 2000m on the Aberdares as shown by the Equator rainfall records were significant at 1.0% with lake levels. Generally the seven year cycle of highs and lows corresponds with overall wet and dry years in the catchment areas. Local experience has it that three years of good rainfall, will put the lake level up, without fail. Unfortunately it appears that Kenya does not have three wet years in succession very often.

Figure 8.

Lake levels from 1908
to the present.

(After Ase 1987)

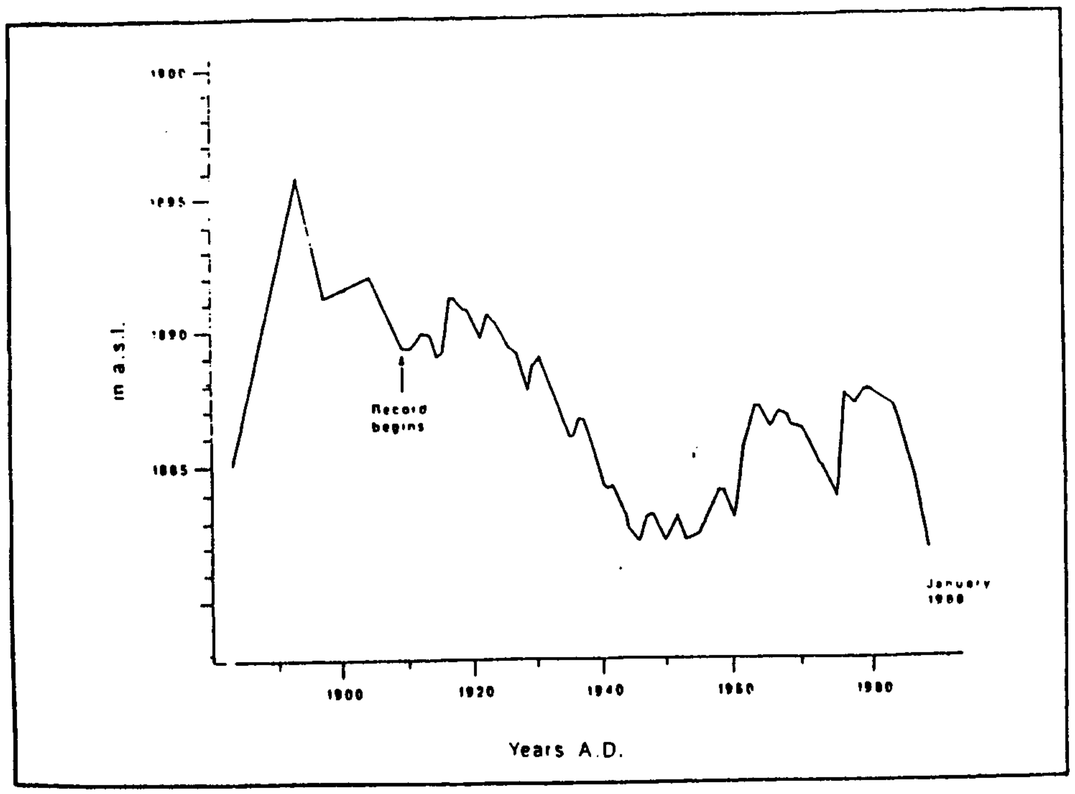
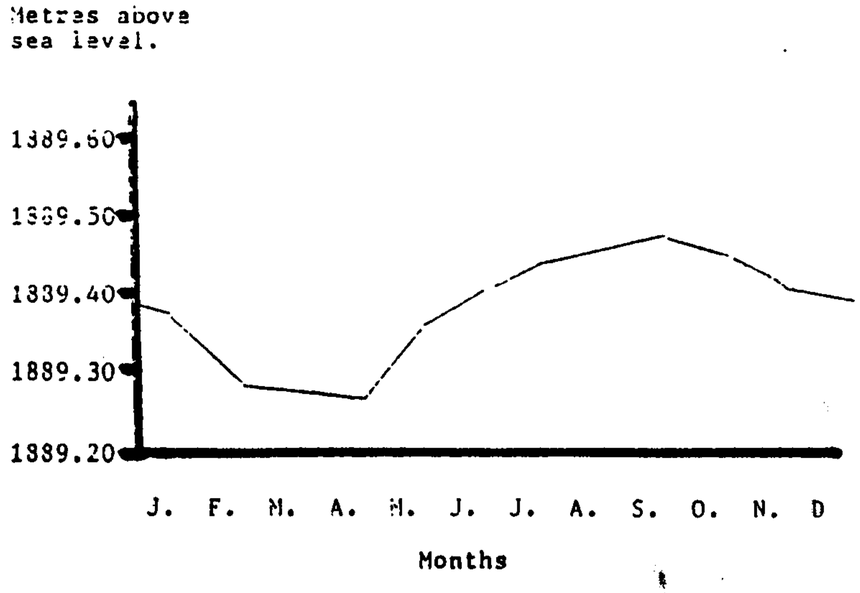


Figure 9.

Variations in lake
level with season.

(1911-1980)



(Note that the actual variation is small at less
than half a metre)

(Source: Ase et alia 1987b)

A falling phase in the lake level, as now, obviously initiates much discussion on whether the lake is going to dry up again and whether man is using too much of the water. It may not comfort those concerned, but in the past there was much concern over limiting the lake to a maximum level. In 1957 (Drind 1957) reported a scheme to control the level of the lake. It was proposed to build a level regulating out-flow at 6185 feet above sea level, and lead this through Hell's Gate gorge after which it would surface six miles from the lake and be used for irrigation. Three capacities of channel were proposed. Needless to say the plan was never implemented, presumably because the lake went down fairly soon after the proposal was made.

There is no doubt that the level of the lake is in a downward trend. Fuchs (1934) has assumed that the second fluvial (wet) period is drawing to a close, and although there will be seasonal variations the possibility of an intense dessication in the relatively near future should not be ruled out. Obviously if this is so, then there is every reason to manage the remaining water resource in order to make it last as long as possible.

To recharge the lake from its dry position in 1882, one must assume that water supply conditions were much better than they are now. The present situation on Naivasha is being repeated elsewhere in the world. Other lakes with no visible outlet are also declining in Australia and America. It could well be that Naivasha is heading for drying out no matter what interventions may be made by man. Lake levels have been far lower than they are at present, and probably have stayed low for some time, as evidenced by the fairly large tree stumps still standing in water off shore at the Lake Naivasha Country Club and other places.

8.4 Lake depths and contours

Thompson and Dodson (1927) did the first depth survey of the lake, but they had no echo sounder so interpreted their results from point readings. **Ase et alia (1986) did the first echo sounding survey.** At that time the deepest part of the lake was Crescent Island crater at 17m and Oloidien Bay at 9m. The bottom of the lake was fairly flat, in contrast to the hilly nature of the surrounding countryside. This is probably due to a flattening out caused by sediment over the years. In the northern area, a small delta of silt can be detected from the in-coming rivers.

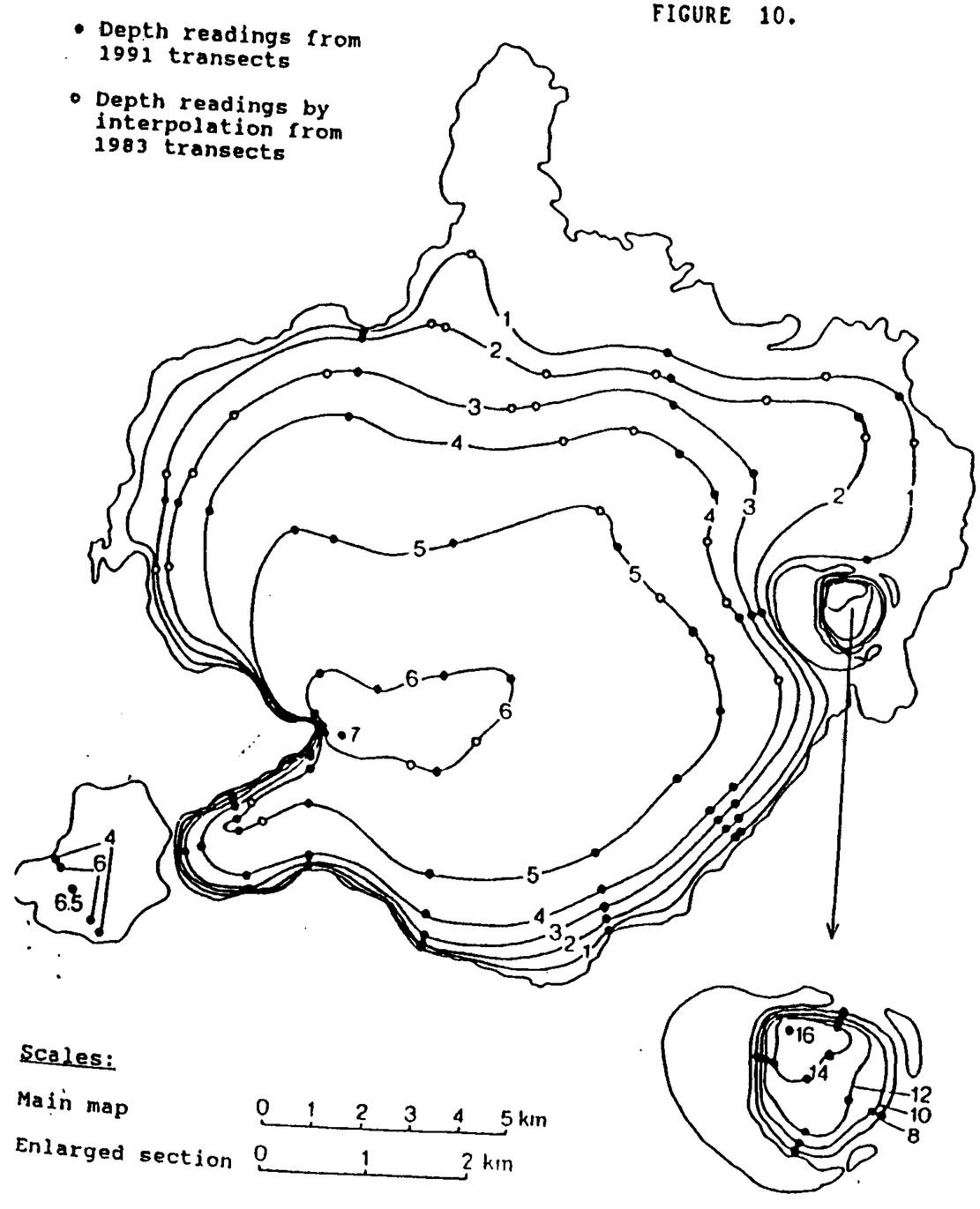
Hickley (1991) improved upon the Ase data using an echo sounder and chart recorder. He produced the contour map and cross sections of the lake as shown in Figures 10-12.

The lake bottom composition differs. In the north-east it is composed mainly of loose flocculant organic matter derived from Papyrus and Salvinia debris. In the west there is more sand and finer organic particles.

Gradients at the bottom are 0.4% near Safariland (3m depth at 500m from the shore). In the north the gradient is 0.1% and in the Crescent lagoon 2%. The south west shore is generally steeper than the north with rocky sides.

LAKE NAIVASHA DEPTH CHART

FIGURE 10.



(P.Hickley/Earthwatch)

LAKE NAIVASHA DEPTH CHART

1991 transects →

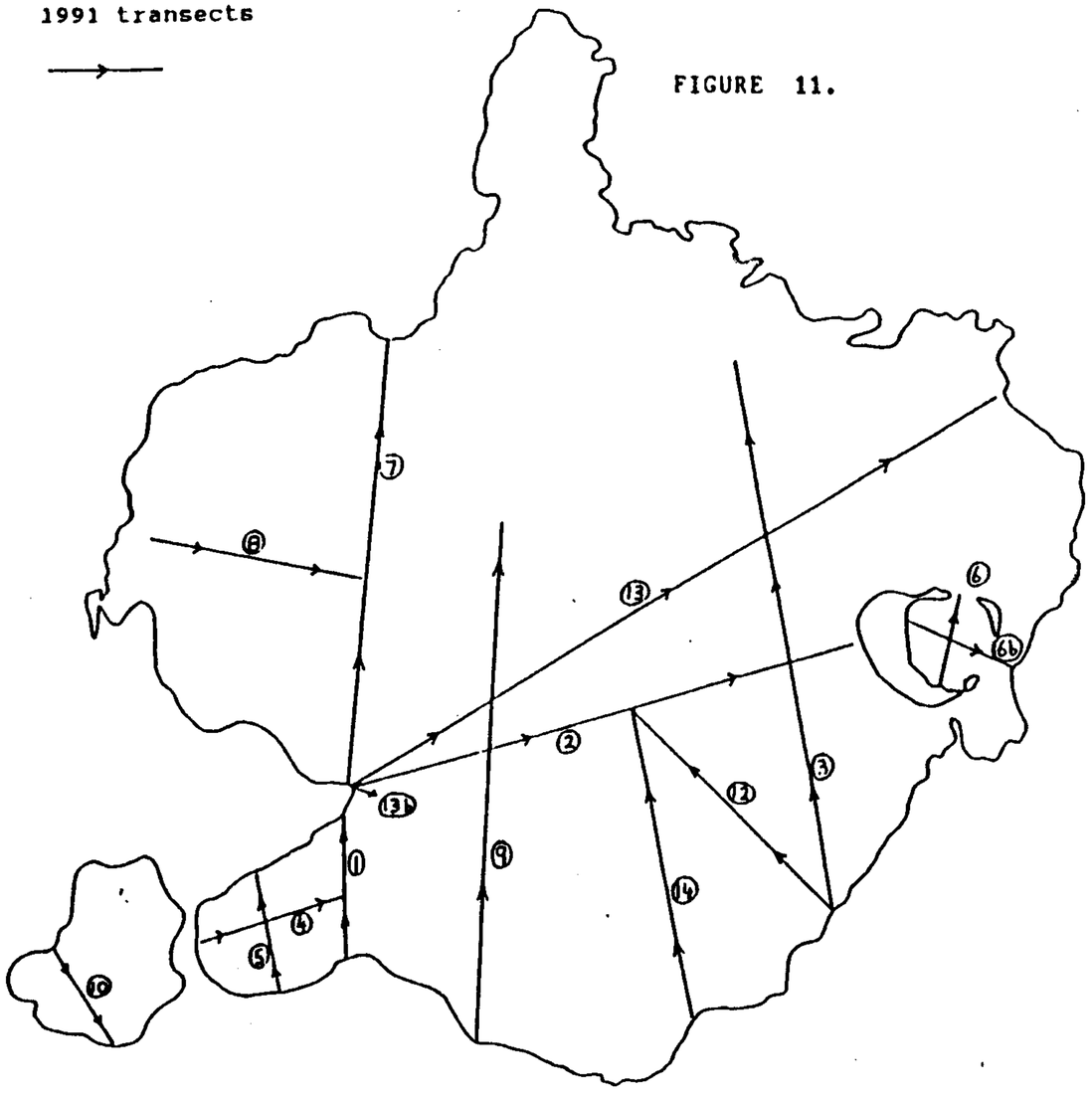


FIGURE 11.

[P.Hickley/Earthwatch]

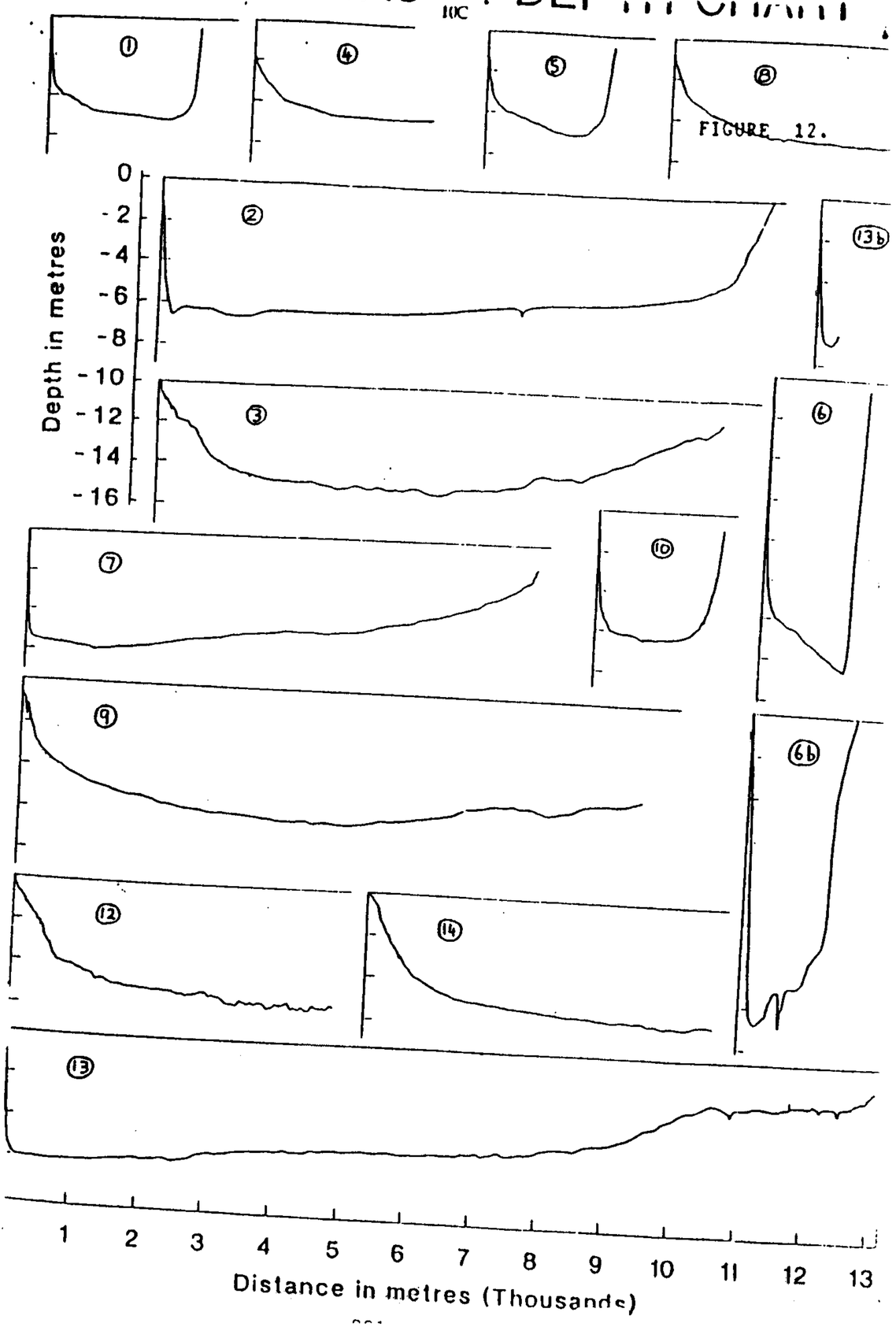


FIGURE 12.

9. ECOLOGY OF THE LAKE AND ITS ENVIRONS

9.1 Climate

9.1.1 Rainfall

Rainfall is bimodal with main pulses in April/May and again in November. Average rainfall for the lake is 608 mm per annum. with a variation round the mean from 443 to 939 mm. (DO's office). Rainfall records for selected stations around the lake and in the catchment area are given in Appendix IV. Rainfall on the lake is only a third of the evapotranspiration rate in the same area.

9.1.2 Winds

There are generally calm conditions or slight winds in the mornings over the lake. In the afternoon winds of 11-15 km/h are typical. Winds are strongest in August to October when they reach speeds of 21 kms/hr. There are often violent storms over the lake leading to serious water movement and high wind speeds. **The direction of wind is mainly from the south-east and north-east depending on season. Winds over the lake in the afternoon cause mixing of the water down the column, and result in well oxygenated water from top to bottom. Temporary thermal stratification occurs in calm weather.**

9.1.3 Insolation

Melack (1976) has reported that monthly means of daily insolation near the lake vary from 624 langleys to 136 langleys (during 1961-68). Highest levels were in January-February, and lowest in July and August. Data on daily insolation and general climatic data for Naivasha are given in Appendix VI. Climate and day length are excellent for flower growing.

9.1.4 Ambient Temperature

Mean maximum and minimum ambient temperatures for Naivasha (Jaetzold and Schmidt 1983) are given in Appendix V. Mean monthly maximum temperatures range from 24.6 to 28.3°C with the highest temperatures in January and February. Mean minimums range from 6.8 to 8.0°C with coldest months in July and August, although the coldest monthly mean ever recorded is 1.7°C in September. Mean monthly temperatures range from 15.9 to 17.8°C. There is quite a big diurnal variation and a definite cold season as a result of cold air coming down from the Nyandarua range. These cold temperatures provide a well marked cold season and make it possible to grow grapes and deciduous fruit round the lake.

9.2 Soils of the Area

Soils on the lacustrine plains around the lake have developed on sediments from volcanic ashes. Soils can vary from well to poorly drained, fine to sandy silts and clay loams of varying colour, but often pale. Fertility is variable and in some areas the soils can be sodic or saline. Generally the soils are easy to work, but very powdery when dry.

Soils in the catchment area are generally developed from volcanic activity, of moderate to low fertility, deep clayish loams, greyish brown to black in colour, often with drainage problems. Soils often degenerate into black cotton soils with impeded drainage in low lying areas. Soil conditions are often quite difficult in so far as working, and communications are concerned i.e. the Ol Kalau plateau.

Delamere in his early farming experiments in the Rift Valley soon found that certain minerals were deficient (Copper and Cobalt) and this is now remedied in special Rift Valley mineral mixes for livestock. The Maasai kept their cattle in the area only for six months at the most, realising that the pasture was lacking in certain elements.

9.3 Ecology

Symoens et alia (1981) have given a broad background to the ecology of inland waters in Africa.

Apart from the riparian land the ecology of the land surrounding the lake makes it suitable only for extensive grazing, unless irrigation is practiced. Stocking rates of one livestock unit per 2-4ha.

Edwards and Bogdan (1951) classified the area as Scattered Tree Grassland dominated by *Acacia-Themeda*; the most extensive vegetative climax in the intermediate elevations. In rocky areas around the lake a large candelabra like Euphorbia is present, and in suitable habitats Aloes and succulents are common. According to Pratt et alia (1966) the area is classified as Group IV/V Acacia woodland.

Themeda is the most common grass species, and *Pennisetum, Eragrostis Hyparrhenia, Setaria,* and *Cynodon plectostachyum* (Stargrass) are all associated with the low grey coloured scrub *Tarchonanthus camphoratus* (Lileshwa). On good fertile soils round the lake with some residual moisture status, The Naivasha Stargrass (*Cynodon plectostachyum*), will be found. A grass of commercial prospects, but which unfortunately in Kenya does not set viable seed.

At the head of the river Malewa the ecology is sub-montane tropical evergreen forest dominated by *Podocarpus* spp. Slopes above the lake are typically *Setaria* grassland, although these areas are now drastically overgrazed. These grade down into the Lileshwa bushland typical of the Rift Valley floor.

Clapp (1977) has concentrated on the study of Crescent Island in particular and describes its ecology.

Vegetation maps of the Hells Gate Park and the area south west of the lake are given in Appendix VII.

9.4 Agro-ecological zones

Based on the classification of Jaetzold and Schmidt (1983) the lake is surrounded by the UM3 (Upper Midland ranching) zone characterised by unimodal rainfall and an intermediate short rains. Under normal rainfall in this area the carrying capacity is rated at 3.5 ha per Livestock Unit.

Surrounding this zone is the UM5 (Livestock-Sorghum) zone with a weak, short to very short cropping season plus an intermediate short rains. Much of the main catchment area of the Malewa river is situated in Nyandarua District. This previously large scale farming area is now densely populated and is in the upper and lower highland belts of Zones 2 and 3, characterised by low temperatures and long but weak main cropping seasons. Most of the area is UH2 (Pyrethrum-Wheat zone), and UH3 (Wheat-Barley zone). Land pressure combined with medium rainfall, frosts and swampy areas, plus the fact that the majority of livestock are grazed off-farm; are leading to gross overgrazing and land degradation. (Goldsun 1992). This has serious implications on the future of the river flows coming into the lake.

Maps showing agro-ecological zones for the Naivasha area and its main catchment in Nyandarua are shown in Figures 13 and 14.

The agricultural land of Nyandarua District and the Naivasha Division of Nakuru District are divided up into the following agro-ecological zones as shown in table 3.

Figure 13.

Agro-ecological zones
Nyandarua District

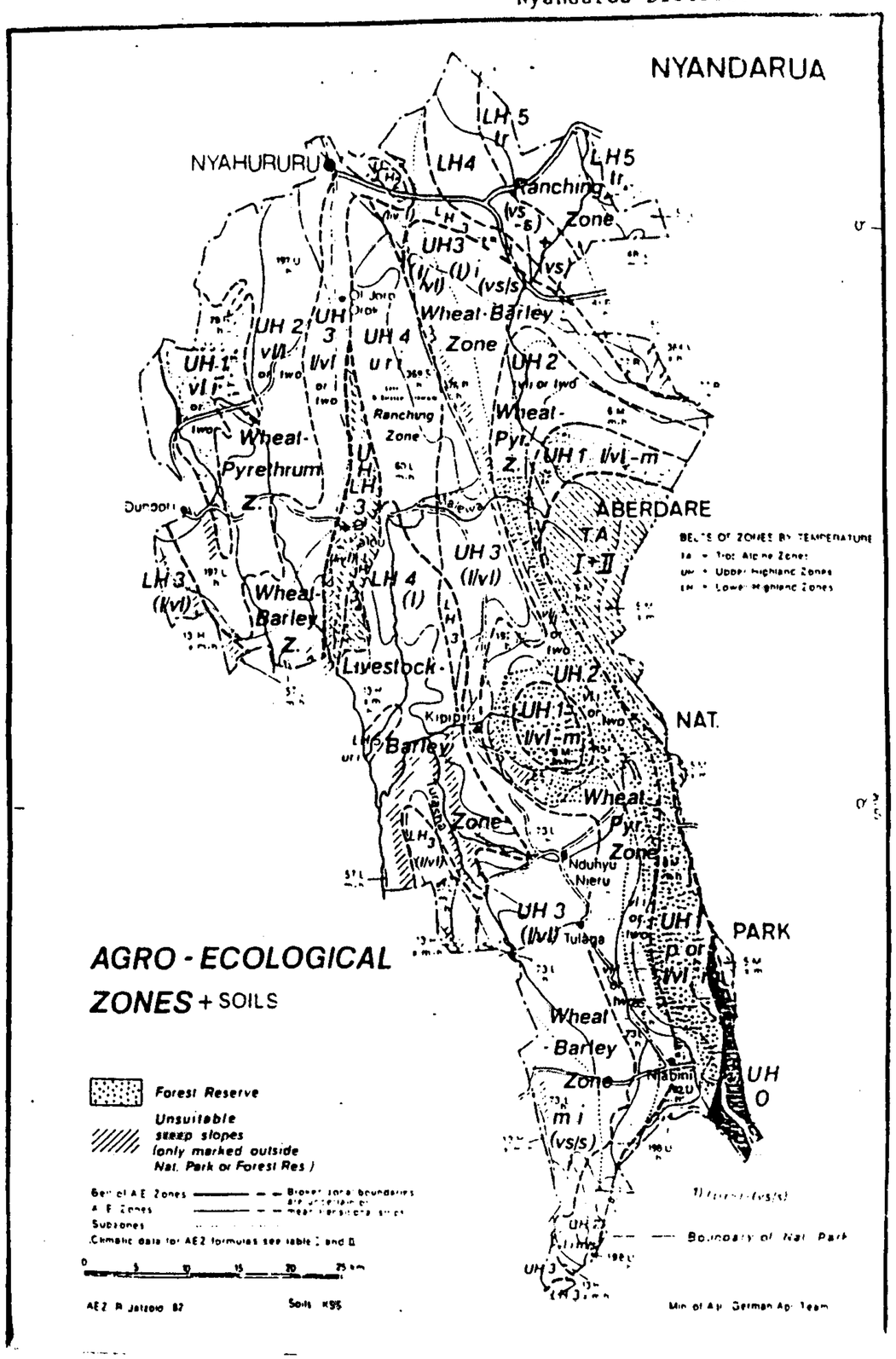


Figure 14.

Agro-ecological zones
Nakuru District.

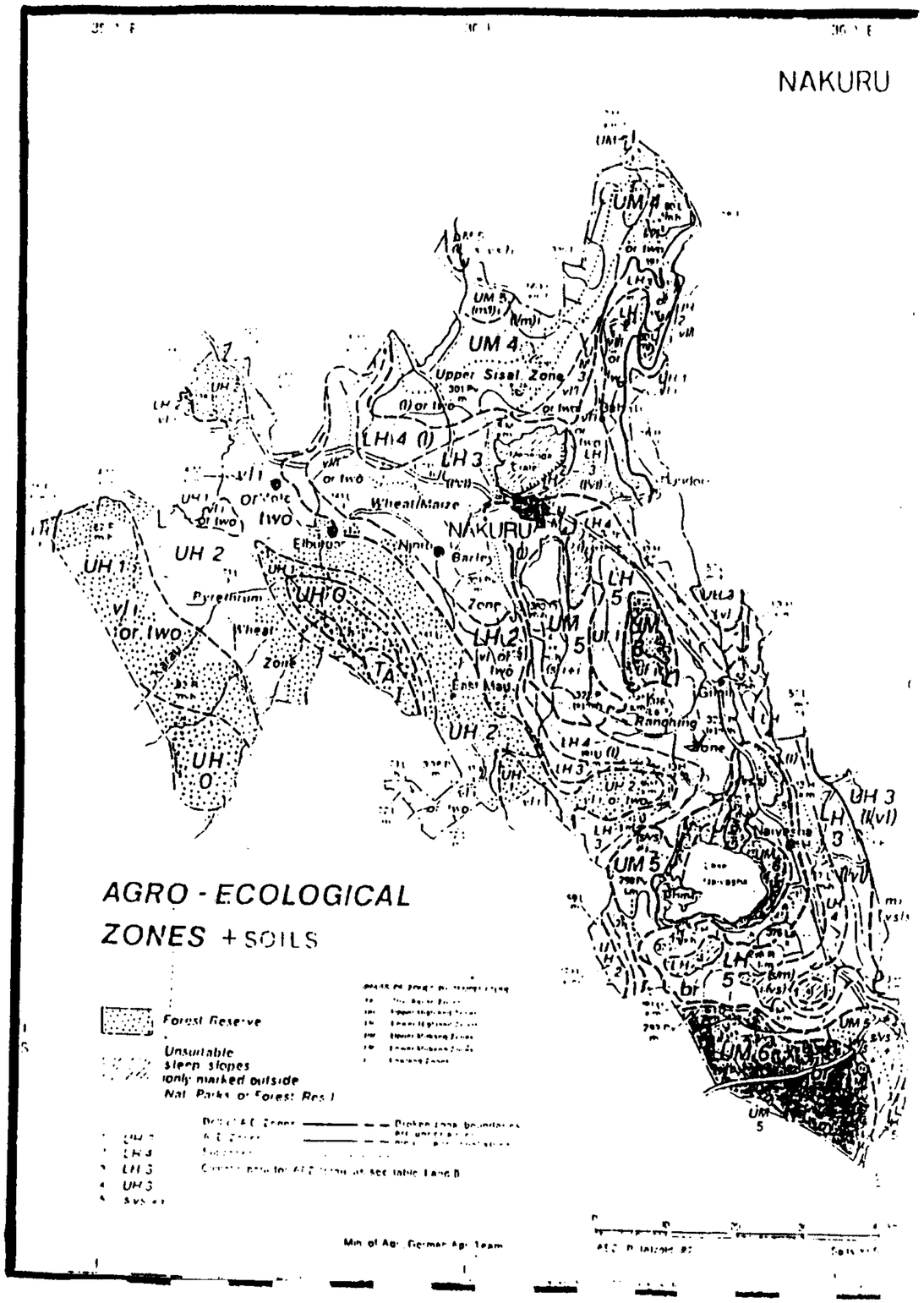


Table 3. Agro-ecological zone areas of Nyandarua District and Naivasha Division (Kms²)

	Nyandarua District	Naivasha Division
UH1 (Sheep dairy zone)	151	
UH2 (Pyrethrum wheat zone)	612	13
UH3 (Wheat barley zone)	636	70
UH4 (Cattle sheep barley zone)	101	113
LH3 (Wheat barley zone)	126	156
LH4* (Cattle sheep barley zone)	21	113
LH4 (Cattle sheep barley zone)	288	230
LH5 (Highland ranching zone)	97	
UM5 (Livestock sorghum zone)		443
UM6 (Upper midland ranching zone)		383

(* Transitional LH3/LH4 zone)

10. THE CATCHMENT AREA

10.1 Physical Area

The area is marked on the map in Figure 15. The area is covered basically by the administrative Naivasha Division of Nakuru District, and the Nyandarua District. Both areas have seen drastic changes in land use over the last thirty years. Naivasha division was largely extensive ranching, and there was no irrigation around the lake apart from Lucerne planted on the riparian land. Nyandarua was a settled area of large wheat and sheep farms. The latter was taken over for settlement soon after Independence and average farm size is now down to 6.4 ha (Gekiaon 1992) with cropping based on maize, potatoes, beans and pyrethrum.

10.2 Population

Nakuru District.

Naivasha is an administrative Division of Nakuru District. The population of the District according to the 1979 census (the last figure available) was 522,709 of which 387,504 were rural persons living on 576,200 hectares of agricultural land, an average of 1.48 ha per person. In the intermediate 14 years the population has certainly gone up. Assuming a modest 3.5% population increase, and ignoring immigration into the district, then the population now is in the region of 846,000, and the agricultural land per person has gone down to 0.68 ha.

Naivasha Division

In the 1979 census Naivasha had the population statistics as shown in table 4.

Figure 15

Lake Naivasha and its catchment area.

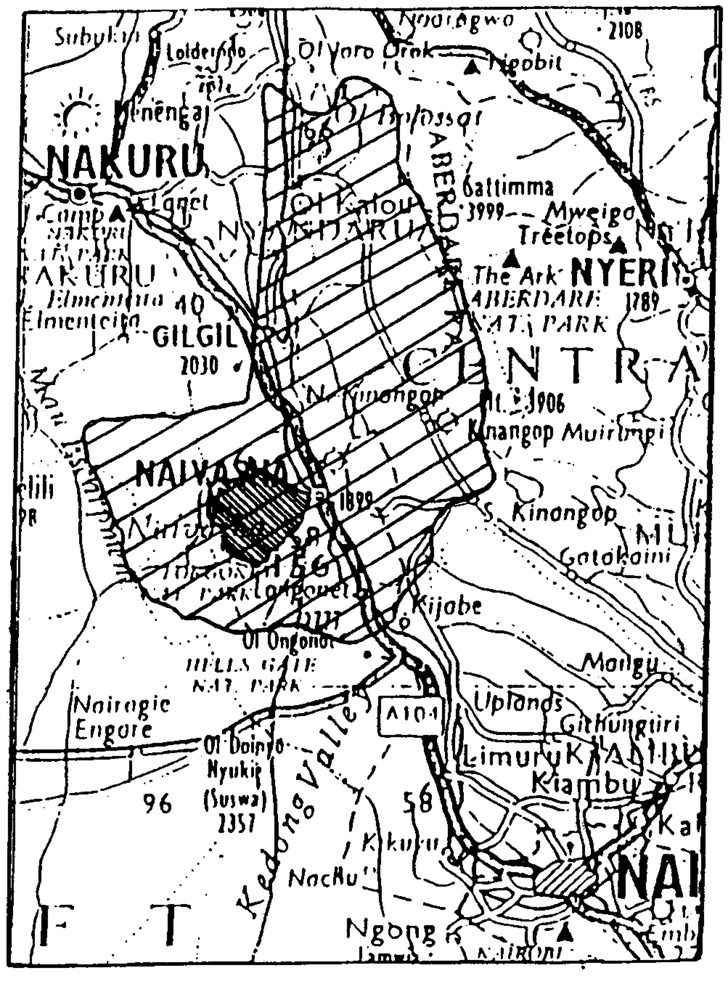


Table 4. Population statistics for Naivasha Division. (Census 1979)

Location	Number of Households	Area Km²	Density pers/km
Naivasha Township	2856	10	1113
Naivasha	12329	967	62
Kijabe	2087	740	13
Gilgil	8221	1039	34
Total	25493	2756	37.8

Average people per household in Naivasha division is 4.09, with an average of 18.73 ha and 4.38 ha land per household and per person respectively.

The population of Naivasha Division at the Census in 1979 was just under 100,000, and based on a 3.5°, population growth rate the population should now be in the region of 150,000. However the last 14 years since that census has seen the rapid development of the horticultural industry round the lake. This is estimated to employ 30,000 people alone. Many of these are imported labour into the Division. Together with their dependants they could well have increased the population round the lake to something in the region of 250,000, compared to the 100,000 for the whole division or 14 years ago. Almost certainly, services such as water, medical, family planning, sewerage and housing have not kept pace with this increase.

Nyandarua District

This District must be mentioned separately as it comprises much of the catchment area and includes the headwaters of the Malewa river and its tributaries, the main river feeding the lake. The District is largely made up of the Kinangop plateau and the Ol Kalau Salient.

Population of the District in 1979 was 233,302 in 43,197 households on 3528 km² area of land. Persons per household were 5.36, a density of 66 persons per km², with land division of 5.33 ha per household and 0.95 ha per person. With the 3.5 population increase applied to this datum, the District population probably now stands at 450,000.

10.3 Land utilisation

The whole face of agriculture has, and is changing in the catchment area. The land is classified as suitable for ranching, but in fact with the increasing land pressure, it is being divided up and forced to host an intensive smallholder system of production more suited to the high potential areas. This is visually obvious on the areas below the main Nairobi-Naivasha road towards Longonot.

Naivasha comprises a total of 1699 km² which is utilised as follows:-

Unsuitable steep and rocky slopes	32 km²
Forests and the lake	171 km²
Roads and tracks	88 km²
Agricultural land	1408 km²
Total	1699 km²

Away from the specialised horticultural industry of the irrigated lake areas, most agriculture is small scale, subsistence, and food crop orientated. In Nyandarua, pyrethrum and vegetables are grown for ca and the area is a major smallholder milk producing area based on the KCC factories at Nyandarua and Naivasha.

In 1969 Watson and Parker estimated that 50% of the catchment area was cultivated, 10% was under forest and the balance used for extensive systems of livestock production. The cultivated area has almo certainly increased and there is more runoff and nutrient and silt load in the rivers. This could have dramatic effects on the future of the lake ecology.

Over the last two decades the area has been increasingly populated and stocked. Soil erosion and degr dation has increased appreciably with semi-intensive farming, as has the demand on available water supplies.

10.4 Livestock production

Prior to 1960, Naivasha Division and the area surrounding the lake was a major livestock farming area both for milk and beef. These enterprises, although still present are now less important as irrigated horticulture has developed.

Although there was and is no official stock route round the lake, the north lake road has traditionally been used by the Maasai in dry years on their trek from the south to central and northern Rift Valley areas. There is no official watering point on this route. The official stock route passes through Naivash and along the old Naivasha-Nairobi road via Longonot. Facilities used to include a quarantine station the edge of town, and a very small 40 ha holding ground near Longonot. Both facilities have been allowed to deteriorate in condition and the route is no longer used.

Present livestock developments in the area amount to a small number of large beef and dairy herds. K has a milk collection depot in Naivasha which handles 30M kg of milk annually from over 2000 suppli and there is one privately operated processing and packing plant. Extension packages amongst smallholder farmers include tick control, zero grazing systems of production, and fodder planting. Sm holder livestock production in the area surrounding the lake is seriously constrained by water shortag

In the late 1970's a pumping station and water pipeline from Lake Naivasha leading towards Suswa a the areas south of Ngong township was opened. This pipeline was interspersed with water troughs fo Maasai cattle. The line ceased operating in the mid 1980s, but it is understood than an NGO organisati is to revive the scheme. As the rural population around the lake increases, there could be more pressu for similar pipelines in other areas.

11. DETAILED ECOLOGY OF LAKE NAIVASHA

11.1 Introduction to the ecosystem

Considerable research has been conducted on the ecology of the Lake. Special mention must be made Drs Gaudet, Melack, and Harper, and local researchers Drs Njuguna, Mavuti, Muchiri and Muthuri f their contribution to the depth of our knowledge of the lake, resulting from their research programme several fields over several years. Over the last ten years much effort has been made by the Earthwatch University of Leicester research teams in expanding our knowledge of the lake ecosystem.

The latter programme was initiated after consideration of the increasing pressure exerted on the lake during the 1970s and 1980s by water level fluctuations, alien species introductions, disappearing lake

margin vegetation, grazing in the Hell's Gate areas, increasing agricultural activities around the lake and lake water extraction for irrigation and the initiation of geothermal power supplies. The objectives of the work have been to investigate, document and quantify the effects of these pressures and make recommendations for conservation. The parameters to be investigated in this programme included light penetration in the water, algal and invertebrate densities, rooted plant distribution, fish species, aquatic bird numbers, vegetation types, large mammal numbers, bird species compositions, and the effect of introduced species such as crayfish, Salvinia and fish. Much of this data is relevant to the writing of a management plan.

Lake Naivasha is unstable and unpredictable. The ecology of the lake is forever changing (Harper 1986). Many of the changes are brought about by the fluctuating level of the lake. There has been a 15m level change during this century and there have been 3m differences over short periods of a few months; the last during the 1984-85 drought. These changes are considerable when it is considered that the average depth of the lake is only 5-6m.

Good descriptions of the general ecology and biology of Lake Naivasha are given by Litterick et alia (1979), and Harper (1990). Lakeside fauna has been generally described by Gaudet (1977), and Clapp (1977) the latter who concentrated his work on Crescent Island noting that the area is host to 251 species of birds, 21 mammals, 5 rodents and 8 reptiles

11.2 The Hydrology of the lake

General accounts of the hydrology of the lake are given in the reports of the Geological Survey of Kenya. Relevant reports are

No 78. Gilgil (McCall 1967)

No 55. Longonot-Gilgil (Thompson and Dodson 1963)

No 43. Kyalu and Kinangop (Thompson 1964)

No 42. Magadi (Baker 1958)

MOW Rept No.3. Nakuru area (McCall 1957)

England and Robertson (1959) have also reviewed the hydrology of the lake area.

Water in general is the current talking point of all people around the lake; and in particular whether utilization by man is increasing the general rate of fall in the level of the lake. There is much conjecture, some finger pointing, and many theories based on scanty information. How much can safely be extracted from the lake without seriously affecting its long term future? Does extraction by man (at the present time) have any significant effect at all on the trend in lake levels? If so is there a safe limit to which abstraction should be limited? Several attempts have been made at calculating a water balance over the last 30-40 years. Many of these attempts have been unsuccessful due to the fact that there has been no accurate estimate of how much water goes in and out of the lake underground. More is known about this water now. This section will review the literature on this subject and attempt to come to some very simple water balance for the lake. However before this can be done, the various parameters which feature in the balance are discussed and calculated.

In the calculations the level of the lake has been taken as 1885m. Additions to and subtractions from the lake are discussed in turn.

11.2.1 Precipitation

Richardson and Richardson (1972) have summarised the water input to the lake through rainfall. Annual rainfall for Naivasha has been recorded as 608 mm. (Appendix IV).

From Figure 7 it can be calculated that the area of the lake at 1885m above sea level is approximately 120 km^2. Therefore the amount of water added directly to the lake from rainfall will be :-

$120 \times 10 \times 0.608$ m^3 = 72.96 x 10 m^3 water

11.2.2 River flows

Only the flows of the Malewa and Gilgil rivers have been included in these calculations.

Inflows from the Malewa and Gilgil rivers for the 29 year period from 1936 to 1964 were calculated by England and Robertson (1969) to produce a change in volume of the lake of 209,000 acre feet, equivalent to 269 x 10^6 m^3, of which 89.9% was attributed to the Malewa.

The same authors quoted flows for the Karati of less than 2000 acre feet in good years, equivalent to 2.6 x 10^6 m^3, when the river flowed for six months or less. As an inflow of 2000 acre feet in a month would result in a lake level rise of only 0.07 feet (without adjustment for evaporation) this river's contribution to the lake can virtually be ignored for all practical purposes.

Ase et alia (1986) gave detailed calculations of river discharge into the lake using the water discharge data from four river gauging stations, two on the Malewa and one each on the Turasha and Gilgil. Unfortunately none of these gauging stations provided continuous uninterrupted records; and even now there is no evidence that gauging stations 2GC4 on the Turasha and 2GB1 on the Malewa are being recorded at regular and uninterrupted intervals. These data are essential if there is to be any meaningful calculation of the water balance for the lake.

Ase et alia (1986) used the data to provide water discharge values using a rating curve. The authors calculated the average annual flow for the 48 year period from 1932 to 1980 to be 153 x 10^6 m^3. During the same period the maximum and minimum values were as follows:-

Maximum 328 x 10^6 m^3 in 1964
Minimum 53 x 10^6 m^3 in 1939

Both the Malewa and Gilgil are perennial. Ase (1987b) gave the following data for the two rivers as shown in table 5.

Table 5. River flow data after Ase (1987b)

River	Malewa	Gilgil
River Gauge stations	2GB1	2GA1
Period of records	21 years	22 years
Max. Daily Average flow and date	4225 cusecs 26-6-37	450 cusecs 21-8-51
Peak flow recorded	5750 cusecs	No record
Av. of highest ann. flow	1649 cusecs	450 cusecs
Av. of lowest ann. flow	23.5 cusecs	1.3 cusecs
Minimum flow recorded	12.1 cusecs	0.26 cusecs
Yield in high rainfall year Equivalent in m^3	29,800 ac ft 378 x 10^6	57,540 ac ft 74 x 10^6
Yield in a low rainfall year Equivalent in m^3	41,000 ac ft 53 x 10^6	2,455 ac ft 3.2 x 10^6

(Note one acre foot = 43,560 cubic feet = 1234 m^3)

Tetley (1948) has also reported on the flow of the two rivers for the 10 year period from 1936 to 1947 as 137,960 and 12,322 acre feet respectively equivalent to 178 x 10^6 and 16.55 x 10^6 m^3.

As one would expect results are varied due to the different periods of recording used, and the varying weather conditions with time. There is no up-to-date and uninterrupted river flow data available for recent years, and therefore before any accurate water balance for the lake can be calculated regular readings of river flows at all catchment area gauging stations are needed.

For the purpose of the simple balance calculated in a later section it appears that no more than 150 x 10^6 m^3 flow on average can be expected from the two rivers on an annual basis.

It should be noted that the extraction of the 19,000m^3 per day from the Twasha for Gilgil and Nakuru, detailed in section 15.5 is done before the 2GB1 gauging station. This water is already lost to the lake before the above calculation is made.

The flows in the rivers have become noticeably lower over the years. Older residents of Naivasha can remember the Karati falls on the River Karati as a permanent and spectacular feature. Now they are seldom seen.

11.2.3 Underground seepage

As early as 1922 Gregory suggested that there was an undiscovered underground outlet to the lake. Nilsson (1932) was the first to suggest that water entered and left the lake via underground seepage of some sort.

Scott Laboratories (Now KARI) estimated that the outflow was of the order of 21 cusecs based on the salt content of the water (Tetley 1948). **Gaudet and Melack (1981) and Ase (1987) showed that hydrologically Lake Naivasha was a seepage lake with input via underground seepage in the northern area.**

Ase (1987) in a major study of the hydrology of the lake, also supported the underground seepage theory and managed to draw up a water balance budget, which although not quantifying the amounts of water entering and leaving the lake underground, was able to suggest how the balance could be arrived at, interpreting underground flows as differences in lake storage as shown by differences in the lake levels.

Gaudet and Melack (1979) described how groundwater can be measured by simple seepage metres and later went on to determine a water budget for the lake. Their data is given in a later section.

Darling et alia (1990) have given some of the latest information on the direction, quantity and character of the underground flows in and out of the lake. The stable isotopic composition of fumarole steam from volcanic centres in the area has been used to infer groundwater composition. Using a simple modelling technique they have traced outflows from the lake up to 30 kms south. **Lake water has also been detected in Olkaria steam**. Their work confirmed that of Allen et alia (1989) that most of the water leaving the lake goes out between Olkaria and Longonot, whilst a smaller portion goes north between Eburru and Gilgil. Their estimates of outflow agreed broadly with other workers as follows:-

Sikes (1935)	43 x 10^6 m^3/year
McCann (1972)	34 x 10^6 m^3/year
Ase et alia (1986)	46-56 x 10^6 m^3/year

It is safely established that there is water flow in and out of Lake Naivasha from underground (Clark et alia 1990).

Water flows out of the lake to the north via Gilgil and under Eburru, and there is a southerly flow following the hydraulic gradient towards Magadi, although there is no evidence at all to suggest that the water ever reaches Magadi.

Clark et alia (1990) have provided the latest and most convincing evidence so far on the amount of water that leaves the Naivasha catchment beneath the ground. They used two methods to determine the water flow - by water balance studies and by the application of Darcy's law of groundwater flow. Their calculations based on water balances estimate that a total of 50 x 10^6 m^3/year flow out of the catchment which represents 20% of the total recharge. The flow to the south is via relatively shallow aquifers, less than 500m depth, and these may account for 50-90% of the total flow. Estimates of the northerly flow by the same authors was 11.3 x 10^6 m^3/year. McCann (1974) calculated a much greater flow to the north at 39 x 10^6 m^3 per year.

It would appear from all of these results and studies that subsurface flows from the Naivasha catchment; the amount contributed to that flow by Lake Naivasha is around 50-60 x 10^6 m^3 per year.

Quantitative evidence of the inflow is not readily available. Howard (1993) has estimated that 16% of (total) inflow into the lake comes underground. Gaudet and Melack (1979) have estimated an inflow varying from 41.1 to 58.5 x 10^6 m^3 per year in their water balance. In other words from all the evidence it

appears that there are annual variations in the underground in-flows and out-flows. In-flows are probably roughly equal to the outflows or in the region of 30 to 60 x 10^6 m^3 per annum. However this may well be influenced by long runs of dry or wet years. For information a difference of 10 x 10^6 m^3 could result in a lake level difference of around 30cms.

11.2.4 Evaporation.

There have been various figures used for evaporation from a free water surface at Naivasha. Tetley (1948) considered that it varied between 5.1 and 7.5 feet with an average annual figure of 6.0 feet. (1.83m). Ase (1986) has pointed out that it is difficult to arrive at an accurate figure. Where evaporation is measured from pan observations any estimate is unreliable. The average figure calculated from pan evaporation is 1865 +106 mm. See Figure 16. Pan evaporation generally results in figures too high due to the walls of the pan giving an extra heating effect. Brind and Robertson (1959) in a study of the Evaporation figures at Naivasha DC, suggested that a multiplication factor of between 0.84 - 1.04 be used instead of the normal 0.8. Ase (1986) then calculated an evaporation of 1492mm per annum.

The District Council Irrigation sub-Committee (1950) used the following evaporation figures for the lake from 1960 to 1964. **There is no record of how they arrived at these data.**

Year	Evaporation in feet	
1960	6.22	(1866mm)
1961	6.26	(1878mm)
1962	5.38	(1614mm)
1963	5.45	(1635mm)
1964	5.23	(1569mm)

Chance (1944) the irrigation adviser in the Ministry of Agriculture at that time regarded evaporation for the lake as 74" (1850mm)

England and Robertson (1959) using the Cochrane formula calculated the evaporation rate at 63.6" ± 10% equivalent to 1358mm.

Obviously more accurate data are required on this subject as evaporation has a tremendous influence on the amount of water lost from the lake. Morrel (private papers) was at pains to point out the relative importance of abstraction and evaporation in the lowering of the lake level. His calculations in 1975 were made when the lake level was at 6193 feet (1888m) and the level of the lake was falling at 6" per month. His calculations showed that the abstraction at that time, would reduce the lake level by 3.67" compared to the drop of 96" over the same period from evaporation, transpiration and seepage.

It is important that evaporation rates for the lake are measured at intervals throughout the year as rates can vary considerably as shown in Figure 16 after Ase (1987).

For the purposes of a simple calculation, assume the evaporation is taken as 1500mm per annum from open water, and we assume a value of 60% of this figure for Papyrus swamp. (Rijks 1969) Also we assume that there are 12 km^2 of Papyrus on the lake. Then evaporation losses will be:

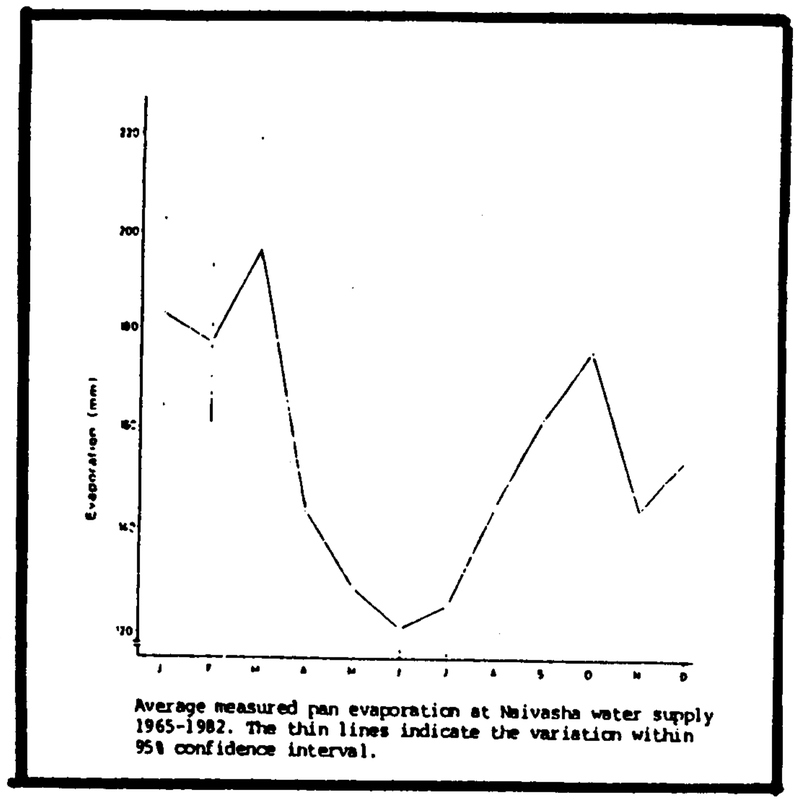
108 km^2 open water at 1500mm = 108 x 10^6 x 1.5 = 162 x 10^6 m^3

12 km^2 swamp at 1500 x 60% = 12 x 10^6 x 0.9 = 10.8 x 10^6 m^3

In this case the total loss by evaporation would be 172.8 x 10 cubic metres of water per annum.

FIGURE 16

Evaporation at Naivasha
Seasonal effects.
(Ase 1987)



Average measured pan evaporation at Naivasha water supply 1965-1982. The thin lines indicate the variation within 95% confidence interval.

11.2.5 Abstraction

Permission to abstract water from the lake direct or from wells/bores adjacent to the lake is relatively easy to obtain. An application from the Naivasha Water Bailiff is completed, and the pump and siting will be inspected by the Bailiff. The application is then considered by the Area Catchment Board which sits in Nakuru at three month intervals; and they make a recommendation to the Water Apportionment Board that conducts business in Nairobi at monthly intervals.

Once approved there appears to be little checking done on the amount of water actually withdrawn, and more over there seems to be no limit set on water abstraction against which new abstraction applications are compared.

(i) **Agricultural use.** In the past the LNROA maintained a rigid policy opposing all schemes to extract water from the Malewa and directly from the lake for purposes of irrigating crops. This was especially so during the war years, when the Lake was very low, and the argument that further extraction would accelerate the drying up, was applied vigorously. At that time there was considerable extraction for the army and POW camps that also irrigated vegetables.

Marula Estate in the post war years applied for, and was granted permission to extract water from the Malewa for irrigation purposes to a volume of 1100 acre feet, equivalent to 1.4×10 m^3, and this created much antagonism amongst Naivasha residents.

Proposals for a Malewa water Scheme to supply Nakuru with 2.145m gallons per day (3.5×10^6 m^3/yr) were considered for the first time in 1947 in order to supplement the supply from the Merasoni River. At that time the Water Apportionment Board approved an offtake of 0.5 m^3/sec from normal flow, and further increases to be taken by storage of flood water. LNROA appealed against this but the appeal was turned down. The on and off plans to extract water from the Malewa/Turasha for Nakuru are not new therefore.

During the 1950s there was increasing pressure to use the waters of the lake and its supply rivers for the purposes of irrigation. The planned cultivation of Ramie, a fibre crop on a large scale, renewed the pressure.

Irrigation of horticultural crops and flowers really began to expand in the 1970s. There is little accurate data on the actual acreage of land irrigated at the moment, and this is vital information that will be required for a management plan. This data could be obtained through aerial surveys.

A report published in 1988 by the Irrigation Unit of the Ministry of Agriculture based at Nakuru (Kinyanjui 1988) is vastly out of date but gave the following data on irrigated areas. See table 6.

Table 6. Irrigation area data for Naivasha 1988

	Number of farms	Area (ha)
River extraction	6	563.2
Lake only direct	53	981.8
Open well	13	255.1
Bore hole	8	764.4
River borehole	2	293.5
Lake borehole	5	329.9
Open well/borehole	1	12.1
Total	88	3200.0 ha

Another more recent estimate of actual abstraction for irrigation and other agricultural purposes has come from the Kenya Power Company at Olkaria, who estimated the amount from a survey of pumps and electricity charges. This information was collected for comparison with their own expected usage. They concluded that irrigation used 30.4×10^6 m^3 per annum. It is not certain whether they ignored diesel pump units which supply a significant amount of water, nor was the distance pumped considered.

A check on this figure can be made. If we assume that there has been an increase of 50% in the Kinyanjui figure over the last five years, then a total of 1472.7 ha are being irrigated direct from the lake. If it is assumed that this land is given an average of 10mm water per day for 264 days of the year then abstraction is calculated at 38.8×10^6 m^3 per annum.

The water Bailiff's total of permitted extraction direct from the lake amounts to 89,735.2 m^3 per day which is equivalent to 32.7×10^6 m^3 per year. There is therefore reasonable agreement amongst the various data sources that agriculture uses approximately 35×10^6 m^3 per annum direct from the lake.

However none of these calculations account for water taken from wells and boreholes around the lake or from the rivers. Are these sources made up of water which would eventually go into, or have come out of the lake, or are they from different aquifers which have no connection to the water balance of the lake at all? These are some of the difficult questions that would have to be resolved if any water balance other than a very simple lake balance is attempted.

(ii) **Geothermal power.** The Olkaria geothermal power station uses water for two purposes. Firstly there is the steam itself used to drive the turbines, and then the water abstracted directly from the lake to condense this steam. Will this usage have an appreciable effect on the water balance? The question has certainly been discussed in detail in the environmental impact study done by international and local consultants for the second phase of the Olkaria programme. Unfortunately this report is still unavailable to the public, but will be released shortly. (Nganga 1993 Pers Comm).

Clark et alia (1990) have discussed the implications of Olkaria based on data of well head steam provided by Bodvarsson et alia (1987). They calculated a discharge rate from the field of 3×10^6 m^3 per year. They pointed out that this was only a small percentage of the total material southerly flow from Lake Naivasha, thought to be in the region of 50×10^6 m^3. They concluded that any geothermal production influence on lake levels was likely to be masked by the effects of natural rainfall over the catchment area.

Of course this conclusion refered to the emergent steam only, and did not include the pumping of water to cool steam. There is some evidence of how much water is currently used for this purpose. The Kenya Power Company stated that they used approximately half of what the irrigators use; and they quoted a figure for the latter. Power usage is 15.2×10^6 m^3 per annum. Presumably this water could be recycled, although there is probably a cost limitation. The figure could more than double once the new NE field is commissioned.

(iii) **Abstraction from the rivers.** A considerable proportion of the water from the supplying rivers does not reach the lake, as it is abstracted up stream for various domestic and agricultural purposes.

There is a permit to abstract 19,000 m^3 per day from the Turasha (6.9×10^6 m^3 per year). Of this amount, 76.4% is for public use and the balance of 23.6 for industry. In addition two other small schemes higher up the river abstract 22,500 m^3 per day (8.2×10^6 m^3 per year). The last permitted abstraction figures for the Malewa refer to 1990 (Water Bailiff 1993) and cover 80 extraction rights, and amount to:-

1,882 m^3/day equivalent to 0.6×10^6 m^3 /yr for domestic purposes from normal flow

58,289 m^3/day equivalent to 21×10^6 m^3 /year from flood flow and subsequent storage.

In theory, all of this water would have reached the lake through the rivers, but now a total of 36.7 x 10^6 m^3/year are utilised upstream.

11.2.6 Safe abstraction from the lake

No other subject has consumed more of the past time of hydrologists and water engineers within the various Government Ministries that have controlled water. Files of the old MOW water department and the Ministry of Water Development give evidence of a host of attempts to calculate the safe level of extraction from the Lake and its supplying rivers.

In 1950 abstraction from the rivers was calculated on the basis of the average dry season flow. 68 permits were issued for the extraction of a total of 1.7644 cusecs which was 11% of the estimated dry season flow of 15.8 cusecs of the Malewa, Turasha and Gilgil.

The work of Svaren (1969) and Ostergaard 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. The Svaren calculations were based on the fact that when water is abstracted from the lake the water level falls, and when the level falls the lake becomes smaller and evaporation is less. He assumed the water level will stop falling when the gain in evaporation loss was equal to the amount of water abstracted. From these assumptions he calculated the drop in water level at varying heights of the lake if certain amounts of water were abstracted.

Results of his calculation are shown in Table 7.

Table 7. Falls in lake level at varying extraction levels and heights (Svaren 1969)

Water level	Abstraction rate in gals/day				
	2 x 10^6	4 x 10^6	6 x 10^6	8 x 10^6	10 x 10^6
6210	0.95	1.55	2.20	2.90	3.50
6200	0.75	1.45	2.05	2.75	3.50
6195	0.80	1.50	2.10	2.75	3.70
6190	0.55	1.05	1.50	2.00	2.65
6185	0.40	0.80	1.20	1.60	2.00
6180	0.40	0.70	0.95	1.30	1.70
6175	0.20	0.35	0.45	0.60	0.75

Svaren (1969) showed that when the lake was at the level of 6182.2 feet above sea level, abstraction of 16.5 x 10^6 m^3/year, would cause the lake to drop by 2.3 feet to 6179.9 feet. The chief Hydrologist of the WDD of MOW in 1984 considered the safe abstraction to be 16.5 x 10^6 m^3/year when the level was 6179.9.

As far as can be ascertained there is no safe limit of abstraction fixed at the moment. Certainly abstraction from the lake is far higher than the amount considered safe in 1984.

11.2.7 The lake water Balance

It is theoretically possible to do a water balance on any body of water or catchment. It is simply a question of balancing what goes in to what comes out. Unfortunately the collection of some of the data

required to calculate the balance accurately is not so easy to obtain. There is much confusion on the water balance for Lake Naivasha, as some researchers are dealing with the lake only, whilst others are dealing with the whole catchment. The balance is further confused as there are varying estimates of the underwater flow in and out of the lake.

Tetley (1948) attempted one of the first water balance calculations. Unknown underground flows were accounted for as storage changes as demonstrated by lake level changes over time. The balance calculation was made to assess the request by Nakuru Municipality to withdraw 4 cusecs from the Malewa.

Gaudet and Melack (1979) determined a water budget for the lake, as did Ase (1986). The balance for the former researchers is given in table 8.

Table 8. Hydrologic balances for Lake Naivasha and Oloidien Lake. Percentages of input and output in [illegible] (after Gaudet and Melack, 1979).

	Lake Naivasha (m^3 x 10^6)					
	1973	(%)	1974	(%)	1975	(%)
Surface run-off	0.6	(0)	0.7	(0)	0.4	(0)
River discharge	90.8	(39)	204.0	(56)	240.5	(67)
Rainfall	106.1	(45)	114.2	(32)	77.1	(20)
Seepage-in	37.0	(16)	42.3	(12)	50.8	(13)
Total Input	234.5		361.7		388.8	
Evapotranspiration (swamps)	14.3		13.2		13.3	
Lake evaporation	309.5		276.0		278.2	
Seepage-out and use for irrigation	24.6	(7)	50.6	(15)	93.3	(25)
Total output	348.4		339.8		304.8	
Change in Storage (Cal. by balance)	-113.9		+21.4		+4.0	
Change in Storage (Cal. from level change)	-113.9		+21.4		+4.0	
	Oloidien Lake (m^3 x 10^6)					
Surface run-off	0.0		0.0		0.0	
Rainfall	3.6		3.8		2.7	
Seepage-in	4.1		6.0		7.0	
	7.7		9.8		9.7	
Lake evaporation	11.3		10.1		10.1	
Seepage-out and use for irrigation	0.0		0.6		0.0	
Total Output	11.3		10.7		10.1	
Change in Storages (Cal. by balance)	-3.6		-0.9		-0.4	
Change in Storage (Cal. from level change)	-3.6		-0.9		-0.4	

Data in this table show that there can be large differences in the balance from year to year, and emphasises the need for up,to date data to be collected on an on-going basis so that balances can be calculated at any time.

Referring to the rough calculations made from past and theoretical data in the foregoing sections we have the following rough balance in table 9.

Table 9. A rough water balance for Lake Naivasha.(X x 10^6 m^3/Yr)

	Addition	Subtraction
Rainfall	72.96	
River discharge	150.00	
Seepage in	49.00	
Evaporation from free water		162.00
Evapotranspiration		10.8
Underground seepage		55.00
Abstraction Agriculture		32.70
Abstraction Olkaria		15.20
Totals	271.96	275.70

Currently more is probably being taken out of the lake, than put in, and this is being corroborated by the fall in the lake level.

This balance will be found disturbing, but not too much credence should be given to the figures until an up to date balance can be made using up to date and accurate data. There is no doubt that large schemes planned to extract large amounts of water from the lake or from the supplying rivers must be opposed as vigorously as possible.

Over the years, more and more water has been taken out of the catchment area, and at present as detailed in section 11.1.5 (iii), there is a total of 36.7 x 10^6 m^3 extracted per year. This amount returned to the lake would put the above balance back into the positive. It would seem now time to resist all further plans to extract water from the catchment areas, unless flood flow storage methods are used.

11.2A Water quality

11.2A.1 Chemical composition

Milbrink (1977) has given a review of lake water chemistry. A considerable amount of chemical data is available on the quality of water in Lake Naivasha and this information is being expanded daily by the major commercial flower growers who regularly take and analyse (in Europe) samples of the irrigation water

Kilham (1972) gives a useful introduction to the subject having sampled and analysed water from every major drainage basin in Africa; 366 in all, including five sets of data for various water bodies of Naivasha.

Beadle (1932), Talling and Talling (1965), and Kilham (1971), have all analysed lake water. Gaudet and Melack (1981) have given a very thorough account of the ion chemistry of the lake.

The water of the lake is characterised by low solute levels (Richardson and Richardson 1972, Gaudet and Melack 1979, 1981). The latter authors did a systematic survey of the various Naivasha water bodies over

the period of a year. The water is alkaline bicarbonate, with sodium and Calcium as the major cations (Gaudet and Melack 1981).

The low levels of solutes are thought to be influenced by the dilute inputs from rivers, uptake of solutes by lake sediments and solute loss through seepage.

Phosphate and Nitrogen levels fluctuate in response to uptake and release from biota, but little is known of the cycling of these nutrients in the lake. The Papyrus (*Cyperus papyrus*) swamp in the northwest of the lake has a considerable effect on water quality. Water chemistry in the swamp has been studied by Gaudet (1978). The swamp acts as a phosphate pump (McRoy et alia 1972). Nitrogen is fixed there and finally finds its way into the water (Gaudet 1979). Gaudet and Muthiri (1981) also stressed the importance of the littoral zone as a filter and store for nutrients, thus explaining the much higher levels of nutrients in the rivers than in the lake.

Gaudet and Melack (1981) and Kilham (1971) have quantified the ion concentration of the Lake. See table 10.

Table 10. Mean concentrations of ions for each compartment (mgl -1) from Gaudet and Melack (1981) and Kilham (1971)

Water body	Na	K	Ca	Mg	HCO_3	CO_3	SO_4	Cl	F	SiO_2
Malewa	9.0	4.3	8.0	3.0	70	0	6.2	4.3	0.4	17.2
Gilgil	16.1	7.4	4.4	2.2	75	0	9.6	3.9	0.8	18.2
Main lake	40	20	21	6.4	192	10.6	6.2	14	1.5	34.0
Cl Basin	52	30	17	7.5	231	15.0	4.8	17	1.5	36.0
Oloidien	125	82	9	6.9	496	43	7.1	32	8.0	44.0
Sonachi	1900	333	4.1	5.1	2837.4	960.2	36	224	67.5	77

Beadle (1932), Jenkin (1936) and Robertson (1958) contended that Naivasha remained fresh by the loss of salts through seepage. More recently Richardson and Richardson (1972) considered, on the basis of core data, that the freshness was due to the burial and deflation of salts, and their intermittent removal by seepage, and their possible removal by fringing swamps.

The north swamp of the lake has a major influence on the chemistry of the lake water through the amount of major ions that are trapped in the detritus and subsequently sedimented. Gaudet (1978, 1979) has made estimates of the amounts of the major ions involved. Data is presented in table 11.

Table 11. Estimate of amounts of major ions trapped in detritus in the north swamp, based on an annual sedimentation rate of 38 x 10^6 kg each year (Gaudet 1978, 1977)

	Present in detritus	Estimated amounts Total amount x 10^6 kg/year	sedimented % retained of annual river input
Na	0.225	86	7
K	0.175	67	19
Ca	0.033	13	1
Mg	0.110	42	13
Cl	0.020	8	1
SO_4	2.880	1094	153
SiO_2	1.200	456	22

Kalff and Watson (1986) have reported seasonal changes in water chemistry. Clark et alia (1989) reported alkalinity and conductivity levels as follows:

	Alkalinity (m eg/litre)	Conductivity s/cm
Naivasha	3.2	340-360
Oloidien	5.4	610-620
Sonachi	20.0	3000

Harper (1985) reporting on an intensive study of the lake waters by the University of Leicester reported identical conductivity figures for Naivasha and also added values for the Gilgil and Malewa rivers at 220 and 150 respectively. Their study was based on sampling done at Hippo point, Korongo lagoon and in Oloidien. They found the levels of dissolved nutrients low at less than 5ug/1 for Phosphate, 10 ug/1 for nitrate and 20ug/1 for ammonium, whereas in contrast, the rivers gave high figures particularly for Phosphate at 50ug/1.

Some work has been done on the calculation of a chemical balance. It is estimated that 0.3 tonnes of solute per year is added in the rainfall, and a further 0.1 tonnes in the runoff. However little is known about the biological carriers, seepage and irrigation losses. There is still a long way to go, and a lot of research to be done before a balance can be drawn up.

Water in the lake is slowly becoming more concentrated (in terms of higher levels of nutrients, more alkaline, higher levels of plankton) (Harper and Mavuti 1991) due to lower rainfall. It is also shallower, and winds help to suspend the sediment. There is more agricultural activity in the area particularly in the catchment areas. Cultivation of the catchments are more intensive, perhaps more fertilisers and nutrients are finding their way into the lake. Phytoplankton are a good measure of the level of nutrients in the water; Harper and Mavuti (1990) have noted that the phytoplankton biomass has increased from 20mg/m^3 in 1982 to 130mg/m^3 in 1987.

The lake water quality changes, but at the present there is no written evidence to suggest that the lake is being seriously polluted. The papyrus beds are an essential requisite to the continued good health of the lake waters. They must remain and be conserved, and a fringe encouraged all around the lake to protect against surface runoff from farms.

11.2A.2 Physical characters

Richardson found vertical stratification of temperature and oxygen concentration in the lake. This was particularly so in the calm mornings, but in the late afternoon, winds of 10-15 km/hr are often experienced, and this results in some mixing in the water column. Mavuti (1990) found the same stratification for oxygen and temperature between the hours of 1000 and 1400 hours. This was broken down by the afternoon winds. Temperatures of the water vary from 15.5 to 22.0°C (Robertson 1958) with only slight daily changes. There is a slight seasonal change in water temperature mainly at the lake bottom (Melack 1979). MacIntyre and Melack (1982) and MacIntyre (1984) have also reported on stratification of lake water in terms of temperature, oxygen content and nutrient levels.

The pH values of the lake water are 8.6 for the main lake, 9.2 for Oloidien and 8.4 for Crescent island.

What is really needed in this sector is a regular sampling of waters at selected sites. Clark (1986) observed that regular sampling over a long period of time will show if there is any pattern to changes in water composition and quality.

11.2A.3 Pollution

One of the most important water qualities to be studied is the possible effects of the intensive horticultural activity round the lake and the possible pollution of the lake water by the introduction of fertilisers and chemicals.

Harper (1988) reported at the time, no evidence of nutrient enrichment in lake waters through farming activity.

30-90% of chemicals applied to crops end up in the soil, and although this is normally degraded rapidly there is some danger of contamination and harm to soil biological life. Ground water contamination may also occur but generally there is insufficient water applied to the soil in the form of irrigation to carry the chemicals down to the ground water level. Flower and vegetable growers at Naivasha plan to wet only the top 30-40 cm of soil in the root zone of plants and below this the soil profile can be quite dry to the water table. However heavy downpours which are not uncommon could be potentially dangerous in washing away agricultural chemicals.

The majority of growers in the area are using acceptable chemicals, but not all growers are willing to discuss this subject and it is almost certain that some toxic chemicals are being used around the lake.

The EU has introduced revised rules for the Union on Pesticide residual levels for both edible and non edible horticultural produce. Maximum limits being surpassed will result in produce being destroyed, and at worst, the exporting country being banned.

The KARI/ODA crop protection project has through the National Research Laboratories Crop Pesticide Residue Laboratory taken samples of lake and river water and soils at Naivasha for determination of chemical residues. This laboratory can determine to a level of one part per billion for some chemicals. Results of some of the latest samples are given in Table 12.

The organo-chlorides would be taken up by aquatic animals and deposited in adipose tissues. The species at the top of the food chain i.e. Raptors might be adversely affected - egg shell thinning. It is interesting to note that Aldrin and DDT have not been used at Sulmac for a very long time, yet the chemicals are still present in the soil. Pyrethrins are biodegradable in the environment.

The level of the pesticides detected in the water and soil is presently too low to cause concern. However pesticide residues are present in lake waters, and the potential pollution threat is there.

Plastic sheeting is used widely for plant housing and soil sterilisation around the lake. The material breaks down in the tropical sun and has to be replaced regularly. Its disposal could become a potential pollution problem. There is a recycling plant in Nairobi, only occasionally working due to water shortages. In the long term this might be profitably resited in Naivasha providing there is sufficient water and pollution safeguards.

The possible 250,000 people living round the lake in often inadequate housing and unsanitary living conditions present a considerable threat to pollution of the lake. So also do the growing population of Naivasha with its inadequate sewage disposal.

Obviously a management plan must include a monitoring service, and the monitoring of the lake waters for noxious residues of agricultural chemicals and high levels of nutrients will be essential.

11.3 Phytoplankton

Symoens et alia (1981) have given a good background to the phytoplankton of East African Lakes. Quite a lot is known about the subject, Van Miel (1954) having listed 1200 algal species of East African lakes. Rich

Table 12. Results of pesticide residues in Lake water samples
PESD/ANAL/1/43 DATE: 13/9/93

LAKE NAIVASHA AND THE ENVIRONS KARI. 1993.

FARM	COMMODITY	LOCATION	PESTICIDE	Conc.
Sulmac	Water	At intake direct from the Lake, Field 90's	Aldrin [organo-chloride - OC]	0.79 ppb
	Water	At intake direct from the Lake, Field 90's	Dieldrin [OC]	0.33 ppb
	Water	At intake direct from the Lake, Field 90's	O'P'DDT [OC]	0.08 ppb
	Water	Puddles of standing water, Field 50's	Aldrin [OC]	0.87 PPb
	Water	Puddles of standing water, Field 90's	Aldrin [OC]	0.87 ppb
			P'P'DDE [OC]	0.30 ppb
Flamingo	Water	in Sump	Permethrin [pyrethroid - P]	0.95 ppm
	Water	~ 70m from Sump	P'P'DDT [OC]	0.21 ppm
	Water	~ 70m from Sump	Permethrin [P]	0.44 ppm
	Surface soil	~ 200m from Sump	P'P'DDT [OC]	0.15 ppm
	Surface soil	~ 200m from Sump	Fenvalerate [P]	0.15 ppm
	Surface soil	~ 200m from Sump	Cypermethrin [P]	0.39 ppm
	Soils 2-4" deep	~ 200m from Sump	Fenvalerate[P]	0.09 ppm
		~ 200m from Sump	Cypermethrin [P]	0.79 ppm

Organo - chlorines [OC] in water would be taken up by aquatic animals and deposited in the adipose tissues. **Potential danger - *Biomagnification*.** The species of animals at the top of the food chain may be adversely affected e.g. Birds eggshell thinning etc. Crop uptake of soil residues of organochlorines is extremely low.

Pyrethroids [P] These pesticides are biodegradable in the environment . The level of the pesticides detected in water and soil is too low to cause any concern.

The work on soil and water sampling in and around Lake Naivasha is still going on.

Joseph Ngatia, *Pesticide Residue Laboratory, NARL.*
c.c. ODA Field Manager, CP Coordinator

(1932), Lind (1965), (1967), Millbrink (1977), and Melack (1979), have all reported on the phytoplankton of the lake, and recorded 143 Taxa between them.

Kallquist reported on seven years of intensive research (1978) (1979). Many recent work has been done by Njuguna (1983), Kalff and Watson (1986), and Brierly et alia (1987). Generally there are high algal concentrations in the shallow lakes of the Rift valley. Levels are even higher when nutrient levels are high, for example after inflow rivers charged with nutrients have been running at a high level.

The main lake supports a wide variety of phytoplankton species including *Microcystis, Lyngbya, Oscillatoria* and *Melosira*.

Melack (1976) has described seasonal changes in species composition and abundance in Lake Naivasha, and also a seasonal variation in photosynthetic activity. Gaudet and Muthiri (1981) have discussed changes in ecology in relation to changes in waterlevel and quality. The drawdown area is particularly important in that when it is dried out, trampled, and cropped by grazing animals, and later rewetted, there is a sudden release of nutrients (Howard Williams and Lenton 1975, and Machachlan 1971). This results in greatly enhanced production from all flora and fauna including the phytoplankton. Harper (1989) recorded a dramatic increase in algal biomass as measured by Chlorophyll 'a' exceeding the figure of 100 mg per cubic metre after rehwetting of the littoral zone in 1988.

Gaudet and Muthiri (1981) have given estimates of open lake standing nutrient stocks and estimated inputs from the drawdown area as:

	Lake Naivasha Standing stock in 1974 (tonnes)	Theoretical annual input from the draw down area	% input from Drawdown
Nitrogen	77	16	21
Phosphates	84	33	39
Sulphates	242	10	4

Variations are affected by seasonal weather changes that alter physio-chemical factors in the water such as river in-flows (bringing in more nutrients), vertical mixing, turbidity, temperature changes, nutrient availability and light intensity. Melack (1979) also showed distinct and similar, (but greater), seasonal variations in the phytoplankton activity in Oloidien and Sonachi over an eighteen month period of study.

Melack (1979) found three patterns of temporal change seasonal; limited seasonality, (as found in Naivasha. It was thought that the Papyrus swamps buffer the effect of rains and rivers.); and change in plankton composition, (as happens in Lake Nakuru).

Phytoplankton abundance can be measured by Chlorophyll 'a' concentrations. Melack (1976) has given values of Photosynthetic rate and chlorophyll concentrations for the four main water bodies at Naivasha as:-

	Photosynthetic rate ($mgO_2/m^3/d$)	Chlorophyll (mg/cha/m³)
Sonachi lake	4.9	45
Naivasha Lake	4.9	52
Oloidien	8.1	62
Crescent Island	5.3	

Chlorophyll 'a' concentrations are below those recorded in known nutritionally rich lakes, suggesting a nutrient limitation on biomass and production.

Harper (1985) gave algal biomass figures of 60, 50, and 20mug/1 for Oloidien, Naivasha and Mennel's lagoon respectively. Most of this was in the top 3m of the lake.

Melack (1981) studied the photosynthetic activity of phytoplankton in Sonachi lake, the most alkaline of the Naivasha water bodies. Likens (1975), Cole (1979), Talling et alia (1973) and Melack and Kilham (1974) have all found such lakes as the most productive of ecosystems. Melack confirmed the finding in Sonachi over an eighteen month study and found that *Spirulina platensis* gave the higher rates of photosynthesis.

There is an even distribution of the algal biomass due to species composition and night time cooling and daily circulation of water. The algal biomass is sufficiently high to restrict gross primary production to the top three metres of the lake.

Milbrink (1977), Melack (1979), Njuguna (1983), and Brierly et alia (1984) have all reported on primary production figures.

The phytoplankton productivity of Sonachi lake has been investigated by Melack et alia (1982). It had been found by MacIntyre that Sonachi was low in P04 concentrations (Peters and MacIntyre 1976). Melack (1981) had also described low photosynthetic rates. The first authors studied the response of phytoplankton to experimental fertilisation with ammonium and Phosphate. Photosynthetic rates in Sonachi are modest compared with other African soda lakes, generally photosynthetic rates of phytoplankton in shallow freshwater and soda lakes in Africa are the highest known in the world. The microflora of the lake is dominated by small 1-2 mum diameter coccoid cillo, *Cyano bacteria* and *Spirulina laxissima*. There is still much to learn about the Phytoplankton of Lake Naivasha. Future work should concentrate on the modelling of the phytoplankton and relationships to various water factors.

11.4 Zooplankton

Kerslake (1990) reviewed the zooplankton sector in 1978 as part of the Cambridge University expedition to the lake. Mavuti (1990) began studying the dynamics of the lake Zooplankton in the same year. He described the taxonomic composition of the species present confirming his previous work with Litterick (1981). His species composition was similar to that described by Jenkin (1934), Lowndes (1933),(1936), Beauchamp (1932,1933), and Worthington and Ricardo (1936).

After all the early work in the 1930s there was a thirty year gap until work was resumed by Pjler (1974) on the Rotifera and also Nogrady (1983)

A new zooplankter *Daphnia pulvex* was introduced to the eastern part of the lake in 1980.

Litterick et alia (1979) listed the main zooplankton genera as:-

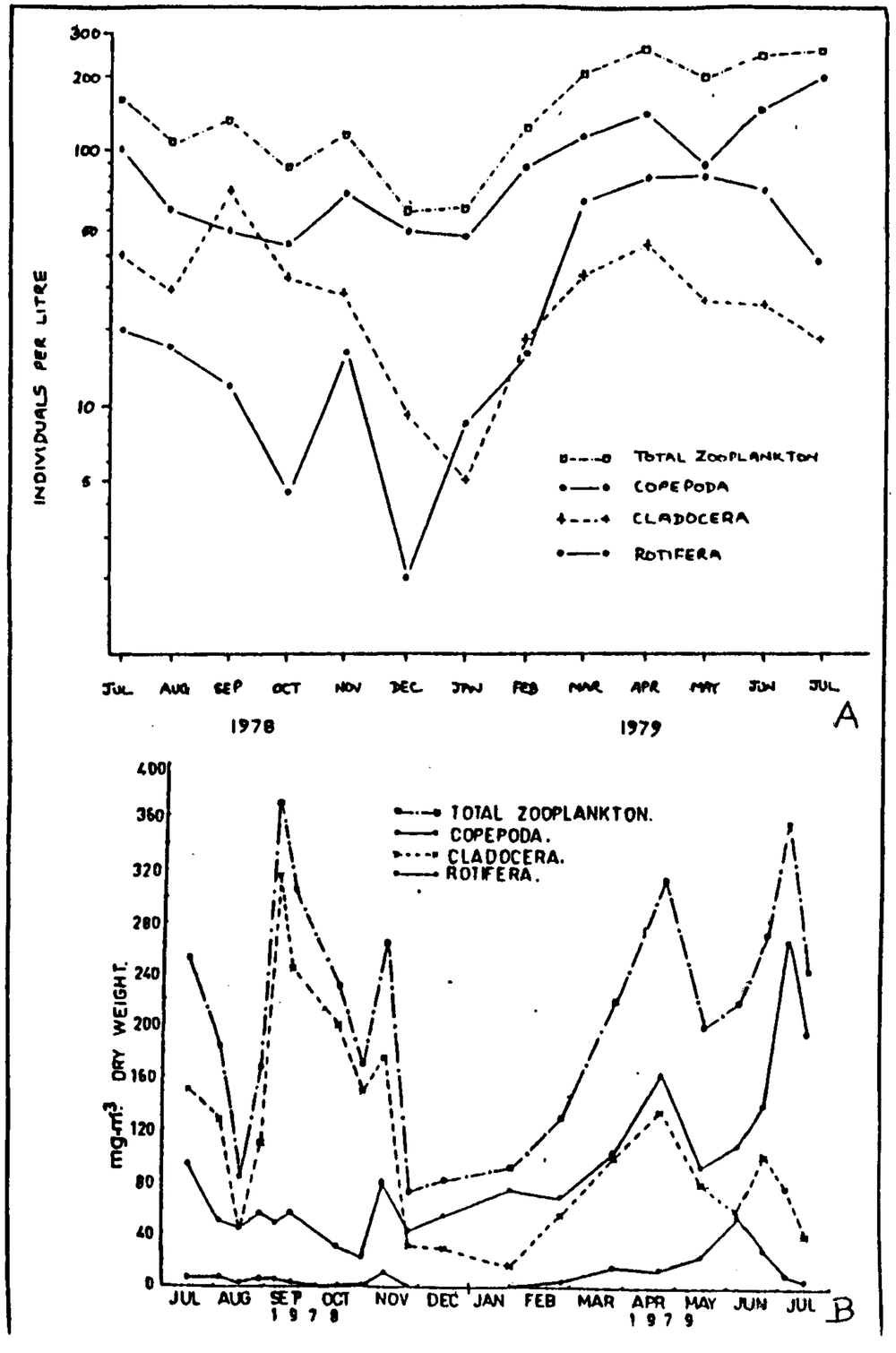
Cladocera	Diaphanosoma	Simocephalus
Copepoda	Mesocyclops	Thermocyclops
Rotifera	Brachionus	

Seasonal variation in numbers and biomass of zooplankton are given in figures 17 and 18 after Mavuti quoted by Litterick et alia (1979).

Zooplankton feed on the phytoplankton and it is therefore not surprising that Mavuti (1990) found that the Zooplankton biomass was positively and significantly correlated with concentrations of phytoplankton chlorophyll 'a'. In addition there was a positive relationship between zooplankton and rainfall, the latter resulting in increased river flows and these bringing nutrients to the lake, which in turn promote phytoplankton growth, which in turn provide grazing, and subsequent growth and production of the zooplankton.

Figure 17 Seasonal variation in Zooplankton numbers

Figure 18. Seasonal variation in Zooplankton biomass (After Mavuti 1979)



Mavuti (1990) has carried out a detailed and lengthy study of the community structure, population dynamics and production of the limnetic zooplankton over the period 1978-80. He found that the community was composed of two Cyclopoids, one Calonoid copepod, eleven Cladocerans and thirteen Rotiferans. The following species were dominant:-

Thermocyclops oblongatus	(54-61%)	Copepod
Diaphanosoma excisum	(18-29%)	Cladocera
Brachionus caudatus	(8-11%)	Rotifera
Brachionus calyciflorus	(7-10%)	Rotifera
Simocephalus vetulus	(1-3%)	Cladocera

Composition was fairly stable over the two years, although there were minor changes associated with wet and dry seasons. High densities were related to high concentrations of zooplankton and rising water levels. Annual mean mass was 237 and 425 mg dw/m^3 for the first and second years respectively. He further found the vertical distribution of the communities was homogenous throughout the water column above the four metre level.

Mavuti (1990) found that in the littoral area, fish fry of the Black Bass and the adults of *Gambusia affinis* exerted predation pressure on the zooplankton, whereas in the open waters the zooplankton were relatively untouched. There the bulk of the population passes to the decomposed food chain and are not used by the higher trophic levels.

Naivasha is an unusual lake in that although a closed system, the water is fresh, and the fluctuating water levels result in an impoverished fauna with many niches unoccupied.

Harper (1987) studied the zooplankton ecology from 1982 to 1986. His lists of species are found in Appendix VIII. He concluded that with minor changes the species list was fairly stable. There was dominance by *T. oblongatus* for most of the year with minor peaks from and *D. excisum* and *S. vetulus* for short periods during or after the rains. Mavuti and Litterick (1981) also noted abundance of zooplankton with rains.

11.5 Aquatic Vegetation

Chapter 10 of Denny (1985) gives good background material to the ecology and management of wetland vegetation; and also gives a valuable cross indexed bibliography of African wetland plants and vegetation. Thompson (1985) has provided a good background paper to the emergent plant species of permanent and seasonally flooded wetlands. Denny (1985) has provided background to the submerged and floating leaved aquatic macrophytes.

The Naivasha lakeside flora is diverse and complicated. 108 species in 43 families have been described by Gaudet (1977), but despite this there is not an impression of diversity, further signs of an unstable and 'young' lake.

11.5.1 The submerged Macrophytes

Macrophytes are important providing suitable habitats for fish feeding and breeding, and valuable mulch for invertebrates. Through their own photosynthetic activity they release O_2 for aquatic fauna. On the debit side they also encourage the spread of water borne diseases by supplying suitable habitats for invertebrates such as snails and mosquitos

Beadle (1933) first described the submerged vegetation of the lake, which at that time was dominated by *Nymphaea* (water lilies) *Hydrocotyle, Ceratophyllum demersum* and *Potamogeton*. Gaudet (1977) recorded 25

species of aquatic macrophyte, including 10 submerged species and eight free floating and also described the primary succession of aquatic vegetation.

Gaudet (1977, 1979) has stressed that the studies of the littoral zone of Naivasha show the great influence that this area has on the biology and chemistry of the lake, and illustrates the fundamental importance of this zone to African Lake limnology. His study of the drawdown area, (Harper et alia 1993) - that area that is exposed when the lake level falls, and its successions of plants - represents some of the most important botanical work on the lake, as well as giving insight into some of the reasons why the littoral area is high in nutrients when inundated with water, after a period of exposure and drying.

Gaudet gave valuable plant lists for all these zones which are found in Appendix IX detailing 108 species in 43 families.

Muchiri and Hickley (1991) and Harper and Hart (1993) demonstrated the role of the submerged plants for the Tilapia population which use the environment for feeding and reproduction. Henderson and Harper (1992) have also indicated that the lake edge plants are very much responsible for the richness of the bird population. Harper (1992) has discussed the general ecological relationships of aquatic plants at the lake.

Harper (1989) has studied the aquatic macrophytes over a period along the same transects through the littoral zone. He lists the main dominant species as :-

Floating species	*Salvinia molesta*
	Pistia stratoites
	Wolffia arrhiza
	Eichhornia crassipes
Submerged plants	*Najas pectinata*
	Potamogeton schweinfurthii
	P. pectinatus
	P. octandrus
	N. caerulea
	Utricularia reflexa
	Utricularia gibba

The areas of submerged macrophytes vary considerably, not least depending on the level (and therefore depth) of the lake. Watson and Parker (1969) recorded an area of 10 km^2 of submerged macrophytes (and 4 km^2 of floating plants and 19 km^2 of emergents, mostly Papyrus)

Generally Harper (1989) found the vegetation of Oloidien much more stable being dominated by *P. schweinfurthii* in waters of 0.5 to 1.0m in depth and *P. pectinatus* from 0.25 to 1.8m. Najas was much more rare in this lake and found under the Potamogeton spp. The fact that Papyrus, Salvinia and Nymphaea cannot grow in the lake due to the alkalinity has also probably helped the submerged Macrophytes by removing competition.

However the submerged plants are the less well studied, and as one third of the lake is less than 3m deep and capable of supporting submerged growth, this is an important group. Submerged macrophyte beds modify the physical and chemical conditions in the lake which results in higher transparencies, lower chlorophyll biomass in the lakewater, and higher zooplankton numbers.

Submerged macrophytes have an important role in providing food and shelter for animals, particularly young fish, and almost certainly in regulating the chemistry of the open water. Harper (1988) found that

the high plant biomass in the swamps could cause O_2 depletion of the swamp and submerged macrophyte beds at night, resulting in the need for fish to move out into the open lake.

Harper et alia (1992) studied four plant communities over a five year period to investigate their relationship with controlling factors. The four communities were emergent Papyrus swamp, Salvinia rafts, Waterlily pads and the submerged angiosperms (*Potamogetons* spp and *Naias* sp). The main controlling factors were identified as water level, Crayfish activity and physical effects of rafts.

Some of the more important plant species of the lake are described individually below.

11.5.2 Cyperus papyrus (Papyrus)

Papyrus (*Cyperus papyrus*), the world's largest sedge, is probably the most important plant of Lake Naivasha, due to its involvement in keeping the waters of the lake fresh.

Thompson and Gaudet (1979) have assembled a complete bibliography on the papyrus plant. Moore (1980) and Jones (1983) have given examples of how the plant can be used; as a filter for debouching rivers; possible use in the partial treatment of sewage effluents and agricultural runoff; and as a possible fuel for the third world (32 tonnes/ha standing biomass). Gaudet (1976), (1977a), (1977b), (1979), (1980), and Njuguna (1982), have discussed in detail the prime use of Papyrus on Lake Naivasha in acting as a filter and causing the retention of nutrients in organic particles in the detritus and generally recycling nutrients. The plants also supply large amounts of fixed nitrogen which results in high productivity. Elder et alia (1971) have described the development of the plant.

The plant is found around the lake shore, and up the Malewa river to a distance of 5km. The Papyrus swamps and fringing vegetation of the lake have been studied in detail by Gaudet (1977) and Thompson (1985). Njuguna (1982) and Jones and Milburn (1978) have pointed out that it is the first freshwater aquatic plant known to be a C4 plant on the basis of low CO_2 compensation point, 'Krantz' anatomy and high optimum temperature for photosynthesis. It is therefore an efficient and massive dry matter producer.

Rijks (1969) found that evaporation from a Papyrus swamp was roughly 60 + 15% of Penman's estimates for evaporation from open water, an important fact when it comes to working out the evaporation for the lake.

The amount of Papyrus on the lake has varied tremendously. From 1983 to 1987 the water level dropped by 3m and much Papyrus was cleared. By 1987 only 2km² was left. However in 1988, the lake rose by 1m. Seedlings of Papyrus re-established and there were soon 12km² of papyrus on the lake, with 80-90% of the lake periphery lined with the species.

In summary the swamps are paramount in importance through the uptake of nutrients and sediment from rivers and their subsequent slow release to the lake water as fine organic particulate matter and accumulation as swamp peat (Gaudet 1979, Gaudet and Muthiri 1981).

The importance of Papyrus for the good health of the lake is acknowledged by Government. A Presidential ban on the destruction of Papyrus was made in 1987. (A ban on the felling of Acacia trees was made earlier).

11.5.3 Water Hyacinth

Water Hyacinth (*Eichhornia crassipes*) is well researched and recorded in the Sudan (Obeid 1975). The plant originates in South America (Brazil) and is a member of the family Potederiaceae. It is capable of producing 800kg dry matter per hectare per day under the right conditions.

It was first noted on the lake in 1988, but surprisingly after its history elsewhere, has spread very little up to the present, and certainly has not yet taken on the aspect of a menace. Harper (1992) has investigated the weed on the lake and has found it in most areas, mainly rooted in shallow water, particularly amongst the Papyrus fringe together with Salvinia. It was however sparse in open water situations. The same author has reported increases in N and P levels in the water, to which the weed is particularly responsive. If these levels continue to rise the weed could become a problem.

In a survey of invertebrates found on the plants (Harper 1992) reported 28 species dominated by Hemiptera and Coleoptera. He recommended that the weed be watched carefully in case it showed signs of getting out of control.

In India (Aggarwala 1988) the plant has been mixed with rice straw and molasses and made into a reasonable quality silage, although deficient in energy. This may be of interest to livestock farmers round the lake.

Water Hyacinth can also be controlled biologically and two curculionid beetles - *Neochetina bruchii* and *N. Eichhornia* have proved successful elsewhere.

11.5.4 Water lilies (*Nymphaea caerulea*)

Water lilies were common on the lake up to the early 1970s. They disappeared over the period 1973-80, and now only a few specimens can be found in protected areas. The cause of their disappearance was thought to be the Coypus and the Crayfish, both of which grazed on the plant. However Salvinia could have contributed by its competition and overshading.

11.5.5 Salvinia molesta

This floating weed was first noted on the lake in 1962 (Gaudet 1976), and was probably introduced from the aquarium of a Nairobi Pet shop.

Gaudet (1973) has given a detailed account of the first sighting, spread and initial control measures attempted for the plant.

By June 1964, 60ha of water north east of Crescent island was covered. At first confined to the northern areas of the lake, but a storm and strong wind in October 1970 broke the retaining Papyrus wall and salvinia was blown to all areas of the lake. It was decided to spray the weed with herbicide (Mitchell 1969). This was subsequently done with Paraquat at the rate of 5.5 litres in 40 litres of water per hectare. The treatment was done twice in July and December at a cost of US$3000, and with support from LNROA. The treatment did cause some browning of the leaves, but the plant survived. Spraying was in fact tried several times in 1964, 65, 68, 71, 79, and 1980. Hiscock (1970) reports on these attempts

Control measures at that time, described in detail by Tarras-Wahlberg (1975) included biological control, Paraquat (grammoxone) spraying and mechanical collection of the weed. Hiscock (1970) studied the weed and found it was often associated with *Pistia stratoites*.

The weed was becoming a serious problem as not only were there the direct and obvious problems like the blocking of water ways, obstruction to recreation activities and the pumping of water; but the scientists also explained that the weed prevented vertical mixing in the water column, shaded out algae (the mats cut out 90% of the light (Tarras-Wahlberg 1975) and macrophytes and allowed the increase of CO_2 and the lowering of the pH. As a result of this inhospitable environment the breakdown of organic detritus under the mat is prevented with a concurrent build up of sludge. The weed was being spread around the lake by fishing nets, boats and the wind. It was becoming associated with Papyrus which helped to establish the stable conditions that the plant likes.

Gaudet (1978) also reviewed the work on the plant and recommended the use of biological control based on the work that had been done on Kariba dam where Salvinia had also taken hold. There, two phytophagous insects had been used *Cyrtobagus singularis* and *Samea multiplicatus*. Mitchell (1972) who confirmed the species as *Salvinia molesta*, also showed it as being only capable of vegetative reproduction. He also advocated biological control. Gaudet (1973) meanwhile confirmed under laboratory conditions the rapid growth characters of the weed which can double its dry matter weight in three days.

Meanwhile in other parts of the world research was going on to find ways of controlling the weed. Kam-Wing and Finlado (1977) reported that paraquat and Diquat were most promising as herbicides, Diatliff (1977) advocated a simple chemical control, but gave no details. CSIRO in Australia went to South America and collected 800 adults of *Cyrtobagous salvinine* as a possible biological control agent for the weed. Another biological control agent was first tried - a grasshopper *Paulinia accuminata*; several introductions were made but they failed to establish probably because of the low temperature of the lake (Hiscock 1970), and needed a higher temperature for reproduction (Thomas 1974). Room et alia (1981) reported excellent biological control of Salvinia using the beetle *Cyrtobagous salviniae* on Lake Moondarra in Australia where the weed covered 400 ha.

Waithaka (1979 and 1981) continued to look at chemical control in the laboratory using Duron, Limuron and Nata, the first two proving the most valuable.

In 1983 The Kenya government were involved and set up a task force from the National Environmental and Human Settlement Secretariat to study the problem which was now getting urgent as over 25% of the lake was covered. Karani (1983) produced the first task force report. Markham et alia (1983) reporting to the task force recommended biological control. By 1991 20% of the lake was covered by the weed. Eventually *Cyrtobagous* was imported in 1990 with active support from LNROA, and 15,000 weevils were introduced to the lake at 23 sites (Owour 1993) in 1991. The Salvinia declined rapidly within eighteen months after the introduction.

Room (1990) and Julien et alia (1987) have given a general review of how biological control of Salvinia has been achieved and discusses the ecological principles involved.

Salvinia is still present on the lake, and a small amount is still needed in order to maintain the beetle. There are other good reasons why a small amount of the weed should be maintained as is discussed in the section on birds.

11.6 Vegetation Zonation and Successions

There is a very definite sequence of vegetation species from the submerged hydrophytes in the lake, working towards the Acacia-grassland on dry land.

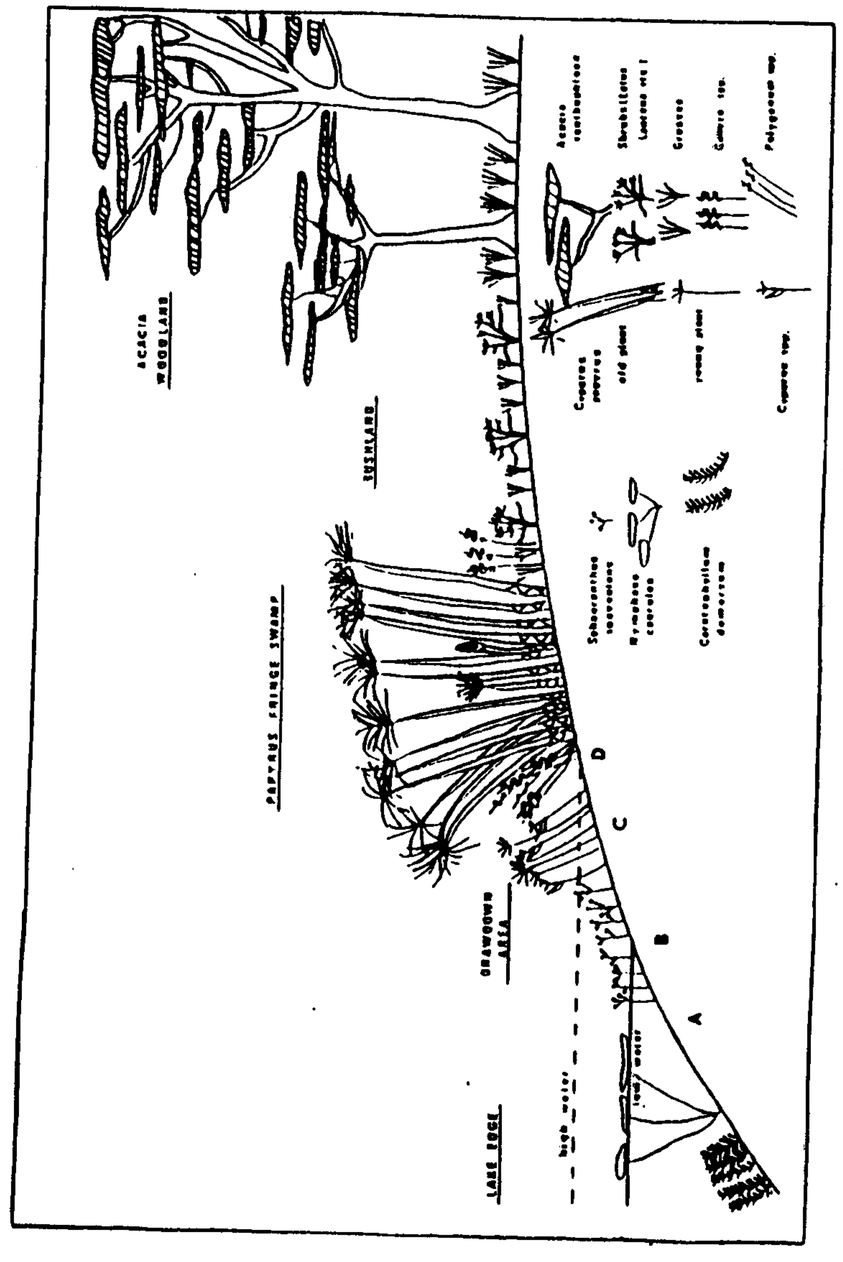
Gaudet (1977) has studied lake side vegetation in detail and has given a sequence of species as shown in the simplified diagrammatic presentation in Figure 19. Common species found in the various zones are given in Appendix IX.

11.7 Land Vegetation

Kiringe (1990) has researched the vegetation of the Hell's Gate National Park between 1988 and 1989. He identified 366 plants in 73 families. 13 vegetative communities were mapped and three vegetation types identified. The most common vegetative cover over the park was dense *Tarchonanthus camphoratus/ Acacia drepanolobium* shrubland.

Figure 19.

Lake side plant communities and general zonation of the Lake Naivasha Flora.



(Source: Gaudet 1977)

11.8 Fish

11.8.1 History and introductions

Muchiri and Hickley (1990) have given a general account of the fishery on Lake Naivasha. The history is short and largely manipulated by man through introductions. But even in its short history the fish have had an effect on other ecologies of the lake including the underwater vegetation and the bird life. Litterick et alia (1979) have reported a substantial increase in the fish eating birds over the last 20-30 years including the White and Pink Backed Pelicans, White necked and long Tailed Cormorants, Herons and Fish eagles.

Prior to 1925, there was only one species of fish in the lake, *Aplocheilichitys antinorii* (Vinc), the small toothed carp, which was unsuitable for commercial exploitation, and appears to have disappeared from the Lake by 1962, (Elder et alia 1971). The presence of only one species in the lake, gives support to the legend that the lake dried out during the mid nineteenth century.

The present fish population in the lake is totally made up of introductions made by man. The general sequence has been:-

The mouth brooding Cichlid *Tilapia nigra* was introduced in 1925 from Athi River by Capt Dent of the Kenya Game and Fisheries Department. A further introduction from dams in Donyo Sabuk were made in August 1926 (Elder et alia 1971). This was to provide food for the Black Bass which was due to be introduced two years later.

The wide mouth Black Bass (*Micropterus salmoides*) was introduced in 1927, reportedly on the advice of President Roosevelt who suggested a sport fishing industry on the lake. Further introductions were made in 1951 and 1956. In fact sport fishing was allowed from 1934 and still continues in the present day.

In 1936, 50 Pelicans and 500 Cormorants were killed to give better protection for the fish and a year later a further 750 Cormorants, Divers and Darters were culled.

Tilapia zillii was brought in from Kisumu in 1956 but the introduction also contained *0. leucosticta* which is now by far the most numerous fish. The introduction was predicted by Greenwood (1960) and confirmed by Garrod and Elder (1960). The introduction was thought to be an hybrid Tilapia and it now outnumbers the Black Bass by 40:1.

Tilapia nilotica (l) was introduced by the Fisheries Department in 1963 and survived until 1969, but then died out.

Three other fish species were introduced to control mosquitos, all Cyprinodants - *Gambusia*, *Poecilia* and *Lebistes*. The former has not been seen in the lake since 1977.

Rainbow trout (*Salmo gairdner*) have been caught in the lake and are presumably strays from the rivers system.

Oreochromis niloticus was introduced in 1965, and was last seen in 1969, although it has been recorded in Oloidien as late as 1986.

Barbus amphigramma was a natural introduction and probably came down the Malewa river (Harper 1984). The species needs to move up the river to spawn, but an irrigation weir has been constructed on the lower river and this may interfere with movement. The small industry based on this species faces an uncertain future.

The Louisiana Red Swamp crayfish (*Procambarus clarkii*) was introduced to the lake in 1970.

Twelve Nile Perch were introduced into the Lake in 1972, and there have been unconfirmed reports that some of these have been caught by local fishermen. However it is thought that the waters of the lake are too cold for the species to flourish.

The five fish species in the lake currently are;-

Wide mouthed black bass (*Micropterus salmoides)*

Oreochromis leucostictus

Tilapia zillii

Barbus amphigramma

Lebistes reticulata (The Guppy)

Sketches of these are shown in Figure 20.

Leicester University have monitored the species composition of the lake. In the last two years there has been a decline in Black bass, and more *T. zillii* than *Oreochromis*, although the latter still dominates the catch. Hickley and North (1992) have recommended that positive sampling needs to continue on an annual basis.

11.8.2 The fishing industry

The two Tilapias and the Black Bass now form the basis of a gill net fishing industry started in 1959. The Black Bass is also caught as a sport fish by rod and line. Fishing is done from canoes using monofiliament nylon nets with a regulated mesh size of 4" (10cms) and a length of 100m.

The industry is controlled by the Fisheries Department, which has now recently been incorporated into the Kenya Wildlife Service. The fisheries office at Naivasha looks after all fresh water fish in Nakuru District. The office is hampered by lack of transport, both road and water, and also operational funds. The Department controls the number of fishermen through the issue of fishing licences. Currently there are 60 licenced fisherman, and each of these is allowed ten nets each of 100m length. When the Department thinks that the fish population is over-exploited then nets per fisherman are reduced rather than licences refused.

In August 1987 fishing was totally suspended for a period in order to allow for the recovery of fish stocks.

All fishermen must be members of the Fishery Cooperative which provides marketing services. All fish should be landed at the Naivasha Town landing ground.

11.8.3 The Crayfish Industry

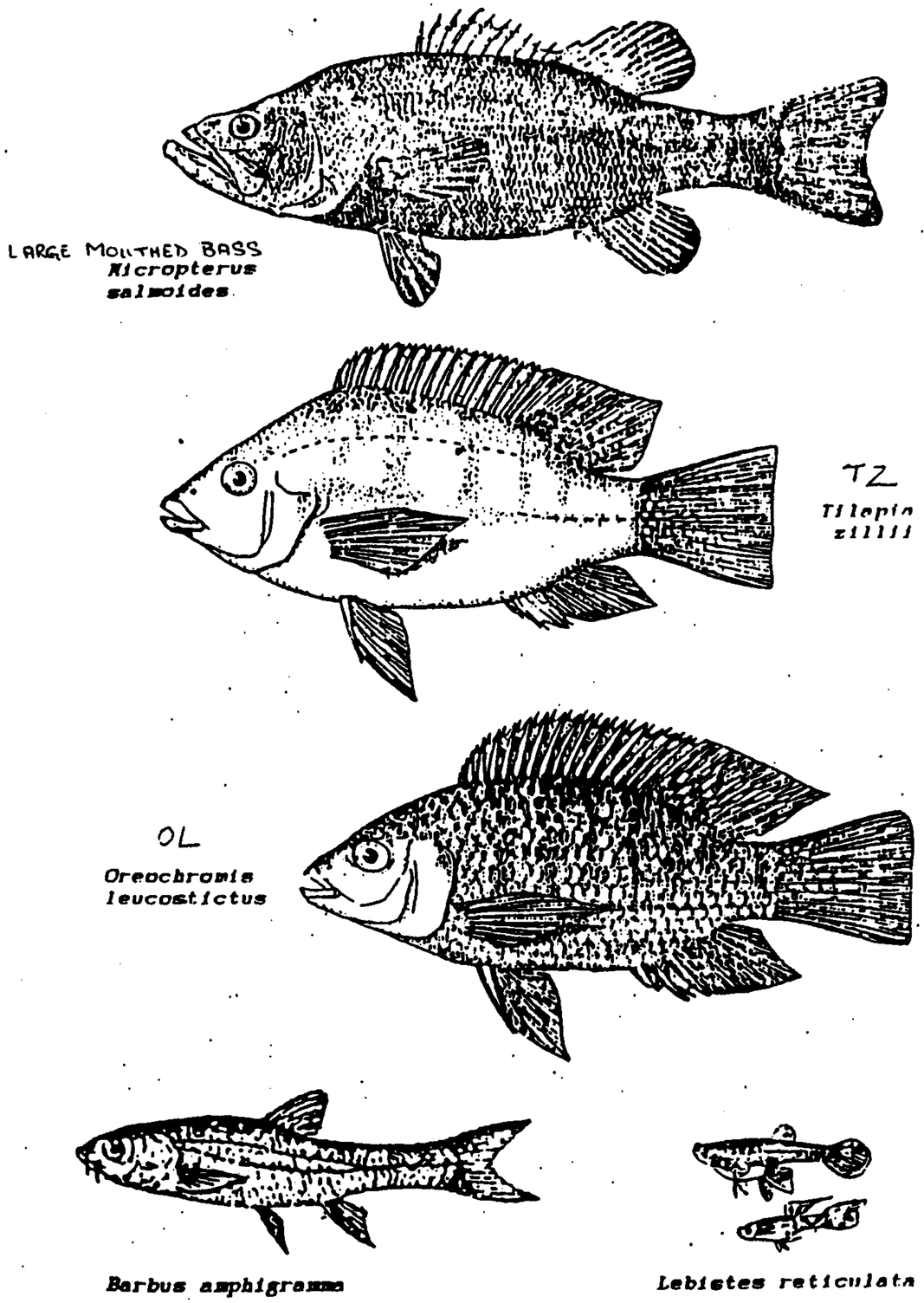
The Crayfish (*Procambarus clarkii*) was introduced by man in 1970 (Parker 1974), and multiplied quite rapidly. The crayfish was planned as a source of food for the Black bass, but the introduction caused considerable problems with the established gill net fishery which was based on the two Tilapias species and the Black bass. The crayfish is a scavenger and will consume netted fish and also cause damage to nets (30% of the fish catch can be damaged by the Crayfish).

After initial fluctuations the population appears to be fairly stable in the eastern side of the lake (the west appears a poorer habitat). In 1976 the population was estimated at 67,000 per hectare, which later reduced to 15,000 in 1978. The species breeds year round, but particularly so at times of water level increase. They breed in the shallow water and in earth burrows. Fecundity is high with a female laying 459 eggs on average. At the beginning of the introduction, production was stated to be 1-3 marketable individuals per square metre. There was some report of poor tails (the edible portion of the crayfish) - a kind of muscular

Figure 20

Sketches of the main Fish species in Lake Naivasha.

LAKE NAIVASHA — FISH SPECIES



dystrophy caused by a dietary deficiency, probably in the vegetation. The crayfish are heavy grazers and are generally regarded as one of the contributing causes of the loss in vegetation in the 1980s.

Production data for crayfish over the last decade are given in table 13 below, and the relationship of crayfish catch to submerged vegetation cover, and importance as feed for Black Bass in Figure 21.

Table 13. Commercial Crayfish Catch in Kg/year

Year	Catch
1980	6454 kg
1981	500000 kg
1982	322018 kg
1983	116155 kg
1984	43340 kg
1985	38745 kg
1986	45372 kg
1987	63318 kg
1988	14175 kg
1989	93833 kg
1990	53040 kg

It is interesting to note that 1983 was the last year in which the crayfish production topped 100 tonnes, by that year the macrophyte beds of the lake had all but disappeared. Later they recovered, but then there was a better balance between the food source and the crayfish population, although the catch of the latter was down.

The crayfish are caught in fish baited traps and the total catch is landed by 40 licenced fishermen. Most of the catch goes for export with The Netherlands taking 95% of total production.

The crayfish are predated by the Marabou storks, Sacred Ibis, Herons, Cormorants, Fish Eagles, Terns and other birds plus the Black Bass. 50-70% of the Black Bass stomachs dissected in the Crescent Island basin contained only crayfish.

Lowery and Mendes (1975), (1976), and (1977) have reported on the introduction, the industry, and the impact of the species.

11.8.4 Fish ecology

The stocks of fish are greatly affected by the variation in the level of the water, and the abundance and variety of aquatic vegetation. Vegetation is needed for food, protection and breeding areas. The disappearance of submerged plants, as happened in the early 1980s, soon results in the decline of catches. Macrophyte growth improved appreciably from 1986 to 1988, and fish catches followed suit. Generally an increase in the Lake level results in more fish two years later (Lowe McConnell 1982). See Figure 22.

A range of factors have affected the fishing industry. Salvinia almost certainly didn't help the industry by over shadowing the breeding areas of the Tilapia. Robotham (1990) has also discussed the problems of overshadowing Salvinia mats in the fry nursery areas of the Black Bass (*Micropteris salmoides*).

Muchiri et alia (1992) have studied the feeding ecology of Tilapia in relation to changes in the ecology of the lake. The diet or tilapia were studied over a three year period with the following results

Figure 21.

Relationship of crayfish catch to submerged vegetation cover and as feed for Black Bass.

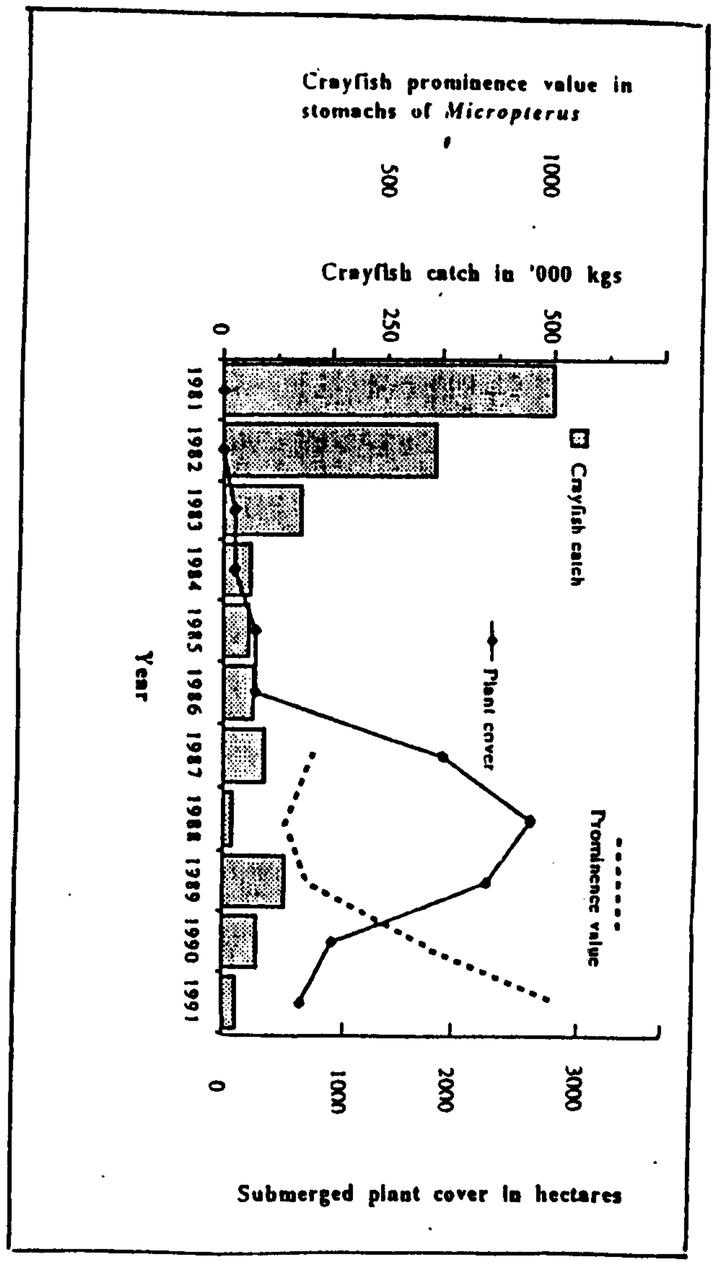
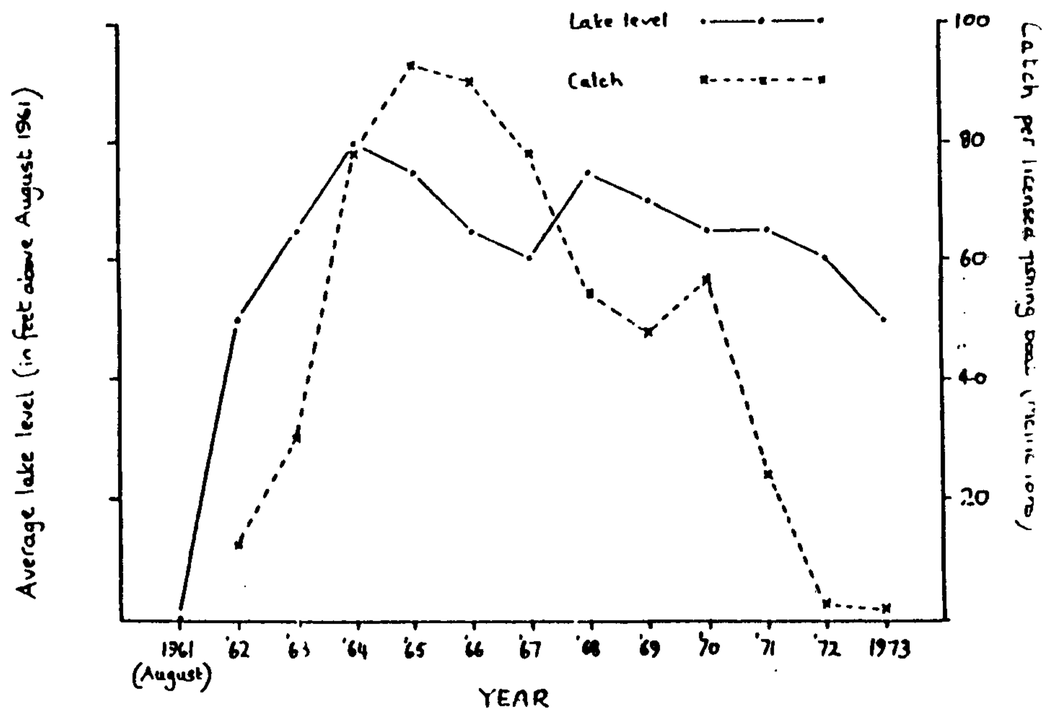


Figure 22.

Showing fish catch data 1961-73 compared to lake levels.



(After Malvestuto 1974).

Table 14. Feed components (%) of the two major Tilapia species

	Oreochromis leucostictus	Tilapia zillii
Detritus	40-50	40-50
Phytoplankton	22	
Benthic Macro invertebrates	17	10
Insects	little	28
Macrophytes		10

The two species are not in competition with each other in so far as food is concerned. Hickley et alia (1992) found that Black Bass up to 250mm fork length had total dependence on invertebrate food organisms particularly water boatmen (*Micronecta Scutellaris*), and thereafter ate mostly crayfish, fish and frogs.

Crayfish may well disturb Tilapia during the nesting phase and also could have eaten eggs. The Crayfish have also been responsible for much of the grazing of macrophytes, essential in the breeding areas of the fish.

White (1982) studied the feeding ecology of fish fry in the lake, and showed that the main food was zooplankton (60%), and chironomid larvae (30%); sand, algae, and detritus making up the balance. Large species of invertebrates were increasingly eaten with increase in mouth gape size. He found the density of zooplankton in the littoral area to be 361 + individuals per litre.

Robotham (1987) looked at the distribution and feeding habits of *Oreochromis* in the littoral areas of the lake and noted the high production and growth rates of this area particularly after recent flooding. Although this area can show big variations in temperature and oxygen content, small fish seemed able to contend with this. The area provided shelter from predators and cannibalism. *Oreochromis* fry fed mostly off *Euchanis* (Rotifer), 81% of stomach contents being largely made up of this invertebrate.

Mavuti (1990) studied the ecology and role of Zooplankton in relation to the fisheries of the lake during a period from 1978-90. He found the species composition remarkably constant since it was first described in the 1929-31 Cambridge expedition. He also confirmed the importance of Zooplankton in the littoral areas for juvenile fish, but found that zooplankton in the open waters of the lake did not enter the food chain in the absence of zooplanktivorus species of fish.

Harper and Muchiri (1990) have estimated that the fish population maintains 80 species of piscivorous bird and mammal species and are therefore an important link in the food chain.

11.8.4 Fish production and species composition.

Muchiri and Hickley (1990) have computed the maximum sustainable yield of fish from the lake as 418.8 tonnes per year, this total being caught by 54 canoes.

Actual yields and composition of the catch over the last five years are given in table 15, and more yield data and catch value are given in Appendix X.

Siddiqui (1977) discusses the species composition of the commercial fisheries.

Table 15. Fish production (kg) and species composition 1987-1991 (Hickley and North 1984)

Year	Leucostictus		Black Bass		Tilapia Zillii	
1987		(26.8)		(55.6)		(12.1)
1988	22969	(59.1)	15063	(38.8)	833	(2.1)
1989	131472	(77.5)	36359	(21.4)	1634	(1.1)
1990	107723	(63.2)	62437	(36.6)	389	(2.0)
1991	224037	(83.0)	42804	(16.0)	253	(1.0)

(Figures in brackets are percentages)

The catch of 299.4 tonnes in 1991 was worth Kshs 5,076,253. The total catch of 1992 was 237,719.5 kg worth Kshs 4,725,431. At the time of the study Tilapia were selling at shs 35/40 per kilo and Black bass at shs 38/05 per kilo, making a similar annual production worth twice this value at today's prices.

Yields peaked to 500 tonnes in 1966, and went down to as low as 34 tonnes in 1974. During that year fisheries were closed (Malvestuto 1974) in order to allow stocks to recover. Since 1977 catches have increased.

However all data presented mean little, as they represent only a portion of the catch. Much fish is landed elsewhere around the lake by licenced fishermen, and a great deal of fish is caught and sold illegally by unlicenced fishermen using small mesh nets.

The Barbus fishery on the river Malewa started in 1983 probably through the chance introduction of the fish down the Malewa River. The species has to go up river to spawn, and therefore any barrage across the river will impede this movement. Limited data is available on yields as follows:-

1985	60.0 tonnes
1986	62.9
1987	26.1
1988	0.5
1989	1.5

Obviously this small enterprise needs careful and controlled management, which is not possible at the moment from the fishery department with no transport. A better understanding of the life cycle and breeding habits of the fish would also lead to better management.

11.8.6 The Fisheries Cooperative

In 1992 there were 71 members of the Cooperative in Naivasha. All officially landed fish is sold through the Cooperative, the latter deducting a cess for its services at the rate of shs 0.60 per kilo for Tilapia and shs 1.00 for Black bass. In 1992 this brought in a total income of shs 301,909 to the Cooperative. Income would certainly be higher if there were more official landing sites round the lake.

11.8.7 Problems

The Fishery of Lake Naivasha is unstable and unpredictable due to associations between fish production and water levels. In addition the poaching leads to inadequate knowledge on catches, and population dynamics.

By far the biggest problem of the fishery at Naivasha is the activity of the large number of unlicenced fishermen that operate on the lake. Mann and Ssentengo (1969) noted that 250 illegal nets were found in use in May 1969. There are almost certainly as many if not more now. The problem started in the mid 1940s and has never been solved. These fishermen use nets with small mesh size, fish closer to the shore than the permitted 100 metres, and also use their fishing as a cover for other activities such as theft of water pumps and boat engines. Inshore fishing disturbs the breeding grounds of the fish, and the nets also catch the Great crested grebe, the African darter and the White backed duck.

The Fisheries Department with no transport are not able to control the situation. It is a social and an educational problem as much as a fisheries problem. It must be tackled through better communications, more personnel and effective transport, but above all more education to show what poaching is doing to the fish stocks. Poaching currently prevents effective management of the fish resource.

The Fisheries Department has been moved to the Kenya Wildlife Service during this assignment. It is hoped that this will enable the department to keep control of net size, nets per boat and other essential rules and regulations.

Currently there are no officially designated fish breeding areas around the lake. This will need to be accommodated in a management plan.

11.8.8 Future potential

There is no doubt that the fishery industry on Naivasha could expand (Muchiri and Hickley 1990, Hickley and North 1992). Muchiri et alia (1992) have discussed in detail the potential for enhancing the fisheries of Lake Naivasha.

The latter researchers looked particularly at the food resources for fish. They listed the main sources of food for the various species as follows:-

Small bass - Micronecta scutallaris, Large bass - Crayfish, Oreochromis - detritus and algae, Tilapia - detritus and Micronecta and macrophytes principally *Najas* and *Potamogeton* spp.

Zooplankton and off-shore benthic macro vertebrates are currently not being eaten, but merely die and add to the detritus on the bottom of the lake. Benthic oligochaetes and chironomid larvae are underutilized. With such niches unutilised, there is some attraction in introducing more species to utilise this food. It is generally agreed that with only five species present, they are unlikely to exploit fully all food resources.

The above authors have suggested the following species for possible introduction:-

Limnothrissa modon (to make use of the open water plankton)

Mormyrus to feed on benthos

Stolothrissa tanganyikae

Alestes spp - all of which might feed on the open water plankton

Heterotus niloticus to feed on phytoplankton

Haplochromis augustifrons to feed on benthos

Such introductions would need serious appraisal, and experimentation prior to introduction, and careful monitoring after, so that appropriate management could be introduced. Once introduced it is impossible to reverse the situation (Fryer and Iles 1972). However Parker (1993) has questioned this approach, contending that what will happen in the lake as a whole is difficult to simulate in experiments.

Harper (1990) has reported that there is a change on-going at the moment in the fish populations. He has stressed the need to develop a model on the relationship between Black Bass, submerged macrophytes and Crayfish so changes in the ecosystem can be predicted. He also recommended regular baseline sampling of the population.

11.9 Invertebrates

The invertebrate community of the lake is poorly described compared to some of the other groups. Some work has been done by Beadle (1932), Jenkins (1936), Cox (1977), and Millbrink (1977)

Two important surveys were done in 1982/83 by Harper (1984) and again in 1984 by Clark et alia (1987)(1989), the latter giving considerable detail on the families present and their whereabouts in the four bodies of water. They noted an increased diversity due to changing ecological conditions within the lake.

Rational management of the fisheries on Lake Naivasha will depend in the future upon a fundamental knowledge of temporal and spatial abundance, and community composition of production of the aquatic invertebrate food organisms, as well as the factors that control and effect these communities.

Barnard and Clark (1986) have identified a new species of Economus which they have named after Roger Mennel, one time secretary of the LNROA, and a leading scientist of the lake area.

Litterick et alia (1979) described seven major species of Chironomids as follows:-

Chironomus formosipennis

Chironomus pilosimanus

Cladotanytarsus pseudomancus

Tanypus guttatipennis

Procladius brevipetriolatus

Clinotanypus claripennis

Psecttrocladius viridescens

Harper (1990) has recently reported on the survey of invertebrates in the extensive macrophyte beds conducted by Leicester University. 28 taxa were identified. He found that the benthos was still dominated by the oligochaete *Limnodrilus loffmersteri, Branchiura sowerbyi*, and the Chinonmid *Chironomus formosipennis.*

The Chironomids are mainly in the west and south of the lake, and the first two species above make up 75% of the population.

Barnard and Biggs (1987), (1988), studied the macro-invertebrates of the Naivasha catchment streams. Work was done on the Malewa and Gilgil, with the latter being studied in detail. A total of 64 species were recorded, which was regarded as quite low, the community being dominated by Ephemeroptera.

Eight species of Mayfly were recorded on a 40km stretch of the river. The river was characterised by little aquatic vegetation and most species were found in the trailing terrestrial plants. The low species number confirms the work of Van Someren (1952) who found the same thing on the Sagana river in Central

Province. It is thought that the low species count is an indication of recent geological origin. Harper (1984) has noted the same phenomena for the lake.

Some specialist studies have been done. Clark and Baroudy (1990) have studied the predatory hemipteron *Laccocoris limigenous* which lives in the littoral zone of the lake. Clark (1990) has studied the distribution and breeding of *Micronecta scutellaris* (stal), one of the most important macroinvetebrates, as it forms an important component (75%) of the diet of juvenile Black Bass. It was found that the species breeds throughout the year with a 52 day life cycle

Harper (1989) reports on the current status of Bilharzia, a term used to describe the disease caused by the blood fluke Schistosomiasis haemalobium. Adult schistosomes live in man and the eggs once expelled in the faeces and urine, develop into larvae and find their alternative host - the Bulinus and Biomphalaria snails. The snails are present in the lake, but as yet Schistosomes have not been found. One theory is that the water is too cold and too alkaline for the schistosome, but later theories suggest that they are the wrong strain. The Snails have been traced to a Libyan strain, and the disease is not expected to develop until the snails find the relevant strain of the Schistosoma. In the late fifties and early sixties the Medical Research Laboratory did regular checks on fishermen and other itinerant workers round the lake, particularly those that originated from Bilharzia areas; and treated those with the disease. With the enormous increase of these workers today such a practice may be recommended but difficult to do in practice. In 1969, it was made an offence for any person with Bilharzia to enter the lake.

Harper (1989) reported on the invertebrate inhabitants of *Eichhornia crassipes*. (Water Hyacinth). 28 Macro-invertebrate taxa were recorded from the root systems. The taxa consisted of

Hemiptera (6)
Coleoptera (5)
Odonata (4)
Culicidae (1)
Chironomidae (2)
Stratomvidae (1)
Ephemeroptera (1)
Crustacea (1)
Mollusca (4)
Oligochaeta (2)
Microturbellaria (1)

The Hyacinth does provide a valuable habitat for a number of invertebrates although, as yet, none are dominant. Some of the inhabitants are useful food for the Lily trotter (Taylor and Harper 1988)

11.10Animals

There has been a wide variety of research done on the fauna of the lake over the last 10-20 years particularly the last decade since Leicester University have made repeated expeditions to the area.

Population and density estimates of the large herbivores are given in Appendix XI for Kedong Ranch and the Hells Gate Park. Species lists for the lake and the surrounding parks are available from KWS.

Lavari and Lucherini (1992) have studied animals in the Hell's Gate Park in terms of their customer satisfaction index. Kiringe (1990) as part of a vegetation study of Hell's Gate National park, also investigated the large mammal population of the park based on road strip transects. He found that Zebras and

Kongoni were the most numerous, followed by Buffalo, Thompsons and Grant's Gazelle and Impala. In his study he found that shortage of watering points in the park had a great affect on behaviour, but the presence of the Olkaria project had none.

Some specialised projects have been done on animals.

11.10.1 Hippopotamus

These represent the biggest animals on the lake, and perhaps are the subject of the most controversy between conservationists and agriculturalists. Their nocturnal grazing up to a distance of ten kilometres from the lake have resulted in damage to crops, and over the last ten years more and more of the lake frontage has been protected with electric fences or ditches of some sort to protect high priced horticultural crops. The problem is not a new one. In 1950 the Kenya Lucerne Growers Association complained of Hippopotamus activity in their fields.

The numbers of Hippo in the lake are generally magnified by the farmer, as several counts have shown there to be less than 300 in all, compared to the 'many hundreds or thousands' as estimated by the farmer.

Diedrichs (1976) counted 227 animals in total, and a decade later Smart (1990) (also reported by Harper 1987) counted 228, with 68-78% of them concentrated in nine sites around the lake. Smart (1990) further showed that although protective fences and ditches had increased to cover 26km of the 60km shoreline on the main lake, and half of the 10km shoreline of Oloidien, this still allowed a grazing density of 1.1/ km² which is regarded as light. Tembo (1987) considered a density of 4/km² to be the danger level.

A further survey was done by Smart and Coley (1992). They counted 61 on Oloidien and 169 on the main lake; a total of 230, virtually identical to previous surveys.

Currently the Hippo population of the lake appears to be living within its enforced boundaries. However numbers seem to be quite static, and although a small number are shot each year due to damage on crops, the breeding of the population does seem to be quite slow.

11.10.2 Giraffes

The University of Leicester group (Harper et alia 1987) have reported on the growing number and ecology of the giraffes on the western edges of the lake, particularly in the region of Ndabibi Estate.

11.10.3 Coypus

Coypus (*Myocastor coypus*) were imported into Kenya from Argentina around 1950 by a Mr Hook in Nanyuki, with the object of producing furs. It is a rodent one metre long and weighing 8kg, and under good conditions is a prolific breeder. The animal escaped from captivity and eventually reached Naivasha, probably via Lake Ol Bolossat and the Malewa river, in the 1970s. When Gosling (1976) did his survey the population in the lake was quite high. He found that the animal fed on Water-lily buds and papyrus rhizomes and stems. The animal was generally regarded, together with the crayfish, as being the main cause of the disappearance of the water lilies on the lake. The Coypu has not been seen on the lake in any number since 1984, although there are reports of single sightings as recently as this year.

Gosling recommended that further work should be done on the animal including a study of population dynamics, social status, feeding habits and reproduction, and an assessment made of their effect on the plants and other animals in the lake.

However before all this could be done, the animal disappeared from the lake. The reason for this has never been identified.

11.10.4 Game control and cropping

A limited game cropping scheme has been introduced round the Lake (Mulndi 1993). Presently the scheme has only been tried on three ranches, which have to be 1000 ha and over in size, and numbers to be cropped are based on the numbers present. Considerable numbers of plains game were seen round the lake during this assignment, when conditions were very dry and the game was attracted to water. There are already one or two gazetted game sanctuaries by the lake, and there seems potential for more economic use of game in the area, in addition to the National Parks.

11.11 Birds

There are over 350 species of birds in and around Lake Naivasha, over 400 in the catchment, and the area has become renowned world wide for its diversity of bird life. There were over 20,000 birds on the lake in 1991/2, of which 12,000 were water birds.

A bird check list for the area is available from KWS.

There used to be bird shooting allowed on the lake through the Gun Club section of LNR0A, shooting Geese, Duck and Coot over a limited season, and generally with limited bags. This was discontinued in the late sixties. It was largely justified under the pretext that the huge Coot population of the lake swamped out other birds and actually ate duck eggs. In fact Wildlife Services Ltd (1969) in a survey of coots and duck species, found no evidence that the coot was in any way detrimental to any species of duck on Lake Naivasha.

Henderson (1987) in a major survey of bird abundance and habitat use, counted 350 species including 90 aquatic birds. He found that Papyrus was widely used as a habitat and that its destruction would not only be detrimental to the quality of the lake waters, but also to the bird population. Salvinia was also noted as being an important substitute for Water lilies. He noted the increasing human demands on the lake and recommended more control needed on its utilisation.

Henderson and Harper (1992) carried out a distribution and habitat study on birds in a three month period of 1987. They concluded that the ecological changes of the lake were important in their effects on bird life, and these changes were stimulation for continuing both pure and applied research. Seven habitats in 13 stations around the lake were studied. The number of species recorded are shown in table 16.

Table 16. Bird species recorded on the lake (Henderson and Harper)

Habitat	Number of species	Unique species
Marsh	47	5
Macrophytes	36	9
Open shore	25	12
Papyrus	25	3
Salvinia	12	0
Open water	8	0

University of Leicester has studied the birds of Hell's Gate National Park. They recorded 142 species, including 33 species of Raptor. These numbers were higher than the previous Earthwatch count done in 1991. The number of Raptors was considered encouraging, an indication that Geothermal activity and

increased recreation use has not upset the bird ecology. However it was noted that the increase in climbing in the gorge needed to be dovetailed into the breeding cycles of the raptors who used the same cliff

Water birds have received particular attention on the lake. University of Leicester (Harper 1990) did a census of the water birds in 1989. They found a decrease in the larger fish eating species as compared with a similar survey of 1987. There were less Cormorants and the African darter had achieved an almost endangered status. However the diversity and distribution had remained much the same as ever. What was not known was whether these differences were a trend or natural dynamics of the ecosystem.

The Kenya Section of the International Waterfowl and Wetlands Research Bureau (IWRB) based in the UK has undertaken annual waterbird counts on the lake since 1991 reported by Benmum (1993). He recorded 69 species (compared to 74 the year before) but concluded that species richness was still high. Fish eaters were up marginally; but gulls and terns had increased. Most of the changes could be explained by the diminished macrophyte beds, the reduced Salvinia area, the increase in papyrus, (where is difficult to count birds) and the increased area of water Hyacinth. Full results of the 1993 count are given in Appendix XII.

Some specialised studies have been recorded.

11.11.1 African Lily Trotter (*Actophilornis africanus*)

This species used to live on the Water Lily pads. The water lilies were eventually eaten out by the combined efforts of the Coypu and the Crayfish. Since then the bird has successfully converted its habit to living and feeding on the *Salvinia molesta* beds (Taylor 1987), (Taylor and Harper 1988). The species now feeds on the Oligochaete worms and Chironomid larvae hosted by the Salvinia. The bird has now successfully transfered to the new Salvinia habitat, which should be remembered if it is ever planned to completely destroy the weed on the lake.

11.11.2 African Fish Eagle (*Haliaeetus vocifer*)

The Fish Eagle is almost the symbol of Naivasha. It is at the top of the food chain, and has therefore received considerable attention.

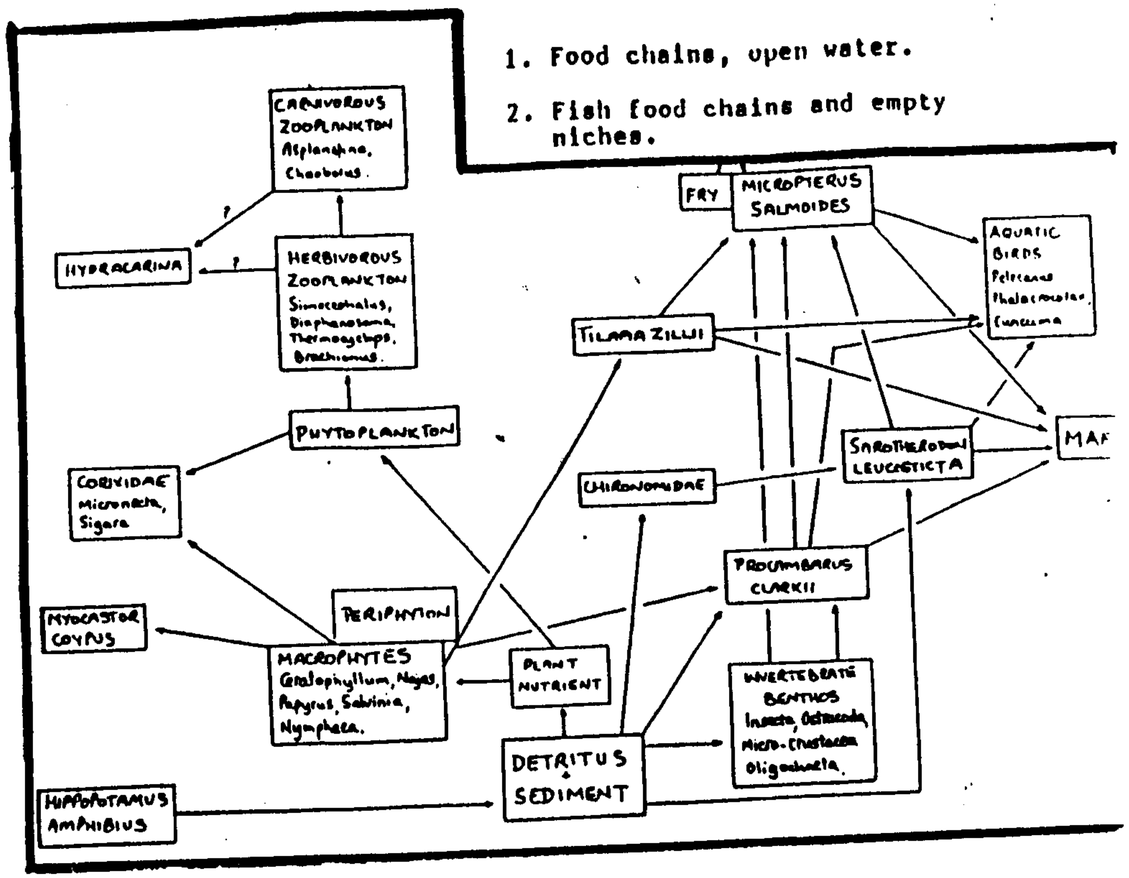
The University of Reading expedition (Johnson et alia 1986) counted 72 pairs, higher than the 1968 and 1979 counts done by Brown and Hopcraft (1973) and the Cambridge Expedition (1979)

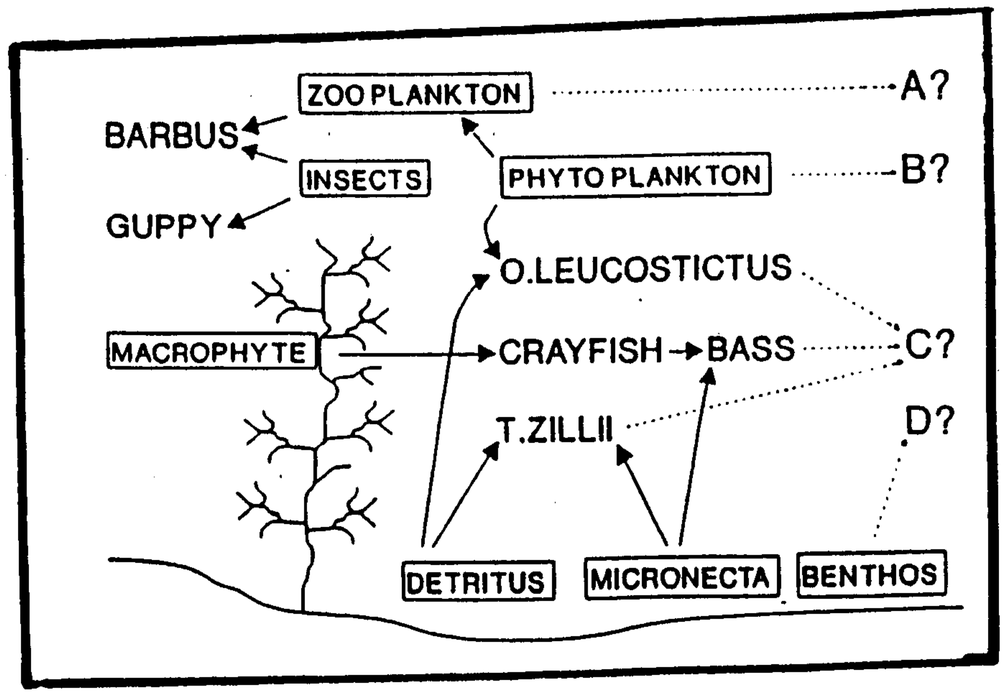
Smart (1991) did a survey of eagles and their distribution. He found a total of 68 pairs on the main lake and a further 13 on Oloidien and a single pair on Sonachi. 6.2% of the birds were immatures. Results were not significantly different from earlier surveys and it was concluded that the population was continuing to accommodate the changes taking place in the ecosystem. Obviously regular counts of the Fish Eagle the top of the food chain, will be a specific requirement in any monitoring programme round the lake.

Full results of the four surveys are given in the table below

Table 17. Fish Eagle counts (1968, 1979, 1986)

Year	Adults	Pre-mature	Total
1968	130	24	154
1979	129	31	160
1986	136	8	144
1991	154	10	164





The same survey counted the raptor species in Hells Gate and noted 11 species and came to the conclusion that the increased human pressure on the area was not reducing the number of birds present.

Harper (1990) has reported on on-going work on the time budgets of Eagles, designed to compare with the work done by Brown twenty years ago.

12. FOOD CHAINS

Diets and food resources for the various fauna of the lake have been discussed in the separate sections.

Litterick et alia (1979) have given the food web for open water as seen in Figure 23. Figure 24 shows the food web for the fishes and the possible niches that might be utilised with new introductions.

13. INTRODUCTIONS INTO THE LAKE

Most of the introductions have been discussed in the various subject sections. Cowell (1982) has described the various introductions made in the lake as 'a comedy of errors.'

A summary of introductions is given here only.

Intentional Introductions

Oreochromis spirulus nigra	Introduced 1925, disappeared by 1971
Micropterus salmoides	Introduced 1929, 1940s, 1951, 1952. present today.
Tilapia zillii	Introduced 1956, Present today
Tilapia nilotica	Introduced 1965, disappeared 1969.
Procambarus clarkii	Introduced 1970, present today
Gambusia sp	Date unknown, disappeared '77
Poecilia sp	Date unknown, disappeared '77
Oreochromis niloticus	Introduced 1967, gone by 197
Lebistes reticulata	Date unknown but there since 1982. Still recorded.
Oncorhyncus mykiss	Introduced in Malewa, date unknown. Caught on occasions
Crytobagous salviniae	Introduced 1991. Still present

Unintentional Introductions

Oreochromis leucosticus	1956 with Zillii.
Salmo gairdner	From rivers (Elder 1960)
Oreochromis leucosticus & *Oreochromis spilurus nigra*	Hybrid but gone by 1972
Salvinia molesta	1962, still present but under control.
Eichhornia crassipes	1988.

Unaided Invaders

Myocastor coypus	1968 to 1979
Salmo gairdner	Still reports of presence
Barbus amphigramma	Natural invader from inflowing rivers. Still present.

More details of introductions in relation to dates and lake levels are given in Figure 24 (Harper et alia).

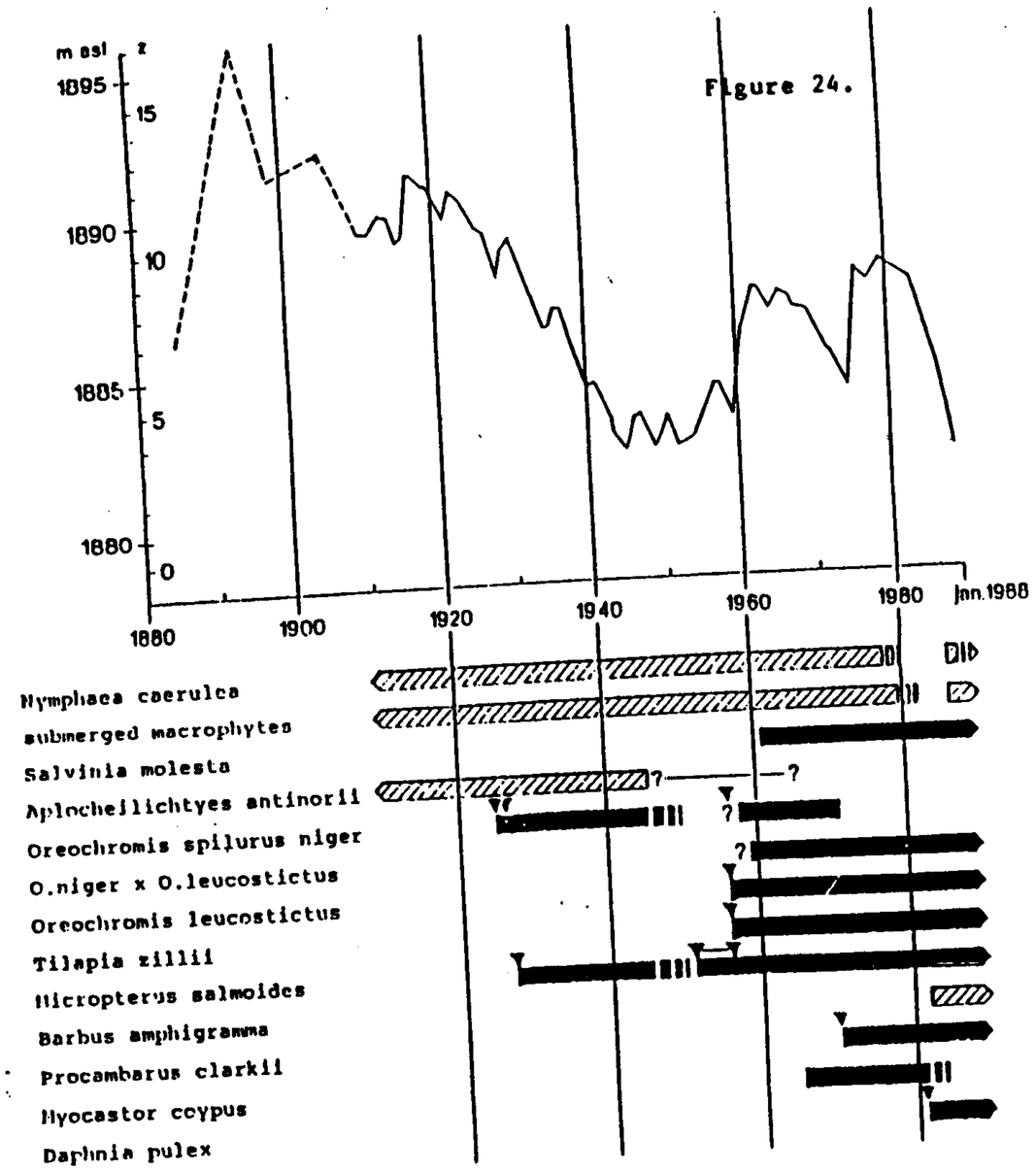


Figure 24.

Water level changes in Lake Naivasha's main basin during the past 100 years (from Harper et al., ms), and overview of the more important faunal changes that have taken place in the same period.

Altitudes above sealevel are at the left of the ordinate axis, corresponding maximum water depths at the right. Water depths in the submerged crater basin to the east of Crescent Island (cf.fig.1) are usually about 10 meter greater.

Hatched bars represent indigenous taxa, whose natural distribution area includes Lake Naivasha. Black bars represent exotic taxa, deliberately (arrows) or accidentally introduced to the lake. Dominating autochthonous aquatic macrophytes are Ceratophyllum demersum, Potamogeton pectinatus and Najas pectinata.

14. MAJOR RECENT CHANGES IN THE ECOLOGY OF THE LAKE

Lake Naivasha is a 'young' lake and is quite unstable and under going continuous change. The changes in lake level, area, and volume are mainly responsible but the introductions, both intentional and unintentional, made by man, through his activities in and around the lake, all of which have been mentioned in the previous section; have also contributed to the changes.

As far as we can tell the vegetation on the lake was fairly stable up to 1970, apart from the flushes and failures of littoral shore plants associated with the rise and fall of the lake levels. Following this period the submerged macrophytes and floating plants began to disappear. This was thought to be due to the introduction of the Coypu and the Crayfish, the former feeding on the buds of the Water Lilies and the latter general graziers on the vegetation at the bottom of the lake. Since that time the Water lilies have virtually disappeared from the lake except in controlled areas.

From 1984 to 1987, with the fall of the lake levels, Papyrus was cleared on the riparian land, and cropping expanded considerably. The area of papyrus around the lake was reduced from 12 ha to 2 ha and the future freshness of the lake was in jeopardy. In addition the clearing destroyed habitats for a large number of birds.

From 1986 there has been a general recovery phase in the history of the lake with papyrus and submerged vegetation returning and in balance with the rest of the flora and fauna of the lake. There is a general consensus of opinion that the presence of Papyrus round the lake is essential to its future well being. The plant is protected by Presidential order. It should not be burnt and LNROA has adopted a voluntary code which includes maintaining at least a 50metre strip of vegetation along the shore line.

Perhaps it is away from the lake that the greatest changes have been experienced, and it is likely that these changes will in turn bring about changes in the lake itself. Over the last ten years there has been tremendous horticultural development round the lake involving high inputs, high intensity production techniques and great use of lake water for irrigation. In the catchment areas there has been increased pressure on the land, brought about through increased populations and resulting in more intensive cultivation of the land, and often cultivation of steep slopes resulting in more run off and soil erosion. In the long term, rivers and runoff into the lake will contain higher loads of silt, nutrients and agricultural chemical residues. All of these will have major effects on flora and fauna in the lake.

The introduction of various fish species has had considerable effect on the ecology of the lake. The Crayfish had an effect on the general occurrence of vegetation in the lake, but despite the fact that they were eaten by the Black Bass the Crayfish also did considerable damage to the fish and nets of the fishery

However the greatest changes in the lake will come about through the last three years of extended dry weather in Kenya. This is already being manifested in the receding lake, the exposure of the littoral zone, the subsequent loss of submerged vegetation, and the important breeding grounds for fish.

These changes are not new, they have happened before. The lake will rise again, as part of its periodic fluctuation. All are part of the changing ecosystem that makes Naivasha such a challenging resource. However superimposed on all these short term changes is the underlying downward trend of the lake. There is no evidence to suggest that this trend has changed.

15. DEVELOPMENT AROUND THE LAKE

15.1 Agricultural and Horticultural Development

Although there has been some irrigation round the lake since the 1940s, major irrigation development and and pumping from the lake has developed over the last 10-15 years. Before that lucerne and potatoes, the two main crops of the area, were grown on ground water and residual moisture on the riparian land.

The growing of cut flowers and vegetables for export is now big business around the lake, and of national importance from the point of view of the foreign exchange that the industry generates and the employment that it offers to an estimated 30,000 work force. By 1991 it was estimated that 7,500 ha of irrigated land was in production round the lake (JICA 1991). In 1992 Harper et alia, estimated that the area of irrigated land was 10,500 ha. Gruhn (1992) has given a detailed analysis of crop cultivation round the lake as indicated in table 18.

The national horticultural industry began exports in 1968 when 1,476 tonnes were airfreighted overseas. By 1989 exports had risen to 50,000 tonnes, worth Kshs 2.2b (HCDA 1990). In 1985 cut flowers were 23% of Kenya's Horticultural export volume and 39%, of its value. By 1990, 269M stems or 14,422 tonnes were exported worth $38M, an increase of 22% over the previous year. 63% of that total were carnations. The industry is one of the fastest growing in Kenya, and of vital importance to the economy.

Horticulture now ranks third behind tea and coffee in agricultural exports and the industry now employs 1.8M people in Kenya and accounts for 21% of exports. Between 1968 and 1990 the fresh horticultural export industry increased by 19.4% per annum.

Farms round the lake range from big companies with hundreds of hectares under intensive flower production, to small farmers growing vegetables for exporters. The area boasts the biggest carnation farm in the world. Although there is a great variation in methods and standards of cultivation, it is encouraging to see that some of the smallest and biggest producers are generally mindful of the environment and the potential of horticultural production to damage the ecology, and are making serious efforts to protect the environment. There is however much that could still be done to improve environmental awareness in the area.

On some farms, drip irrigation is replacing overhead sprinklers, especially after the establishment period of plants; natural drainage pits are built into the water system so that no water runs back direct into the lake, trees are being planted and the safe-use of chemical sprays are practiced. LNROA carried out an agricultural chemical use survey in 1993, and this needs to be followed up.

All of the fruit and vegetables now going to the EC countries have very strict standards for residual chemicals on fruit, vegetables and flowers. Consignments carrying more than the permitted levels of acceptable chemicals or traces of banned chemicals are destroyed. It is not in the interest of the Naivasha farmers to use banned chemicals.

In addition there is a move in Europe for the big chain stores, who buy much of the Naivasha produce, to buy only from environmental friendly producers. These voluntary restrictions will undoubtedly help in keeping farmers up to the mark.

The major horticultural producers spoken to during this assignment gave positive pledges of help in efforts to manage and monitor the lake. For instance two of the exporters have full analyses of irrigation water done in Europe each week. They would be happy to lodge this information in any properly organised data centre that may be set up in the future.

Table 18. Estimates of crop areas around the lake. (Ha) Source - Gruhn 1992.

Compass direction	Farm land				Fodder crops			Horticulture crops								
	Holding area	Cultivated area	Irrigated area	Non irrigated	Lucern	Pasture	Maize	Asparagus carrots	French beans	Cabbages	Grapes	Oranges	Straw-berries	Apples	Flower bulbs	Cut-flowers
Eastern	3,123	1,303	1,018	285	66	185	111	142	212	121	65	32	43	16	12	13
Western	22,074	1,265	1,257	8	120	230	475	110	39	3		10	50			220
Southern	11,258	1,289	1,289			87		20							4	1,178
Northern	8,764	3,574	3,344	230	685	863	721	339	282	215	1	19		15	1	203
	45,219	7,431	6,908	523	871	1,365	1,307	611	533	339	66	61	93	31	17	1,614

One environmental factor which does appear to present potential dangers in the area is the major use of plastic for shelters over the flowers and in the packing of produce itself. There is a recycling factory in Nairobi, but this has ceased work due to water shortages. Naivasha would appear to be an ideal site for the re-siting of the project; raw materials are on the spot, but there might be water problems, and pollution potential.

A considerable amount of irrigation is done from bore holes and wells adjacent to the lake or the supplying rivers. There are 137 bore-holes around the lake. 37 of these are definitely not working including 17 which have been abandoned. 10 out of 47 farms use bore holes solely for irrigation. Often wells provide only saline water.

Most ground water seems to exist in small magnitude aquifers distributed over different horizons as stratum water or fissure water. It would be difficult to prepare a groundwater contour map in the survey area.

There are some essential information requirements needed in order to write the agricultural section of a management plan, not the least being the need for accurate data on irrigated areas, chemicals used, and the amount of water abstracted..

15.2 Tourism

Tourism and recreational facilities around the lake are also important foreign exchange earners and employers. The area is particularly popular with week-enders from Nairobi being no more than one and an half hours drive from the capital on tarmac.

There are three tourist class hotels, two with conference facilities; one tented camp in Sonachi crater; at least three other camp sites, three sets of self help bandas, and several houses that are available for tourist or holiday lets. There are at least six managed boat moorings sites where boats can be hired for fishing, bird watching and general pleasure.

Naivasha provides easy access to Hell's Gate and Longonot National Parks and the Aberdares National Park; Lake Nakuru National Park and its famous flamingos are no more than an hours drive away on tarmac. Between June 1992 and June 1993 a total of 38,500 visitors entered the two parks in the Naivasha system. There is a yacht club on Lotus island founded in 1931 and there are demanding rock climbing faces on the cliffs at Hell's Gate. The bird species richness of the lake are world famous. The Black Bass provide relaxing rod and line fishing for the sportsman.

There is something for every one. A management plan has been written for the Hell's Gate and Longonot Parks, and the management plan for the lake, especially in the tourism sector needs to fit in with this plan.

The plan should also provide reasonable public access to the resource.

15.3 Geothermal power

It would appear that Geothermal power could have the greatest impact on the lake and its environs in the long term; more so perhaps than agriculture.

There is in existence a National Power Development Plan (Acres 1987), which is a master plan for the orderly and economic expansion of the geothermal sector. Geothermal energy is scheduled to produce 280MW electrical energy by the year 2006 (Acres 1987). The potential of Olkaria has been outlined by GENZL (1972). At present the only potential source for this energy in Kenya is in the Olkaria-Eburru-Longonot area.

Currently Kenya generates one third of its electricity from imported fossil fuel. Geothermal energy which is comparatively cheap, clean, and environmentally acceptable is obviously attractive to the Government.

The first exploration for possible geothermal sources was done in 1956, but it was not until 1980 that the first station was constructed, and commissioned in the following year. By 1985 the project was producing its planned output of 45MW or roughly 15% of National requirements.

The present Olkaria east field is working with 34 wet steam wells drilled to a depth of 1000m. It is proposed to expand the project to another unit in the north-east with a further 28 wells drilled to a depth of 2000m. The Kenya Power Company is now looking for donor finance for this extension. The present field generates 45 MW and the new field at full development will generate 64 MW

Prior to this new development an environmental impact study was commissioned by Government and carried out by International and local consultants. Subjects covered included water usage, water disposal, noise levels, air quality, gas dispersion, land disturbance and aesthetics. The consultants have seen this report briefly, but it is not yet a public document until it has been fully discussed within KPC/KPL/ GOK. It should prove interesting and essential reading when it is released.

The Olkaria Project (1990) admits to the presence of chlorides, fluorides, arsenic and boron in Geothermal liquids but assures the public that surface disposal, evaporation and seepage has been an adequate means of disposal up to now. There is also H_2S and Co_2 released in the escaped gases, as from natural fumaroles, and the spent steam contains ammonia and sulphates which might change vegetation in the long term. Currently Oserian Development Company which is likely to be the first affected by any aerial pollution, is cooperating with KPC over trial plots of flowers close to some of the wells.

However the biggest environmental impact is likely to be the use of Lake water which is used for cooling and not returned to the lake. This could be recycled back to the lake, but presumably there are cost factors. Currently the KPC utilises 15 x 10^6 m^3 /year, approximately half of the current agricultural use, but destined at full development to be twice that amount.

The new project will increase generation by 1.5x. It is not known whether water consumption will also increase at the same rate.

15.4 Naivasha Town Developments

The town is situated on the north shore of the lake and is a fast growing agricultural, tourist and a long distance trucking centre. Given Municipal status a year ago, the Council serves an area of 940 km^2 and between 250-500,000 people. The township has a population of 50,000, and is expanding fast; out growing at an alarming rate, the essential public health services of water, sewage and refuse disposal.

15.4.1 Water supplies

There are three bore-holes supplying water to the town, one run by the Water Conservation and Pipeline Board (WCPB) and two by the Council with a maximum output of between 50-100 m^3 per hour. With a 12 hour pumping this will result in a water allocation of 12 litres per person per day in the township, ignoring any commercial, tourism and industrial requirements. Other private bore holes have been developed by the Catholic Church. There is a water pipeline from the Aberdares that used to supply the town, but lateral offtakes on the Kinangop have resulted in this supply now not reaching Naivasha.

The Council is actively considering alternative supplies including a dam and gravity feed from the Nyandarua mountains, and perhaps an offtake from the Greater Nakuru Water Supply on the Malewa if this was ever implemented. A clear example of divided interests in the community. However shortage of

funds prevent any feasibility studies or plans being made. Improved water supplies to Naivasha town is an important priority.

15.4.2 Sewage

The town sewerage process is even more inadequate than water. Phase I of a new sewerage system was built over ten years ago funded by NORAD, but never commissioned due to the severance of relations between Kenya and Norway. Any improvement in water supplies to the town would overwhelm the sewage facilities and obviously both must be developed in parallel. Properly processed, sewage water can be recycled for other uses which could help meet the general demand.

15.4.3 Refuse disposal

The town's refuse tip is situated in a natural drainage channel and in heavy rains refuse is spread over a large area of the foreshore. It is possible to convert garbage to compost and this process should be introduced.

15.5 Developments in the Catchment Area

Various developments in the catchment area, would appear to be perhaps the most disturbing, in so far as the long term future of the lake is concerned.

15.5.1 Water supply to Nakuru

The Greater Nakuru Water Supply project being funded by the Japanese Government is perhaps the most serious issue. Currently there is in phase I, a barrage and offtake from the Turasha, 10 kms upstream of the confluence with the Malewa. Phase II which has been curtailed largely through the efforts of the LNROA was designed to take water off the Malewa to raise the total offtake to 100,000 m³ per day. This scheme has raised considerable concern around the lake, although it should be noted that Naivasha Council have ideas of tapping this source for some of their water if the scheme is ever implemented.

What seems to be historically important in the development of this scheme, was the fact that there was very little discussion or opportunity to question the scheme by the people who will be most affected by the offtake - the people of Naivasha. Despite requests for a sight of the feasibility study for phase I, the latter was started before the study report was seen by the people of Naivasha, and before any environmental impact study was done. GOK rejected statements that a full environmental study would not be done, and the water balance of the lake fully investigated. It would appear that a water balance was done prior to the construction; but it appears that such balance was confined to the river rather than the lake or the lake basin. A computer model was designed but the alarming results that this model generated appeared to be ignored.

The supply was first studied in 1985 and recommendations made for various water sources to be tapped. Current water demands for Nakuru exceed the capacity of existing supplies. Sewage disposal works for the town are only a quarter of requirements.

The scheme eventually selected for development was the Turasha intake scheme and the cost of development was funded by Japan. The scheme now supplies 13,300 m³ per day to Nakuru, one third of the town's current supply through the NWCPC, and a further 4,700 m³ per day to Gilgil and the rural areas.

Suggestions have now been made for an alternative long term supply from the Itare river Chemosit Dam to the west of Nakuru in Kericho District. Medium term sources will involve investigation of further ground water supplies, and if these are negative, then the long term Itare supply will be brought forward.

A 12 month study of Nakuru water supply and sanitation is due to start in February 1994 funded by the African Development Fund. One of the terms of reference of this consultancy is to investigate alternative sources of water for Nakuru and to compare these sources with sites in the earlier study, namely the Malewa Dam in terms of environment, technical feasibility and cost.

The Malewa Dam Phase II has been shelved for the time being, but is definitely not off the drawing board.

A further withdrawal of 83,000 m³ per day of water off the Malewa would have disastrous effects on the water balance at Naivasha. The dam as designed, could divert 166,000 m³ per day at full development reducing stream flow by 27%. It should be remembered that there are already two other offtakes above the potential dam site - the Kipipiri project (6,100 m³ /day) and the Ol Kalau Project (16,400 m³ /day). A water simulation model was constructed by the investigating team and the effects of various extraction levels detailed in terms of lake level and decrease in level plus lake area data. The results are given in Table 19.

Table 19. Water balance simulation model - Malewa Dam

Items	Without project	With project. Case number 1	2	3	4	5	6
Water supply 000s m³/day	0	56	105	121	138	51 1	166
Lake level							
Max	1886.9	1886.4	1886.2	1886.0	1885.8	1885.7	1885.5
Av.	1885.2	1884.0	1884.3	1883.9	1883.6	1883.4	1883.1
Min.	1883.2	1883.0	1882.5	1882.5	1881.5	1881.0	1880.0
Fall of lake Level (1)							
Highest	0	0.5	0.7	0.9	1.1	1.2	1.1
Av.	0	0.4	0.9	1.3	1.6	1.8	2.1
Lowest	0	0.0	0.5	1.0	1.5	2.0	3.0
Lake area km²							
Highest	257	257	235	226	213	207	198
Average	185	170	156	150	145	143	139
Lowest	138	138	133	129	123	117	101

At maximum extraction the lake would retract some 3 kms in the north, and the surface area will reduce to 73%. Most of the present extraction points would be isolated on dry land and hotels would have no close water for recreational facilities. As the lake would be much shallower, there would be proportionally much more water used and the water would be more saline. There would be major changes in the ecology of the lake, and pollution levels and pH would rise significantly.

Obviously the Malewa Dam if ever revived should be vigorously opposed by all who are interested in t continued presence of Lake Naivasha. Even smaller extractions would be dangerous, as if a dam was built, it would almost certainly be built to maximum specifications purely on economic grounds. Then i could always increase its offtake with the same works. The balance in the present equation is not sufficient to carry an offtake of this size and still maintain the lake. To be more meaningful the model shoul be sensitized to the increased offtake of geothermal and agricultural development over the next five years, and the result will be even more dramatic.

16. GENERAL FEATURES OF THE PAST RESEARCH PROGRAMMES AND ACCUMULATED KNOWLEDGE

There are some features of the assembled information that needs noting.

16.1 Scattered Data Resource

Although the Mennel collection does bring together a great number of the scientific papers and other material relevant to the lake, much is still scattered in different places; in different Ministries, organisations, libraries and files. Neither is it easily accessible or retrievable. The material is not in one place, and not tabulated nor organised. A home for all this information is needed before it is lost. The material should be available to all who have a genuine interest in the lake.

16.2 Scattered Research Personnel

Not only are the results and papers scattered but so also are the researchers who did the original work. Gaudet, Melack and Harper who feature prominently in the reference list now reside and work in different continents. Drs Mavuti, Muchiri and Muthuri who have given much local expertise and work to the lake are in different Universities in Kenya.

16.3 Lack of Coordination in Research

Although there is obviously coordination within programmes of research, for example the University of Leicester programme; there appears to be little formal contact and coordination between various groups of researchers. This is not surprising, as at the moment there is no person nor organisation to coordinate work; and research programmes are managed by individuals or organisations with their own mandates and objectives. Much of the work done for example, although very interesting scientifically has little relevance to the writing of a management plan for the lake.

16.4 Priorities in Research

There seems to have been little thought given to the priorities of research on the lake. Certainly there is no body as far as can be ascertained that decides on what research will be done by the various inputs. The water balance would seem to be the most important issue of the lake, yet this has received the least attention in formal research programmes, possibly because such programmes would cost a lot of money in terms of time, personnel and equipment. Much of the research is selected on the basis of it being possible to get results in fairly short periods, or falls within the scientific fields of the people concerned, or because the subject is suitable for the preparation of a paper or a higher degree. This approach is understood and accepted. However if the lake is to be managed, then research has to be guided into the areas where results and data are needed in order to refine management.

16.5 Research on the Catchment Area

Lake Naivasha's future is to a great extent dependant upon what happens in the catchment areas. There have been tremendous changes in the catchment areas over the last thirty years. Land utilisation has gone from extensive ranching and settler dominated large wheat and sheep farms; to small scale intensive subsistence agriculture. Not only is the lake under pressure, so also is the catchment.

Most of the research has concentrated on the Lake and its immediate environment. Less attention is given to the catchment areas, and perhaps in the future research programmes, more attention must be given to these areas, for it is here that Lake Naivasha's future health and long term existence will be determined.

17. PROBLEMS OF THE LAKE AS PERCEIVED BY THE RESIDENTS

During the course of interviews with Lake residents and project managers, a note was made of the main problems as perceived by the residents. No statistical presentation of the answers are given but the point are given in a rough order of priority as seen by those interviewed.

Water balance -	This appears to absorb the interest of every one around the lake. Is the lake drying up? Is there too much extraction. What is the safe extraction limit.
Pollution -	Of equal interest to conservationists and horticulturalists. Flowers and vegetables die or are unacceptable to the consumer when polluted. They are affected just as much and as easy as birds and animals
Encroachment on the lake -	The fact that some farmers do not heed the LNROA voluntary 50m margin from the water as a limit of cultivation.
Fish poachers -	Refered to at some time by all residents. Poachers are a law unto themselves and are responsible for much property and ecological damage.
Naivasha pollution -	Pollution from the town in the form of the town's sewerage plant and the expansion of industry.
Use of dangerous chemicals -	It is thought that some of the operators are using banned chemicals, and it is almost certain that most farmers are unaware of the safe handling code for chemicals.
Human settlement -	The huge unplanned and often inadequate townships for labour in the horticultural industry.
Hippo damage -	Mentioned by a few farmers.
Tree felling -	Goes on despite the ban in order to clear areas for horticulture.
The catchment areas -	mentioned by several as a possible problem for the lake in the future, from erosion, intensive farming, leaching of chemicals and fertilisers.

18. FUTURE REQUIREMENTS FOR RESEARCH

The University of Leicester research programme on the lake should be encouraged to continue in the future. Or any other similar body should be encouraged to start work in the ecosystem. It is acknowledged that not all research being done is directly applicable to the management of the lake, but all knowledge is valuable in this ecology, and the work costs Kenya nothing.

There are also other positive values to the work in that it forges links with the local Universities, and assists local students and researchers to work for higher degrees with scholarship assistance from the British Council.

However if there is to be a management plan for the Lake and the setting up of a management body to manage the lake (as will be the recommendations of this report) then future research should, as far as possible, be aimed at the needs of that management plan and management body. More work should be done which will have direct application to management.

Note has already been made, that much of the research that has been done has been retrospective in nature, trying to investigate and explain what happened in the past and why. If management of the lake is to be effective there will be a need for research to face present and future problems, so that management can anticipate changes and problems and take appropriate action.

There is reference in the literature to work that should be done in the various fields in the future. These obviously represent some of the gaps in our knowledge, and some of those gaps need to be filled if we are to understand the ecology of the lake, and be able to manage it in a sensible manner.

A lot of the work needed in order to write and implement a management plan is not pure research, but merely the collection of routine information that for various reasons has become neglected. Lake levels, river flows, meteorological information, agricultural statistics and routine sampling and analyses. Without these data, a management plan is a non starter.

Research is therefore needed in two sectors as follows:-

18.1 Monitoring Programme

This is priority for the implementation of a management programme. A carefully thought out monitoring programme conducted on a regular basis, with continuity of method and detail, so that a broad picture of the health of the lake can be built up over time. Providing the correct parameters are selected, it should be possible for the management body to keep its finger on the pulse of the lake and, when any parameter appears to be showing abnormal results, then matters can be investigated.

The selection of parameters will obviously need considerable thought and planning, but might include some of the following:-

The collection of data that will enable a water balance to be calculated at regular intervals.

Routine sampling and full analysis of water samples taken from the various water bodies, and the rivers in order to determine nutrient levels and the presence of chemical residues.

Species composition and abundance of submerged vegetation in the lake, taken at different stations round the lake, on the same transects.

Surveys at regular intervals of particular bird species that will indicate the general health of the ecosystem. The raptors and the Fish Eagle in particular would seem to give vital results.

Areas of different vegetation types on the lake particularly areas of Papyrus, Salvinia and Water Hyacinth and submerged hydrophytes.

Considerable information could be collected on vegetation areas and agriculture if it was possible to do annual aerial photography of the lake.

The lake levels on the three water bodies should be recorded daily or weekly on markers zeroed to Ase's bench mark.

River flows need to be monitored regularly at all the official gauging stations in the catchment area.

Full meteorological records must be collected from a well maintained met station close to lake. Records should include evaporation. Other stations above 2000m in the catchment ar should also be recorded.

An up to date record of permitted abstraction should be available, and records of actual abstraction should be made on a regular basis.

Fish catches must be monitored, including the species composition of the catch. More recorded landing sites should be established. In order for these data to mean anything, it i obvious that poaching has to be stopped on the lake.

Regular census of game must be made, the Hippopotamus obviously to take priority.

The list is endless, and advice should be taken on how this should be prioritised and organised. The monitoring programme can also be as large or as small as is needed to suit a budget. Obviously there be priorities, the recording of parameters to allow the regular working of a water balance and the rout analysis of lake waters would appear essential.

18.2 Research Gaps and On-going Research

In the literature there are several recommendations for future work on the lake and its ecology and the following would seem to be of importance, in that they are relevant to the implementation of the mana ment plan.

- More work in the catchment area, including monitoring of forest cover, analysis of runoff soil erosion and conservation, production systems. (Njuguna 1993)
- Investigation and appraisal of suggestions that new species of fish should be introduced i the lake in order to expand the fishery potential.
- More work on the ecology of the crayfish, Black bass and submerged hydrophyte stand a the linking food chains with the object of establishing a computer model of the various relationships so that changes in the ecology can be predicted.
- More work on producing field guides and flora for the vegetation of the lake, particularly the submerged plants.
- More work on the water chemistry of the lake with the objective of calculating a chemical balance for the lake
- Modelling of the water plankton and their relationship to ecological factors.
- More information on the invertebrates particularly their role as a fish food.

The direction of research into the agreed priority areas could be done by a small research advisory bo appointed by the management board and meeting once or twice a year. They could advise on the field which seem of particular importance and try and persuade various research organisations to take up these studies.

19. THE WAY FORWARD

The terms of reference required that recommendations be made on the programme of research that should be undertaken in Phase II of the study, and to set out terms of reference for that phase.

After consideration of the wealth of information available, and after talking to interested parties around the lake; it would appear that further research is not of the main priority, but that the information that is available now, should be utilised as quickly as possible to draw up a management plan for the Lake, which will be implemented by a management body. Gaps in the knowledge will not be neglected, but can be filled by an on-going, donor funded research programme, which will feed results and relevant information into the management plan in phase II.

There are some obvious difficulties in such a course of action, and the LNROA is aware of these. If it is decided that the steps outlined below are not acceptable, then a much smaller programme can be initiated. The essential feature of this would be a monitoring programme round the lake, monitoring of essential parameters, and when irregular results are found, the LNROA can lobby the relevant authorities to take action, as they have done with great effect in the past. Such a programme is essential.

Having pointed out that there are possibilities for limited action, the consultants do recommend the full action, with steps in the way forward as follows.

19.1 Data Information Centre

There is a need to set up a data information centre where all relevant information on the lake can be stored, and is open to inspection and study by those who are interested. One of the problems about the lake at present appears to be that people are not well informed about the facts.

The reference list in the bibliography could well be the start to such a centre, all referenced papers being put into a well managed document/data resource centre. Several of the commercial horticultural enterprises around the lake expressed their willingness to contribute their data on water and soil analysis and climatic records to this data centre once it was established.

Suitable sites for such a centre might be :-

(i) Elsamere Trust Field Study Centre where a new library is in the process of being organised. The LNROA should negotiate with the Centre's Trustees. This centre has advantages in that it is open to all.

(ii) The offices of the management body once estsblished would be the obvious site for the data as a part of that centre.

(iii) It is essential that the lake management body of the LNROA do not contemplate large office complexes the downfall of most Basin authorities in this country. As a cheap and initial starting point, and until it is seen how the project is working out, the centre could be attached to a member of the committee of the LNROA, although the Centre must still be accessible to everyone.

Initially the material could be indexed and organised in a simple filing system indexed under author and subject headings, allowing for easy access and retrieval of data. As data builds up, the possibility of computer storage of data will need to be considered. The data centre and the data stored should remain the property of the LNROA who will take full responsibility for its management and storage.

19.2 Establishment of a Lake Monitoring Scheme

A lake monitoring scheme need not be expensive. Providing a member of LNROA is prepared to organise and manage it on a part time basis, it could be done by one person on a motor cycle. One hopes that some of the work can be done by the visiting Research teams as part of their programme (ie University of Leicester), and other work could be contracted out to local laboratories and other already established programmes. Much of the monitoring would be to see that the work is actually being done. Suggestions have been given in section 18 of what might be monitored, but this needs more thought in terms of what should be done, how often, where, when and by whom. This would appear to be one of the first tasks for the next stage of the programme.

Some of the monitoring should already be done by various Ministries and organisations. For example the river flows at the gauging stations. But are they? It will be the work of the monitoring team to make sure that this data is collected and stored properly.

19.3 The writing of the Lake Naivasha Management Plan

The conference in Nairobi on African Inland Waters (Denny 1985) stressed the need to ensure that there is a proper scientific basis for the planning, decision making and management of African aquatic resources. Such a basis exists for Lake Naivasha, sufficient for a start to be made on its management.

A plan has been drawn up for the Hell's Gate and Longonot National Parks/the Suswa Ecosystem by the Kenya Wildlife Services (1992). The latter is still only in draft form but shows what is needed for the lake. It sets out the reasons for the plan, management objectives, it gives a general description of the ecology of the area, and then outlines the plans, methods, funds and resources that will be used to initiate the plan.

A management plan not only sets out the plans of development and management of an area in the future but also details how this is to be done, the rules and regulations to be followed, the staff needed, and the work and financial timetables.

There is sufficient information available to write the first draft of a management plan for the lake. A plan for Lake Naivasha would include such topics as water abstraction, agriculture, recreation and tourism, fisheries management, education and information, conservation of flora and fauna, development near the lake and the rules and regulations to be followed in this development, and catchment management, to name but a few of the topics. The plan should mesh with the KWS and geothermal plans for the area.

The preparation of this plan would be a core task in the next phase of the programme. In this phase the plan would not only be written, but advice given on the formation and its financing and organisation.

19.4 Lake Management Body

The idea of a body to manage the Lake is not new to the LNROA, as in an undated Association paper probably related to the fifties it was suggested that the lake needed an organisation to look after it. It further suggested that something like The Tennessee Valley Authority should be tried which would take control of all aspects of the lake including the whole catchment, afforestation, soil conservation and abstraction.

In 1971 the LNROA considered urging Government to set up a Lake Naivasha Authority which would be given powers to lay down and enforce a long term plan of land and water management which would manage all resources of the area. Darling in the same year reported the views of Murray Watson and Parker who called for a management plan for the lake and powers to determine priorities of exploitation, to manage the lake and control activities in the catchment. Colonel Cowie of the National Parks also confirmed the need.

Njuguna (1982) has suggested an authority similar to that of a National Park or Reserve might be suitable, although, with so many people and interests involved around Naivasha this might be difficult.

Harper suggested in one of his papers that a Naivasha Lake Basin Development Authority was needed to manage the affairs of the lake. Although the consultants agree with the proposal, the name has connotations of Government controlled bodies, which have a poor reputation for success in this country.

This report again calls for a management plan and a lake authority. Will this recommendation get further than the previous recommendations? There is every indication that the present LNROA has the sense of purpose, ability, and the will to write a management plan-and implement it. Plans to do this are far more advanced now than they have ever been in the past.

The formation and running of such a body will not be easy and, in the opinion of some, fraught with problems. The more obvious might be:-

Under what authority will the management body be formed. Who will decide on composition.

How will the body react and work with the existing and established authorities in the area - the Administration, Municipal Council and Government Departments.

Will the body have authority

How can such a body manage a lake without having control also of the catchment. Is some measure of control in the catchment possible.

The Government of Kenya is currently going through some painful exercises recommended by the International Monetary Fund and major donors to slim down its Civil Service. The Government has already taken steps in some Ministries to introduce privatisation; for example in the Veterinary Department. It seems certain that in the end Government Services will look much different to what they do today. In this current climate therefore, there seems little point in loading Government with more management bodies, that almost certainly will not have the funds to operate effectively; but on the other hand, there seems to be an excellent opportunity to try other forms of resource management.

The Consultants therefore suggest a community based management body. In other words the lake would be managed by the people who live there and use the resources. Some representation from Government would be needed in order to give the body muscle in order to carry out its duties. Such a management body would have to be financed in some way by and through community activities. There must be sustainability after initial donor help, and the body must not be dependant on Government resources. Donors will support LNROA, and the Association has the motive, the ability, the willingness and the money to do the job.

The management body for the lake should be established under the auspices of the LNROA and its membership should include agriculture/horticulture and conservation interests, Naivasha Municipal Council, District Environmental Officer, KWS, KPC, National Museums, and IUCN/Ramsar.

The establishment, terms of reference, authority and relationship of the body with already established authorities of the area need to be spelled out in detail. These tasks will be achieved in the next phase.

19.5 Information and Education

Obviously this will be one of the subjects that will occupy the management body. Informing the people who use the lake about the ground rules - leaving natural vegetation strips around the lake, conserving the papyrus, using only nets of a certain mesh size and so on.

This task should begin now. With all respect to the residents around the lake, there seems to be a lot of theorising, which is often not backed by facts. Yet the facts are there, the review of literature proves that. But this literature needs to be made available to far more people than as at present. This Phase I report should help achieve that objective.

20. INTERNATIONAL INTEREST AND ASSISTANCE

RAMSAR is an organisation committed to the protection of Wetlands of International importance throughout the world. Kenya is a signatory to the RAMSAR convention that was signed in 1971 in Iran, and came into force in 1975. Lake Nakuru was designated as Kenya's first, and at present, only site, managed by KWS. The possibility of Naivasha becoming the second RAMSAR site in Kenya has been suggested to the Director of KWS by LNROA. There are some problems with this at the moment , in that Naivasha is a much more commercially exploited lake, and the Kenya Wildlife Service does not have full protection and control of the area, and may not want that role. Wetlands are currently under threat from pollution, development and drainage, and countries signing the convention are under obligation to protect their wetlands, although RAMSAR does accept the 'wise use' of wetlands. The definition is complex, but the possibilities of Naivasha being a RAMSAR site should be pursued in the future. Acceptance would help to safeguard Naivasha as a protected area of combined commercial activity and interest under ecologically sound management. The World Conservation Union (IUCN) is another world organisation committed to wetlands conservation. IUCN in its Wetlands programme encourages the multiple use of all wetlands so people can benefit from their products, hydrological services and traditional and sociological values. The Union helps Governments to develop wetland strategies, and sustainable utilisation. The Headquarters of the organisation are in Switzerland, and there are five regional offices. One of these is in Nairobi to look after the Eastern Africa programme that was started in 1986. The office can provide skills in species survival, national parks and protected areas, ecology, environmental strategies and planning, environmental law, education and communication.

Technical assistance and advice will certainly be available from the IUCN office to the management authority; and this offer of practical help and advice should be pursued.

The major donors to Kenya are now re-thinking their assistance strategies, and there seems to be a change in emphasis, with a swing away from the strict Government to Government assistance of the past; to more assistance through NGOs and other organisations such as LNROA, and support to properly constituted and managed community based programmes. Already the idea of a LNROA community based management authority for the lake has attracted contributions in principle from the following donors:-

(i) The Royal Netherlands Government is prepared to put a two man pesticide team into the field now, for a three week period to advise on the safe use of pesticides and give advice in an Agricultural chemical usage handbook which would be part of the management plan for the lake. In the longer term they are also prepared to consider assistance in phase II in terms of equipment for monitoring and general funding.

(ii) The Overseas Development Administration (ODA), the British Aid agency is prepared to help through its already established Crop Protection programme, and give assistance to a pesticide residues determination programme.

(iii) The United States Agency for International Development (USAID) has shown interest in the programme and might fund some aspect of phase II through an American organisation such as Winrock International. This group is already involved in the Lake Victoria working group and has pledged support to Phase II of the Lake Naivasha Project.

21. SUGGESTED TERMS OF REFERENCE FOR PHASE II

Phase II of the Environmental Impact Study should consist of four main sections:-

(i) The formation of the management body consisting, at a minimum, of representatives of the Agricultural and Horticultural industry, Naivasha Municipal Council, District Environmental Officer, KWS, KPC, National Museums, IUCN/Ramsar and LNROA, under the auspices of LNROA; and the confirmation of its authority, terms of reference, financing and operation.

(ii) The writing of a management plan for the lake and its environs.

(iii) The design planning and implementation of a monitoring programme for the lake.

(iv) In conjunction with (iii) the collection of hydrological data that will enable the calculation of a practical water balance for the lake as soon as possible.

(i) should be initiated and implemented by LNROA.

(ii) (iii) and (iv) should also be implemented by the LNROA with inputs of expertise in the fields of Hydrology, Agriculture, Economics, Community Development, Fisheries, Botany, Zoology and Wildlife. The team could well be supported by Technical Assistance inputs from Donor countries (ie. Pesticide usage from Royal Netherlands Government) who will help write part of the Lake Management Plan. The terms of reference for the work will be:-

1. Establish and empower a community based management body for the Lake. Organise how this body will be formed and to whom it will be responsible. Recommendations will also be made on the staffing and funding requirements and how the latter will be maintained in a self financing situation. Special attention will be given to its working relationships with other authorities already established in the area.

2. Write a detailed management plan for Lake Naivasha and its catchment areas. The plan to include a description of the area and set out in detail the present and expected developments for the area. How this development is to be managed and details of work plans, personnel, and funding should be given.

3. Design, cost and set out the organisation of a monitoring scheme for the lake and its catchment in detail, which will provide information useful for the day to day management of the resource. Details should include what parameters to be measured, where, how often and by whom. If acceptable, implement this programme on a sustainable basis.

4. To set up a data resource base for the lake, and establish a centre of information. Design suitable systems of storing the material, indexing, retrieval and access.

5. To seek donor participation and funding for the programme and assistance in filling the gaps in the knowledge needed to update the management plan.

6. In particular, the hydrologist will examine the availability of up-to-date information and data which is needed for the calculation of a practical water balance for the lake. If this data is not available, then steps will be made to collect it.

7. As and when data is available, the hydrologist will calculate a simple water balance for the lake, and after consideration of the results make recommendations for future utilisation of lake waters particularly abstraction levels and metering of abstraction.

8. Inform residents and relevant authorities of the plans, and actively seek their cooperation in the plan as it develops to ensure smooth transition from Phase II to Phase III

9. To recommend steps leading to the adoption of Naivasha as a RAMSAR site

10. To outline terms of reference for Phase III of the study.

The full work programme involved in (ii), (iii) and (iv) is likely to take approximately six months, and involve a total of 300 man days, costing approximately $60,000.

22. CONCLUSIONS AND RECOMMENDATIONS

The review of scientific literature and available information has confirmed that there is considerable information available on the ecology of Lake Naivasha which is relevant to the writing of a management plan. There are gaps in the knowledge, the main one being the lack of routine water monitoring data necessary for the working of a water balance for the lake. Obviously research and monitoring programmes should try to complete these gaps in the future.

There does seem to be a need for a research committee to advise the management body, which will decide more clearly on research priorities, particularly those relevant to a management plan; and which can help to influence individuals and organisations who are interested in doing research at this site.

There is a lack of knowledge on the present water balance of the lake. No up-to-date figure has been found on what is likely to be the 'safe' offtake from the lake for agriculture, horticulture, geothermal power and other uses. With fairly accurate estimates of underground outward flow from the lake now available, the only missing piece of data appears to be the estimate of inward flow. But if we know all the other inputs and outputs and these can be measured, then there seems to be no reason why a practical balance cannot be constructed interpreting the inflow as a change in the storage of the lake as indicated by the lake levels. What appears to be needed is a check of the basic data that will be needed to calculate this balance, and if this data is no longer collected, to make sure that it is collected in the future.

There are pressures building up on the available water supply from the lake which could have far reaching effects on its long term future. It is important that the water balance is worked out with some accuracy as rough calculations in this paper suggest that extraction has overtaken replenishment in the drier years. It is important that an authority is established to manage the lake. There is evidence that the lake could be heading towards another major drying out phase in its history. This would appear to indicate more than ever the need for good management in order that its valuable resources last as long as possible.

Currently all the information that has been collected is not being used in any practical way for the betterment of the lake. There is an urgent need to use it to write a management plan for the next 10-20 years. There will obviously be gaps in this plan, but these can be filled as data becomes available from the ongoing research programme, and it will provide a sound base on which the lake can be managed for the

future. Currently the lake survives by a combination of its resilience to put up with man's interference, good luck, and the hard work of certain individuals. What is needed is an overall plan, to which everyone can adhere, and if they are not willing to play a part, can be made to work to the rules. With the increasing pressures on the lake this plan should be written as soon as possible.

In addition a properly designed and organised monitoring system is seriously needed on the lake, that will provide regular information on the health of the lake, and by which the lake can be managed. It is essential that routine checks on all vital parameters are recorded and acted upon.

Having written a plan and monitored the lake's essential parameters, then there is a need to have an authority or body that can manage the lake and its catchment. Various forms of authority have been suggested, but Lake Naivasha would appear to be the perfect site for a community based management body. The lake should be looked after by the people who have the greatest interest in it; the people who live and make their livings from the lake.

The Consultants believe that there is in Naivasha an opportunity to prove to the rest of Kenya, that community based management of natural resources can work for the benefit of all. If it can be made to work in Naivasha there will be an example for the rest of Kenya to copy. The formation of such a body and its working relationship with already established authorities will not be easy. However it would appear that the climate for the implementation of a plan for the lake has never been better, and the LNROA must take the opportunity now to implement the plans outlined in this report as soon as possible.

22. ACKNOWLEDGEMENTS

There are many people I wish to thank, who gave me their help during this assignment.

To the Chairman and Secretary of LNROA, and members of the implementation committee charged with the responsibility of Phase I of this study; for information, encouragement and guidance.

To the Trustees and management of Elsamere for access to the collection of papers of the Late Roger Mennel.

To Mrs Joan Root and Mr Rick Hopcraft for allowing access to the papers of the late Mrs Jean Hayes and Mr Wilfred Hopcraft respectively. To the Chairman of LNROA for access to his Association files.

To the many people to whom I have talked over the last five weeks, who have all contributed to this report in their many ways.

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December 1993.

APPENDIX I

TERMS OF REFERENCE

1. Collect all information relevant to a management plan on the lake, including published scientific papers and reports, unpublished material, Government information, and data from private individuals and commercial organisations.
2. Review this information in a condensed and readable document, and evaluate the importance of the lake.
3. From this review indicate where there are gaps in our knowledge required for a management plan of the lake ecosystem.
4. Indicate, evaluate and prioritise what research should be done in the future to fill these gaps
5. Give recommendations on how and where a library of resource documentation should be established, and managed.
6. Give recommendations on the scope of, and write terms of reference for, Phase II of the environmental impact study as per the LNROA's three phase proposal.

APPENDIX II

LIST OF RESOURCE PERSONS MET

Mr Bernard Ayugu	District Fisheries Officer, Nakuru District.
Mr Wolf Bagwitz	Production Manager, Sulmac.
Mr Walt Verweij	Senior Roses Manager, Sulmac.
Mr Joseph Ng'ang'a	Geothermal Development Manager, Olkaria Geothermal Project.
Mr Benjamin Kubo	Environmental Scientist, Forestry, Olkaria
Mr Frank Njenga	Environmental Scientist, Hydrology, Olkaria.
Mr Henry Ndede	Elsamere Field Centre.
Mr P. Zwager	Oserian Development Company.
Mr Fred Rukunga	Manager, Lake Naivasha Country Club.
Mr Mervyn Camelly	Fisherman's Camp
Mr R. Hopcraft	Loldia Ltd, North lake.
Mr and Mrs Angus Simpson	Residents, Naivasha
Mr and Mrs John Barton	Farmer, Naivasha.
Mrs Sarah Higgins.	Secretary, Lake Naivasha Riparian Owners Association.
Mr Del Hovey	Goldsmith Seeds Ltd.
Mr and Mrs Tony Bates	Elsamere Conservation Centre.
Mr Nyagambi	Fisheries Training Centre Naivasha.

Mr C. Chirchir	Manager Manera Farm, Delamere Estates.
Mrs Joan Root	Conservationist and Lake Resident
Professor Steven Njuguna	Coordinator, EA. Biodiversity Conseravtion Programme. World Conservation Union, Nairobi
Dr Geoffrey Howard	Regional Coordinator. IUCN Nairobi.
Dr Leon Bennum	Head Dept. of Ornithology, National Museums of Kenya.
Mr Charles Chuma	Assist. Manager Marula Estate.
Mr Rodrick Kundu	Fisheries Officer, Naivasha
Mr Peterson Njue	Fisheries Officer, Naivasha
Mr John D'Olier	Lake Naivasha Vineyards.
Mr J.F. Campbell Clause	Treasurer, LNROA.
Mr Roger Jocelyn	Manager, Kongoni Estate
Mr Dickie Evans	Homegrown Ltd. Naivasha
Mr Henry K Muhindi	Kenya Wildlife Services, Naivasha
Mr Jim Harvey	BDDEA, Nairobi
Mr Joseph Ngatia	Pesticide Residue Laboratory, NAL, KARI, Nairobi.
Dr John Sutherland	ODA Field Manager, KARI/ODA Crop Protection Project.
Mr Nico Visser	Attache for Agriculture, Nature Management and Fisheries, Royal Netherlands Embassy
Mr Mohammed Osman Hassan	District Officer, Naivasha
Mr S. M. Muchumu	Water Bailiff, Naivasha.
Mr S. Kimani	Water Supplies Inspector, Naivasha Water office.
Mr Guy D'Olier	Farmer, Naivasha resident.
Mr Ayub Ayieko Olweny	Current manager, Lake Naivasha Country Club.
Mr Joseph Kangari	Farmer, Naivasha resident.
Dr B. Muruli	General Manager, ADC.
Dr R. Bunny	Resident, Lake Naivasha.
Mr J. Waweru	Livestock Officer, Naivasha
Mr G. M. Mwangi	Town Clerk, Naivasha M.C.
Mr I. S. C. Parker	Wildlife Consultant.
Earl of Enniskillen	Chairman, LNROA.
Mr C. Archer	Naivasha Resident and committee member LNROA.
Mr Peter Mwangi	Farmer and Vice Chairman LNROA.

APPENDIX III

WORK PROGRAMME AND ITINERARY

October 6th	To Elsamere Conservation Centre, collect part of the Mennel collection of scientific papers.
October 7th to 9th	Paper and report reading
October 10th	To Elsamere. Return and collect more papers.
October 11th to 13th	Paper and report reading.
October 14th	To Elsamere, return and collect papers Visit DO's office, Div. Agric. Office, Veterinary Office, Fisheries and Mrs Higgins.
October 15th to 18th	Paper and report reading.
October 19th	Visit MLRRWD and MALDM libraries
October 21st	To Naivasha visit Elsamere, Lake Naivasha Country Club, Fisheries, Mr P. Robertson, Goldsmith Seeds.
October 22nd	Visit Delamere Estate, Kongoni Estate, Marula Estate, Fishery Training Centre, Kenya Wildlife Service.
October 23rd	Visit Mr M. Carnelly, Shalimar Ltd, Loldia Ltd
October 24th	Visit Mr Cambell Clause, Mr John D'Olier, Mr and Mrs Barton.
October 25th	Visit Oserian Development Co., Sulmac Ltd. Fisheries Training Centre.
October 26th	Olkaria Geothermal Centre. Return to Nairobi.
October 27th to 30th	Nairobi visits - BDDEA, IUCN, KARI, Homegrown, Dr Bennum
November 1st to 7th	Writing of first draft of report
November 8th	Submission of draft report.
November 22nd to 23rd	Further visits in Naivasha - DO, Town Clerk, Mr G. D'Olier, Mr Kangari, Dr Bunny.
November 24th	Discussion of draft report with Chairman LNROA.
November 25th to 30th	Reading further reports and papers
December 6th to 10th	Preparation of second draft of report.
December 11th	Submission of second draft report.
December 20th	Discussion of second draft report with Chairman LNROA.
December 21st and 22nd	Preparation of third draft report.
December 24th	Submission of third draft report.
January 17/18th 1994	Discussion of third draft report.
January 19th	Submission of final report.

APPENDIX IV

Table 1. Mean rainfall figures (mm) for selected stations.

Month	Bahati	Gilgil station	Naivasha Town	Naivasha Vet.St.	Marula	Korongo	Eburru Sett.	Long-onot farm
Years	44	38	41	39	35	27	42	27
Average	1227	646	666	729	653	667	802	680
Alt.(M)	2408	2006	1900	1829	2042	1890	2438	1890
January	21	22	37	36	32	27	29	30
February	36	28	41	33	35	38	37	47
March	51	54	47	60	43	49	66	56
April	142	98	114	121	107	116	145	125
May	195	75	109	103	93	108	117	97
June	119	53	45	52	38	57	69	34
July	137	60	39	44	43	50	65	31
August	165	66	53	54	56	50	73	36
September	115	38	25	46	35	36	43	47
October	110	43	45	63	54	44	46	54
November	91	58	64	71	71	52	63	65
December	46	41	48	47	48	41	49	58

(Source: Jaetzold R and Schmidt H. (1983)

APPENDIX IV

Table 2. Rainfall from selected stations in the catchment area.(mm)

	Nyahururu	Ol Kalau	Ol Bolossat	Sasamua Dam	Bahati FS.
Altitude(m)	2354	2361	2371	2475	2408
Years of recording	35	36	27	26	44
Mean rainfall	968	774	1055	1620	1277
January	33	29	33	79	21
February	38	14	34	97	36
March	55	34	51	155	51
April	117	88	99	325	142
May	92	88	128	254	195
June	86	83	102	86	119
July	131	91	160	64	137
August	152	127	174	65	165
September	68	61	76	57	115
October	42	52	46	149	110
November	82	76	88	199	91
December	71	30	63	90	46

(Source Jaetzhold and Schmidt 1983)

APPENDIX V

Temperature data for Naivasha Vet. Expt. Station Degrees C

	Mean Max	Mean Temp	Mean Min	Absolute Min
January	27.7	17.5	7.3	2.8
February	28.3	17.5	6.8	2.8
March	27.8	17.8	7.9	4.4
April	26.3	17.3	8.4	2.2
May	25.1	16.9	8.8	3.3
June	24.7	16.3	8.0	2.2
July	24.7	15.9	7.2	2.2
August	24.6	16.1	7.7	2.8
September	25.7	16.3	7.0	1.7
October	26.1	16.8	7.6	4.4
November	25.5	16.6	7.8	3.3
December	25.7	16.7	7.7	4.4
Mean	26.0	16.8	7.7	1.7

(Source - Jaetzold and Schmidt 1983)

APPENDIX VI

General climatic data Naivasha

Climatological statistics Naivasha (00° 43' S , 36° 26' E; 1900 m above sea level) (East African Meteorological Depart. 1964)

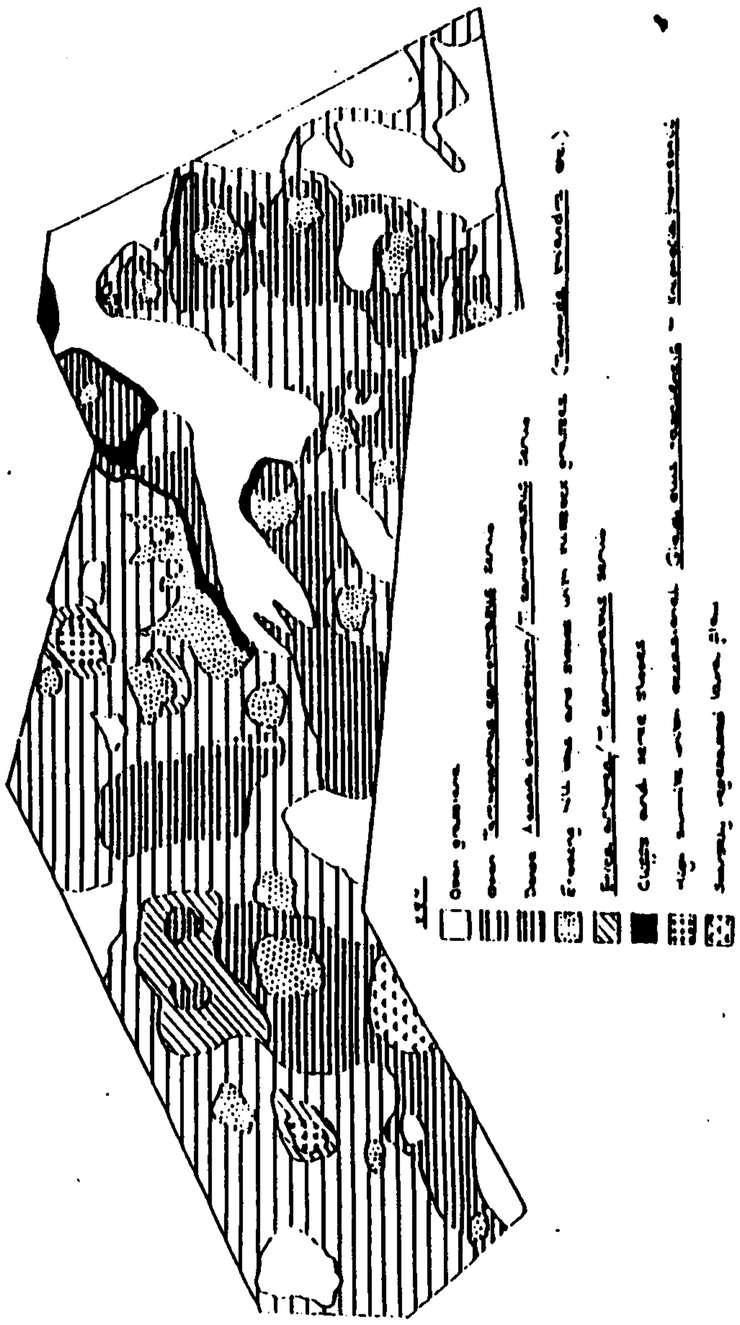
Month	Temperature, °C (1937-54) Mean Max.	Mean Max.	Mean	Mean Min.	Min.	Relative Humidity 1500, %	Rainfall (1910-62) Mean, mm	Wind, km/h (1938-54) 0900	1500
January	30.8	27.7	17.9	8.1	1.9	28	22	5.5	11
February	32.1	28.3	18.3	8.2	3.1	28	35	5.5	11
March	32.6	27.3	18.5	9.8	2.8	34	59	5.5	11
April	30.5	25.1	18.3	11.5	5.6	51	107	5.5	11
May	27.6	23.8	17.5	11.3	6.1	54	86	5.5	13
June	27.6	23.0	16.5	9.9	4.4	51	41	5.5	13
July	26.8	22.5	15.9	9.3	4.6	49	32	5.5	13
August	27.2	22.9	16.1	9.4	4.4	48	44	5.5	15
September	28.4	24.5	16.7	8.8	2.2	43	44	5.5	15
October	30.3	25.6	17.3	9.1	3.9	41	47	5.5	15
November	28.9	24.7	17.0	9.3	3.9	47	58	5.5	11
December	30.1	25.8	17.3	8.7	3.3	40	36	5.5	11

Daily Insolation, langleys (East African Meteorological Depart.)

	Kedong Ranch 0° 55 5,36° 30 E (1961-68) Max. Mean	Min. Mean	Mean	Kisumu 0° 06 5,34° 45 E (1973) Max.	Mean	Min.
January	583	550	503	658	587	412
February	621	547	480	697	573	250
March	570	526	405	671	593	547
April	525	473	431	662	566	447
May	512	435	362	638	548	342
June	519	419	371	621	541	432
July	474	377	252	595	469	366
August	466	390	136	656	550	392
September	576	509	442	703	540	276
October	624	530	480	688	575	470
November	544	479	388	645	561	444
December	543	495	464	659	582	441

APPENDIX VII

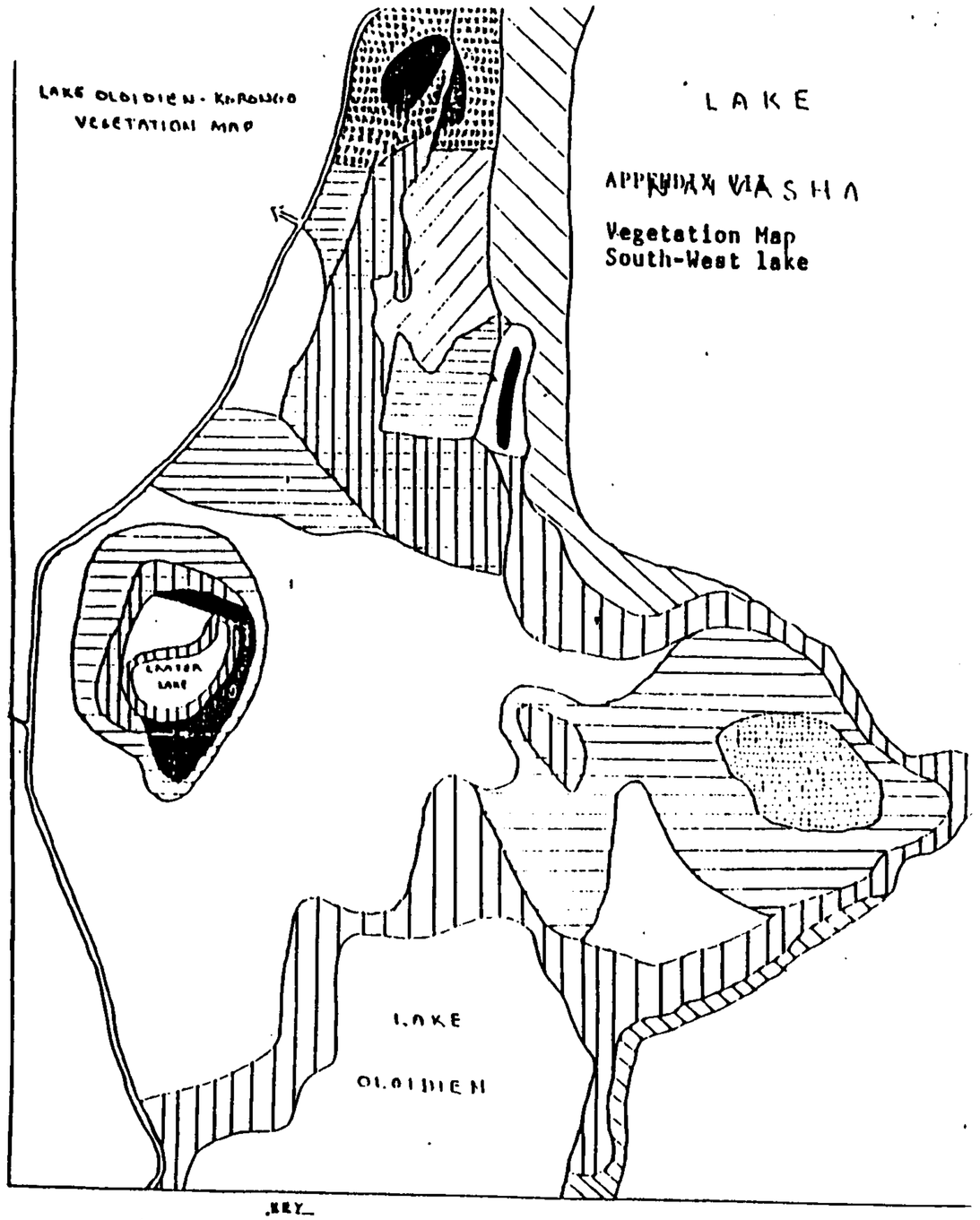
Vegetation Map
Hells gate Park



LAKE OLOIDIEN - KHRONGO
VEGETATION MAP

APPENDIX VIA SHA

Vegetation Map
South-West lake



APPENDIX VIII

Taxonomic list of Zooplankton groups and species found in Lake Naivasha 1978-80.

COPEPODA

1 *Thermocyclops oblongatus* Sars o
2 *Mesocyclops equatorialis* Kiefer
3 *Tropocyclops prasinus meridionalis* Kiefer

CLADOCERA

1 *Diaphanosoma excisum* Sars
2 *Simocephalus vetulus elizabethae* King
3 *Daphnia barbata*
4 *Daphnia pulex*
5 *Ceriodaphnia reticulata* Richard
6 *Moina micrura* Kurz
7 *Macrothrix* sp.
8 *Ilyocryptus sordidus* Richard
9 *Ilyocryptus dentifer* Richard
10 *Leydigia* sp.
11 *Leydigia* sp.
12 *Chydorus sphaericus* King

ROTIFERA

1 *Brachionus caudatus* Barrois & Daday
2 *Brachionus calyciflorus* Pallas
3 *Brachionus patulus* Muller
4 *Brachionus falcatus* Zacharias
5 *Brachionus quadridentatus* Hermann
6 *Epiphanes macrourus* Barrois & Daday
7 *Keratella tropica* Apstein
8 *Asplanchna brightwelli* Gosse
9 *Ascomorpha* sp.
10 *Filinia opoliensis* Ehrenberg
11 *Filinia longiseta* Ehrenberg
12 *Hexarthra jenkinae* Beauchamp
13 *Polyarthra* sp.
14 *Trichocerca* sp.
15 *Lecane* sp.
16 *Brachionus plicatilis* Gosse

APPENDIX IX

Plant lists for the littoral zone (Gaudet 1977)

Volcanic sand

Seedling Zone
- Cassia didymobotrya*
- Sesbania sesban

Grass-Sedge Zone
- Pennisetum clandestinum*
- Cyperus laevigatus*
- Cyperus rigidifolius

Leguminous Zone
- Cassisa didymobotrya*
- Hibiscus diversifolius*

Composite Zone
- Tarchonanthus camphoratus*
- Conyza hypoleucs*
- Psiadia punctulata
- Rhue vulgaris
- Lantana camara

Papyrus mud

Seedling Zone
- Senecio moorei*
- Gnaphalium luteoalbum*
- Sphaeranthus suaveolans*
- Nymphaea caerulea (on very wet mud)
- Cyperus spp.*

Sedge Zone
- Cyparus papyrus*
- Cyperus immensus*
- Cyperus digitatus ssp. auricomus*
- Scirpus inclinatus
- Sphaeranthus suaveolans

Composite Zone
- Conyza floribunda*
- Conyza bonariensis
- Gnaphalium luteoalbum*
- Sphaeranthus suaveolans
- Senecio moorei
- Polygonum spp.*
- Cyperus spp.

CHECK LIST OF LAKE EDGE FLORA

(* = not collected during present study, but earlier collect ion seen at the East African Herbarium, Nairobi).

APPENDIX IX

DICOTYLEDONS

Plant lists for the littoral zone

ACANTHACAEA
Hypoestes verticillaris (L.f.) Roem.& Schult.
Monechma debile (Forsk.) Ness

AIZOACEAE
Glinus lotoides L. X oppositifolius (L.) A.D.C.

AMARANTHACEAE
Achyranthes aspera L.
Amaranthus graecixans L

ANACARDIACEAE
Rhus vulgaris Meikle

APIACEAE (Umbelliferae)
Hydrocotyle ranunculoides L.F.

ASCLEPIADACEAE
Gomphocarpus physocarpus E. Mey.

ASTERACEAE (Compositae)
Aster muricatus Less.
Sidona piiosa L.
Conyza bonariensis (L.) Cronq.
Conyza floribunda H.B.K.
Conyza hypoleuca A. Rich.
Conyza steudlii A . Rich .
*Conyza stricta Willd.
Crassocephalum picridifolium (D.C.) S. Moore
Gnaphalium luteoalbum L.
*Gnaphalium undulatum L.
Melanthera scandens (Schumach. & Thonn.) Roberty ssp. madagascariensis (Bak.) Wild
Pluchea ovalis (Pers.) D.C.
Psiadia (arabica Jaub. Spach) punctulata (D.C.) Vatke
*Senecio discifolius Oliv.
Senecio moorei R.E. Fries
*Senecio nandensis S Moore
*Senecio petitianus A. Rich
*Senchus oleraceus L.
*Sphaeranthus confertifolius Robyns
Sphaeranthus suaveolens (Forsk.) D.C.
*Sphaeranthus napierae Ross-Craig
Tagetes minuta L.
Tarchonanthus camphoratus L.
Vernonia glabra Vatke

page flora book

yield check

area + zone

BRASSICACEAE (Cruciferae)
Erucastrum arabicum Fisch. & Mey.

CAESALPINIACEAE
Cassia didymobotrya Fres.

CARYOPHYLLACAE
Polycarpon prostratum (Forsk.) Aschers & Schweinf.

CERATOPHYLLACEAE
Ceratophyllum demersum L.

CHENOPODIACEAE
Chenopodium album L.
Chenopodium ambrosoides L .
Chenopodium opulifolium Koch & Ziz

CONVOLVULACEAE
Cuscuta campestris Yuncker
Ipomoea cairica (L.) Sweet

CUCUBITACEAE
Zechneria scabra (L.f.) Sond.

FABACEAE (Papilionaceae)
Lotus corniculatus L. var. eremanthus Chiov.
Sesbania seban (L.) Merr. var. rubica Chiov.
Vigna luteola (Jacq.) Benth.

GERANIACEAE
Monsonia senegalensis Guill. & Perr.

LAMIACEAE (Labiatae)
Leonotis nepetifolia (L.) Ait. f.
Pycnostachys deflexifolia Bak.
Satureja biflora (D. Don) Benth.

LENTIBULARIACEAE
Utricularia gibba L.
Utricularia inflexa Forsk.
Utricularia reflexa Oliv.

MALVACEAE
Abutilon mauritianum (Jacq.) Medic.
Hibiscus diversifolius Jacq.

MIMOSACEAE
Acacia xanthophloea Benth.

NYMPHAEACEAE
Nymphaea caerulea Savigny

ONAGRACEAE
Lugwigia stolonifera (Guill. et Perr.) Raven

POLYCONACEAE
Polygonum pulchrum Blume
Polygonum salicifolium Willd.
Polygonum senegalense Meisn. f. senegalense
Polygonum senegalense Meisn. f. albotomentosum R. Grah.

*Polygonum strigosum R. Br.
Rumex usambarensis (Dammer) Dammer

RANUNCULACEAE
Ranunculus multifidus Forsk.

SCROPHULARIACEAE
Rhamphicarpa montana N.E. Br.

SOLANACEAE
Physalis peruviana L.
Solanum nigrum L.

VERBENACEAE
Lantana camera L.
*Verbena officinalis L.

MONOCOTYLEDONS

ARACEAE
Pistia stratiotes L.

CYPERACEAE
Cyperus alopecuroides Rottb.
Cyperus digitatus Roxb. ssp. auricomus (Sieber) Kuk.
Cyperus immensus C.B.Cl.
Cyperus laevigatus L.
Cyperus nudicaulis Poir.
Cyperus papyrus L.
Cyperus rigidifolius Sted.
*Cyperus stuhlmannii C.B.Cl.
Pycreus mundtii Nees
Scirpus inclinatus (Del.) Aschers. & Schweinf.

LEMACEAE
Lemna perpusilla Torrey
Lemna trisulca L.
Spirodela polyrhiza (L.) Schleid.
Wolffia arrhiza (L.) Wimmer
Wolffiopsis welwitschii (Hegelm.) den Hartog & v.d. Plas

NALADACEAE
Naias pectinata (Perl.) Magnus

ORCHIDACEAE
Eulophia paivaeana (Reichb. f.) Summerh. ssp. borealis Summerh.

POACEAE (Gramineae)
Cynodon aethiopicum Clayton
Pennisetum clandestinum Chiov.
Sporobolus spicatus (Vehl) Kunth
Rhynchelytrum repens (Willd.) C.E. Hubb.

POTAMOGETONACEAE
Potamogeton octandrus Poir.
Potamogeton pectinatus L.
Potamogeton schweinfurthii A. Bennett
Potamogeton thunbergii Cham. & Schlecht.

TYPHACEAE
Typha domingensis Pers.
Typha latifolio L.

FERNS

ADIANTACEAE
Pteris dentata Forsk.

AZOLIACEAE
Azolla africana Desv.

MARSILEACEAE
Marsilea gibba A.Br.

SALVINIACEAE
Salvinia molesta Mitch.

THELYPTERIDACEAE
Thelypteris confluens (Thunb.) Morton

MOSSES

AMBLYSTEGIACEAE
Drepanocladus sparsus C. Mull.

LIVERWORTS

RICCIACEAE
Ricciocarpus natans L.

ALGAE

CHARACEAE
Chara braunii Gmel.
Nitella oligospira Br.
Nitella knightiae Gr. et St.

APPENDIX X

Table 1. Fish and Crayfish catches for 1989 (kgs)

Month	T. Leucosticta	Black Bass	T. Zillii	Crayfish
January	5471	1687	120	5462
February	9185	1969	131	8803
March	13434	2574	340	10766
April	13446	2329	45	9097
May	11433	2566	80	10156
June	12458	3488	21	9885
July	12066	3400	56	6704
August	10897	3354	166	8390
September	12811	3745	21	6146
October	10316	4527	75	6062
November	8660	3751	225	2378
December	11292	2968	60	9982
Totals	131,469	36,358	1,340	93,833
Overall total tonnage	263.0			

Table 2. Total fish catches including crayfish and value in 1992.

Month	Weight (kg)	Value (shs)
January	34,612	693,886
February	33,647	425,402
March	29,258	517,918
April	33,403	656,659
May	20,076	402,442
June	19,598	363,082
July	13,597	292,738
August	12,111	281,107
September	8,703	225,634
October	11,554	285,691
November	6,691	184,487
December	11,828	296,385
Totals	235,078	4,725,431

(Source. Fisheries Department, Naivasha.)

APPENDIX XI

Density of Herbivores around the lake.

1. Kedong ranch
2. Hell's Gate Park.

Mean(±S.E) population and density estimates of large herbivores in Kedong

Ranch Species	Mean	S.E	n	density/km²
Kongoni	73	99	8	6.15
Zebra	451	61	8	3.76
Eland	226	27	8	1.88
Thomson's gazelle	1023	91	8	8.53
Grant's gazelle	64	7	8	0.53
Warthog	6	1	7	0.05
Reedbuck	3	0.8	7	0.03
Wildebeest	1	-	6	0.08
Impala	155	10	8	1.29
Reticulated giraffe	5	0.5	6	0.04
Masai giraffe	9	1	8	0.08
Dikdik	3	0.4	5	0.03

S.E-standard error
n-the number of months a species was counted
density was calculated using total ranch area

(Source; University of Leicester)

Mean(+S.E) population and density estimate of large herbivores in the park

Species	Mean	S.E	n	density/km²
Kongoni	298	13	8	4.35
Zebra	223	33	8	3.27
Thomson's gazelle	44	5	8	0.64
Warthog	22	0.5	8	0.32
Klipspringer	11	1.3	8	0.16
Eland	89	23	7	1.30
Steinbuck	13	3	4	0.19
Reedbuck	8	0.9	8	0.12
Masai giraffe	9	2	8	0.13
Grant's gazelle	32	6	8	0.47
Reticulated giraffe	5	0.5	8	0.07
Buffalo	99	3.3	5	1.45
Dikdik	8	0.7	7	0.12

S.E-standard error
n-the number of months a species was counted
density was calculated using total park area

Appendix XII

Table 1. Water bird counts on Rift Valley Lakes (Bennum 1993)

	NAV[a]	OLD	SON	ELM	NAK	BOG[b]	TOTAL
Grebes							
Great Crested Grebe	0	2	0	0	0	0	2
Black-necked Grebe	0	0	0	19	596	619	1234
Little Grebe	512	277	10	431	1232	23	2485
Unidentified grebes	0	0	0	0	72	0	72
Pelicans							
White Pelican	78	36	0	432	4607	6	5159
Pink-backed Pelican	1	14	0	60	4	0	79
Cormorants and darters							
Long-tailed Cormorant	1027	8	0	0	8	0	1043
Great Cormorant	480	75	0	55	578	0	1188
African Darter	1	0	0	0	0	0	1
Herons							
Grey Heron	40	9	0	99	31	1	180
Goliath Heron	37	2	0	0	0	0	39
Black-headed Heron	2	0	0	2	0	0	4
Purple Heron	97	0	0	0	0	0	97
Cattle Egret	68	1	0	0	49	0	118
Great White Egret	4	1	0	70	6	0	81
Black Heron	0	0	0	10	0	0	10
Little Egret	37	7	0	106	49	0	199
Yellow-billed Egret	8	0	0	4	4	0	16
Squacco Heron	96	0	0	8	1	0	105
Night Heron	0	0	0	2	0	0	2
Unidentified bittern	1	0	0	0	0	0	1
Storks							
Hamerkop	0	0	0	0	2	1	3
White Stork	0	0	0	0	1	0	1
Wolly-necked Stork	0	0	0	0	1	0	1
Saddle-billed Stork	1	0	0	0	0	0	1
Marabou	6	0	0	1	140	5	152
Yellow-billed Stork	43	5	0	133	9	0	190
Ibises and spoonbills							
Hadada Ibis	21	8	0	2	17	0	48
Glossy Ibis	102	12	0	14	820	0	948
Sacred Ibis	63	0	0	21	46	0	130
African Spoonbill	42	1	0	121	22	0	186

	NAV[a]	OLD	SON	ELM	NAK	BOG[b]	TOTAL
Flamingos							
Lesser Flamingo	0	0	0	2497	750169	268139	1021805
Greater Flamingo	82	0	0	23772	612	229	24695
Ducks and geese							
Fulvous Whistling Duck	102	0	0	0	0	0	102
Cape Teal	0	7	0	294	45	328	674
Red-billed Teal	31	0	0	66	5	0	102
Hottentot Teal	264	83	35	20	56	6	464
Yellow-billed Duck	157	0	0	0	0	0	157
Southern Pochard	12	4	16	0	0	3	35
Maccoa Duck	0	92	0	0	0	0	92
Shoveler	83	0	0	141	0	0	224
Pintail	113	0	0	40	0	1	154
Wigeon	2	0	0	0	0	0	2
Garganey	64	0	8	20	7	0	99
Egyptian Goose	144	195	0	44	161	4	548
Spur-winged Goose	6	0	0	0	4	0	10
Knob-billed Duck	6	0	0	0	0	0	6
Unidentified ducks	2	0	0	0	0	0	2
Birds of prey							
Eurasian Marsh Harrier	11	0	0	4	3	1	19
African Marsh Harrier	20	0	0	3	10	0	33
Unidentified harrier	0	0	0	0	1	0	1
African Fish Eagle	92	12	0	8	32	6	150
Osprey	5	1	2	0	0	0	
Cranes							
Grey Crowned Crane	0	0	0	0	12	2	14
Gallinules and coots							
Common Moorhen	25	0	0	0	0	0	25
Blake Crake	152	0	1	0	0	0	153
Purple Gallinule	3	0	0	0	0	0	3
African Water Rail	1	0	0	0	0	0	1
Red-knobbed Coot	4802	1081	0	1	19	0	5903
African Jacana	266	0	0	0	0	0	266
Plovers							
Ringed Plover	21	37	0	31	92	8	189
Kittlitz's Sandplover	0	2	0	23	167	10	202
Three-branded Plover	0	0	0	12	0	1	13
Blacksmith Plover	187	74	0	14	160	0	435
Long-toes Plover	121	0	0	0	0	0	121
Spur-winged Plover	80	4	0	0	2	30	116
Unidentified Plover	1	0	0	0	18	2	21

	NAV*	OLD	SON	ELM	NAK	BOG*	TOTAL
Sandpipers, stints etc.							
Common Sandpiper	94	51	9	22	30	6	212
Curlew	0	0	0	5	4	0	9
Wood Sandpiper	113	30	8	1	9	1	162
Greenshank	11	0	1	4	19	0	35
Marsh Sandpiper	89	63	16	125	164	6	463
Snipe sp.	0	6	0	2	1	0	9
Curlew Sandpiper	22	3	0	26	28	0	79
Little Stint	48	149	0	1841	702	385	3125
Black-tailed Godwit	32	10	0	0	4	6	52
Unidentified godwit	1	0	0	0	0	0	1
Ruff	530	189	6	421	1285	465	2896
Unidentified sandpiper	23	0	0		0	0	23
Black-winged Stilt	71	34	6	508	228	364	1211
Avocet	0	0	0	1066	80	9	1155
Red-necked Phalarope	0	0	0	1	0	0	1
Unidentified waders	21	0	20	0	2	0	43
Gulls and terns							
Grey-headed Gull	424	33	1	348	1207	10	2023
Lesser Black-backed Gull	58	0	0	4	6	0	68
Slender-billed Gull	0	0	0	0	1	0	1
Black-headed Gull	4	2	0	5	69	0	80
Unidentified gulls	1	0	0	0	0	0	1
Whiskered Tern	140	34	0	436	307	0	917
White-winged Black Tern	61	27	0	82	674	0	844
Chlidonias tern sp.	146	0	0	0	0	0	146
Gull-billed Tern	22	21	0	30	180	0	253
Unidentified Terns	1	37	100	0	0	0	138
African Skimmer	1	0	0	0	0	0	1
Kingfishers							
Giant Kingfisher	3	11	0	0	0	0	14
Pied Kingfisher	87	31	0	2	0	0	120
Malachite Kingfisher	16	0		0	0	0	16
Total flamingos	82	0	0	26269	750781	269368	1046500
Total other birds	11559	2781	239	7240	14089	2309	38217
Overall total	11641	2781	239	33509	764870	271677	1084717
No. of species	69	43	13	55	58	29	85

*NAV, Lake Naivasha; OLD, Lake Oloidien; SON, Lake Sonachi; ELM, Lake Elmenteita; NAK, Lake Nakuru; BOG, Lake Bogoria. *Complete count for flamingos; around 60% of shoreline covered for other species.

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August 1995

PART II : Management

LIST OF TABLES AND FIGURES

SUMMARY OF MAIN POINTS

Introduction

Lake Naivasha is a highly significant national freshwater resource in an otherwise water deficit area. Apart from the invaluable freshwater it also supports large and vitally important economic activities - mainly flower growing and geothermal power generation. The area is thus a major contributor to Kenya's GDP and employment effort and to socio-economic development of the country as a whole. Lake Naivasha is also a Ramsar site being a wetland of international importance with a rich biodiversity, including some endangered species, and supports tourism and research activities.

The Lake and its surrounds are fragile with dynamic ecosystems and a yet uncertain water balance in a basin surrounded by intensively irrigated agricultural land and a fast growing township. It seems certain that **the Lake cannot sustain further development on the scale seen over the past 10 to 15 years without there being in place a coordinated plan for the future.** The land surrounding the Lake is mainly in private ownership and there exists an Association of such owners with a large degree of consensus over the future management of the Lake, and thus ideally suited to lead a community based management team.

Objective

The prime objective of the Management Plan is to manage existing human activities in the Lake ecosystem through voluntarily adopted sustainable wise use principles to ensure its conservation.

Secondary objectives are:

- to maintain, conserve and, where necessary, restore the natural beauty and biodiversity of the Lake;
- to promote and encourage the major contribution made to the national economy;
- to achieve consensus, an understanding of and support for the Management Plan through voluntarily adopted codes of practice and dialogue;
- to facilitate public access, tourism and research activities whilst at the same time respecting the private ownership of the surrounding land;
- to immediately adopt practices on which there is consensus based on current knowledge and to adopt others as the Plan is updated in the light of new information from the monitoring programme.

Method

The institutional framework under which the management of the Lake will be effected initially, will be a Trust formed by Lake Naivasha Riparian Owners Association (LNROA), to be incorporated under the Companies Act. Trustees would be 4 suitably non partisan individuals appointed by the LNROA. The Trustees will appoint a Management Committee to implement their policy. The Management Committee will be a more widely representative body of not more than 12 individuals including, as a minimum, representatives from the Kenya Power Company, the Municipal Council, local administration, the Kenya Wildlife Service and IUCN, and majority LNROA representation. Later a Company limited by guarantee may be formed to replace the Trust.

The LNROA does not have jurisdiction over or membership from persons beyond the Lake edge and Catchment residents. Central Government and Research Institutions are unrepresented. In order to ensure that a wider cross section of the community are involved, the LNROA will open its membership by invitation to Associate membership so that those with a legitimate interest and contribution to make can become directly involved.

The Plan

The principal immediate measures envisaged by the Management Plan are to:

- strengthen the water abstraction licensing procedures;
- establish metering of abstractions and monitoring the use of water;
- promote efficient use of water;
- protect and where necessary re-establish the Papyrus fringe around the Lake and allow its natural growth;
- maintain and where necessary restore to a natural state a minimum 50 metre buffer zone on the landside of the Papyrus edge
- discourage the reclaiming of flooded land, intensive irrigated agriculture, and building of permanent structures, below the 1906 Lake level (6210' contour);

- establish sources of revenue to fund the Management Plan;
- establish direct representation on appropriate regulatory bodies of local and central administration;
- establish accepted codes of practice in pesticide use, publish a list of acceptable products and monitor their use, publish a list of unacceptable chemicals and outlaw their use;
- influence a reversal of adverse activities in the watershed;
- implement a technical study of the full water budget and support a study of an alternative source of water for Nakuru;
- implement monitoring, education and awareness programmes.
- establish contingency planning for natural and man made disasters;

The Impact on the LNROA Members

The main impact of the immediate actions called for by the Plan on the Riparian landowners and others in the Catchment will be:

- a return to, respect for, and adherence to existing regulations on, among others, water apportionment, cultivation of river banks, activities in forest areas, agrochemical use, and preservation of Papyrus;
- a formalisation of the authority of the Trust over the Plan's recommendations and empowerment of enforcement where necessary, primarily through peer and market pressure;
- a voluntary limitation on the degree of expansion of existing, or implementation of new, projects requiring high input of Lake/River water;
- a requirement for more input than in the past from the members of time, money, exchange of information and community spirit to build consensus and develop the Plan for the benefit of all.

PART I

BACKGROUND

1. GENERAL DESCRIPTION

1.1 Geographical Location

Lake Naivasha is a shallow freshwater Lake situated in the Eastern Rift Valley in Kenya at a mean altitude of 1885m above sea level. It is located at latitude 00° 46'S and longitude 36° 22'E in Nakuru District, about 100 km Northwest of Nairobi. The Lake ecosystem consists of a Main Lake, a smaller sometimes separate Oloidien, and the smallest of the three - a Crater Lake Sonachi. The two smaller Lakes are much more alkaline than the Main Lake.

1.2 Natural Resources

Lake Naivasha has important natural resources - in some cases unique within a wide area including:

- Fresh water
- Geothermal power
- Diverse habitats
- Wide variety of mammals and birds
- Productive fishery
- Natural beauty and mild climate

1.3 Guiding factors of the Management Plan

The following factors determine the management options for Lake Naivasha and its environs:

- Lake Naivasha is a national resource of great value but mainly surrounded by private land;
- activities around the Lake make multiple and large contributions to the national economy;
- the diversity of present human activities is desirable and should be continued provided that they are sustainable;
- the Lake is a closed system whose watershed boundary is beyond the authority of Naivasha Division and the riparian owners;
- the ecosystem of the Lake is dynamic and changes rapidly due to its nature and characteristics;
- the Lake level is presently some 7 metres below the boundary between privately owned and riparian land - the level attained in 1906 of 1893.3 masl (6210' asl);
- Riparian land is granted by Government to the adjacent land owners to conserve;
- there are many and sometimes conflicting demands placed on the Lake's natural resources;
- the Lake is a wetland of recognised international importance;
- local resource users should play a major part in sustainable wise use principles, management, and biological diversity conservation;
- the largest component by far of the water input comes from the Malewa River. Both the river and its Catchment are vital for the Lake, and all its allied human activities and must be conserved at all costs.

2. OBJECTIVES

2.1 Long-term Management Objectives

- to maintain and enhance the quality and quantity of freshwater resources;
- to ensure sustainable wise use of all resources of the Lake for the development of the local area and the country in general;
- to manage and conserve the natural beauty and biological diversity of the Lake and its environs;
- to improve the standard of living of the people through regional development and economic growth while conserving biological diversity;
- to promote research and awareness of the value and fragility of the ecosystem;
- to provide sustainable recreation, tourism, and public access facilities for national and international visitors.

2.2 Short-term (operational) Objectives

- to produce an acceptable and effective Management Plan, disseminate its principles and objectives and ensure its voluntary adoption by members of the LNROA;
- to set up an institutional framework and binding principles for the management of the Lake;
- to obtain Government and local administrative support for the Plan;
- to establish a monitoring programme and a data base to improve understanding of the Lake's water budget and the general ecology of the Lake and its environs;
- to ensure the management of Lake Naivasha under the principles of wise use applicable to a Wetland of International Importance under the Ramsar Convention;
- to restore the ecological character of the Lake and its environs where appropriate;
- to determine research priorities and funding requirements to support management planning;
- to develop educational programmes and increase public awareness to support the management process.

3. ATTRIBUTES

3.1 Size and Position of Ecological Unit

Lake Naivasha is a relatively small Lake compared with the other Rift Valley Lakes. The Catchment is approx. 3200 km^2. The area of the Lake is prone to major fluctuations, varying from 102 km^2 during dry cycles to 150 km^2 during wet cycles. The Main Lake is shallow, deepening towards its southwestern part to a maximum of 8m in depth, though the deepest part of the Lake is at 16m off Crescent Island. The volume of the Lake has varied between $50x10^6$ m^3 and $600x10^6 m^3$ in recent times though once was part of a much larger Lake.

The area of Lake Naivasha and environs is important for its biological diversity and freshwater resources. It supports intensive irrigation-based agriculture, geothermal power, fishery, and tourist industries. Its freshwater and altitude make it extremely enviable. The rivers and groundwater sources within the watershed provide water supply to Naivasha and Nakuru townships and adjoining human activities. Due to the intense use of the land and the Lake waters and being a closed basin system, it is extremely susceptible to pollution from farmlands, settlements and industries, and river inflows.

3.2 Biological Diversity

For the purposes of the Management Plan, the area has been divided into two regions, namely the Lake Zone and the Catchment and Rivers. The Lake Zone is an open water wetland and riparian area with characteristic plants and animals, while the Catchment is a drier region with only two permanent rivers, steep gradients, and fragile soils.

The vegetation of both regions supports a large number of herbivores. Nearby Hells' Gate National Park, with access corridors to the Lake, is home to many species of wildlife. More than 350 species of birds including 74 species of water birds have been recorded in the Lake zone in the regular counts for the African Waterfowl census. One farm alone, with an area of 460 ha., is home to 251 species of birds, 34 mammals including 5 rodents, and 8 reptiles.

3.3 Naturalness, Rarity and Fragility

Lake Naivasha has a natural beauty and features which have attracted tourists and tourist infrastructure, including Hell's Gate, Mt. Longonot (2777m) and the Lake itself. Despite the rapid growth of human activity in the Lake's surrounding area it has retained most of its natural beauty which is planned to be enhanced for posterity. With the absence of an overall authority, Management Plan, or a strong institutional framework, the present uncoordinated use of resources is capable of permanently damaging the ecosystem and cannot be allowed to continue without a plan.

Lake Naivasha is the only freshwater Lake on the floor of the Rift Valley in Kenya, with good quality water for agriculture, all others being sodic. Due to its shallow nature and fragility, there are unique challenges for management to maintain its biodiversity. Since it is often difficult to assess the effects of nutrient enrichment on shallow Lakes until it is too late for remedial measures, severe restriction should be placed on inflows of nutrients, pollutants and toxic substances. It also supports Kenya's only economically justifiable geothermal power station using naturally occuring underground superheated water. Geothermal power is one of the most eco friendly sources of electric power.

4. THE WATER BUDGET

4.1 Introduction

Lake Naivasha Catchment has an internal drainage system. There is no surface outlet. It has underground water inflows and outflows and the freshness of the water is largely as a result of such outflows from the Lake.

The water inputs to the Lake include rainfall that occurs directly over the Lake, inflow from the rivers and surrounds (runoff) and also through underground water movement from the Catchment (seepage-in). The outputs are direct evaporation from the water body and transpiration from the swamp area and other aquatic vegetation (the combined outputs of evaporation and transpiration is referred to as evapotranspiration). The other outputs are underground seepage out of the Lake and water abstraction for human activities. The accounting of water inputs and outputs including consequent change in storage is called the water budget.

4.2 Estimates of the Inputs and Outputs

Most of the data used in the water budget are from different periods because of varying availability and reliability. The mean rainfall, evaporation and river flows were determined and averaged for the Lake area and therefore reflect changes in rainfall regime over the recent past years (see Table 2). Where information on water abstraction was unreliable, estimates based on electric power consumption used in pumping water were made based on The Kenya Power & Lighting and the Ministry of Water office records in Naivasha. For this first approximation, it has been assumed that seepage-in is equal to seepage-out during all cycles of climates in the area as there is no data to suggest other values. Substantial flash floods from the unguaged areas of the watershed have been computed, and their magnitudes reflect increasing areas that have been made impervious as a result of the establishment of greenhouses, cultivations and settlements. Shallow boreholes around the Lake (pumping from levels of 40m or less from the surface) are assumed to be pumping from the Lake aquifer. These data are preliminary, unconfirmed and will be reviewed and refined once the monitoring programme begins to yield information upon which to build a more accurate water budget.

Table 1. **Variables Used in the Water Budget** (figures subject to confirmation)

Variables	Wet Conditions	Mean Conditions	Dry Conditions
Direct rainfall on the Lake	939 mm	608 mm	442 mm
Open Water Evaporation	1529 mm	1529 mm	1743 mm
vapotranspiration from swamps	2141 mm	2141 mm	2440 mm
Area of swamps	18 km^2	12 km^2	9 km^2
Area of Lake	150 km^2	120 km^2	102 km^2
Lake Storage (millions of cubic metres)	600	320	50
Average Lake Level (masl)	1888.3	1885.0	1882.3

Table 2. **The Annual Rainfall at Representative Stations on the Lake**

YEAR	STATION 1 (mm)	STATION 2 (mm)	STATION 3 (mm)
1975	–	644	603
1976	–	452	501 D
1977	–	739	810 W
1978	905 W	830 W	1011 W
1979	658	599	751
1980	609	553	696
1981	756	692	673
1982	567	689	934 W
1983	639	569	796 W
1984	610	429 D	391 D
1985	676	479 D	704
1986	445 D	521 D	500 D
1987	389 D	507 D	675
1988	608	607	725
1989	1048 W	984 W	740
1990	868 W	717	760
1991	602	518 D	549
1992	589	677	568
1993	562	519 D	563
1994	633	750	691

Notes:

a) Station 1 is in the South of the Lake, Station 2 in the South East and Station 3 in the North.
b) 25.4 mm = 1 inch
c) The definition of "Dry", "Mean" and "Wet" Conditions used in Tables 1 and 3 is an average of 442, 608 and 939 mm of rainfall per annum respectively. The mid points between these figures (525 mm and 774 mm) have been used to differentiate between Dry, Mean, and Wet years in analysing the above figures. (W = Wet, D = Dry)
d) Rainfall figures are only partly indicative of Dry, Mean, or Wet Conditions. The pattern of rainfall is probably more important than the quantum and in several recent years although the aggregate rainfall for the year may indicate a "Mean" year, the way in which the rain has fallen has produced "Dry" conditions.
e) Analysis of the above figures shows considerable variation from one station to another though they are relatively closely located. They also show that dry and wet years tend to come in two's or more at a time.

Figure 1. The Inputs & Outputs of the Water Budget for mean conditions.

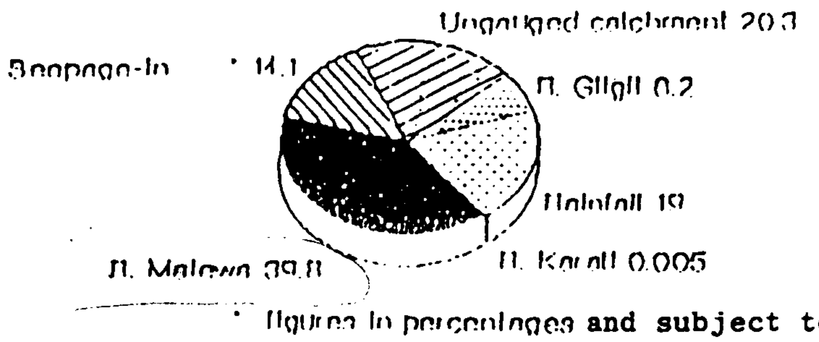


Fig. 2: The Outputs of the Water Budget for Mean Climatic Conditions

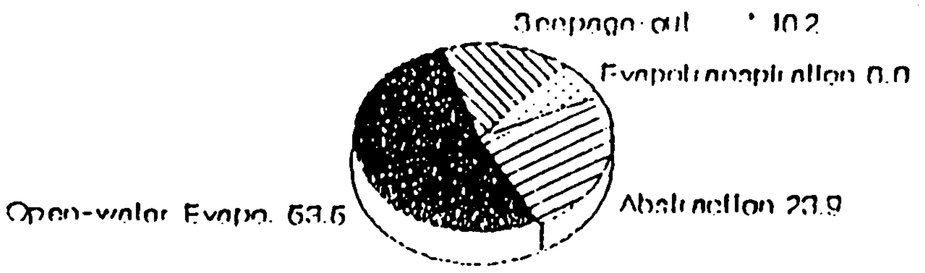


Fig. 3: The Inputs of the Water Budget for Dry Climatic Conditions

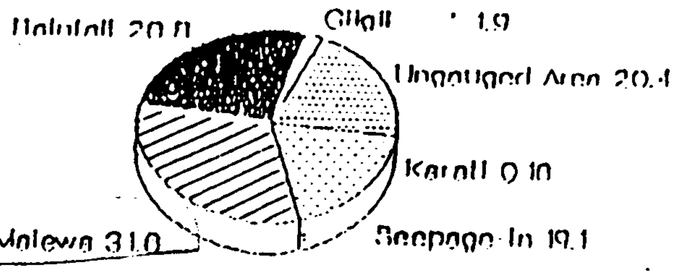


Fig. 4: The Outputs of the Water Budget for Dry Climatic Conditions

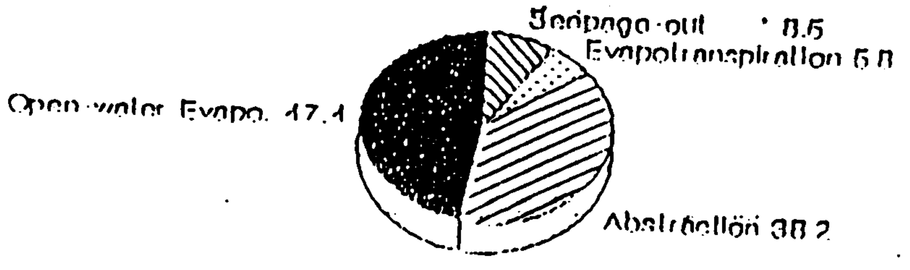


Table 3. **The Preliminary Annual Water Budget (in millions of cubic metres of water) (subject to confirmation)**

Inputs	Wet Conditions	Mean Conditions	Dry Conditions
Direct Rainfall over the Lake*	140.8	72.9	45.0
Malewa River	378	153	53
Gilgil River	74	24	3.2
Karati river	6.5	2.1	0.28
Unguaged Area of the watershed	117.8	77.9	34.2
Seepage-in	54	54	32
TOTAL INPUTS	**771.1**	**383.9**	**167.7**

Outputs	Wet Conditions	Mean Conditions	Dry Conditions
Loss due to Evapotranspiration*	38.5	26.7	21.9
Evaporation loss*	229	183.5	177.8
Seepage-out	54	54	32
Abstraction (Estimated)	33.8	44.6	53.2
TOTAL OUTPUTS	**355.3**	**308.8**	**284.9**
BALANCE	**+415.8**	**+75.1**	**-117.2**

* Note: Amount in Table 1 x Area in Table 1 = the volume in Table 3

The following can be deduced from this water budget:

- the surplus during mean conditions is mainly from surface runoff or flash floods from rivers and ungauged areas of the watershed;
- in prolonged dry conditions the Lake is acutely threatened by present levels of abstractions;
- increased abstraction or expansion of present activities cannot be sustained if several dry years follow each other.

The management strategy has been based on data for dry conditions because it safeguards investment being based on a "worst case scenario" and the Management Plan is conservation-oriented. Water abstraction may be increased in future if additional data, especially on the water budget, becomes available and indicates a safe surplus. Opportunities for increased allocation of water will also arise from improved irrigation technology and increased efficiency of water use.

5. THREATS TO SUSTAINABLE UTILISATION OF LAKE NAIVASHA FRESHWATER RESOURCES

5.1 Out of Basin Transfer

The greatest single threat to the Lake is out of basin transfer of water from any river inflow source - particularly the main river, the Malewa. Being situated in a water deficit district this is a constant threat until alternative supplies are found for Nakuru town - 60 km to the North in its own dry basin.

5.2 Water Abstraction

Another serious threat to the ecological and economic sustainability of the Lake is the amount of water abstracted each year. Assuming mean climatic conditions, there appears to be a surplus just enough to increase the Lake levels by 4.0 cm per year, but the water budget for dry conditions shows a disturbing deficit. The probability of more frequent dry conditions in future as observed from past records and current trends is considered likely.

5.3 Water Pollution

The Lake is under threat of nutrient enrichment and pollution from urban and agricultural activities in its Catchment and surrounding. In other similar situations discharges from highly fertilised agricultural lands give rise to nuisance growth of aquatic plants such as algal blooms resulting from increased nutrient load of phosphorus and nitrogen, leading to decreased water transparency and decrease in dissolved oxygen concentrations. This may occur in Naivasha unless the Papyrus swamp around the Lake (which is known to have a purifying influence on the surface water inflows by taking up nutrients and toxins) is preserved. Burning Papyrus releases toxins into the Lake in the form of ash and must be avoided.

The 250,000 people living around Lake Naivasha (often in inadequate housing and unsanitary living conditions) are a potential threat. The urban sewage system has broken down in the last two years, and its inadequate capacity and lack of resources from the Council compound the problem. Besides sewage effluent, impervious surfaces and thus storm runoff will increase as the population of the municipality grows and the opportunities for increasing industrial pollution to the Lake will rise.

Increasing use of pesticides also threatens the life of the Lake, especially through bio-magnification in the food chain. This needs to be addressed by promoting knowledge about and commitment to environmental issues amongst the farmers. Unchecked commercial fishing activities also have the potential to seriously pollute the Lake water.

Table 4. **Potential Sources of Pollution unless properly managed**

Sources of Pollutants	Estimated Magnitude	Remarks
Agriculture	significant	Mainly agro-chemicals and silt
Municipal & Domestic	significant	Expected to increase with adequate water supply to the town and other settlements
Rivers and Catchment	significant	Sediment discharge into the Lake causes siltation and delta formation at the river mouths
Industrial	significant	Mainly from flash floods from the town, industrial developments, and air and river pollution
Airborne	negligible	Acid rain reported but not substantiated
Recreation & Tourism	negligible	Little evidence at present

5.4 Weeds and Introduced Species

Several species of exotic water plants have become weeds in the Lake itself while increased nutrient levels and soil disturbance have encouraged the growth of terrestrial weeds in the Lake zone.

Various exotic animals have been introduced to the Lake zone in the past and have caused problems while seriously affecting native species.

The present status of weeds and other exotic species should be closely monitored and action taken where necessary to protect the fragile ecosystem.

5.5 Inappropriate Activities on Riparian Land

The following activities are considered to be inappropriate or illegal on Riparian land, i.e. the land below the 1906 Lake level or 1893.3 masl, 6210' contour:

- 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 from other than its natural state;
- intensive irrigated agriculture particularly involving the use of fertilizers or pesticides.

5.6 Threats from within the Catchment

Increasing population growth and intense land utilisation in the Catchment are likely to:

- accelerate the rate of soil erosion and consequently cause increased siltation and nutrient enrichment in the Lake;
- impoverish the soil, hence increase the need for agro-chemicals as farm inputs;
- increase destruction of forest cover to open steep slopes to cultivation, charcoal burning, etc;
- encourage unplanned growth of human settlements in Naivasha town and other satellite areas;
- increase demand for food thus promoting intensive farming practices that may cause high water use from, and runoff pollution into, the rivers;
- increase demand for water abstraction from the rivers for domestic and power generation purposes.

5.7 Tourism and Recreation

Between 1985 and 1992, the number of visitors to Hells' Gate National Park increased by more than 600%. In 1994 a total of 41,000 visitors entered the two parks in Naivasha system - Hells' Gate and Mt. Longonot.

The following features of tourism and recreation are of concern:

- rapid growth of the tourist industry may outstrip the provision of infrastructural facilities, such as sewage disposal;
- mass tourism may cause disturbance to breeding places and fragile ecosystems;
- availability of public access may become inadequate and overcrowded.

5.8 Future Plans of KPC

Geothermal energy is one of the most environmentally friendly sources of power. This indigenous and relatively cheap source of energy for Kenya, available at the Olkaria geothermal power production plant of The Kenya Power Company Limited is expected to play a significant role in the country's economic development for some years to come. Generation of power from geothermal resources is planned to increase in Kenya for at least the next 20 years from the present 15% or there abouts to approximately 28% of the country's demand.

Without real attention to environmental issues the development and expansion of Ol Karia geothermal power production by the Kenya Power Company has the potential to threaten the biological diversity and the water relations in the area. Effluent and gases from the geothermal facility may impact on the environment. The present KPC monitoring programme on the impact of the geothermal power station which is conducted using the World Bank's Operational Directive 4.01 guidelines must be continued and liaison maintained between KPC and LNROA. More importantly it is not yet known how the drilling affects the underground in and outflow of the Lake water or the interrelationship of the aquifers. However, The Power Company maintain that their use of water affects the lake aquifer very little and that their expansion plans can be accommodated provided that the current attention to environmental matters is sustained.

The KPC Environmental Impact Assessment Study of the Ol Karia Power Station development raises the following concerns:

- the existing and proposed geothermal developments may affect the Lake levels through abstraction for drilling wells, current power station operation and domestic use in company housing;
- possible hydraulic-link from the Lake to the geothermal field could result in a lowering of Lake levels;
- waste water from geothermal wells containing high fluoride, arsenic and mercury levels are potentially dangerous if improperly disposed;
- a method must be found of fixing elements such as arsenic and mercury in a harmless form;

5.9 Change in Land Use

Pastoralists occupied the area from the 18th century grazing the land and watering their stock on the Lake. The land use pattern has changed over the years with the arrival of sedentary farming and ranching. Pastoral activities have given way to intensive irrigated farming, land subdivisions, intensive use of agro-chemicals, deforestation and growth of Naivasha township, all of which adversely affect the ecosystem even though their benefits in development terms are obvious. However, further unplanned development cannot be sustained.

5.10 Conflict between Socio-economic Development and Biodiversity Conservation

The Lake presents an ideal situation where a community based management of the natural resources can be implemented. The management body must include representatives of residents of the Catchment area, local communities and Government. Lake Naivasha freshwater resources are already used for water supply, irrigation, industry, fishery, and tourism. The horticultural industry employs more than 20,000 people directly and many others indirectly, and also earns billions of Shillings in foreign exchange. Nearly 15% of Kenya's total electrical energy demand is supplied from Ol Karia geothermal power plant. Such rapid population and economic growth and consequent intensified demand on the already stretched resources can only be sustained within an integrated planning and management process.

The resources of Lake Naivasha and its surrounding area should be put to multipurpose use for power generation, agriculture, industry, fishery, tourism, and recreation, and for the promotion of rural development without damaging the resource base. Conflicting goals of various users must be harmonised within an integrated Management Plan otherwise socio-economic development is bound to exceed the sustainable capacity of the natural resources.

5.11 Uncoordinated Research

Although Lake Naivasha and its environs have been subject to much research in the past, especially in the late 1970s and '80s, and since 1983 annual research missions from Leicester University in U.K., in collaboration with the University of Nairobi, have carried out many investigations, there is a general lack of awareness that the natural resources of the Lake - especially its water - are finite and limiting to continued development. There is also a deficiency of information available to residents and the general public who may thus become antagonistic to a planning and management process.

There is an urgent need to co-ordinate and set priorities of such research and design methods of disseminating results so that the Management Plan can be constantly and appropriately updated to ensure that the Lake benefits from all research activities and the Plan is supported.

6. FACTORS INFLUENCING ACHIEVEMENT OF LONG-TERM OBJECTIVES

6.1 Role of the Local Community

The co-operation of the Government, both local and national, and the local community is important for obvious as well as other reasons, namely, in providing technical advice through extension in agriculture, health, natural resources utilisation, environment, and secondly to eliminate any suspicion. The Government has a right to demand proper management of the Lake's resources and in default can always invoke current legislation to ensure that a proper Management Plan is implemented. Cooperation in designing and implementing the Management Plan is the most effective method of consensus building and understanding the issues involved. The local community must have access to the management process and be able to influence it.

6.2 Internal Natural Factors

The Lake can be considered to be a fragile ecosystem which can change rapidly through natural processes which complicate management issues. Such complications are:

- small changes in the Lake levels have great effects on surface area;
- unstable ecology;
- changing water quality and quantity;
- changes in position and extent of Papyrus fringe and buffer zone;
- potential to become more sodic in dry spells.

6.3 Internal Human-induced Factors

The internal human-induced concerns can be summarised as:

- rapid growth of population due to job opportunities;
- unplanned human settlements in Naivasha town and along the road sides;
- high water demand for domestic, industrial, irrigation agriculture use, etc;
- discharge of pollutants, from pesticides used in agriculture and waste water from industrial and township developments;
- water quality deterioration;
- habitat destruction;
- encroachment of land use to the water's edge and the destruction of the buffer zone;
- deforestation and erosion in the watershed causing siltation and sedimentation of the Lake;
- increased storm runoff generated by development activities;
- long-term changes as a result of intensification of irrigated agriculture.

6.4 External Natural Factors

The main external natural factors may be summarised as:

- steep slopes with a predilection for soil erosion and relatively sparse vegetation being West facing and in a rain shadow;
- fragile and erodable nature of the soils;
- occasional flash floods causing high overland flow and storm runoff;
- recent trend towards dry conditions.

6.5 External Human-induced Factors

The external human-induced factors include:

- out-of-basin water transfer;
- population increase within the District;
- improper land use especially in the Catchment areas;
- absence of management plans for use of resources;
- lack of a monitoring programme;
- Catchment and Lake being in different administrative Divisions.

6.6 The Management Plan in the National Context

Lake Naivasha is a unique wetland ecosystem for Kenya in that its Riparian land is privately owned while the waters "belong" to Government. A Management Plan must take these facts into consideration while merging a local management process with national plans and policies. At the same time all users of Lake Naivasha must feel that they "own" the management process.

The following factors are considered important for the proper management of the Lake:

- encourage transfer of Government land within the Lake zone to the Municipality and KWS;
- planned urban development;
- a comprehensive national environmental legislation;
- strong institutional framework locally within which to implement the Management Plan;
- review of policies and licensing for natural resource use.
- developing a strong sense of community amongst, initially, LNROA members, and ultimately amongst all the land users within the watershed.
- establishing effective communication with the various relevant Government Ministries who may otherwise set different priorities.

6.7 Available Resources

6.7.1. Funding

Availability of necessary financial resources is essential because the required tasks cannot be financed by the Association alone. Though funding for the implementation of the Management Plan will be contributed by the membership, it will be supplemented by grants from donors who may sponsor a specific study of relevance to the Management Plan or contribute funds to it directly or provide technical assistance. The contribution of Government of Kenya will be in the form of support for the implementation process and in information dissemination. It is considered important that the funds required are raised through the LNROA in order that they may retain a controlling share of the management process. In addition donors are currently more inclined to fund private enterprise directly.

6.7.2. Human Resources and Training

Research needs to be practical and relevant to the Management Plan. Some of the large farms have Research and Development divisions with qualified technical staff and laboratories which will significantly contribute to the core of human and institutional resources required to oversee and manage the monitoring programme and implement the action plan on research. Elsamere has ideal facilities for training for education and public awareness. The Naivasha Wildlife & Fisheries Training Institute is also present in Naivasha. Thus many relevant facilities already exist for training on site and can be supplemented, and motivated individuals who are prepared to contribute are also available.

6.7.3. Institutional Collaboration

Public Universities and Research Institutes comprise the largest centres of learning and research in Kenya. Staff and student research has been useful in providing some of the basic knowledge on Lake Naivasha available today. In addition, their collaboration with external Universities and Institutes has been extremely valuable. Leicester University, in particular, must be mentioned. While the research has not been coordinated in the past, the Management Plan will facilitate not only co-ordination but also setting priorities and closer collaboration between Universities and the LNROA in future is envisaged.

The Ministry of Environment and Natural Resources, in collaboration with other institutions such as KWS and others, have formed a National Wetlands Standing Committee. This group has started work, embarking on the preparation of a National Wetland Policy. The LNROA should be represented on this Committee.

Collaboration will also be sought with organisations that have similar goals as the LNROA in the areas of sustainable Lake management, or who are involved in provision of major inputs for economic activities such as agro-chemical industries.

As a Ramsar site, Lake Naivasha may draw technical and financial support through IUCN and KWS. The Plan will also benefit from the programmes supporting and implementing the Convention on Biological Diversity which Kenya has ratified.

6.7.4. Equipment and Facilities

The Elsa Conservation Trust, through Elsamere Field Study Centre, has made its facilities available to the LNROA. These include library, laboratory, computer and accommodation. Other institutions and flower growers within the Lake area have equipment and facilities that will be useful for the monitoring programme and implementation of the Management Plan. These facilities include laboratories, individual data bases and field instruments. Requirements can thus be adequately provided at reasonable cost by supplementing existing equipment and facilities.

6.7.5. Awareness and Information

The LNROA has embarked on an applied environmental research and awareness raising programme that will improve the members' understanding of the Lake's ecosystem. The aim will be to not only increase awareness of the fragility of the ecosystem amongst LNROA members, but also through schools and the communities within the Catchment in general to educate the community about the objective of the Management Plan and to gain their voluntary support without which the management of the Lake cannot be achieved.

The members of LNROA are united in accomplishing their objectives in spite of their diverse activities and priorities. The Association has been growing from strength to strength, largely because of their common goal. The leadership of the Association has been keen in following up issues and ensuring that appropriate actions are taken. It is recognised that information sharing amongst the membership is essential for the maintenance of that unity.

The LNROA has no jurisdiction outside the immediate Lake environs and other interested parties such as residents in the Catchment area, research bodies etc, are not represented among its members. It is therefore desirable to broaden the membership by inviting Associate members from among those with a legitimate interest in the Lake. This will ensure a greater awareness among a wider section of the community.

PART II

MANAGEMENT

7. THE MANAGEMENT PLAN

Against the background of what is already known, and whilst the results of further research and monitoring are awaited, a preliminary management plan can be implemented to ensure that adverse trends are corrected. Such a plan is proposed hereunder and seeks at this stage to address those items on which there is already a large degree of consensus or where legislation already exists which supports the proposed management strategy but which is not effectively implemented for whatever reason. In this way it is hoped that LNROA members will cooperate fully with what is proposed at the outset. If there are more controversial issues on which more data or discussion are required, they will be dealt with at a later stage as the Plan develops.

7.1 Water Use

Planned control of water abstraction will be achieved by taking the following immediate actions:

- employ a professional hydrologist to refine the water budget;
- implement monitoring of Lake levels, rainfall, river flows and evaporation to improve the water budget data base;
- avoid watering livestock directly from the Lake because it degrades the shoreline and increases nutrient levels into the Lake;
- control the expansion of water abstraction through the licensing process;
- review water permits and establish the current level and efficiency of water usage;
- revitalise the South Rift Water Apportionment Board and support the Office of the Water Bailiff;
- ensure the Management Committee is represented on the Apportionment Board;
- encourage conservation of water through appropriate technology choices, especially in irrigation and re-use of waste water;
- utilise information from automatic weather stations to minimise application of water to irrigate land;
- institute metering for water abstractions;
- request assistance from interested donors to support an urgent study on Nakuru water supply.

The following long-term actions will be undertaken:

- commission a study on the subsurface inflows and outflows;
- determine modalities of water allocation and establish water use policy;
- determine the hydrological impact of cutting bamboo forest and other watershed activities on water resources;
- develop suitable incentives for water conservation methods to support the Management Plan.

7.2 Habitat Management and Nature Conservation

7.2.1. The Lake Zone (the area within the Moi North and South Lake Roads)

The following actions are required:

- the Papyrus fringe will be restored and allowed to grow naturally all around the Lake because of its water purifying effects and as a habitat for wildlife;
- allow the natural vegetation to regenerate and form a buffer zone of at least 50m back from the landside edge of the Papyrus fringe;
- monitor the distribution and health of floating weeds and their biological control agents and take appropriate corrective measures on adverse trends;
- allow the natural establishment of the Acacia woodland;
- provide stock watering points at strategic locations for large herds including along stock routes;
- encourage the plantation of indigenous vegetation;
- re-vegetate degraded areas in order to conserve the soil moisture and ground water conditions;
- promote security measures to prevent illegal activities and damage to Papyrus and buffer zones;
- discourage the reclaiming of flooded land;
- discourage intensive irrigated agriculture and building permanent structures below the 1906 Lake level;
- encourage planting fuel wood crops and screens for unsightly developments;
- encourage cultivation of reverse slopes away from the Lake.

7.2.2. The Catchment and Rivers

Through appropriate channels of communication with authorities in the Catchment areas the LNROA will seek to:

- request donor support for an environmental appraisal of the watershed including erosion hazards and to assist in evolving a District Forestry Action Plan;
- ensure that Environmental Impact Assessments are done for major water impoundments and that the Management Committee participates;
- support both the Ministries of Agriculture and of Natural Resources in the rehabilitation of degraded and damaged areas;
- ensure that cultivation on the river banks is stopped;
- control bamboo harvesting and charcoal burning.

7.3 Species Management

The health of plant and animal species is a good indicator of the health of the Lake and it is important to:

- monitor the food chain and support studies of raptors etc;
- monitor the composition and abundance of submerged vegetation in the Lake;
- protect sensitive areas of the habitat, especially breeding, feeding and resting sites and fragile ecosystems;
- preserve (and if necessary establish additional) wildlife corridors;
- carry out regular water bird counts twice each year;
- stop introduction of species without Environmental Impact Assessments on the ecology of the Lake.

7.4 Tourism and Recreation

As an important resource of National and International interest tourism and recreation facilities must be enhanced and steps taken to:

- monitor the impacts of tourists and sport fishing on the Lake and its environs;
- improve tourist infrastructure;
- provide information to visitors;
- facilitate Lake Naivasha becoming part of a tourist circuit;
- promote awareness among tourists in support of the Management Plan.

7.5 Fisheries

The Lake fishery industry is capable of greater production. The following measures will be taken:

- ensure that LNROA is represented in the Fishery Management Team;
- monitor and collect accurate data on the commercial catch and Maximum Sustainable Harvest;
- design an appropriate management strategy to eliminate illegal fishing, enforce fishing regulations and train fishermen;
- enhance fish production (including new species introduction after suitable Environmental Impact Assessment);
- establish additional fish landing grounds;
- establish regulations to protect fish breeding areas, especially within, and 500 meters out from, the Lakeside edge of the Papyrus fringe;
- set up appropriate sites for fuelling boats to minimise oil spills;

7.6 Pesticide and Agro-chemical Use

Improper use of pesticides is a potential threat to the Lake and it is important to:

- monitor the use of agro-chemicals, their life span, storage, use, disposal and appropriateness;
- monitor the quality of water from the Lake, rivers and boreholes;
- encourage alternative, particularly biological, methods of controlling soil fertility, pests and weeds;
- promote waste water management strategies such as storage ponds, constructed wetlands etc;
- produce a list of approved/recommended agro-chemicals.

7.7 Waste Disposal

Proper disposal of waste products in such a productive area in a closed basin system must be ensured by:

- facilitating the rehabilitation of the Naivasha town sewage treatment works;
- developing a constructed wetland around the existing treatment works to purify its output;
- regulating the use and siting of septic tanks around the Lake;
- seeking alternative sources and appropriate technology for recycling common irrigation materials such as plastics, bamboo, wood, etc;
- establishing a facility for the disposal of used chemical containers and plastic;
- monitoring the discharges of aerial chemicals and disposal of wastewater particularly from the urban sewage plant and industrial developments.

7.8 Public Access

Specific areas in and around the Lake will be protected from human interference, especially the:

- breeding sites for wildlife and fish;
- sensitive and fragile ecosystems;
- areas under a rehabilitation programme;
- wildlife corridors between the Parks and the Lake;
- private land.

Public access will be provided:

- for educational purposes at KARI, Fishery Training School and Ponds, Elsamere Conservation Centre;
- for recreation purposes at hotels, marinas, etc;
- at fish landing sites;
- at Government land;
- in municipal council land, recreation areas, etc.

7.9 Research

To ensure maximum return from research activities it will be necessary to:

- set up research priorities;
- develop understanding of the water balance;
- study the food chain including plankton and their relationship to ecological factors;
- develop knowledge on fishery resources, including the ecology of Crayfish, Black Bass and submerged hydrophyte stands;
- monitor impact of socio-economic activities on biological resources, both within the Catchment and the Lake.

7.10 Awareness and Information

Success of the Management Plan will not be achieved unless all concerned understand the objectives. This will be achieved by:

- establishing a data information centre at either Elsamere Field Study Centre or any other building that may house the Management Secretariat;
- mounting awareness campaigns in schools and for local and central Government;
- producing field guides on the ecology of the Lake;
- providing information signboards at the main junctions to direct visitors to public places of general interest;
- promulgating the Management Plan and inviting input;
- encouraging appropriate Associate Membership of LNROA;
- promoting awareness and sense of participation among the Catchment area community.

APPENDIX I

Those wishing to contribute to the on-going development and future amendments of this Management Plan, please write to:

THE HONORARY SECRETARY
LAKE NAIVASHA RIPARIAN OWNERS' ASSOCIATION
P.O. BOX 1011
NAIVASHA
KENYA

Tel: (00 254) 0311 21008
Fax: (00 254) 0311 21009

LAKE NAIVASHA MANAGEMENT PLAN STEERING COMMITTEE

This document has been produced for the Lake Naivasha Riparian Owners Association by a Steering Committee appointed for the purpose, consisting of :

Lord Enniskillen	-	Chairman
Joseph Kangari Muhu	-	Vice Chairman
Sarah Higgins	-	Secretary
Members:		
Anderson Koyo	-	(KWS)
Ben Kubo	-	(KPC)
Dr. Geoffrey Howard	-	(IUCN Alternate)
Geoffrey Mwangi	-	(Municipal Council of Naivasha)
Mohammed Hassan	-	(D.O. 1 Naivasha)
Prof. Steven Njuguna	-	(IUCN Alternate)
Richard Fairburn	-	(Sulmac Ltd)
George Krhoda	-	Executive Officer

It was presented to the Executive Committee of the LNROA on 27th May '95 and approved for dissemination to the membership as a whole. The conclusions and recommendations it contains are those of the Steering Committee and have the endorsement of the Executive Committee of the LNROA. When it receives the endorsement of the membership of the LNROA, it will be forwarded to Government in the hope that it will be officially adopted as the Plan for the management of Kenya's second Ramsar Site. Meanwhile the Executive Committee commend its recommendations to the membership as a whole for dissemination and voluntary adoption with immediate effect.

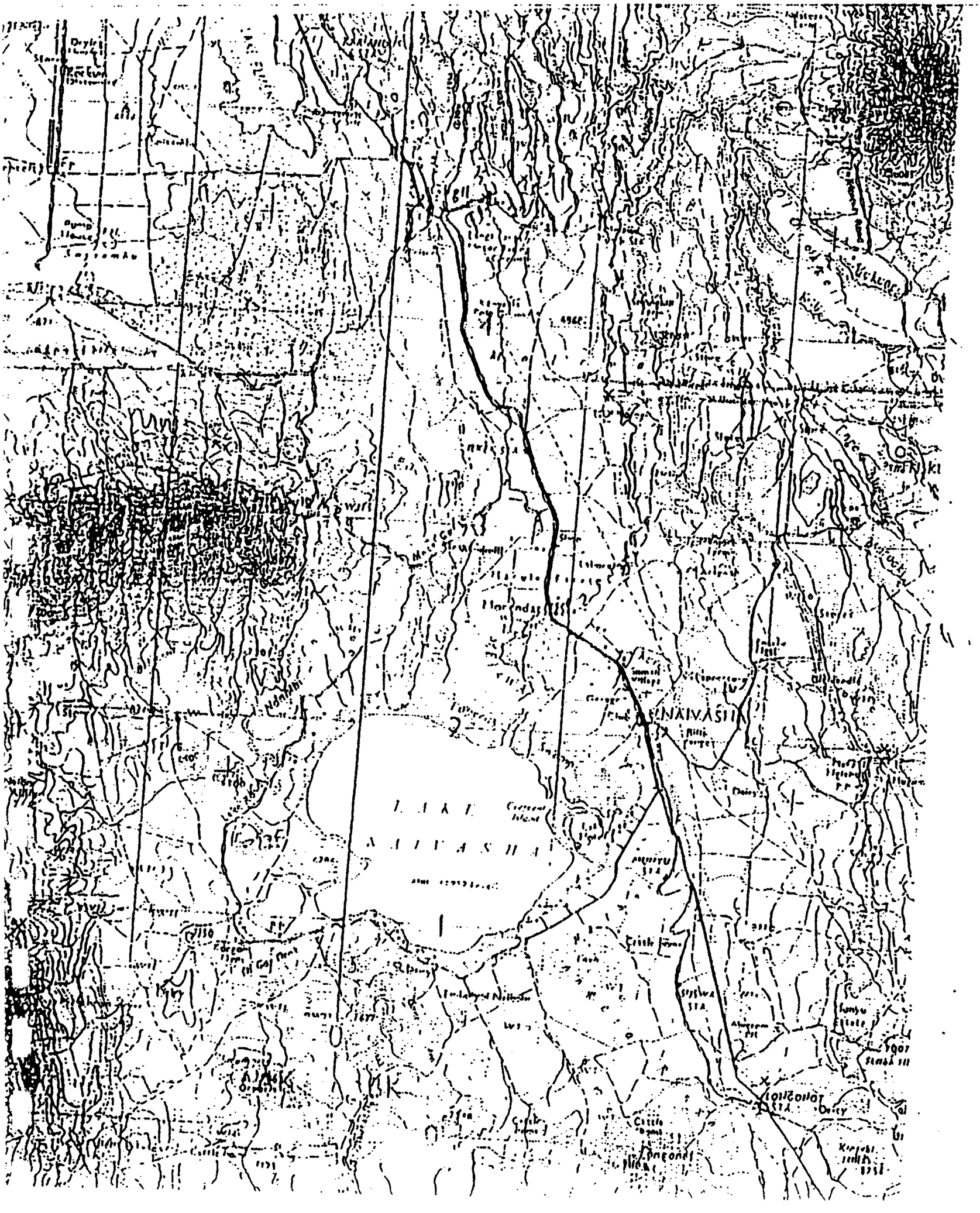
Enniskillen - August '95

LORD ENNISKILLEN
CHAIRMAN
LNROA

APPENDIX II

MAP OF LAKE NAIVASHA AREA

Scale 1:250.000



APPENDIX III

LIST OF ACRONYMS:

D.O.	•	District Officer
GDP	•	Gross Domestic Product
GOK	•	Government of Kenya
IUCN	•	International Union for Conservation of Nature
\RI	•	Kenya Agricultural Research Institute
KCC	•	Kenya Cooperative Creameries
KPC	•	Kenya Power Company
KWS	•	Kenya Wildlife Service
LNROA	•	Lake Naivasha Riparian Owners Association
MASL	•	Metres above sea level

LAKE NAIVASHA MANAGEMENT PLAN IMPLEMENTATION PROJECT

CONTENTS

ABBREVIATIONS AND ACRONYMS

CBO	Community Based Organisation
DDC	District Development Committee
DEMC	District Environment Management Committee
ECC	Elsamere Conservation centre
ECP	Environmental Conservation Programme
EEPP	Environmental Education and Planning Programme
EHA	Erosion Hazard Area
EHC	Environmental Health Communities
EIA	Environmental Impact Assessment
EMP	Environmental Monitoring Programme
GOK	Government of Kenya
KARI	Kenya Agricultural Research Institute
KMFRI	Kenya Marine and Fisheries Research Institute
KPC	Kenya Power Company
KWS	Kenya Wildlife Service
KWWG	Kenya Wetlands Working Group
LNEMC	Lake Naivasha Environment Management Centre
LNGG	Lake Naivasha Growers Group
LNROA	Lake Naivasha Riparian Owners Association
MIPC	Management Plan Implementation Committee
MLRRWD	Ministry of Land Reclamation,Regional and Water Development
NEMA	National Environment Management Authority
NEMC	Naivasha Environment Management Committee
NGO	Non-government organisation
NMC	Naivasha Municipal Council
NSTW	Naivasha Sewage Treatment Works
NWFTI	Naivasha Wildlife and Fisheries Training Institute
SOK	Survey of Kenya
UON	University of Nairobi

1. EXECUTIVE SUMMARY

1.1 Introduction

The area of Lake Naivasha, including its environs, is important for its rich biological diversity and freshwater resources. It supports intensive irrigation-based agriculture and geothermal power, fishery and tourist industries. In April 1995, the lake, including its immediate environs, was designated Kenya's second Wetland of International Importance or Ramsar Site.

Lake Naivasha is a natural resource of great value and is mainly surrounded by private land making it suitable for a pilot community-based management project. The Project will seek to manage the existing human activities in the Ramsar Site and the wider catchment through voluntarily adopted wise use development principles to ensure the conservation of the area's rich biological diversity and to improve the living standards of the resident communities.

The background information on the Project is contained in the Lake Naivasha Management Plan (Parts I and II) prepared by the Lake Naivasha Riparian Owners Association (LNROA, 1996). The Project will implement the Lake Naivasha Management Plan in three phases over a period of nine years (1997 to 2005). The annual workplans for the first three years, which will be approved by the Lake Naivasha Management Trustees, will be more specific than those for the subsequent years and will initially focus their activities within the Ramsar Site. Subsequent phases (II and III) while addressing issues within the Ramsar Site will also include conservation issues of the wider catchment area.

The Project's implementation will be directed by LNROA's Management Plan Implementation Committee (MPIC). This committee will include agriculture/horticulture representation as well as Naivasha Municipal Council, District Officer/District Environment Officer, Kenya Wildlife Service (KWS), Kenya Power Company (KPC), and IUCN/Ramsar representation. The majority of the committee members will be drawn from LNROA and at least one Committee member will become a member of the Government's National Wetlands Standing Committee. MPIC, which will not exceed twelve members in all, will have powers to co-opt and will be accountable to the Lake Naivasha Management Trustees. LNROA will elect the Trustees, who will be responsible for policy issues, and the members of the MPIC.

1.2 Project Framework

The Lake Naivasha Management Plan has identified the following threats to sustainable utilization of the basin's biodiversity and natural resources (LNROA, 1996; 7-9 p):

1. Out of basin water transfer from the main river, the Malewa River, resulting in a water deficit.
2. Water abstraction from the lake threatening the ecological and economic sustainability of the lake.
3. Water pollution and nutrient enrichment from urban and agricultural activities.
4. Invasive alien plants and animals which have infested the lake and its surroundings.
5. Inappropriate activities on riparian land including construction of permanent buildings, destruction of papyrus and the use of fertilizers and pesticides.
6. Soil erosion within expanding agricultural settlements in the catchment.
7. Unplanned growth of human settlements in Naivasha Town and other satellite areas.
8. Rapid growth of the tourist industry threatening to outstrip the provision of infrastructural facilities.
9. Geothermal power generation resulting in increased water abstraction and pollution from wastewater.
10. Changes in land use adversely affecting the lake ecosystem.
11. Uncoordinated research and lack of awareness that the natural resources of the lake such as water are finite and limiting to development.
12. Overfishing threatening sustainable lake fishery

1.3 Project Objectives

The overall goal of the project is to ensure the long-term conservation of Lake Naivasha ecosystem and its catchment by managing existing human activities through the adoption of sustainable wise use development principles. The specific objectives are:

* To design and implement programmes to monitor the water balance in the Lake Naivasha catchment basin and to assess human impacts on the natural environment.
* To integrate environment policies into planning and management of development projects within the catchment basin.
* To promote environmental awareness among members of the public and draw attention to the impacts of human activities on Lake Naivasha ecosystem.
* To effect the rehabilitation of Naivasha Sewage Treatment Works.
* To establish a Lake Naivasha Environment Management Centre (LNEMC).

1.4 Justification

Lake Naivasha basin is world famous for its rich biodiversity. It plays a significant role in the national economy as an earner of foreign exchange through the horticulture industry, a contributor to government revenues, and a valuable source of subsistence and commercial opportunities for the local community.

The future of Lake Naivasha, Kenya's second Ramsar Site, is under threat from unsustainable development practices within the catchment basin of the lake. The Project seeks to eliminate this threat by ensuring that sound conservation principles are rapidly adopted as the basic guidelines for development in the area.

1.5 Project Implementation

This Project is designed to implement the Lake Naivasha Management Plan through three programmes and two discrete projects described below to address the issues listed above. The project will be implemented by LNROA with technical assistance from relevant Government of Kenya (GOK) departments, local institutions, NGOs, the private sector and the local communities.

i) Environmental Monitoring Programme (EMP)

Major changes in rural landuse, urban development and catchment hydrology have taken place in the Naivasha basin since the early 1970's when the geothermal power station and the first flower farm were established. Ecological monitoring of the basin lakes has been inadequate in scope and largely uncoordinated. Lake levels have been monitored, discharge of feeder rivers measured, limnological studies carried out and waterfowl counts sporadically undertaken. None of this information, however, has been sufficient to provide a clear analysis of the effects of recent developments on the aquatic and terrestrial ecosystems.

EMP will be implemented for Lake Naivasha and its catchment. This programme will monitor the water balance, pollution, aquatic and terrestrial weeds infestation, introduced animal species, siltation, biodiversity loss, and environmental impact assessments. The findings will constitute the basis of decision making on development projects in the Naivasha catchment basin by the MPIC and build a long-term environmental monitoring programme.

ii) Environmental Conservation Programme (ECP)

ECP will provide technical advice and material support to promote safe handling, storage and disposal of pesticides, soil conservation, landuse improvement, reafforestation, proper fishing techniques, controlled water use, nature conservation, species management and riparian land conservation. This will involve extension programmes.

The programme will include group training sessions, field demonstrations, selection and training of individual farmers, fishermen and pastoralists. Support will be provided to the establishment of individual and group tree nurseries. This programme will be implemented in close collaboration with the GOK and NGO extension staff.

iii) Environmental Education and Planning Programme (EEPP)

EEPP will be carried out at the KWS's Naivasha Wildlife and Fisheries Training Institute (NWFTI) and Elsamere Conservation Centre (ECC). Environmental conservation and sustainable development courses will be offered to the local people and school children in the catchment basin. Participants will include farmers, fishermen, tour operators, women groups, school teachers, school children, ranchers, chiefs, pastoralists, local residents, extension officers, Naivasha Municipal Council (NMC) staff and government officials.

The courses will be designed to increase environmental awareness and to draw attention to the impact of human activity on the lake ecosystems. In addition, efforts will be made to create awareness of the beneficial effects of environmental conservation on the lives of the local people and the nation in general. Participants will understand their roles and responsibilities in conservation and sustainable development in the area. Demonstration sites will be established to illustrate good practices. The programme will also be responsible for dissemination of policy changes resulting from the findings of EMP.

The integration of conservation principles into the development planning process is crucial to the future of the Naivasha basin. EEPP is designed to make the local planners and policy makers aware of the threats facing the lake ecosystems and to include the conservation of the lake basin's biodiversity into the local, district and national planning processes.

v) Naivasha Sewage Treatment Works (NSTW) Project

The NSTW plant, which was constructed in 1984, stopped its operation in 1992 because of vandalisation of essential accessories in the main power switchboard which deprived the main pumps of power. The electrical fittings for the industrial area extension were also vandalised. As a result the two main pumps,the four aerators and an additional sludge pump lack electrical power and cannot be operated.

Absence of aeration causes a very strong stench to emanate from the plant. Impaired through flow causes frequent flooding by sludge of the surrounding areas during and after rains, posing a health risk to neighbours and Naivasha Town residents.

The Project will restore the NSTW plant to full working condition. The plant purification capacity will be increased to account for the increased sewage inputs from increased urban population and expanded industrial activities. The Project will also increase the plant's purification capacity by adding a constructed wetland of papyrus. This will enhance the tertiary treatment capacity.

vi) Lake Naivasha Environment Management Centre (LNEMC) Project

The NWFTI's Annex located near the north-eastern shore of Lake Naivasha was constructed in 1984. It has not been commissioned since. The Annex consists of an office block, hostels, laboratories, a conference hall and a boat repair facility.

The Project will convert NWFTI's Annex into a permanent Lake Naivasha Environment Management Centre. The overall objective of the project is to provide a repository for information on Lake Naivasha and its catchment,a water quality laboratory and a centre for training in fishing and aquaculture techniques. A pilot fish processing facility will be established. The Project will renovate existing structures to make the centre operational.

1.6 Project Implementation Strategy

The Project will be directed and coordinated by the MPIC. An essential feature of this project is the coordination of inputs from a number of institutions within Kenya including government agencies, universities and NGOs. The overall sanction for the project activities will emanate from the LNROA and KWS (see Organogram, Annex I). The Project Office will be based at the Naivasha Wildlife and Fisheries Training Institute.

1.7 Gender Issues

Every effort will be made to ensure that women needs are considered. The role of women in agricultural activities is a big one. In implementing the three programmes of the Project, special attention will be paid to women's activities. ECP and EEPP will have activities specifically directed to women's interests.

1.8 Monitoring and Evaluation

An internal evaluation process will form a major component of the Project. Immediate objectives will be addressed by the Project staff through preparation of annual workplans.

An mid-term evaluation will be carried out in a participatory mode involving outside consultants and the Project staff. Various collaborating agencies will produce their own records which will be used for monitoring and evaluation.

At the end of the project, a terminal evaluation will be undertaken by an independent team of consultants appointed by the LNROA in conjunction with KWS.

1.9 Resources

The Project will require resources in terms of personnel, equipment, vehicles information and finance. The various categories of staff required are summarized in the organogram. Other staff will be recruited as consultants to do specific tasks or as daily paid assistants. In addition to these two cadres of human resources requirement, the collaborating institutions will avail staff to work on specified activities.

1.10 Budget Summary

The total budget to implement the Project is shown below.

a) Grand Summary

	K.Shs	US $
Phase I	110,909,700	2,016,540
Phase II	52,565,700	955,740
Phase III	31,175,000	566,800
TOTAL	**194,649,400**	**3,539,080**

b) Project Components

	PROJECT COMPONENTS	Phase I	Phase II	Phase III	TOTAL	
					K.Shs	US $
	Environmental Monitoring Programme	20,911,000	11,464,200	7,645,000	40,020,200	727,640
I	Environmental Conservation Programme	26,400,000	14,300,000	8,635,000	49,335,000	897,000
III	Environmental Education and Planning Programme	19,082,800	10,230,000	7,276,500	36,589,300	665,260
IV	Naivasha Sewage Treatment Works	21,173,900	3,261,500	0	24,435,400	444,280
V	Lake Naivasha Environment Management Centre	23,342,000	13,310,000	7,617,500	44,269,500	804,900
	TOTALS	110,909,700	52,565,700	31,174,000	194,649,400	3,539,080

2. PROJECT DEVELOPMENT STRATEGY

2.1 The Strategy

This Project Proposal presents three phases of the Lake Naivasha Community-based Management Project. The threats to the conservation of Lake Naivasha have been identified by the Lake Naivasha Management Plan. The essential requirement for the Management Plan's implementation is the active participation of the local communities in implementing for themselves the water and soil conservation measures, sustainable resource use, and the safe disposal of agricultural and urban effluents.

The Project will have three core programmes and two discrete projects, namely:

- Environmental Monitoring Programme (EMP)
- Environmental Conservation Programme (ECP)
- Environmental Education and Planning Programme (EEPP)
- Naivasha Sewage Treatment Works (NSTW) Project
- Lake Naivasha Environment Management Centre (LNEMC) Project

2.2 Environmental Monitoring Programme (EMP)

Overall Objectives

To design and implement programmes to monitor and evaluate changes in the natural environment using Lake Naivasha, influent rivers, forests and vegetation cover and resident wildlife as indicators of environmental health.

To analyse and interpret this information so that it is translated into appropriate policy and management decisions.

Specific objectives

1. Monitor the water quality and quantity in lakes and rivers, and rainfall in the catchment area.
2. Monitor water balance in Lake Naivasha and catchment basin.
3. Monitor vegetation cover in the catchment.
4. Monitor the extent of the fringing vegetation including the papyrus buffer zone and the impacts of human activities.
5. Monitor and document urban and rural landuse.
6. Develop capacity in local institutions for future environmental monitoring.

Activities

- Monitor the water quality and quantity parameters. In addition, monitor biological parameters such as phytoplankton, macrophytes, salvinia, water hyacinth, wildlife, waterfowl and fish. Identify sources of pollutants. Measure suspended sediment loads in influent rivers to help determine erosion prone areas.
- Install infrastructure for collecting, hydro-met data. Set up lake and river gauging stations in Lake Naivasha catchment basin. Establish and maintain a database on hydro-met data. Analyse water balance and water budgets for Lake Naivasha and prepare reports.

- Investigate extent of vegetation cover in the catchment. Assess impact of human activities on the vegetation cover.
- Investigate the extent of fringing vegetation and the papyrus buffer zone. Assess the impacts of human activities on the buffer zone.

- Collect data on land use changes using satellite imagery, aerial photographs, land registration records and site visits. Determine and publicise environmental implications of major landuse changes in the catchment.
- Co-opt partners from the collaborating institutions into ongoing work. Develop guidelines for long term monitoring. Develop a proposal for inter-agency collaboration in future monitoring.

Expected outputs

- A database of basic water quality and quantity parameters. Identification of impacts of aquatic and terrestrial weeds. Register of sources and pathways of pollutants. Identification of erosion hazard areas (EHAs)
- Infrastructure and regular collection of hydro-met data. Hydro-met database. Water balance and water budget reports.
- Forest and vegetation cover maps. Identification of impacts and mitigation measures.
- Database on fringing vegetation. Identification of impacts on fringing vegetation including the papyrus buffer zone.
- An updated GIS database of landuse in the Lake Naivasha catchment basin. Status reports reflecting major landuse changes in the catchment basin.
- Target groups involved in monitoring work. Guidelines and documentation of monitoring methods. Proposal for long term monitoring involving collaborating institutions.

Target Groups

- Lake Naivasha Riparian Owners Association (LNROA)
- Lake Naivasha Growers Group (LNGG)
- Kenya Wildlife Service
  District Environment Management Committee
- Ministry of Land Reclamation, Regional and Water Development (MLRRWD)
- Naivasha Municipal Council (NMC)
- Fisheries Department
- Kenya Agricultural Research Institute (KARI)
- Fishermen
- Forestry Department

Resources Needed

- Human resources
  A Monitoring Programme Officer (Ecologist)
  An Assistant Programme Officer (Water Technician)
  Consultants and researchers
- A desktop computer with printer and other accessories
- Limnological equipment
- Hydrological equipment
- Finance for water quality analysis at national laboratories
- A 4WD vehicle and 2 motorcycles
- Camera and accessories
- Finance for training project staff and collaborating partners on environmental monitoring
- Finance to support short-term investigations and studies
- Finance to conduct seminars, workshop etc.
- Finance to publish and distribute reports generated by the programme
- Materials such as topographical and aerial maps, satellite images etc.

2.3 Environmental Conservation Programme (ECP)

Overall objectives

Catalyse immediate conservation action in target areas within the lake and the catchment with special emphasis on water and soil, and institute strategies to promote and guide sustainable landuse in future.

Specific Objectives

1. To provide training in essential conservation skills within the Ramsar Site and the catchment.
2. To create enabling environment for the immediate application of acquired conservation skills.
3. To ameliorate impacts of human activities on the Lake Naivasha ecosystem.
4. To restore degraded habitats (soil conservation and re-afforestation)
5. To institute strategies to sustain conservation effort.
6. To strengthen systems to undertake environmentally sound landuse planning and management within the catchment.

Activities

- Facilitate short-term training of community groups including chiefs, women group leaders, farmers, wildlife managers, school teachers in various aspects of environmental conservation. Conduct field training in basic conservation techniques. Promote farmer to farmer training sessions.
- Promote technical and material support for water and soil conservation. Upgrade technical skills of existing extension officers. Mobilise community support for rehabilitating degraded sites. Promote the protection of threatened species and sites.
- Ascertain the conservation of papyrus buffer zone. Promote appropriate fishing techniques. Initiate pilot aquaculture projects for commercial and conservation purposes.
- Develop re-afforestation programmes. Develop soil and water conservation programmes in the catchment.
- Develop partnerships among locally represented organisations such as LNROA, LNGG, KWS, NMC, GOK and Local NGOs. Develop technical capacity within these organisations.
- Facilitate the establishment of linkages between environmental committees (riparian and village) and the District Environment Management Committee. Facilitate the establishment of Lake Naivasha Environment Management Committee. Develop an integrated catchment area management plan.

Expected Outputs

- Increased conservation skills in target groups. Improved communication skills among extension officers.
- Adoption of water and soil conservation measures. Degraded sites rehabilitated. Threatened species and sites protected. Environmentally friendly farming techniques such as organic farming and intergraded pest control adopted. Maintenance of improved quantity and quality of lake water.
- Buffer zone of papyrus and natural vegetation protected and restored. Appropriate fishing techniques in use by fishermen. Pilot aquaculture project initiated.
- Improved vegetation cover in the lake zone and the catchment. Improved soil and water conservation in the catchment.
- Collaborative and multi-disciplinary implementation of conservation programmes.
- Establishment of an inter-institutional approach to planning and managing development in the catchment. A catchment area management plan.

Target groups

- LNROA
- LNGG
- Rural communities
- Urban communities
- Organised groups e.g. women groups, church groups
- Development committees
- District Environment Management Committee
- Extension officers (Forestry,Water and Agriculture Departments)
- Fishermen
- Local leaders
- KWS
- NMC
- Fisheries Department

Resources needed

- Human resources
  A Conservation programme Officer
  5 Programme Assistants
  Extension agents
  Consultants and hired labour when required
- Vehicles A 4WD Vehicle
  2 Motorcycles
- Laptop computer with printer and accessories
- Materials
  Inputs for tree nurseries
  Inputs for check dams/gabions on gullies
  Inputs for aquaculture ponds
  Inputs for water conservation
- Training costs
  Residential and field training
  Project staff training
- Finance to conduct meetings and workshops
- Finance for printing and distribution of training materials

2.4 Environmental Educational and Planning Programme (EEPP)

Overall Objectives

Increase environmental awareness among riparian and catchment residents and planners. Encourage public discussions and debate on local environmental issues.
Ensure that appropriate conservation methods and environmental impact assessments (EIAs) are used in all planning processes and develop ways to sustain public interest in the environment beyond the life of the project.

Specific Objectives

1. Organise education sessions for riparian and catchment residents to expand and update their knowledge on the local environment.
2. Create awareness about the economic opportunities arising from wise use of natural resources.
3. Encourage community action for environmental conservation.
4. Institutionalize environmental education.
5. Promote the integration of appropriate environmental policies in landuse planning and development.

Activities

- Provide short-term environmental education courses. Conduct thematic workshops, seminars, conferences. Conduct school lectures, exhibitions and tours to places of environmental interest.
- Explore economic possibilities to be pursued by the local communities. Promote and start-up viable enterprises.
- Facilitate the organisation of community environmental action groups. Provide environmental health education. Support waste reuse, recycling and reduction initiatives.
- Develop and produce environmental education materials featuring Lake Naivasha and its catchment. Integrate environmental education materials into existing curricula. Develop capacity for environmental education in KWS, NMC, WCK, LNROA, LNGG, and other local NGOs and CBOs. Create opportunities for dialogue between members of the public and managers of the environment of Lake Naivasha and its catchment. Encourage dialogue between development agencies and conservation organisations.
- Facilitate the formulation of environmentally sound landuse guidelines for development activities in the catchment. Commission socio-economic studies in Lake Naivasha Zone and its catchment.

Expected Outputs

- Development of greater environmental responsibility among all stakeholder groups.
- Development of proposals for viable enterprises focusing on agro-based projects and the ecotourism market. Operating self-sustaining enterprises.
- Formation of community-based environmental health committees. Community involvement in solid waste management.
- Involvement of the youth, adults and church groups in matters related to environment management. Environmental education packages in use in schools.
- A structure for vetting plans at locational, divisional, and district level. Endorsement of guidelines by the DDC and relevant institutions. Environmentally-based socio-economic development plans addressing spatial planning and resource base constraints.

Target groups

- LNROA
- LNGG
- Industries
- District Environment Management Committee
- District Development Committee
- Naivasha Municipal Council
- Schools (primary and secondary)
- Other educational institutions
- Rural communities (farmers and ranchers)
- Urban communities in Naivasha and satellite areas
- Local leaders including women groups and clergy
- Field and Technical Officers in Government, NMC and NGOs
- Domestic and international visitors to the Parks
- KWS
- Development agencies
- Fishermen
- Tour operators

Resources needed

- Human resources
  - A Programme Officer
  - A Programme Assistant
  - A Driver/Messenger
  - Consultants for educational material production and curriculum development
- Equipment
  - A slide projector, overhead projector, camera with accessories
  - A desktop publishing unit
  - A portable generator for use in rural schools and villages
- Vehicles
  - A minibus
  - A motorcycle for use by Programme Assistant
- Publication and training materials
  - A reference library
  - Funds to produce a video on Lake Naivasha and its catchment
  - Funds to commission the production of posters and calendars to disseminate environmental messages
  - Funds to produce educational materials for schools, colleges, adult literacy classes
- Training costs
  - Finance for the cost of residential and field training programmes
  - Finance for Project staff training programmes.

2.5 Naivasha Sewage Treatment Works (NSTW) Project

Overall Objective

Improve public health and protect Lake Naivasha's rich biodiversity.

Specific Objectives

1. Rehabilitate the NSTW plant to full working condition.
2. Increase the plant's purification capacity. Catalyse the use of a constructed papyrus wetland for tertiary treatment.
3. Maintain and protect the biodiversity of Lake Naivasha.

Activities

- Replace electrical main switches and other electrical repairs. Repair ponds and operate pumps and aerators. Train plant personnel in management, water quality monitoring, produce marketing. Repair fence, gates, locks, burglar proof buildings and pump houses.
- Design a constructed wetland of papyrus. Select site, delineate plot, landscape and prepare soil. Mobilise equipment and material and construct. Plant papyrus rhizomes and inundate impoundment. Monitor papyrus growth and design harvest cycle.
- Operate plant properly. Monitor effluent water quality and implement corrective measures.

Expected Outputs

- Operational sewage treatment plant. Competent plant personnel. Improved effluent water quality (physical, chemical and biological). Effluent quality at all times within national standard limits for all parameters. Effective security system.
- Functional constructed wetland for sewage effluent purification and research. Marketing system for papyrus.
- Influx of nutrients and pollutants to lake reduced relative to pre-project levels.

Target Groups

- NMC
- Naivasha Town residents
- LNROA
- NSTW plant personnel
- Farmers
- Researchers and Educators
- MLRRWD

Resources Needed

- Project Consultant
- NMC seconded personnel
- Materials and labour for civil works
- Materials and labour for electrical works
- Materials and labour for mechanical works
- Materials and labour for repair of security systems
- Finance for training plant personnel
- Finance for professional advice
- Finance for transport of equipment and materials
- Finance to cover printing and production of reports.

2.6 Lake Naivasha Environmental Management Centre (LNEMC) Project

Overall Objectives

Improve the availability of environmental information on Lake Naivasha and its catchment. Establish a water quality analysis laboratory in Naivasha.
Promote good fishing techniques and encourage the initiation of aquaculture projects for commercial and conservation purposes.

Specific Objectives

1. Rehabilitate NWFT'S Annex and establish it as a Lake Naivasha Environment Management Centre.
2. Establish an information focal unit at the centre.
3. Establish a water quality laboratory.
4. Promote training in fishing techniques and aquaculture.

Activities

- Carry out repairs on buildings, ponds, pump house and install electrical equipment.
- Equip and provide the necessary documentation for the information unit.
- Develop and make available water quality analysis guidelines. Equip the water quality laboratory.
- Initiate training courses on fishing techniques and aquaculture. Establish a pilot fish processing facility.

Expected outputs

- Operational Lake Naivasha Environment Management Centre.
- A well stocked information unit and library. Improved availability of information on Lake Naivasha and its catchment.
- A functional water quality analysis laboratory in use.
- Trained fishermen. Initiation of aquaculture projects in the catchment basin. Lake re-stocked with fish. Processed fishery products. A functional boat repair facility.

Target Groups

- LNROA
- LNGG
- NMC
- KWS
- Fisherman, Farmers
- Schools in Naivasha catchment basin.
- Researchers and Educators
- Tour operators
- Visitors
- NGOs

Resources Needed

- Human resources
  - Centre Manager
  - Instructors (3)
  - Information Officer
- Materials and labour for civil works
- Materials and labour for electrical works
- Materials and labour for mechanical works
- Finance for training
- Finance for consultants
- A boat
- A Centre vehicle
- Laboratory equipment
- Fish processing equipment
- Expendable materials
- 2 computers with printers and accessories
- Overhead projectors, slide projectors and screens
- Finance to cover printing and production of documents.

3. THE ROLE OF COLLABORATING INSTITUTIONS

3.1 Lake Naivasha Riparian Owners Association (LNROA)

Lake Naivasha Riparian Owners Association (LNROA) has prepared the Lake Naivasha Management Plan to be implemented through the Project. LNROA will provide the framework under which the project will be implemented initially. A Trust will be formed by LNROA to be incorporated under the Companies Act. The Trust will ensure the continuation of the environmental management activities beyond the life of the project.

3.2 Kenya Wildlife Service (KWS)

The Kenya Wildlife Service (KWS) has a critical role in the Project. KWS's principal role is to provide the link between LNROA and the Government. KWS will also provide the base for the Project operations at the Naivasha Wildlife and Fisheries Training Institute. The institute will also be used for holding seminars, workshops, conferences and training courses. It will also form the focal point for educational activities. KWS field staff will be involved directly in the Project. The institute's annex will be converted to a Lake Naivasha Environment Management Centre (LNEMC).

3.3 Naivasha Municipal Council (NMC)

It is crucial that the Naivasha Municipal Council (NMC) gives the Project its full support. This should be formalized by the endorsement of a memorandum, of understanding (MOU). NMC has an active role within the Project. It will be involved in environmental monitoring, conservation, education and planning programmes. NMC will also ensure clean-up operations including proper disposal of solid waste, rehabilitation and expansion of the sewage works and the production of urban structural plans.

3.4 Local and Foreign Universities

Local and foreign universities will assist in carrying out adaptive research. They will respond to the research priorities identified by the Lake Naivasha Management Plan. The universities will also assist in analysing collected data on status of the lake in response to locally induced environmental impacts.

3.5 National Environment Management Agency (NEMA)

Once formed, the National Environmental Management Agency (NEMA) will provide the guidelines for environmental impact assessments. It will also ensure that national development projects do not impact adversely on Lake Naivasha and its catchment. NEMA will also review the reports of the District Environment Management Committee and provide the necessary advice and guidance.

3.6 Ministry of Land Reclamation, Regional and Water Development (MLRRWD)

The District Hydrologist and the Pollution Officer will be involved in the Project. The Ministry will provide technical support in the installation of equipment for collection of hydro-meteorogical data and data on sewage and storm water discharges. Hydro-meteorological data from the Ministry's own records will be made readily available to the Project.

3.7 Fisheries Department

The Fisheries Department will monitor the fish catches from the lake. It will also be involved in introducing appropriate fishing techniques. Advice will be sought from the Fisheries Department during the establishment of pilot aquaculture projects. The Department will ensure fishermen's compliance with the closed fishing seasons to allow fish breeding.

3.8 Kenya Wetlands Working Groups (KWWG)

KWWG will conduct the regular bird census. It will also undertake to inventory the wetlands in the lake zone and the catchment.

3.9 Wildlife Clubs of Kenya (WCK)

Wildlife Clubs of Kenya will be invited to participate in the Project. It will be involved in providing environmental education sessions to the youth using the facilities at Elsamere Conservation Centre. WCK will also promote the establishment of environmental youth clubs in the schools within the Lake Naivasha catchment.

3.10 Ministry of Education

The Ministry of Education will support the introduction of all educational packages in schools. In addition the Ministry will facilitate the training of teachers in environmental education and in environmental curriculum development. The Kenya Institute of Education (KIE) will be consulted regularly during the environmental education curriculum development process.

3.11 Kenya Power Company (KPC)

The Kenya Power Company will continue to monitor the impact of the geothermal power station on the environment. In particular, KPC will monitor the impacts of effluents and the emitted gases from the geothermal facility. KPC will also initiate studies to determine the possible hydraulic-link from the lake to the geothermal station, and the proper fixing of toxic elements such as arsenic and mercury into harmless form.

3.12 Lake Naivasha Growers Group (LNGG)

The Lake Naivasha Growers Group has prepared a Code of Conduct with regard to the use and disposal of pesticides and toxic chemicals used in agricultural activities. LNGG will ensure compliance with the guidelines contained in the Code of Conduct with respect to use of pesticides, toxic chemicals and fertilizers. LNGG will be involved in providing demonstrations on the safe use and disposal techniques.

3.13 Forest Department

The Forest Department will map and inventory the forest areas within the catchment. Forest extension officers will be involved in tree nursery establishment and in re-afforestation programmes. The Department will ensure the observance of forestry regulations within the catchment.

3.14 Kenya Agricultural Research Institute (KARI)

KARI staff will be involved in soil conservation programmes within the catchment. KARI will also carry out biological control of water hyacinth and other aquatic weeds in Lake Naivasha. The Institute will work closely with LNGG to ensure the compliance with the pesticides and toxic chemicals guidelines developed by LNGG.

3.15 Kenya Marine and Fisheries Research Institute (KMFRI)

KMFRI, which has a base in Naivasha, will be involved in routine water quality monitoring. It will also assist in determining the pollution sources and pathways. KMFRI will carry out fish stock assessments and also assess the environmental impacts of the invasive aquatic needs.

4 MONITORING AND EVALUATION

4.1 Internal Monitoring and Evaluation

Within the Project, the processes for achieving the objectives will be monitored and evaluated. The final results of these processes such as change in landuse practices, people attitudes etc. will be determined. Self- evaluation by the implementers will be an important component of this project. In doing this, the Management Plan Implementation Committee will establish a set of project objectives which can be achieved within a given time frame as reflected in annual work plans.

The Project implementers will prepare quarterly reports. Field visits will also be made where progress in the field will be assessed. The Project implementers will send quarterly reports to the Management Plan Implementation Committee which will in turn report to the donors. In addition the KWS Programme Leader will undertake field visits to monitor progress.

4.2 Mid-Term evaluation

A mid-term evaluation will be carried out by a team comprising outside consultants and the Project staff in a participatory mode. This mid-term evaluation will recommend necessary changes in the Project arising as a result of the evaluation.

4.3 Terminal Evaluation

Finally, a terminal evaluation of the Project will be carried out by a team of independent consultants. The many collaborating agencies will provide their records for use in the evaluation. The evaluation team will asses and make recommendations on the long-term sustainability of the Project's activities.

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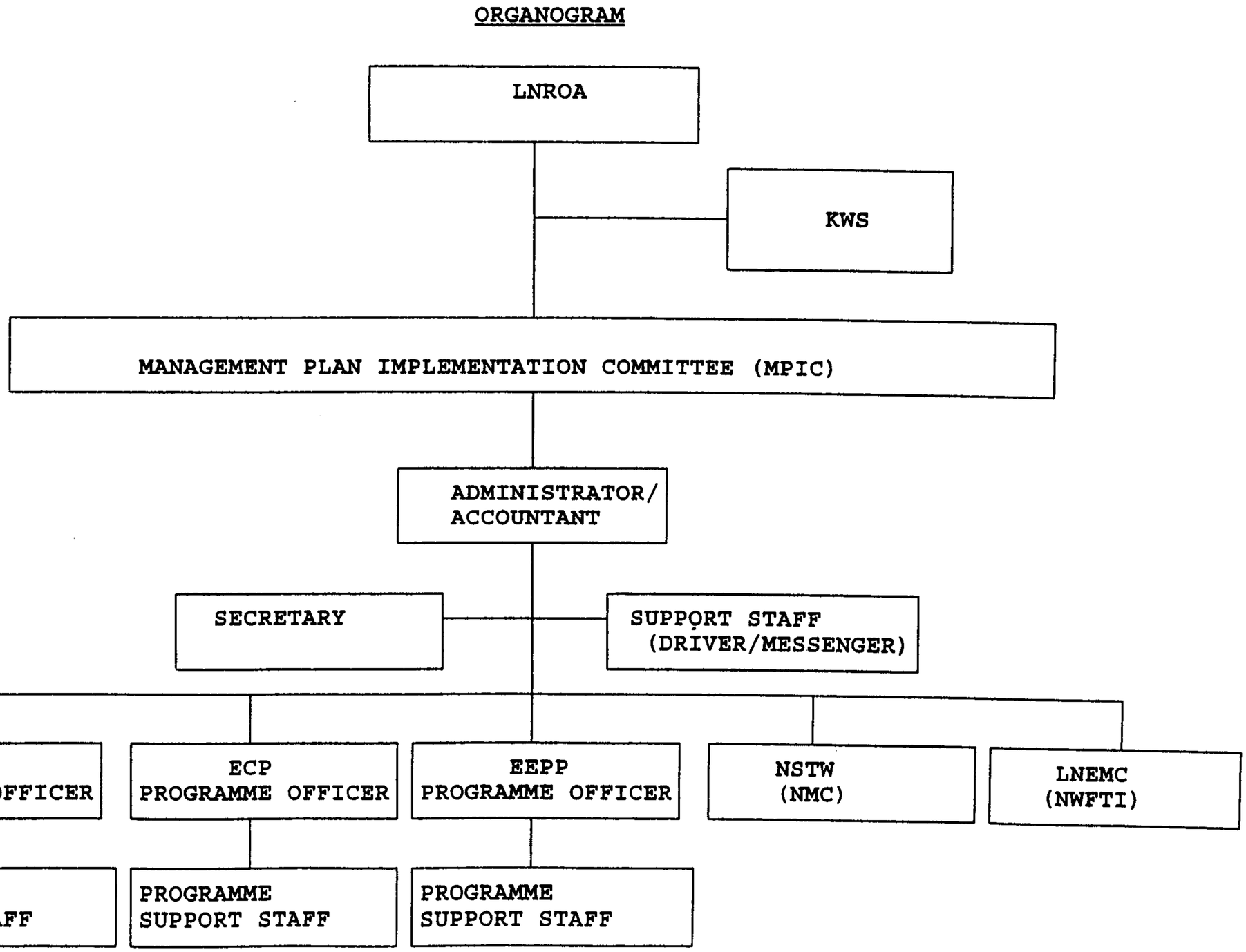
I. Project Organogram



II. **Budget Tables**

ENVIRONMENTAL MONITORING PROGRAMME (EMP)

(Main issues: water quality, water quantity, water balance, vegetation cover, papyrus buffer, aquatic weeds, fish)

ITEM		PHASE I 1997 - 1999 K Shs				PHASE II 2000 - 2002				PHASE III 2003 - 2005			
		Year 1	Year 2	Year 3	Total	Year 4	Year 5	Year 6	Total	Year 7	Year 8	Year 9	TOTAL
01	SALARIES	720,000	1,008,000	1,400,000	**3,128,000**	1,300,000	1,200,000	1,000,000	**3,500,000**	900,000	800,000	800,000	**2,500,000**
02	DAILY PAID ASSISTANTS	48,000	48,000	36,000	**132,000**	24,000	24,000	24,000	**72,000**	0	0	0	**0**
03	CONSULTANTS/ RESEARCH	900,000	450,000	450,000	**1,800,000**	400,000	300,000	100,000	**800,000**	100,000	100,000	100,000	**300,000**
04	TRAVEL AND SUBSISTENCE	300,000	350,000	400,000	**1,050,000**	300,000	250,000	200,000	**750,000**	200,000	150,000	150,000	**500,000**
05	VEHICLES	3,200,000	0	0	**3,200,000**	0	0	0	**0**	0	0	0	**0**
06	CAPITAL EQUIPMENT/MATERIALS	3,000,000	500,000	500,000	**4,000,000**	500,000	500,000	400,000	**1,400,000**	350,000	300,000	300,000	**950,000**
07	PROJECT RUNNING EXPENSES	600,000	1,200,000	1,200,000	**3,000,000**	1,100,000	900,000	800,000	**2,800,000**	750,000	600,000	500,000	**1,850,000**
08	TRAINING	800,000	950,000	500,000	**2,250,000**	250,000	200,000	150,000	**600,000**	150,000	100,000	100,000	**350,000**
09	PRINTING AND PUBLICATION	100,000	150,000	200,000	**450,000**	200,000	150,000	150,000	**500,000**	150,000	150,000	200,000	**500,000**
10	CONTINGENCY 10 %	966,800	465,600	468,600	**1,901,000**	407,400	352,400	282,400	**1,042,200**	260,000	220,000	215,000	**695,000**
	TOTALS K.SHs	**10,634,800**	**5,121,600**	**5,154,600**	**20,911,000**	**4,481,400**	**3,876,400**	**3,106,400**	**11,464,200**	**2,860,000**	**2,420,000**	**2,365,000**	**7,645,000**
	TOTAL US $	**193,360**	**93,120**	**93,720**	**380,200**	**81,480**	**70,480**	**56,480**	**208,440**	**52,000**	**44,000**	**43,000**	**139,000**

ENVIRONMENTAL CONSERVATION PROGRAMME (ECP)

[Main issues: Water conservation, soil conservation,papyrus zone restoration, re-afforestation,training,weed control]

ITEM		Phase I 1997-1999 K Shs				Phase II 2000 - 2002				Phase III 2003-2005			
		Year 1	Year 2	Year 3	TOTAL	Year 4	Year 5	Year 6	TOTAL	Year 7	Year 8	Year 9	TOTAL
01	SALARIES	900,000	1,500,000	1,800,000	**4,200,000**	1,400,000	1,300,000	1,200,000	**3,900,000**	1,000,000	800,000	750,000	**2,550,000**
02	DAILY PAID ASSISTANTS	100,000	150,000	200,000	**450,000**	150,000	100,000	50,000	**300,000**	0	0	0	**0**
03	CONSULTANTS/RESEARCH	600,000	400,000	300,000	**1,300,000**	250,000	200,000	200,000	**650,000**	150,000	100,000	100,000	**350,000**
04	TRAVEL AND SUBSISTENCE	450,000	500,000	550,000	**1,500,000**	450,000	400,000	400,000	**1,250,000**	300,000	200,000	200,000	**700,000**
05	VEHICLES	6,400,000	0	0	**6,400,000**	0	0	0	**0**	0	0	0	**0**
06	CAPITAL EQUIPMENT/MATERIALS	1,500,000	750,000	750,000	**3,000,000**	500,000	450,000	450,000	**1,400,000**	400,000	250,000	250,000	**900,000**
07	PROJECT RUNNING EXPENSES	1,200,000	1,400,000	1,400,000	**4,000,000**	1,200,000	1,100,000	1,000,000	**3,300,000**	800,000	700,000	600,000	**2,100,000**
08	TRAINING	900,000	800,000	750,000	**2,450,000**	600,000	500,000	500,000	**1,600,000**	250,000	200,000	150,000	**600,000**
09	PRINTING AND PUBLICATION	200,000	250,000	250,000	**700,000**	200,000	200,000	200,000	**600,000**	150,000	200,000	300,000	**650,000**
10	CONTINGENCY 10 %	1,225,000	575,000	600,000	**2,400,000**	475,000	425,000	400,000	**1,300,000**	305,000	245,000	235,000	**785,000**
	TOTAL K.SHs	**13,475,000**	**6,325,000**	**6,600,000**	**26,400,000**	**5,225,000**	**4,675,000**	**4,400,000**	**14,300,000**	**3,355,000**	**2,695,000**	**2,585,000**	**8,635,000**
	TOTAL US $	**245,000**	**115,000**	**120,000**	**480,000**	**95,000**	**85,000**	**80,000**	**260,000**	**61,000**	**49,000**	**47,000**	**157,000**

ENVIRONMENTAL EDUCATION AND PLANNING PROGRAMME (EEPP)

[Main issues: education sessions, environmental awareness, education materials, public health, environmental planning, town mapping, catchment area management plan, environmental impact assessments]

ITEM		PHASE I 1997 - 1999 K Shs				PHASE II 2000-2002				PHASE III 2003 - 2005			
		Year 1	Year 2	Year 3	TOTAL	Year 4	Year 5	Year 6	TOTAL	Year 7	Year 8	Year 9	TOTAL
01	SALARIES	840,000	1,100,000	1,200,000	**3,140,000**	1,200,000	1,150,000	1,100,000	**3,450,000**	1,000,000	900,000	840,000	**2,740,000**
02	DAILY PAID ASSISTANTS	36,000	36,000	36,000	**108,000**	0	0	0	**0**	0	0	0	**0**
03	CONSULTANTS/RESEARCH	400,000	300,000	150,000	**850,000**	150,000	150,000	100,000	**400,000**	100,000	75,000	50,000	**225,000**
04	TRAVEL AND SUBSISTENCE	450,000	400,000	400,000	**1,250,000**	400,000	300,000	300,000	**1,000,000**	250,000	200,000	200,000	**650,000**
05	VEHICLES	2,800,000	0	0	**2,800,000**	0	0	0	**0**	0	0	0	**0**
06	CAPITAL EQUIPMENT/ MATERIAL	1,700,000	1,000,000	400,000	**3,100,000**	300,000	250,000	250,000	**800,000**	200,000	150,000	150,000	**500,000**
07	PROJECT RUNNING EXPENSES	1,500,000	1,400,000	1,000,000	**3,900,000**	900,000	800,000	750,000	**2,450,000**	600,000	500,000	450,000	**1,550,000**
08	TRAINING	600,000	300,000	200,000	**1,100,000**	150,000	100,000	100,000	**350,000**	100,000	75,000	75,000	**250,000**
09	PRINTING AND PUBLICATION	450,000	350,000	300,000	**1,100,000**	300,000	300,000	250,000	**850,000**	200,000	200,000	300,000	**700,000**
10	CONTINGENCY 10 %	877,600	488,600	368,600	**1,734,800**	340,000	305,000	285,000	**930,000**	245,000	210,000	206,500	**661,500**
	TOTAL K.SHs.	**9,653,600**	**5,374,600**	**4,054,600**	**19,082,800**	**3,740,000**	**3,355,000**	**3,135,000**	**10,230,000**	**2,695,000**	**2,310,000**	**2,271,500**	**7,276,500**
	TOTAL US $	**175,520**	**97,720**	**73,720**	**346,960**	**68,000**	**61,000**	**57,000**	**186,000**	**49,000**	**42,000**	**41,300**	**132,300**

NAIVASHA SEWAGE TREATMENT WORKS (NSTW)

[Main issues: Rehabilitation, civil works, mechanical works,electrical works,constructed papyrus wetland, training)

ITEM		PHASE 1 1997 - 1998 K Shs				PHASE II 2000 - 2002			
		Year 1	Year 2	Year 3	TOTAL	Year 4	Year 5	Year 6	TOTAL
01	SALARIES	660,000	720,000	840,000	**2,220,000**	300,000	300,000	300,000	**900,000**
02	DAILY PAID ASSISTANTS	240,000	240,000	120,000	**600,000**	120,000	100,000	100,000	**320,000**
03	CONSULTANTS/RESEARCH	750,000	500,000	500,000	**1,750,000**	250,000	150,000	150,000	**550,000**
04	TRAVEL AND SUBSISTENCE	200,000	150,000	100,000	**450,000**	50,000	50,000	50,000	**150,000**
05	VEHICLES	2,600,000	0	0	**2,600,000**	0	0	0	**0**
06	CAPITAL EQUIPMENT/MATERIALS	7,000,000	2,000,000	750,000	**9,750,000**	200,000	200,000	200,000	**600,000**
07	PROJECT RUNNING EXPENSES	300,000	375,000	404,000	**1,079,000**	100,000	100,000	100,000	**300,000**
08	TRAINING	250,000	150,000	100,000	**500,000**	30,000	20,000	20,000	**70,000**
09	PRINTING AND PUBLICATION	150,000	75,000	75,000	**300,000**	25,000	25,000	25,000	**75,000**
10	CONTINGENCY 10 %	1,215,000	421,000	288,900	**1,924,900**	107,500	94,500	94,500	**296,500**
	TOTAL K.SHs	**13,365,000**	**4,631,000**	**3,177,900**	**21,173,900**	**1,182,500**	**1,039,500**	**1,039,500**	**3,261,500**
	TOTAL US $	**243,000**	**84,200**	**57,780**	**384,980**	**21,500**	**18,900**	**18,900**	**59,300**

LAKE NAIVASHA ENVIRONMENTAL MANAGEMENT CENTRE (LNEMC)

[Main issues: Rehabilitation, civil works, mechanical works, electrical works, water quality laboratory,aquaculture, fish processing,training,information unit]

ITEM		PHASE I 1997-1999 K Shs				PHASE II 2000 - 2002				PHASE III 2003 - 2005			
		Year 1	Year 2	Year 3	TOTAL	Year 4	Year 5	Year 6	TOTAL	Year 7	Year 8	Year 9	TOTAL
01	SALARIES	1,680,000	1,700,000	1,900,000	**5,280,000**	2,000,000	1,750,000	1,750,000	**5,500,000**	1,500,000	1,100,000	1,000,000	**3,600,000**
02	DAILY PAID ASSISTANTS	240,000	200,000	200,000	**640,000**	150,000	150,000	100,000	**400,000**	100,000	0	0	**100,000**
03	CONSULTANTS/RESEARCH	750,000	500,000	300,000	**1,550,000**	250,000	200,000	200,000	**650,000**	150,000	100,000	75,000	**325,000**
04	TRAVEL AND SUBSISTENCE	300,000	350,000	350,000	**1,000,000**	400,000	350,000	250,000	**1,000,000**	200,000	150,000	100,000	**450,000**
05	VEHICLES	3,000,000	0	0	**3,000,000**	0	0	0	**0**	0	0	0	**0**
06	CAPITAL EQUIPMENT/MATERIALS	4,000,000	1,000,000	1,000,000	**6,000,000**	750,000	500,000	500,000	**1,750,000**	250,000	250,000	200,000	**700,000**
07	PROJECT RUNNING EXPENSES	500,000	500,000	600,000	**1,600,000**	500,000	450,000	400,000	**1,350,000**	350,000	250,000	250,000	**850,000**
08	TRAINING	300,000	250,000	200,000	**750,000**	200,000	150,000	150,000	**500,000**	100,000	100,000	100,000	**300,000**
09	PRINTING AND PUBLICATION	500,000	500,000	400,000	**1,400,000**	300,000	350,000	300,000	**950,000**	250,000	200,000	150,000	**600,000**
10	CONTINGENCY 10 %	1,127,000	500,000	495,000	**2,122,000**	455,000	390,000	365,000	**1,210,000**	290,000	215,000	187,500	**692,500**
	TOTAL K.SHs	**12,397,000**	**5,500,000**	**5,445,000**	**23,342,000**	**5,005,000**	**4,290,000**	**4,015,000**	**13,310,000**	**3,190,000**	**2,365,000**	**2,062,500**	**7,617,500**
	TOTAL US $	**225,400**	**100,000**	**99,000**	**424,400**	**91,000**	**78,000**	**73,000**	**242,000**	**58,000**	**43,000**	**37,500**	**138,500**

PROJECT TITLE : LAKE NAIVASHA COMMUNITY-BASED MANAGEMENT PROJECT
GOAL : Ensure long-term conservation of Lake Naivasha and its catchment by managing existing human activities through the adoption of sustainable wise use development principles.
B. ENVIRONMENTAL CONSERVATION PROGRAMME (ECP)
OVERALL OBJECTIVES
Catalyse immediate environmental conservation action in target areas within the lake environs and the catchment with special emphasis on water and soil.
Institute strategies to promote and guide sustainable landuse in future.

IMMEDIATE OBJECTIVES

1. Provide training in essential conservation and sustainable landuse skills.

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUT	MEANS OF VERIFICATION	ASSUMPTIONS
Short term intensive training	Increased conservation and sustainable landuse skills in target communities	Number of farmers trained	Project records	Willingness of trainees to acquire skills
Routine field training	Increased conservation and sustainable landuse skills	Number of sectors influenced	Training Institute records	Vacancies in training institutions
Farmer to farmer training	Improved communication skills among trainees	Level of adoption of water and soil conservation measures	Site visits and interviews	Willingness of farmers to train others
Establishment of demonstration sites	Increased skills in conservation and sustainable landuse	Level of adoption of sustainable landuse methods	Site visits and interviews	Cooperation from communities

2. Create an enabling environment for the immediate application of acquired skills.

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Provide technical direction and material support for water and soil conservation	Increased adoption water and soil conservation measures	Number of units embarked on conservation programme.	Project GOK and unit records	Cooperation from communities and GOK
Rehabilitate degraded sites	Community participation in rehabilitation works	Number and area of recovering rehabilitation sites	Site verification	Conducive environmental conditions
Protect threatened sites	Community participation in protection of threatened sites	Number and area of protected sites	Site Verification	Cooperation from resident community
Adopt environmentally sound farming techniques	Reduced reliance on agro-chemicals for fertility enhancement and pest control	Number of farms routinely using farming and IPC strategies	Surveys	Continued availability of necessary inputs

3. Ameliorate impacts on the lake ecosystems

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Maintain and restore buffer zone of papyrus and other aquatic vegetation	Fringing buffer zone of papyrus	Extent of buffer zone of papyrus	Site verification	Riparian owners willing to maintain buffer zone
Promote appropriate fishing techniques	Increased adoption of appropriate fishing techniques	Increased use of appropriate fishing techniques	Project records	Willingness of fishermen to cooperate
Initiate aquaculture projects	Adoption of aquaculture	Number of farms embarked on aquaculture	Project/Fisheries Department records	Cooperation from resident community
Initiate water hyacinth control	Water hyacinth control programme in place	Water hyacinth impact reduced	Site verification	Cooperation from KARI
Establish water abstraction control	Water abstraction controlled	Water meters installed and licenced. Abstraction curtailed	Water apportionment board inspection	Cooperation from MLRRWD

4. Institute strategies to sustain conservation effort

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Develop partnerships between locally represented institutions (LNROA, KWS, NMC, GOK, LNGG)	Collaborative implementation of conservation programmes	Work plans and reports reflect collaborative effort	Project records	Willingness of organisations to cooperate
Develop technical capacity within these agencies	Enhanced capability of partners	Partners carry out responsibilities efficiently	Interviews/Partners record	Willingness of donors to accept proposals

PROJECT TITLE: LAKE NAIVASHA COMMUNITY-BASED MANAGEMENT PROJECT
GOAL: Ensure long-term conservation of Lake Naivasha and its catchment by managing existing human activities through the adoption of sustainable wise use development principles.
C. ENVIRONMENTAL EDUCATION AND PLANNING PROGRAMME (EEPP)
OVERALL OBJECTIVES
Increase environmental awareness among riparian and catchment residents, and institutionalize sustainable wise use and EIA enforcement practices.
Develop ways to sustain public interest in the environment beyond the life of the project.
IMMEDIATE OBJECTIVES
1. Organise education sessions for riparian and catchment residents to expand and update their knowledge on the local environment.

ACTIVITIES	OUTPUT	INDICATORS OF OUTPUT	MEANS OF VERIFICATION	ASSUMPTIONS
Provide short-term environmental education courses	Well informed representatives of stakeholder groups	Increased public awareness of local environmental issues	Education materials/records	Cooperation from Communities
Conduct thematic workshops,seminars,conferences.	Informed officials and community	Increased community participation in educational events	Project records/interviews	Cooperation from communities
Conduct school lectures,exhibitions and tours	Informed schools of target areas	Increased participation of schools in local environmental issues	Project records/survey	Schools willingness to participate
Provide courses on sustainable development principles	Applied sustainable development principles	Increased application of sustainable development principles	Course materials/site visits	Cooperation from Communities
Provide training for trainers	Trained trainers (extension staff)	Increased extension programmes	Project/Community records	Cooperation from GOK

2. Create awareness of economic opportunities arising from wise use of natural resources

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTION
Explore economic incentives	Developed proposals for viable enterprises	Developed proposals	Project records	Continued demand for products and services
Promote and start-up viable enterprises	Operating self-sustaining enterprises	Operating enterprises resulting in increased Income	Records of operating enterprises and interviews	Continued demand for products and ecotourism
Promote indigenous knowledge and skills	Developed projects based on indigenous knowledge	Increased availability of indigenous products	Project records/surveys	Cooperation from communities

3. Encourage community action for environmental conservation

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUT	MEANS OF VERIFICATION	ASSUMPTIONS
Assist organization of environmental action groups	Formation of environmental health communities (EHC)	Number of active environmental health communities	Project records/EHC records	Community Cooperation
Provide environmental health information	Informed residents of target areas	Cleaner settlement maintained through community efforts	Interviews with communities	Continued cooperation from Naivasha Municipal Council
Support waste reuse/recycling/reduction initiatives	Community involvement in solid waste management	Increased incidence of waste reuse/recycling	Site evaluation	Community cooperation
Promote Participatory Rural Appraisal (PRA) techniques	Trained local people in PRA	PRA reports of selected areas	Project reports of selected areas	Cooperation from communities

4. Institutionalise environmental education

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Develop and produce environmental education materials	Adult literacy classes and Church groups	Availability and use of materials	Visits to education centers	Materials easily accessible to all users
Integrate environmental education materials into existing curricula	Educational packages in use in schools	Educational packages adopted by schools	Check teachers workplans/interviews	GOK and teachers willing to use materials
Capacity building in KWS,NMC and WCK	Increased commitment and involvement by partners	Active participation of partners in environmental education	Project records/Partner's records and future plans	Partners willingness and commitment.

5. Promote integration of appropriate environmental policies into landuse planning and development

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Conduct thematic seminars, workshops, conferences for planners	Proceedings of seminars, workshops and conference records	Number of seminars, workshops and conferences	Project records/Training institute's records	Cooperation from partner Institutions
Facilitate formulation of environmentally sound landuse guidelines	Endorsement of guidelines by DDC and relevant institutions	Approved integrated Landuse development plans	Endorsed development action plans	Cooperation from GOK
Commission studies on socio-economic issues within the catchment	Environmentally based socio-economic document addressing spatial planning	Socio-economic findings and recommendations	Project reports	Cooperation from the community
Initiate integrated multi-sectoral planning	Catchment area management plan	Endorsed catchment area management plan	Project/Partner records	Cooperation from GOK

6. Strengthen systems to undertake environmentally sound landuse planning and management.

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Establish linkages between environment committees, riparian village, DEMC and NEMA	Increased involvement of the local committees in managing the environment	Number of operating committees	DEMC records/ local environment committee records	Cooperation from DEMC
Establish Lake Naivasha Environment Management Committee	Increased capacity for handling environmental concerns	Records of Lake Naivasha Environment Management Committee	Project records/LNEMC records	Cooperation from stakeholder groups
Provide support for the establishment of an environmental database.	Updated environmental database	Availability of up to date environmental data	Project records	Availability of the essential equipment
Provide training an integrated planning procedures	Trained LNEMC on integrated planning	Trained LNEMC in place	Integrated plans	Technical expertise available

PROJECT TITLE LAKE NAIVASHA COMMUNITY-BASED MANAGEMENT PROJECT
GOAL: Ensure long-term conservation of Lake Naivasha and its catchment by managing existing human activities through adoption of sustainable wise use development principles

D. NAIVASHA SEWAGE TREATMENT WORKS (NSTW) PROJECT
OVERALL OBJECTIVE
Improve public health and protect Lake Naivasha's rich biodiversity.

IMMEDIATE OBJECTIVES

1. Restore the NSTW plant to full working condition

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUT	MEANS OF VERIFICATION	ASSUMPTIONS
Carry out civil mechanical and electrical works	Operational sewage treatment plant	All parts installed and functioning	Project records/Site visit	Spare parts available
Train plant personnel in plant management	Trained plant operators	Proper functioning of the plant	Course certification	Low personnel turnover
Repair fence,gates,buildings	Effective security systems	Absence of vandalization	Plant inspection	No violent theft

2. Increase the plant's purification capacity by adding a constructed wetland of papyrus

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Design a constructed wetland of papyrus	Design criteria feasible	Constructed wetland design	Project records	Availability of expertise
Construct an artificial wetland	Artificial wetland constructed	Impoundment as specified by design criteria	Site observation	Large enough land available
Plant papyrus and design harvest cycle	Complete impoundment planted with papyrus	Harvested papyrus	Site observation/Project records	Sewage not too polluted

3 Maintain and protect the biodiversity of Lake Naivasha

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Operate plant properly	Reduced eutrophication and pollution of the lake	Low levels of nutrients and pollutants at the outlet	Monitoring records	Laboratory facilities available
Monitor affluent and effluent water quality	Reduced eutrophication and pollution	Conformity to nutrient and pollution standards	Monitoring records	Water quality guidelines
Monitor aquatic weeds growth near the effluent point	Reduced growth of aquatic weeds	Non-proliferation of aquatic weeds	Site visits	Baseline data available

PROJECT TITLE LAKE NAIVASHA COMMUNITY-BASED MANAGEMENT PROJECT

GOAL: Ensure long-term conservation of Lake Naivasha and its catchment by managing existing human activities through adoption of sustainable wise use development principles.

E. LAKE NAIVASHA ENVIRONMENT MANAGEMENT CENTRE (LNEMC) PROJECT

OVERALL OBJECTIVE

Improve the availability of environmental information on Lake Naivasha and its catchment.
Establish a water quality analysis facility in Naivasha
Promote good fishing techniques and encourage aquaculture projects

IMMEDIATE OBJECTIVES

1. Rehabilitate NWFTI's Annex and its management to full operation

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTION
Carry out civil mechanical and electrical works	Operational facilities	All parts installed and functioning	Project records/Site visits	Spare parts available

2. Establish an environmental information focal unit in Naivasha

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Provide equipment for documentation centre	Equipment in use	All equipment installed and in use	Project records/Site observation	Assumptions equipment available
Collate data,reports, publications, maps, etc on Naivasha basin	Information library established	Relevant documents on Naivasha basin available	Library records/site observation	Availability of data and information

3. Establish a water quality analysis laboratory

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTION
Provide equipment and materials	Functional water quality analtytical equipment in use	Equipment installed and in use	Project records	Analytical equipment available
Develop water quality analysis guidelines	Standard methods for water quality analysis	Standard analytical methods in use	Standard methods manuals	Expertise available
Train laboratory personnel on analytical techniques	Trained laboratory personnel	Trained personnel in place	Certification/project records	Trainers available

4. Promote good fishing techniques and aquaculture

ACTIVITIES	OUTPUTS	INDICATORS OF OUTPUTS	MEANS OF VERIFICATION	ASSUMPTIONS
Train local people on fishing techniques	Trained local people	Register of trained people	Project/Partner records	Cooperation from local community
Train local people on aquaculture	Trained local people	Register of trained people	Project/Partner records	Cooperation from Local community
Establish a pilot fish processing facility	Operational fish processing facility	Processed products marketed	Site observation and records	Availability of expertise
Establish a boat repair facility	A functional boat repair facility	register of repair services	Project/Partner records	Cooperation from fishermen

DRAFT

PUBLIC INVOLVEMENT IN THE PREPARATION AND IMPLEMENTATION OF THE LAKE NAIVASHA MANAGEMENT PLAN, KENYA

Conflicts over natural resources

Epcem report

Laszlo Czuczor

Kenya Wildlife Service Training Institute
Naivasha, Kenya
July 1997

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PREFACE

The author of this report is a participants of the European Postgraduate Course in Environmental Management (Epcem)[1]. The report was written during the internship module of Epcem. The internship started on the 19th of May and ended on the 18th of July in 1997. The aim of the internship was to learn to work as an environmental expert in a practical working situation at an environmental-organisation, to obtain understanding of this organisation's role in the field of environmental policy, to get familiar with the structure, tasks and functioning of the organisation and to learn to analyse an environmental issue in a short period of time and to advise on the possible solutions.
The host organisation was the Kenya Wildlife Service Training Institute (KWSTI), Naivasha, Kenya.

Insufficient public involvement is often an obstacle for project implementation. The decision-makers often fall into the same pitfall, namely not to give publicity for the project. Passivity of the affected parties in the beginning can also cause conflicts in a later stage. Certain, marginal groups and communities get to know of the project just at the start of implementation. At that stage the plan is not that dynamic, new ideas, remarks can not be incorporated. And coercion does not work.
For the government in power is responsible for good environmental management and utilisation of a certain area, therefore management plans are usually developed at governmental level. This top-down approach comprises the danger of not taking into account the local interests. Local people are often not consulted, do not have a stake in management of the local environment and local resources.
It has been recognised that local management can ensure that grass-root needs are met through negotiating solutions between local stakeholders. When a tailor-made management plan is developed, all the stakeholders are satisfied and committed to implement it.
The government can establish local management groups with management power or the initiation can come from grass-root level. The concept of local management groups is new, it is hardly researched, only a few case studies were elaborated. Specially for the latter there are only few examples, if any. The Naivasha-case can be considered as a pilot project for locally initiated management. Therefore, Naivasha merits more attention, the management process should be studied, analysed and evaluated.

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[1] The European Postgraduate Course in Environmental Management (Epcem) is a co-operative programme between the Interfaculty Department of Environmental Science (University of Amsterdam), the Institute for Environmental Studies (Free University Amsterdam), the Centre of Environmental Science (Leiden University) and the Centre for Environment and Climate Studies (Agricultural University Wageningen).

This report presents a description and analysis of the management process around Lake Naivasha focusing on public involvement and participation. Data were obtained from literature sources and interviews. The main conflicts within the area are explored. Aiming at a situation which all parties benefit, the different opinions were integrated and feasible recommendations were given. This report can be considered as a study which closes the past, evaluates it and gives recommendations about public involvement for future.

The report is not a blueprint, it is the perception of the author taking into consideration of the impressions of 2 months. The Kenya Wildlife Service does not bear any responsibility for the content of the report.

SUMMARY

Lake Naivasha is a unique place. It is situated among volcanic formations at the bottom of the Rift Valley in Kenya. It is the only permanent fresh water lake in the bottom of the Rift Valley. It is famous for its rich biodiversity, specially birds, it hosts more than 350 bird species, including some endangered bird species.
In the last century European settlers arrived to the area and occupied land around the lake. Their main activity was farming and ranching.
Over the last 15 years there has been tremendous increase in commercial agriculture. Development, resource exploitation became a big burden on the ecosystem. Ecological disaster was not recorded, but few signs alarmed sober heads. A group of local farmers established an association, the Lake Naivasha Riparian Owners' Association, and started to lobby for the protection of the Lake. The members were wealthy European farmers with great economic interest. The active core of LNROA made big progress in nature protection and realised the need of a management plan for the lake. They resolved to start a three phase environmental program, with the aim of introducing sustainable utilisation of the area. The first phase was designed to collect all available information on the lake, particularly what is relevant to the preparation of a management plan for the area. In phase two the management plan was written for the area which - as a result of active lobbying by LNROA - meanwhile became a Ramsar site. Phase three was the implementation of the management plan.
The main idea was to start a community based management process. The aim of this grass-root initiative was to develop a management plan which, when implemented, will make sure there is long term future for both the farmers and the lake. Governmental approval would ensure implementation and enforcement, therefore this was set as an other objective. LNROA enjoyed the backing of international organisations and went through the first and the second phase, currently they have been implementing the plan.
Implementation did not go smoothly, several problems arose due to imperfect public involvement and conflicting interests. Some marginal groups were not involved in the compilation of the plan and their interest were not taken into account. LNROA members had prepared a management plan for themselves, only for the riparian land owners. The interests of other lake users, living further from the lake, were not incorporated.
Also some farmers felt their economic development being threatened. Those giant horticulture farms abstract big amount of water, their business depend entirely on the availability of water. The plan would potentially comprises the chance of restriction of water abstraction. This was very much adversely to the big flower growers' interests so they strongly opposed the legalisation of the plan. They formed their own group (LNGG) and separated themselves from LNROA.
After 9 months silence the Kenya Wildlife Service, as the custodian of Kenya's Ramsar sites, offered its help. Several stakeholder meetings were organised and held at the KWSTI which brought the break-through of the conflicts. LNGG and LNROA again could work together, other suppressed stakeholders could express their concerns, too.

The plan was legalised on district level, now the aim is governmental approval on higher level. The new environmental bill is under discussion, it would give management power for the local management group.
Implementation started last year, sub-committees have been working on terms of references and their realisation.

Acronyms

ASAL	Arid and Semi-Arid Land
CoC	Code of Conduct
EIA	Environmental Impact Assessment
EPCEM	European Postgraduate Course on Environmental Management
GoK	Government of Kenya
HCDA	Horticulture Crop Development Authority
KARI	Kenyan Agricultural Research Institute
KMFRI	Kenya Marine and Fisheries Research Institute
KPC	Kenya Power Company
KWSTI	Kenya Wildlife Service Training Institute
LNGG	Lake Naivasha Growers` Group
LNMPIC	Lake Naivasha Management Plan Implementation Committee
LNROA	Lake Naivasha Riparian Owners` Association
NEAP	National Environmental Action Plan
NES	National Environmental Secretary
WRAP	Water Resources Assessment Project

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1. INTRODUCTION

Lake Naivasha is situated in a shallow depression on volcanic deposits in the Rift Valley in Kenya. It is a freshwater lake surrounded by the alkaline lakes of Elmenteita, Nakuru, Magadi and Bogoria. Lake Naivasha is in a closed drainage basin and has no visible outlet.

Traditionally the lake was a centre for sport and recreation, and with its natural diversity and beauty and being only 100 km from the capital, presents an ideal tourist centre. The lake is world famous for its biodiversity, specially birds, it is a host of more than 350 bird species. Hippopotamuses, giraffes, buffaloes and game also live in the area and the lake is an essential environment for them.

The local population is also dependent on the lake for it provides fish and water for the cattle and the adjoining areas are used as grazing fields or agricultural land.

Over the last 10 to 15 years there has been a tremendous increase in commercial agriculture. The cultivation of flowers and vegetables in the dry climate is based on extraction of water from the lake for irrigation. The domestic and irrigation water demand of this sector is a main concern of conservationists and other users. No reliable hydroiogical study is carried out for the catchment.

Potential geothermal energy was discovered and is exploited. Now, geothermal power generation near the lake provides 15% of Kenya`s electricity requirements. The Kenya Power Company plans further expansion of the plant.

The presence of intensive agriculture, the energy production and other human activities threaten the state of the environment. Several environmental problems occurred in the region. Rapid population growth and the forecasted development of tourism shed light on potential problems which will occur in the near future.

The limited natural resources were exploited over years and years in an unsustainable way. When water and land became scarce resources, conflicts arose. The opposing interests of stakeholders clashed and there was an urgent need for solutions.

The problems and conflicts were not recognised on governmental level. National environmental policy did not exist and the existing laws were not enforced. Although the local horticulture industry is one of the most important foreign exchange earner of Kenya and more than 250 000 people depend directly or indirectly on it, there was no significant effort to resolve the problems.

Therefore, the Lake Naivasha Riparian Owners` Association (LNROA)[2] resolved to start a three phase environmental program, with the aim of introducing sustainable utilisation of the area.

The first phase was designed to collect all available information on the lake, particularly what is relevant to the preparation of a management plan for the area.

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[2] The Lake Naivasha Riparian Owners` Association (LNROA) was formed in 1926. It has strong interest in sustainable development and therefore in nature conservation. LNROA has been playing an important role in the management process. LNROA proposed lake Naivasha to be a Ramsar site and in 1995 the Government of Kenya designated the lake as a Ramsar site.

In phase two the management plan was written for the Ramsar site. A campaign was undertaken to inform all concerned parties so that once complete, the plan is understood and accepted by all.
Phase three is the implementation phase. Changes in agricultural practise, waste disposal and other measures recommended in the management plan is being executed.

1.1 Problem definition

There was a lack of actual involvement of all stakeholders, therefore the needs of some local communities were not considered adequately. This occurred due to the passiveness of the communities and also because active lobbying by the Lake Naivasha Riparian Owners` Association was lacking in the management process.

1.2 Objectives and target group

The main objective of the research is to assess public involvement in the management process.

Reasoning:
Imperfect public involvement became an obstacle in the management process. There is a need for clear assessment on public involvement to realise the faults and to correct them.

Objectives:

I) The first part of the study aims to give an overview of the values and benefits of the lake and its surroundings. Another objective is to write an inventory of the stakeholders and their interests, also to list the human activities and their impacts on the environment and the socio-economics.

II) The second part of the study will be the evaluation of phase 2. The preparation of the management plan as a process, the management plan itself as a final product will be assessed. During the process evaluation, emphasis will be put on the public involvement. Also the integration of different interests and sectors will be studied. The management plan will be checked whether it is consistent, complete and whether it touches all the relevant issues. Another objective is to reflect opinions and interests which were not sufficiently incorporated in the management plan.

III) The third part of the study will be the evaluation of phase 3. The objective is to report on the implementation of the management plan. To summarise the progress and achievements. The objective is to examine the process of implementation according to the following criteria:

2. IMPORTANCE OF LAKE NAIVASHA AND ITS ENVIRONS

Lake Naivasha has several values and benefits which are important for the ecosystem and for the human society. To define the importance of Lake Naivasha and its environs, it is necessary to define the values and benefits of it. Although decision-making would be easier with monetised values, that was not the intention of the study. The wetland values were not calculated in monetary terms only qualitative description is given.

2.1 Aesthetic/Landscape value

Lake Naivasha is situated in the bottom of the Eastern Rift Valley. The surrounding mountains, the faults form a beautiful landscape making the area very attractive for tourists. From the top of the escarpment there is a picturesque view on the lake and the valley. The game parks with high rocks, cliffs and gorges are fascinating. The beautiful scenery is one of the most important values of the Naivasha area.

2.2 Ecological values

In 1995 Lake Naivasha`s extraordinary biodiversity found international recognition when Kenya designated the lake as its second Internationally Important Wetland Site.

2.2.1 Outstanding biodiversity values

Birds

More than 350 species of birds including 74 species of water birds have been recorded in and around the lake. Including some endangered species the lake provides nesting and resting place for a lot of indigenous and migratory bird.

Mammals

34 species of mammals including 5 rodents live in the area. The vegetation supports a large number of herbivores, among others game, about 500 Hippopotamus, 11 Giraffes, Buffaloes, Zebras, Coypus (introduced) and other mammals.

Reptiles

8 species of reptiles found good, suitable living environment in the area.

Papyrus

Papyrus is probably the most important plant of Lake Naivasha, due to its involvement in keeping the waters of the lake fresh and in preventing eutrophication. The papyrus fringe around the lake shore has a capability for extract nutrients from run off and from ground water. This natural purification system operates "free of charge" without any investment.
It also produces significant amount of biomass for it grows very fast in the nutrient-rich environment. The papyrus is also used as a habitat by waterfowl.

2.2.2 Lost biodiversity values

Extirpation of a unique, endemic fish species
Prior to 1925, there was only one species of fish in the lake, the small toothed carp. Introduction of Tilapia and other fish species for commercial purposes caused the extirpation of the small toothed carp (last record in 1962).

Loss in bird population
In 1936, 50 Pelicans and 500 Cormorants were killed to give better protection for fish. A year later a further 750 Cormorants, Divers and Darters were killed.
Until the late 60`s bird shooting was allowed on the lake as a sport.
The continuous destruction of papyrus is also detrimental to the bird population and cause big biodiversity loss.

Loss of part of the papyrus fringe
100 years ago the lake was entirely surrounded with papyrus. The papyrus has been burned to gain more land and be able to cultivate it.

2.3 Economic values

The wetland resources have been used by local population as an important source of income.

2.3.1 Commercial

The Lake and its environs has natural resources being commercially exploited. This intensive resource use and its questionable sustainability is of main concern of the nature conservationists.

Agriculture
Although agriculture already existed around the lake in the beginning of this century, the major development in this sector happened 10-15 years ago and is still going on.
The area is very advantageous for intensive agriculture. The climate is dry enough to prevent plant diseases, the radiation is intense, the temperature rarely too cold and only occasionally too hot and there is a supply of good quality water [KWSTI, 1996].

Horticulture, fruit and vegetable growing
Almost the whole area around the lake is cultivated and privately owned. Farms around the lake range from big companies with hundreds of hectares under intensive flower production, to small farmers growing fruits and vegetables and producing wine for export. The biggest carnation farm in the world is here. They sell flowers on the world market, through European distributors (Aalsmeer, the Netherlands).
The intensive agriculture employ 30.000 people. Approximately 8 family-members depend on the income of each worker, so 250.000 people's life depend entirely on the horticulture industry. Naivasha is one of the most affluent areas in Kenya due to the high employment rate and stabile individual income.
The local horticulture industry earns a significant amount of foreign exchange for the Government of Kenya.

Livestock and dairy farming
The livestock industry did not develop at such a rapid pace as the horticulture industry did. The present livestock developments in the area amount to a small number of large beef and dairy herds. Fencing and irrigation of pastures contributes to the main threats to the environment namely land and water shortage. [LNROA, 1993].

Fisheries
Prior to 1925, there was no commercial fisheries on the lake. The present fish population - which is suitable for commercial exploitation - is totally made up of introductions made by man. The fishing industry started in 1959.
Currently there are approximately 40 legal fishermen on the lake. They all must have a valid license issued by the Fisheries Office. The fish industry produces significant amount of fish for export and import.
The crayfish industry started in 1970. Nowadays, 30 licensed fishermen catch crayfish mainly for export to the Netherlands.
The fish yield continuously diminishing. There are no designated and protected fish breeding areas in the lake.

Geothermal energy
The first exploration for possible geothermal sources was done in 1956, but it was not until 1980 that the first station was constructed, and commissioned in the following year. Geothermal energy, which is comparatively cheap, clean and is environmentally friendly, was attractive to the Government of Kenya. By 1985 the project was producing its planned output of 45 MW, roughly 15% of the national requirements. The Kenya Power Company is willing to expand the project. KPC use significant amount of water from the lake [LNROA, 1993].

Pastoralism
Approximately there are 20.000 pastoralists in Narok and Nakuru district, who are potential users of the lake, 15.000 in Narok and 5.000 in Nakuru district. Their main activity is animal husbandry, they keep cows, goats and sheep. The estimated number of the cow herd is 200.000.

Drinking water
The ground and surface water is tapped at several places. A significant amount of water is abstracted which is used by the citizens of Naivasha. Improved water supplies to Naivasha town has an important priority.
The upstream of river Malewa, which runs into the lake, is dammed to supply drinking water for Nakuru.

2.3.2 Subsistence

Many agricultural products are consumed without being sold in the market. Although less people depend on the subsistence production, its importance is unquestionable.

Agriculture
Some small farms around the lake supply vegetables and fruits for home consumption. These are small-scale subsistence agriculture-farms provide basic food for individual consumption.

Fishing
The minor part of the fishcatch by legal fishermen and bigger part of the fishcatch by poachers are consumed without distributing it on the market.

2.4 Socio-cultural values

It is necessary to enlighten the social context of the economic activities. These social factors can have big influence in planning and in judging interventions.

2.4.1 Recreation

The recreational facilities around the lake are important. It is a place where visitors can enjoy nature without any disturbance.

Residents
Riparians can enjoy the natural beauty of the lake being on the bank of it. Sport fishing, boat trips, bird and game watching are very popular. School groups also visit the lake for picnic, bird and game watching.

Travellers
The area is particularly popular among week-enders from Nairobi, being no more than one and a half hours drive from the capital. They usually spend one or a few days in local lodges or riparian hotels.

2.4.2 Tourism

Naivasha is a key site for international tourism and its attraction depends entirely on the lake. Naivasha is one of the stations of the tourist circuits. Lots of international tourists come here to sport fish, for bird and game watching.
The area is frequently visited by tourists, specially interested in birds. and in geology. Local hotels are busy and usually fully booked.
The area has great potential for further eco-tourism development.

2.4.3 Education

With good facilities, the Training Institute of the Kenya Wildlife Service provides basic and specialised upgrading training and organises courses and seminars for staff of KWS and its partners. A sanctuary called Annex with its fish-farm and laboratory has a great potential educational value.

2.4.4 Scientific value

The area offers opportunities for research and ecological monitoring of a wide variety of environmental resources.
A lot of scientific research has been going on, mainly concentrated on the lake and its immediate environment. Concerning KWSTI, research is going on the behaviour of hippos and a research program will start on fisheries in the near future.

2.4.5 Historical values

Archaeological findings prove that people have lived round the lake for the last 10.000 years. There was an extensive Neolithic settlement 6-10.000 years BP on Crescent Island. They buried their dead under stone cairns, the remains of which have been found on the Island [LNROA, 1993].

3. MAIN STAKEHOLDERS

The main stakeholders and their interests are listed in this chapter. A distinction was made between "stakeholders" and "lake users". A stakeholder is every sector and administrative body, what has any kind of relation with the lake. This relation can be actual use of the lake, but also responsibility, authority and jurisdiction on the lake. The lake user is the one whose livelihood and income directly depend on the lake (the last seven stakeholders in chapter 3.1).

3.1 Main stakeholders and their interests

This chapter is a description of stakeholders, their activities and interests concerning the lake.

3.1.1 Fisheries Office

The Fisheries Office falls under the Ministry of Fisheries and Wildlife. The role of the Fisheries Office is the management of the fisheries in Nakuru district, which implies commercial fishery, acquaculture, and sport fishing. The main objective is to conserve the fishery resources and regulate its exploitation. The principles are laid down in the Code of Conduct for the fishery sector (see appendix 9.3). They are supposed to designate and protect fish breeding areas in the lake. They continuously monitor the fish catch at the fish banda which is a landing beach on riparian land. The fishermen have to report at the banda where an officer examine the fish. The Fisheries Office process the data, make a stock assessment and define the trend (yield prediction). According to the registered fish catch the Office issues permits on an annual basis. The number of issued licenses depend on the amount of fish what was caught. However, if the catch is poor, the fishermen will not renew their permits, but will fish somewhere else.
The Fisheries Office has been suffering of lack of technical and financial resources. The shortage of fuel, lack of transport means and personnel jaupodise adequate law enforcement.
There are more and more poachers fishing on the lake using unsustainable fishing methods. They also approach the lake on private land through the farms. The office has full powers of arrest and can set up road blocks on their own or in conjunction with the police and Game Department. They are prepared to act on information given them by riparian farmers who have proof of poaching gangs operating in their area. The local farmers are being a good help and are ready to collaborate for they provide inside information for the office. However, the Office is not able to monitor the lake adequately, neither the trespasses on private land. Foot patrols comprising a small number of people are dangerous, as they can be easily outnumbered and overcome by the opposition. Large patrols are directional and therefore easily avoided by poachers. The sentences given to offenders are not a deterrent and the number of cases are negligible.
It is not easy to control the legal fishermen neither, unless they have a self-regulatory approach. The fishing community has a crucial role to play. Their self-regulatory approach would enhance and increase the fish stock and would partly

unload the Fisheries Office from the burden of enforcement. To achieve this, the Office should emphasise public awareness of the fishermen through educating them.
Poor facilities are improved by the help of KWS and the riparian farmers for they provide engine for the boat and fuel for transport. Internal relations are good, the officers and fishermen are on good terms with each other.
Because there is a direct connection between lake level and productivity, their indirect interest is high lake level.

3.1.2 Ministry of Land Reclamation, Regional and Water Development

The Ministry and its regional Water Development Office play an important role around lake Naivasha. They manage water abstraction, its regulation and also manage municipal sewage treatment.
The legal framework for apportioning water is provided by the Water Act. The act supposed to be enforced by this Ministry and its Water Apportionment Board. The Boards' task is to define the sustainable water abstraction level and to allocate the available water amount among the water users to ensure that the sustainable level is not exceeded. The Apportionment Board enforce its measures through the Regional Water Development Office and its extension the Water Bailiff Office. Because of the lack of resources and the lack of full commitment water permits are not issued after considering the water budget, but automatically. Everybody can get a license who pays the application fee. Permits are given for fixed amounts - even when that may exhaust the resource base. Only the technical aspects are considered, EIA is not prepared. Also operation of the bore-holes are not monitored, so there is a chance that farmers use more water than what they applied for.
In 1981 a joint project of the MLRRWD with the Norwegian Government resulted an operating sewage treatment plant which receives the wastewater of Naivasha town. Although the scheme is anticipated to cater for flows up to the year 2000, the plant broke down after 4 year operation. Recently big efforts has been made to rehabilitate the plant by LNROA, a local community and the local municipality, who has jurisdiction over the plant.

3.1.3 Kenya Wildlife Service

The KWS, as the custodian of the implementation of the Ramsar Convention in Kenya trains wardens and foresters, who become capable to manage National Parks on different levels. They are particularly charged with the responsibility of managing human-animal conflicts like wild animals eat the harvest or danger for human by wild animals.
KWS and the Elsamere Conservation Center are the only active nature conservation organisations in the area. However, KWS's focus in on the wildlife conservation.
The Tourism Department of the KWS is responsible for promoting sustainable tourism in the area.
In 1984 KWS has established the Hell's Gate National Park near to the lake. As a consequence, the Maasais were forced to leave the area, their traditional land. This caused several problems later.

The Training Institute of the Kenya Wildlife Service is situated near the lake. It was established in 1985 with a financial support of the World Bank. A fish farm complex was built at the Annex, a natural area on riparian land. The fish farm - after its rehabilitation - will have an important role to regenerate the fish stock by introducing fish from the farm to the lake.

3.1.4 Horticultural Crop Development Authority

This governmental authority is mandated to promote, monitor and co-ordinate horticultural development in the country.

3.1.5 Ministry of National Environment and Natural Resources

The Ministry is a kind of umbrella department responsible for sustainable development.
Because of international recommendations towards the GoK, the national environmental action plan was prepared and was gazetted in 1994. The NEAP report addresses environmental issues in a cross-sectoral and in an integrated fashion. It has laid down the principles of sustainable utilisation and involvement of local communities. The development of EIA guidelines and drafts have been completed and incorporated into NEAP. It is envisaged that the EIA will become formalised as an integrated component of all development activities.
The draft version of the Environmental Management and Co-ordination Bill was prepared in1995, and is waiting for governmental approval. Its content implies guidelines for environmental conservation and management, including promotion of community based management and establishment of local resource management groups. This new bill gives more room for individuals to complain and sue. Approval of this Bill is going to be a milestone in the management process around the lake.
The National Environmental Secretary (established in 1974) is a governmental department in the Ministry of Environment and Natural resources that enhances the protection of environment and sustainable development. The activities of the NES are:

- promotion and interpretation of environmental policies, plans, programmes and projects,
- ensuring rational utilisation of the nation`s natural resources on a wise use basis.
- co-ordinating, initiating and formulating of policies on conservation, protection and environment
- assessing and mitigating environmental impacts of development activities.
- promoting proper land use practises
- monitoring the nation`s resource base and preparation of periodic reports on the state of the environment.

The ministry suffers from lack of resources. Governmental instruments are not used adequately.

3.1.6 Kenya Association of Tour Operators

KATO is the umbrella organisation of all the travel agencies and tour companies in Kenya. One of their objectives is promotion of sustainable tourism. The KATO's interests match with the interests of the hotel owners, namely adequate infrastructure, security, solid waste disposal, etc.

3.1.7 Nakuru and Gilgil townships

Nakuru and Gilgil are townships in Nakuru district. As a result of a governmental water project a dam was built on river Malewa for water supply for Nakuru and Gilgil. The second dam was never built on river Malewa for Nakuru. LNROA stopped the project because of its effect on lake ecosytem.

3.1.8 Municipality of Naivasha

Naivasha town has 200.000 inhabitants. Urbanisation is a problem, the town needs infrastructure, roads, water supply, sewage treatment, garbage collection, housing facilities. The town has been expanding rapidly. The lack of birth control because of religion and also lack of awareness yields an annual 3,5% population growth. High land demand associates with increased amount of wastewater generation. The town is national 3rd in earning income for the GoK.
Improved water supplies to Naivasha town is an important priority which is in conflict with the interest of the nature conservationists.

3.1.9 DHV

DHV, a Dutch consultancy firm carried out several water assessment projects in arid and semi arid areas (ASAL). Recently they have been working on a water resources assessment project (WRAP) in the Naivasha catchment. The study will result a reliable water budget for the whole catchment, which will be a great help in decision-making. The following factors are going to be defined:

- underground seepage in
- underground seepage out
- evaporation
- transpiration
- water extraction
- precipitation
- discharge of river Malewa and other periodic rivers

DHV is going to build water resource models for the Lakes Naivasha, Elementaita and Nakuru catchments, including the two large towns of Nakuru and Naivasha, using surface, river and ground water flows and abstractions. They are going to formulate a district water management plan, specify how much surface and groundwater will be available, describe existing supplies and present and future demands and chart future developments.

3.1.10 Pastoralists

There are 20.000 pastoralists in Narok and Nakuru district, who are potential users of the lake, 15.000 in Narok and 5.000 in Nakuru district. They are Maasais, a traditional tribe that still practises its traditional customs and religion. Being traditional pastors, their main activity is animal husbandry, they keep cows, goats and sheep. The estimated number of the cow herd is 200.000. Recently, some of them have shifted to farming, bean and maize cultivation. They have not settled, they don't stay permanently at one place but constantly move according to available green pastures. The government has been helping them by issuing permits to pass along roads and next to farms.

The Maasais have been living in this part of Kenya for hundred's of years. The big opened grass-lands were advantageous for cattle grazing and therefore the herd was expanding rapidly. At the end of the previous century European settlers arrived to the area and occupied traditional Maasai land after making a treaty with the Kenyan Government. More white people meant less available land for them. Finally they were forced to leave between artificial boundaries set up by the government, the Ministry of Agriculture Livestock Development and Marketing. Also free access to the lake was stopped in 1970 because all the riparian land became private, cultivated land.

Other problems are in relation with land is originated from the establishment of national parks in 1984. After the establishment of the Hell's Gate National Park the Maasais were forced to leave the area. Nowadays, for medical care and also just to reach the place they live they need to pay charges to pass the gate of the Hell's Gate National Park. Also leopard, buffalo endanger human life.

This instant "over-population" of these indigenous herders caused by the alienation of their land and the establishment of commercial enterprises became a serious problem which deserves governmental attention.

Land became a scarce resource, specially during droughts. In periods of resource scarcity (droughts), the Maasais ignore private property and enter farms. The herd often destroys significant amount of crop. During droughts they also migrate to northern areas with green pastures on private land. Farmers complained and there were even some violent incidents, between the farmers and the Maasais.

In 1972 the East-African Power and Lighting Company (later KPC) came to the Olkaria area to survey the potential geothermal energy and to test the wells. As they established a geothermal station on Maasai land, and as they did not want to deepen the pastoralists` most stressing problem (access to fresh water for livestock) they were ready to assist the Maasais. The Company had built a pipeline to supply water for the cattle what was a great help for them. The water supply was solved at least in the environment of the watering points. Still from remote areas it is a long way till the ponds and the washing of the cattle against ticks is problematic. The help from the Company came voluntarily, there was no legal agreement between the Company and the Maasais. For the first year they had to pay the water bill but then the water was free for them. KPC can cut the water supply anytime. The Maasais call the situation as a „temporary solution".

Some flower grower company (Oserian, Sulmac, Home-grown) assist the Maasais, too, by let them pass on their land to the lake. They can also forbid this in future.

Therefore, the Maasais want a permanent solution namely free access to the lake. Several access to the lake, where they will be able to approach the lake and give water to their cattle would prevent former conflicts during droughts.

The Maasais have customary laws and traditionally believes. They still hold regular ceremonies and carry on with the traditional way of life. The older people stay at the villages, the young go and move with the cattle. For the Maasais more cattle means wealth and safety. This perception appears in their methods. They don't consider the carrying capacity of the available land. When a pasture is overgrazed they move further as they did 100's years ago. They will not reduce the cattle herd to achieve sustainability.
Concerning this issue there is a conflict within the Maasais community. The respectful old generation, which is believed to have special memory, don't care about overgrazing. They represent the old Maasai line of thinking, namely to have as much cattle as possible. The younger generation is more aware of sustainability.
Approximately every 2 months or when a ceremony is held, the representatives of each family in the locality gather together on the „Council Hill". Also every evening the family leaders (about 60 men) have an advisory committee meeting. This advisory committee meeting is not compulsory and only those men go who have something to say. On the Council Hill and also at the advisory committee meeting relevant issues are discussed. There are no written records about these meetings. The young generation often try to convince the old generation and use arguments against unsustainable pastoralism. The discussion is opened but the final decision is made by the elders.

The Maasais can not accept the current situation and still claim their former land back although considering the current legislation they have no chance at all. They are resistant to change. They still arbitrarily occupy private land, still graze their cattle in National Parks, which is forbidden. The relations with the park management (KWS) and with some farmers are not good.

3.1.11 Camp-sites, hotel and lodge owners

Hotel and land owners in Naivasha and around the lake have a „big stake" in proper management of the lake. They „use" the landscape value of the lake. The area is frequently visited by foreign tourists. Big limitation factor is the inadequate infrastructure, tourists want good roads, good food, security, running water and sewage treatment. The tourists' claims are the hotel owners' interests. They are interested in proper solid waste disposal, increased human health, gaining contribution for maintenance of existing infrastructure and the ones what were already mentioned.

3.1.12 Fishery Co-operative Society

The Society was established in 1968. They are governed by the Co-operative Act, by the Ministry of Co-operation Development. There are about 40 fishermen using the lake with 3 crew per person. Almost every fishermen is a member. The Society helps to identify a market for the fish and in general provide marketing services.

There is a membership fee, the fishermen can get loans to buy fishing equipment. The Society represents the interests of the common fishermen, the communication within the Society is good. They launched a self regulatory program to ensure sustainable harvest on the lake. The majority of the fishermen fish according to the recommendations of the Code of Conduct prepared by the Fisheries Office (see appendix 9.3).
The total annual registered fish catch diminishes every year due to the poaching activity and also due to the unsustainable methods used by some of the legal fishermen. In practise not everybody follow the recommendations of the Code of Conduct.
Another problem is the insufficient amount of landing beach. Although in the past there were several places where fishermen could approach the lake and land their fish, currently there is only one such legal landing beach and even this is a favour of one of the farmers. Due to fluctuating lake levels, the fishermen are forced to keep changing their landing points. It is inconvenient and time consuming to return to this place each time and report on the fish catch at the banda. On the other hand, the Fisheries Office would not be able to provide technical means and personnel for new landing beaches.
The fishermen are accused of using farmers' land for access, installing nets across water frontage and trespassing on the land at night to the lake. It is not known what part of these statements is true. The fishermen are sometimes charged with trespass, when it was the wind that carried their canoes and boats further than they intended to go. In some cases they do it deliberately. The small fines imposed by the courts are no deterrent to the fishermen, who earn good money from the catches.
In the Society the relation is good. Fishermen meet on the lake and on meetings organised by the Society.

3.1.13 Poachers

200-300 poachers use the lake and exhaust its fish stock. Every day 30-40 poachers fish on the lake.
Associated activities with poaching:

- Use of undersize-nets (small mess size) i. e. prohibited nets
- Distributing the poached fish
- Transporting the poached fish
- Trading in fish which is illegally obtained (poached)

The interest of poachers is to catch as many fish as possible without punishment for their own consumption and also for trade.
The poachers fish in shallow water where they make the biggest harm. Unsustainable fish harvest is perceived as a low-priority problem relative to satisfying their basic needs in the short term. The actions following this perception cause significant and increasing environmental problem as overexploitation of the fish stock. The fisheries becomes a „resource-poor sector". The poachers and the fishermen are the most affected by it and some of them are aware of it, but they are simply obliged by their circumstances to act in ways that undermine both their capacity to fulfil their own basic needs and the longer term viability or sustainability of their physical environment.

Monitoring of the poachers is difficult because in case of action they quickly disappear in private land. They use several illegal route through private land to approach and to leave the lake.
Their interests are inadequate policing by authorities and excess to the lake.

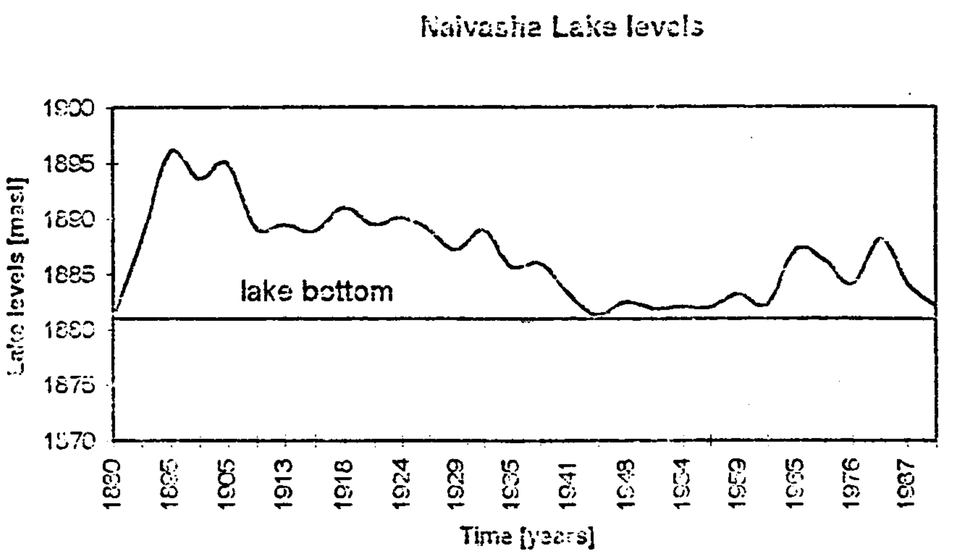
3.1.14 Kenya Power Company

In 1972 the East-African Power and Lighting Company (later KPC) started exploring-drilling. The found out that the area has exploitable geothermal energy. This relatively cheap source of energy was attractive for the GOK. With foreign aid (World Bank) a big geothermal station was built (Olkaria). KPC is expected to play a significant role in the country`s economic development. KPC plan future development (World Bank), they want to expand the plant with new exploration fields, which will yield 64 MW extra capacity.
KPC use significant amount of lake water for industrial and domestic purposes. The environmentally friendly technology ensure water-saving (reuse and recycling) and cut pollution. However, the impact of KPC on the water balance is evident, the plant is one of the main water users in the area.
KPC is an active management actor. They mediate between the massais and the LNROA. They also operate a pump and a pipeline to supply water for the massais.
Their interests are sustaining water abstraction and expanding the plant.

3.1.15 Lake Naivasha Riparian Owners` Association

The Association is a voluntary and non-profit-making organisation made up of the landowners surrounding the lake. It was established in 1926. LNROA is officially registered under the Society`s Act as a local community based group. Almost everybody who owns riparian land is a member. Membership is not automatic, there is a membership fee.
The European, mainly British riparian land owners' main activities are farming, ranching and hotel, lodge management. Crop farming, flower growing, animal husbandry and dairy farming is very common. A few farms (Home-grown, Sulmac, Oserian) developed and extended their farms in rapid pace. They became massive, intensive agro-industries, producing products for the world market. The Horticulture Crop Development Authority has been regulating the development.
The LNROA has been playing an important and leading role in the management process what was initiated by them. They are aware of the environmental threats in the region. LNROA realised, that such a development pace is no longer sustainable.
Their biggest concern is the quantity and the quality of lake water. The amount of abstracted water should be regulated and water pollution should be mitigated. Their interest is to promote sustainable development in the area, to preserve the natural beauty of the environment.
The lake has been receding because of unknown reasons (see chart below). As a consequence more and more formerly covered land become available for cultivation. The land between the 1906 lake contour and the current edge of the lake is called riparian land. Because the lake is quite shallow, this land can have the length of 2 km. The ownership of this riparian land was regulated by law in 1932. The „Foreshore Rights of Riparian Owners", a governmental degree states, that the

riparian land and the lake is governmental property and should be kept free for public use (see appendix 9.4). Although land tenure was legally clarified, the riparian farmers have been following the lake every time it recedes and they cultivate the riparian land sometimes even until the lake. Some farms are fenced right at the lake shore, forcing the game, buffaloes and hippos to smaller and smaller areas. Fishermen and researchers often run into trouble when they enter to riparian land. Some farmers are being arrogant and rather unfriendly, others help and assist local people, fishermen and pastoralists. However, LNROA members want to control the riparian land and not only use it.



3.1.16 Lake Naivasha Growers' Group

In 1995 some farms stepped out from LNROA and formed their own group. They are big, intensive flower grower farms, producing flowers and seeds for the world market. Although big amounts of agrochemical and water are used on these farms, they are making serious efforts to protect the environment [LNROA, 1993]. This environmental awareness is due to strict standards of the European consumers. The growers have customers who are increasingly critically interested in the way they farm. The Growers's Group put special emphasis on the pesticide policy.
When they were formed in 1995 they sent out questioners to 12 major growers to survey their pesticide policy. Members have been introducing EMS and environmentally friendly technologies like dripping irrigation system and special fertiliser.
The primary interest is to not loose customers and keep up the water extraction, which is the crucial factor of production, since production almost entirely depends on water extraction.

4. HUMAN ACTIVITIES AND THEIR IMPACTS

Activities of stakeholders in the past and current activities had/have big impacts on the environment and on the socio-economics. The following matrix presents the human activities and their impacts.
The column of the activities shows the human activities on the lake and in its environment and after the thick line the human activities in the catchment. The row of the impacts shows the impacts on the environment and after the thick line the impacts on the socio-economics. A qualitative analysis.

Code: - negative, deteriorating impact
+ positive, advantageous impact
N negligible
0 indifferent
Pot indicates potential impact.

Impacts: / Activities:	Change in lake level	Change in water quality of the lake and of the groundwater	Change in plant and animal population	State of the pasture and the agriculture land	Habitat	Public access to the lake	Transport on lake	Economy	Public health
Introduction of water-hyacinth	**Pot N**[3]	**Pot +**[4]	+ provide breeding and spawning place for several fish species and provides habitat for birds (e.g. Jacana)	**Pot +**[5]	- disturbance; it created a new habitat	0	- sometimes it blocks the harbour	**Pot +**[6]	**Pot -**[7]
Introduction of alien fish species (e.g. Tilapia) and crayfish	**0**	**0**	- Extirpation of a unique, endemic fish species	**0**	**0**	**0**	**0**	+ commercial fishery	+ cheap protein source

[3] Vegetation cover of the lake surface by water-hyacinth would reduce the evaporation and would increase the transpiration. It is unknown which process results in more water loss.

[4] If water-hyacinth is present in large quantity, it removes large amount of heavy metals from the water and assimilates it to its tissues. If water-hyacinth is removed from the lake-body it would definitely improve the water quality. It is not known that after burning or utilisation how much heavy metal would return to the lake through ground water and air.

[5] Removed water-hyacinth could be used as mulch. Ploughing it in to agriculture land would enrich the soil (amelioration) and would improve its water, air and temperature house-hold.

[6] Water-hyacinth utilisation could be a profitable investment. A few options: biogas-production, mulch, fodder.
[7] Water-hyacinth could provide an excellent breeding place for mosquitoes. This comprises the potential danger of spreading of malaria. Also water-hyacinth shelters populations of disease vectors thereby increase the incidents of waterborne diseases.

Impacts: / Activities:	Change in lake level	Change in water quality of the lake and of the groundwater	Change in plant and animal population	State of the pasture and the agriculture land	Habitat	Public access to the lake	Transport on lake	Economy	Public health
Agriculture/ Livestock farming Diary farms	N - consumption by animals - irrigation of pastures and meadows for fodder production	- polluted ground and surface water due to liquid slurry - untreated waste water discharge to lake	0	+ good state of pastures due to irrigation and fertilisation	- disturbance, shrinking of the habitat	- fenced farms became an obstacle	0	+ individual income source + employment	- risk of diseases (e.g. pox, anthrax, pest) - untreated wastewater discharge imposes danger for human health
Pastoralism	0	N - cattle urinate and defecate into the water	- cattle eat the vegetation - competition with game - cattle spread diseases among game	- grazing grounds are often overgrazed	- herd destroys the natural vegetation - pastoralists burn the papyrus	0	0	+ individual income	- risk of diseases (e.g. pox, anthrax, pest)

Impacts: / Activities:	Change in lake level	Change in water quality of the lake and of the groundwater	Change in plant and animal population	State of the pasture and the agriculture land	Habitat	Public access to the lake	Transport on lake	Economy	Public health
Agriculture/ Crop farming	- water intake from lake	- unused fertiliser (agrochemical) seeps into groundwater and/or flushed into lake - destruction of buffer zone (papyrus)	- loss in biodiversity (e.g. papyrus)	- impoverishment of soil	- disturbance, shrinking of the habitat	- farms became an obstacle	- nuisance growth of aquatic plants due to nutrient enrichment	+ individual income	0
Horticulture	- water intake from the lake	- unused fertiliser (agrochemical) seeps into groundwater and/or flushed into lake - destruction of buffer zone (papyrus)	- loss in biodiversity (e.g. papyrus)	- impoverishment of soil	- disturbance, occupy big natural areas, shrinking of the habitat	- farms became an obstacle	- nuisance growth of aquatic plants	+ individual and significant national income	- untreated waste water discharge imposes danger to human health
Legal fishing	0	0	- exploitation of fish stock	0	0	0	- fishing nets are obstacle for boats	+ individual income	+ cheap protein source
Illegal fishing	0	0	- overexploitation of fish stock	0	0	0	- fishing nets are obstacle for boats	+ individual income	+ cheap protein source

Impacts: / Activities:	Change in lake level	Change in water quality of the lake and of the groundwater	Change in plant and animal population	State of the pasture and the agriculture land	Habitat	Public access to the lake	Transport on lake	Economy	Public health
Rapid population growth (Naivasha)	- decreased water supply from rivers to lake (drinking water intake)	- increased waste water generation and untreated discharge to lake[8]	- loss of biodiversity because of pollution - eutrophication	- overexploitation of soil to satisfy the increased food demand	- disturbance (unplanned human settlements)	0	0	- unemployment	- side-effects of overpopulation - untreated waste water discharge imposes danger to human health
Recreation	0	0	N - disturbance due to game and bird watching	0	- destruction by sailing	N - sometimes overcrowded corridors	0	+ individual income	+ relaxation, rest
Geothermal energy production/ generation	- water intake	0	0	0	- habitat disturbance	0	0	+ electrical energy supply	0

[8] Pollution of BOD, SS, Heavy metals, Pathogen organisms, etc.

Impacts: / Activities:	Change in lake level	Change in water quality of the lake and of the groundwater	Change in plant and animal population	State of the pasture and the agriculture land	Habitat	Public access to the lake	Transport on lake	Economy	Public health
Tourism	0	N - wastewater generation	- eutrophication due to waste water discharge N - exploitation of fish stock due to sport-fishing	0	- disturbance (permanent construc-tions, e.g. hotels)	- sometimes overcrowded corridors	0	+ individual income	0
Deforestation	N change in time-distribution of run-off discharge (higher peaks in shorter time)	- high SS load to lake due to erosion, thus siltation	0	0	0	0	- siltation, shallowing of the lake	0	0
Inappropriate use of agro-hemicals	0	- nutrient and chemical enrichment in lake due to the flushing of unused fertilisr, pesticides and toxic compounds	- eutrophication - toxification	0	0	0	- nuisance growth of aquatic plants	+ high productivity of land	0
Rapid population growth (in the catcment)	- increased drinking water intake from rivers - increased demand for food promote intensive farming practises, thus high water use from rivers	- increased waste water generation and untreated discharge to rivers - increased demand for food promote intensive farming practises, thus runoff pollution to rivers	- loss of biodiversity because of pollution - eutrophication	0	0	0	0	- unemploy-ment	- side-effects of overpopulation - untreated waste water discharge imposes danger to human health

5. NATURAL RESOURCES WITH CONFLICTING CLAIMS

5.1 Natural resource use by stakeholders

This matrix shows the stakeholders (rows) and their demands for the natural resources (columns). The darker is the rectangle, the more the demand is, in relation to other demands in that column. The darkness does not represent overexploitation or unsustainable claim. A qualitative analysis.
Note: The nature (ecosystem) appears as a stakeholder. Nature contains the resources but it is also a resource user.

Stakeholder - natural resources matrix.

Resources: **Demand of:**	**Land (pastures, meadows, farmland)**	**Water (irrigation, drinking, etc.)**	**Biomass (papyrus, fish, etc.)**	**Geothermal energy (steam, heat)**
Pastoralists	grazing land	water the cattle		condense steam for human consumption
LNGG	riparian land (construction and cultivation); other farmland (soil exploitation);			use of steam for heating and sterilisation of soil
LNROA	riparian land (construction and cultivation) other farmland (soil exploitation)	irrigation		
KPC		industrial and domestic water		
Poachers			fish, papyrus	
Legal fishermen			fish, papyrus	
Ecosystem (incl. water weeds)	riparian land for hippos, sanctuaries for wildlife	ecological water need (ecologically sustainable lake level)		
Naivasha township, citizens	expands on natural areas	drinking water	fish (food for the citizens)	

5.2 Threats

The above table (see 5.1) shows the resource use by the different stakeholders. It can be seen that the all the resources are used by several stakeholders. Although the availability of the resource can not be discovered, it can be said that the claims are overlapping, the stakeholders want to use the same resource. This fact impose big danger for the environment. These threats are mentioned below.

Land:
The land is privately owned by colonial settlers.
Some farmers do not heed the voluntary 50m margin from the water. Construction of permanent structures and cultivation on riparian land (see paragraph 3.1.15) impose threat for birds and wildlife. The lake frontage has been protected with electric fences or ditches to protect horticultural crops from hippos and buffaloes. This activity disallows wildlife to migrate and graze on riparian land, so they are forced to live between narrow boundaries.
Cultivation of the land for long decades caused impoverishment of the soil. Agro-chemicals are used to enrich the soil, which cause high nutrient load to the lake.
Naivasha town expands rapidly and occupy more and more -formerly- natural areas.

Water quantity:
No reliable study was carried out on the hydrology of the lake. Water abstraction contribute to the receding of the lake, but it is not known whether it is significant concerning the hydrological model of the lake or it is a negligible factor.
Every sector uses water. It can be a small or big amount, groundwater or surface water, almost every sector depend on a good fresh water source
Water abstraction for watering the cattle, for irrigation, for industrial and for domestic purposes imposes threats to the lake ecosystem. for sustaining the ecologically sustainable water level has no priority over the other water needs.
Receding lake level influence the fish stock, too. There is a direct connection between lake level and productivity.

Water quality:
The quality of the water is vital and the greatest danger is from local agricultural runoff. The residues of the agro-chemicals end up in the groundwater and through percolation, in the lake. Inappropriate agro-chemical-use causes nutrient- and agrochemical enrichment in lake. The not operating sewage treatment plant lets the municipal raw sewage flow straight into the lake without purification This also cause nutrient enrichment in the lake. Soil erosion in the catchment causes siltation of the lake.

Biomass:
The fish stock is harvested on an unsustainable level, fish don't have the chance to spawn thus reproduction is problematic.
The papyrus has been utilised in many ways by locals and is also burned to clear up land and be able to cultivate it [LNROA, 1996].
Aquatic weeds (Salvinia and Water hyacinth) are present in the lake, imposing potential danger for the lake ecosystem.

5.3 Conflicts

Land:
There is conflicts between the Maasai community and the management of the Hell's Gate National Park (KWS). Establishment of the park forced the Maasai to leave their traditional land in 3 weeks notice. They denied, KWS made some violent steps to convince them to leave.

The traditional pastor community - the Maasais - used to own the land around the lake. The land was used for grazing their cattle and the lake was used to water them.
In the end of the previous century European settlers arrived to the area and occupied big lands without agreement with the maasais. They were pressed to smaller and smaller areas. Under favourable climatic conditions there was still enough grass to feed their cattle, but during droughts problems arose. Ignoring private property they entered farms and destroyed a significant amount of crop. They also migrated to northern areas on private land. Farmers complained and there were also some violent incidents between the farmers and the Maasais. Three people and eighty livestock were killed and nearly one hundred farms were destroyed by wildlife. These events remained in the minds and the relation is not improving between the Maasais and the farmers, specially the ones who were victims. To prevent conflicts during droughts, they want several ways of access to the lake, where they will be able to approach the lake and give water to their cattle. This permanent solution would satisfy them.

The process of arbitrary land-allocation effected other sectors too. The common fishermen had no free access to the lake and could reach the lake only at several places by enroachment. This causes time loss and other inconveniences.

The common local people do not have free access to the lake, neither. They can not enjoy and use the lake as they did before.

Farmers protect their land from hippos and buffaloes with fence. Nature conservationists oppose fencing of the riparian land because it shrinks the habitat of the wildlife.

Water:
European farmers established farms around the lake. Because of the dry climate they have been abstracting water from the lake for irrigation. It is not known how much they abstracted, but it can be said that the amount of water did not affect the ecosystem. Over the last 10-15 years there has been a tremendous increase in commercial agriculture. The economically attractive conditions (cheap labour, climate, etc.) were recognised by some of the farmers and they established an intensive agro-industry. A big amount of water has been abstracted from ground and surface water bodies to supply irrigation and domestic water for the agro-industry.

The water resource pool has been exploited, nature conservationists oppose further agro-development.

The government initiated a water project to dam the Malewa and Gilgil rivers (both flows into the lake) to supply drinking water for settlements. Nature conservationists opposed the project.

The operating geo-thermal plant near the lake depends on the lake water, too. There was no correlation explored between water abstraction, precipitation and lake level. But nature conservationists expressed their concerns about the definite impact of the abstraction by the plant on the lake.

LNROA was about to legalise a management plan, which would restrict the farmers in water abstraction. The restriction would have had a definite impact on production and profit. Some farmers (LNGG) felt, that their businesses are endangered and opposed the plan making use of their influence in the politics.

Biomass:
Significant amount of poachers fish on the lake without licenses. The unsustainable methods they use endanger the reproduction of the fish-stock. Because of the unsustainable fish harvest, the legal fishermen can catch less and less, they can not harvest enough for living. This is a conflict between the legal and illegal fishermen.

6. THE MANAGEMENT PROCESS

6.1 The beginning

The local management was started with the establishment of LNROA in 1926. The primary aim was to unite the riparian farmers and form a body, which can lobby for the common interests of the members. LNROA was officially registered under the Society`s Act. They regularly held meetings where the current issues, problems and nuisances were discussed. At that time the scope of work of the association was the recognition of inadequate services and inconveniences of the members and try to upgrade the situation. Although the relevant environmental issues and threats were also mentioned and tried to be solved, the emphasis was not on those. On annual meetings the achievements were summarised and the follow up was defined.

The main issues were:

- complain about the extortionate water charges for irrigation
- inadequate telephone service
- the appalling state of roads round Naivasha
- Salvinia control (spraying of the Salvinia, introduction of weevil)
- town sewage scheme
- illegal fishing
- in 1982 concern was expressed about a possible damming of the Malewa river
- up-dating the Rules and Constitution of the Association
- fishing nets form an obstacle for boats
- threats from possible seepage and flooding of sewerage into the lake
- over-licensing of fishermen
- discussion on the theft of engines of boats (require the Fisheries and police to take action)

In time LNROA's activity has almost entirely shifted to the scope of nature conservation and environmental protection. It became an active nature protection organisation, which lobbies for their own interests, for conservation of the lake and for upgrading the state of the environment. A citation from one of the LNROA meetings: „ ... that is what we are here for, to safeguard the National Asset of Lake Naivasha - with its charms of views and birds and gardens and lagoons - something we shall quietly lose if we are not constantly vigilant".

6.2 Recognition of the need for a management plan

The need for a management plan was recognised locally, but only by LNROA. LNROA realised that further development can not be sustainable for the lake ecosystem. They saw the potential threats for the area and started to lobby for the protection of the lake. Their intention was preservation the existing situation and restoration the damage. A plan was needed that lists the threats and allocate the natural resources among the users.

The Ministries and their regional offices incorporated sustainability in their program, but enforcement was inadequate because of lack of commitment and lack of resources. Sustainable management and monitoring existed only on papers.
The only governmental company, which achieved something towards sustainability was the KPC. The Company has installed green technology and even prepared a full-fledged, comprehensive EIA.
Other stakeholders did not care about pollution and environmental damage.

LNROA has established a Steering Committee to co-ordinate the writing of the plan. The objective was to compile a management plan for themselves, which defines the threats and gives recommendation for better environmental management.
Representatives:

- IUCN
- KWS
- LNROA members
- LNGG members
- local administration
- town council
- KPC
- district environmental officer

It was not a complete cross section of the society. Actors with less influence like the pastoralists and the Fishermen's Society were not invited to the Steering Committee and did not have a say.

Just at the beginning of the 3 phase environmental program in 1995, several articles were published in different newspapers and also a radio program was broadcasted on the BBC World Service. They gave false, superficial information about the horticulture industry in Naivasha. They were talking about an ecological disaster, water misuse and high chemical load. There was a public outcry in Britain. The damage in credit was obvious, the image of the Lake Naivasha farmers was damaged and big efforts were needed to restore the reputation.

6.3 The three-phase environmental program

The idea of LNROA was to start a community based management process which is a modern concept of environmental management. They enjoyed the backing of the international organisations. The World Bank has been carrying out research in actual experience of the functioning of central and street-level bureaucracies and their role of promoting sustainable environmental management. It is necessary to empirically test the theoretically elaborated models about resource management. Naivasha, as a case study played the guinea-pig to test locally initiated management.

LNROA resolved to start a three phase environmental program, with the aim of introducing sustainable utilisation of the area.
The first phase was designed to collect all available information on the lake, in particular what is relevant to the preparation of a management plan for the area.
In phase two the management plan was written for the Ramsar site.
Phase three is the implementation of the management plan.

LNROA has commissioned a consultant to draw up the management plan. This consultant was a hydrologists focusing on the hydrology of the area and therefore the result was too scientific. LNROA hired another consultant who elaborated the management points, too. LNROA paid for both studies.

6.3.1 Data collection, consultation

It was necessary to collect all the available information (environment, social,..) what is relevant for the preparation of a management plan.

6.3.1.1 Collation of the available data

LNROA sent out questionnaire on information about the lake and the catchment. The Executive Officer of LNROA also was gathering information and was setting up monitoring of the important parameters for the lake.
Available natural scientific data was well collected.
Social data had lower priority. Some stakeholders were not consulted directly, impacts, interests are not explored sufficiently. The pastoralists were missed out from the social context.

6.3.1.2 Involvement of the stakeholders

Involved
Significant input was done by LNROA, LNGG and the Fisheries Office. Old liaison and co-operation between LNROA and the Fisheries Office resulted involvement of the Office during data collection.

Negligible input was done by the Municipality, the Fisheries Society, the KPC, and the KWS. The Town Council was represented, the Society was more or less represented by the Fisheries Office, the KPC and the KWS were involved in data collection for certain extends. They all received the draft plan and could commend on it.

Not involved
The pastoralists as important social actors with high relevance to the agricultural innovation process were not consulted at all. Pastoralists did not even object later because they did not know about the whole program.
The tourist sector was left out. The hotel owners on riparian land were involved but, but the hotel management on the surrounding areas were not consulted.

6.3.1.3 Findings, conclusion

Stakeholder-stakeholder matrix:
Shows information flow/communication from the stakeholder of that row towards the stakeholder of that column. (before the stakeholder-meeting)
Scale: no-slight-medium-good

To: From:	Pastoralists	LNGG	LNROA	KPC	Poachers	Legal fishermen
Pastoralists	medium*	slight	no	medium	no	no
LNGG	slight	good	good	good	no	slight
LNROA	slight	good	good	good	no	slight
KPC	medium	slight	good	good	no	no
Poachers	no	no	no	no	no	no
Legal fishermen	no	slight	slight	no	no	good

* Only within the locality. Within the region no communication.

According to the matrix the communication was good between LNROA and LNGG. The poachers did not communicate with others and there is only slight communication concerning the fishermen. LNROA made attempt to inform the fishermen and the pastoralists.

Contextualization of the problems of resource use was missing. The data collection should have taken into account ongoing processes of change in society and the resource base.
LNROA carried out a survey to get feed-back from the riparian farmers. LNROA did not realise that involving the riparian farmers is not enough. There are other groups (locals, pastoralists) who do not live next to the lake, but regularly use it.
LNROA did not see the importance of participation of other stakeholders. They were satisfied with the one way communication, namely sending out papers and report on the actions taken.

The natural scientific data was well collected and collated. A rough water balance was defined without including the ecological water need. The sustainable lake level was not defined, nature was not considered as a water user.

6.3.2 The management plan

"The document has been produced for the LNROA by a Steering Committee. It was presented to the Executive Committee of the LNROA on 27th May, 1995 and approved for dissemination to the membership as a whole.... When it receives the endorsement of the membership of the LNROA, it will be forwarded to Government

in the hope that it will be officially adopted as the plan for the management of Kenya`s second Ramsar Site." [LNROA, 1996]

The management plan was meant to summarise the threats and what should be done. It aims at a win-win situation without any hidden agenda.
The table of contents of the management plan is shown in appendix 9.1.

When the plan was ready, it was presented to the Executive Committee and was unanimously accepted by every represented parties.

6.3.2.1 Strong points

The strong points of the management plan are:

- quite consistent
- one of the recommendations is the renewal of the plan every 2 years
- education is incorporated as a goal
- complete list of the threats
- rough water budget
- good recommendations for future

Comfort with legislation:

- The plan is largely in agreement with the Fisheries Act
- the plans objectives are in line with NES policies and NES priorities fit nicely in the plan
- the plan is in line with the KWS mission statement (biological diversity conservation)
- the provisions of the Water Act are not in conflict with the Ramsar Convention`s wise use principle under which the lake is managed.

The plan was harmonising with governmental strategies.

6.3.2.2 Weak points

- A management plan should touch every sector and stakeholder, should analyse the natural and social context. It can not be said about this plan, since the holistic approach was missing. The plan does not put the problem into the context. It misses too many important aspects and dimensions.
- The plan does not contain concrete management measures, therefore it can not be called a „management plan". (e.g. there are no concrete solutions like: with local communities, work out and establish a buffer zone of papyrus and natural vegetation around the lake.)
- The plan contains only a few deadlines and those are vague and unrealistic. (e.g. implementation in 5 years). The objectives are not set properly (no time frame).
- The feasibility of self-auditing, recommended by the plan, is questionable.
- The plan contains an objective of restoring the not functioning sewage works and build a constructed wetland to purify the sewage effluent. It is LNROA's recommendation without any cost-benefit analyses and impact study results.

6.3.2.3 Missing issues

- The management plan was not written for the Naivasha catchment but only for the riparian land. The activities in the catchment have considerably bigger impact on the lake than the activities on riparian land.
- Concerning water use there are no priorities defined. Only a rough estimate can be found and 3 different scenarios for wet, mean and dry conditions. If the reason was the lack of data, then it could have been recommended.
- The complete list of the lake users and stakeholders can not be found in the plan.
- The plan does not include a section on fishermen landing rights.
- The plan does not mention the land and water need of the Maasais, it only talks about the issue of „public access".

6.3.2.4 Findings, conclusion

LNROA has fired the first consultant because his approach was too scientific. LNROA feels the plan as its property („our plan"), they want to define even the content of the plan. This is the opposite of being open and let the relevant issues appear in the plan. Participation of other stakeholders was inadequate.
The management plan is in line with the international guidelines for wetland utilisation. It also harmonious with other Kenyan governmental plans and strategies.
It lacks recommendations for monitoring, evaluating and specific procedures. Monitoring and evaluation (m&e) are not emphasised. M&e may have a very positive impact on the performance of the current programme. M&e may, for instance, open up discussions that were previously blocked because of internal conflicts.
The plan recommends that the sectoral Code of Conducts (CoC) have to be attached to the plan as appendixes. If the final document is not one integrated management plan, it comprises the danger of incompatible sectoral documents and uncoordinated activities. Communities can have different aspects of the same resource. Different resource-users might want to use the same resource, e.g. water, land.
The scope of the plan was too narrow, it should cover the entire catchment because there are several stakeholders within the district whose livelihood depends on the lake. The catchment goes trough regions, so an inter-regional plan is needed and not one which deals only with riparian land. However, LNROA can not be blamed to not deal with the catchment, they do not have the resources, the manpower and time to deal with the entire catchment. It is only a small local organisation. They have no capacity to comprise their activity to the whole catchment but later they intend to do so.
But for the lake and its environs an inter-sectoral plan could have developed which deals with all the different ways the lake is used.

The passiveness of the relevant Ministries have to be mentioned. The Ministry of National Environment and Natural Resources would like to see a basin-wide management plan, not only for the Lake and its direct environment. They encourage LNROA but they themselves - whose task would be the management of the area - do not do too much.
The Water Apportionment Board don't do the task what they were established for. The available sustainable amount of water is not defined by research and is not allocated properly among the water users. Wet and dry climatic conditions are

unconsidered. Permits are easy to obtain and are issued to everyone who pays the fee.

The focus should be on nature conservation and upgrading the living standards of the inhabitants of the area, and they both have to be kept in balance.

6.3.3 Implementation

When the plan was drawn, LNROA started phase 3, the implementation of the plan. In 1996 LNROA has established a Management Committee, later Lake Naivasha Management Plan Implementation Committee. Its membership included agriculture/horticulture representation as well as Naivasha Municipal Council, District Officer/District Environment Officer, KWS, KPC, and IUCN/Ramsar representation. The majority of the Committee was LNROA members. The Committee did not exceed twelve members and met every 2 months. The Management Committee will be responsible for the implementation of the Management Plan and may appoint sub-committees. First task of the Management Committee was to accomplish a detailed workplan what is still not ready.

A medium opposition was expressed by some farmers. They did not agree on the water balance of the management plan. They required and independent and reliable hydrological study for the whole catchment. After LNGG consulted with its legal expert the disagreement was clarified and again everybody was convinced and felt commitment towards the plan.

6.3.3.1 Clash

In the beginning of the Implementation, LNROA was successfully lobbying for governmental approval. The management plan was about to be legalised. Legal ground would ensure good progress in implementation and enforcement. They called a final meeting where governmental officers were invited, too. The agenda of the meeting was discussion of legal aspects.
The meeting was cancelled by police. It was the result of active lobbying of some farmers, who felt that their businesses are endangered if the plan is legalised. Their main concern was water, what the whole agro-industry depends on. The legalisation of the plan would potentially comprises the chance of restriction of water abstraction, would affect production and profit. And this would have been adversely to the big flower growers' interests. The growers involved the Horticultural Crop Development Authority. The Authority was looking at the plan as a threat for future horticultural development. Restriction in water use - what was one of the measures of the management plan - would scare investors away, that's why the Authority strongly opposed the plan.

With the influence of this authority the flower growers have managed to proclaim the meeting. HCDA's priority was development and production sustainability. It did not want to let a local management group jeopardise permanent income of government from the horticulture sector.

The growers have formed their own group (LNGG) and left LNROA. From this point communication became very bad, the relation between LNROA and LNGG was burdened by personal conflicts.

The process had stopped for 9 months. LNGG claimed, that they were not consulted in the process. However, communication and information flow was quite good before the clash (see table on page 42). It was an unfounded accusation towards LNROA.

6.3.3.2 Conflict resolution

The Kenya Wildlife Service as the custodian of the Ramsar site stepped in the process. As a facilitator it organised workshops and stakeholder meetings. The workshops organised by the KWS were great opportunities to obtain and to exchange knowledge and opinions. New alliances were established during these meetings.

Stakeholder-stakeholder matrix:
Shows relationship/assistance of the stakeholders before and *after* the stakeholder meeting.
Scale: bad-neutral(no relationship)-fair(medium)-good
Progress is indicated with ➪.

	Pastoralists	LNGG	LNROA	KPC	Poachers	Legal fishermen
Pastoralists	good* *idem*					
LNGG	bad ➪*fair*	good *idem*				
LNROA	bad? ➪*fair*	bad ➪*fair*	good *idem*			
KPC	good *idem*	good *idem*	good *idem*	good *idem*		
Poachers	neutral *idem*	bad *idem*	bad *idem*	neutral *idem*	good *idem*	
Legal fishermen	neutral *idem*	good** *idem*	fair ➪*good****	neutral *idem*	bad *idem*	good *idem*

* In spite of the intrinsic conflict the relationship is good and not tensed.
** Home-grown and Oserian assist the fishermen and provide access to the lake.
*** LNROA members realised that access to the lake for the fishermen is essential and in future they will assist them.

Opinion of different users about the need for public access to the lake (after the stakeholder meeting):

Users of the lake:	**Pastoralists**	**LNGG**	**LNROA**	**KPC**	**Poachers**	**Legal fishermen**
Opinion:	crucial	just*	just*	just	wanted	crucial

* Some of the riparian farmers did not support the idea.

The matrix shows that everybody supported the claim.

Environmental awareness-matrix:

Users of the lake:	**Pastoralists**	**LNGG**	**LNROA**	**KPC**	**Poachers**	**Legal fishermen**
Awareness:	not aware*	aware	aware	aware	not aware**	not aware**

* There is an inner conflict within the Maasai community between the old and the young generation. The young generation realised the danger of overgrazing and are aware of the unsustainable pastoralism. The elderly people want to continue with the tradition to have as many cattle as possible.
** Except some individuals the rank and file is not aware of sustainability.

Code of Conduct of the Growers` Group was presented in the first meeting (the table of contents are presented in appendix 9.2). It is a detailed program of monitoring of soil and water contaminants on the farms. It contains daily management guidelines and concrete measures. Should the safety regulations not be fulfilled, corrective action is taken promptly. The CoC of the LNGG is very complete and detailed. It is reviewed on an annual basis.
The 2 documents (management plan and CoC) were handled as they would be far from each other. After thorough examination and comparison, it was found out that actually there is not too much difference between the 2 documents. The CoC is almost entirely compatible with the management plan. All parties, including LNROA and LNGG agreed, that the 2 documents (management plan of the LNROA and the Code of Conducts of the LNGG) are compatible and they can be integrated. This agreement was a big result.

5 stakeholder meetings were held at the KWS in the period between 1996 March and 1996 October. Main agenda points were report on progress, report and briefing to the different sectors, implementation progress reports and updating the management plan. The terms of references (TOR) of the Implementation Committee were defined.

A featuring meeting was the one at KWSTI, 8 October 1996.
The objectives were:

- Explain the ecological and economic importance of Lake Naivasha
- Present an overview of the Management plan and the Horticulture Code of Conduct.
- Provide information, education and awareness of the stakeholders
- Identify roles and responsibilities of stakeholders.
- Establish a participatory approach to the Management Implementation Process among all the stakeholders.
- Answer questions and address concerns of the stakeholders on conservation and development issues.
- To draw conclusions and forward recommendations to the Government.

6.3.3.3 Implementation Committee

A Trust formed by LNROA appointed a "Management Committee" to implement the management plan. Later their name was changed to "Lake Naivasha Management Plan Implementation Committee (LNMPIC)". This Committee consists of 12 individuals and includes representatives from the Kenya Power Company, the Municipal Council, local administration, the Kenya Wildlife Service and IUCN and LNROA.

The structure of Lake Naivasha Management Plan Implementation Committee

The LNMPIC has several sub-committees. Each of them has different terms of references and missions.

Sewage sub-committee

Its membership includes individuals from KWS, KPC, the Municipal Council and the LNROA. The objective of this sub-committee is the rehabilitation of the municipal sewage works of Naivasha town.
The plant was stopped in 1992 because of vandalism. The sewage from Naivasha town flows through the not operating treatment plant and then discharged to the lake. Due to this several environmental problems occurred in and around the lake. The high nutrient load promote eutrophication, thus degrade biodiversity, the pathogen organisms imposes dangerous threat for human health and the stench is a serious nuisance for people living around the plant.
The rehabilitation of the sewage work can be considered as the first step in a long term infrastructure development program. The beneficiaries will be the local residents, hotel owners and tourists, the KATO, fishermen and farmers and of course the nature.
The sub-committee appeared to be very active and successful. They frequently met in 1996 and in 1997. KWSTI accomplished a project proposal for the rehabilitation of the sewage work. The proposal was positively judged by the World Bank, the fund

raising was successful. Naivasha was one of the pilot towns that the World Bank had identified for potential funding. The delegation from the World Bank was impressed with the good community spirit and the involvement of locals in decision making. The World Bank is willing to partly finance the rehabilitation project. The Municipal Council and the LNROA will also contribute to the project with land and financial support, respectively.

Technical (biodiversity) sub-committee

Among its members the following institutions are represented:

- KWS - Regional Biodiversity Co-ordinator (RBC)
- KWS - Area Warden
- KEMFRI
- Fisheries Department
- LNROA
- KARI
- Ministry of Agriculture
- Forestry Department

This committee was established to involve external institutions and experts which and who can contribute with data and resources and can help the work of the Implementation Committee. The main task is to identify the problems, target groups and to collate the available data. Also this committee should lobby for and co-ordinate biodiversity conservation since Naivasha area has no KWS biodiversity officer (see Appendix 9.6).
The terms of references are:

- co-ordinate research (define research)
- monitoring
- collection of data
- co-ordination of proper land-use
- enhancing public awareness and education
- co-ordinate EIA
- render services to the Implementation Committee
- conducting surveys of activities in catchment area
- co-ordinate wetland restoration
- monitoring and evaluation of the management plan
- develop project proposals
- review budget proposals

The sub-committee was established as the first one. The terms of references is just recently defined and is still a topic of discussion. They have been carrying out a survey on human activities in the catchment (fieldtrips).

Land-use Sub-Committee:

Its membership is opened not only for LNROA members but for everyone who is involved in land-use questions.
The objectives of the sub-committee is to promote proper land-use practises around the lake. To solve the question of "public access" and to protect the papyrus fringe around the lake. Big question is the maintenance of land what will be opened for public. Funds should be allocated to cover the maintenance costs (litter collection).

Code of Conduct Sub-Committee
Every sector is represented in this committee who supposed to prepare a code of conduct. The Fisheries Office, the KPC (end of this year the CoC will be finished), LNROA, LNGG, livestock industry, town council, the tourism sector are all represented.
The final aim is that - after intensive consultation - every sector write a code of conduct which will be in line with the guidelines of the management plan. The role of the sub-committee is to co-ordinate the writing of the CoC's. The chair of LNGG - which sector has already prepared a code of conduct - is chairing this sub-committee.
The Fisheries Office has already prepared a CoC. Concerning the tourist sector a team of 5 people (residents with interests) have been working on the CoC. They start with a survey.

6.3.3.4 A case-study: the Sheir Agencies

These sub-committees have been established to implement the management plan. For the LNMPIC is not an authority, it and its sub-committees have no jurisdiction on the members of LNROA nor on other actors. Without legal power the measures can be enforced only via peer-pressure and market pressure. The one who violate the management plan can not be taken to court.
Without legal ground enforcement and implementation is difficult and not feasible.
Therefore LNROA has been lobbying for governmental approval. Approval is going to be a big step, however, the enforcement power and commitment of the governmental institutions and authorities are questionable. Governmental Authorities largely failed because of lack of adequate law enforcement.

Levels of enforcement:
1. level: peer pressure
2. level: report to competent authority - legal procedure

Good example for poor enforcement power is the case of the Sheir Agencies. They built a dam and a bird observation house on riparian land (according to the management plan it should be a buffer zone without any human activities and constructions). Construction works had been observed and contact was established between LNROA and the Sheir Agencies. The "bird observation house" appeared to be a big guest house complex. There are a lot of arguments to convince the Sheir Agencies, and they are willing to co-operate, but actual legal instruments can not be used.

6.3.3.5 Findings, conclusion

Similar to the approach of LNROA towards the management plan (see 6.3.2.4), the same can be said about LNROA`s approach towards the implementation procedure. Although LNROA is only one of the actors in the area, LNROA wants to be the manager of the implementation. LNROA is well organised, with good facilities and secretariat and is capable to co-ordinate. There is no doubt that LNROA was the organisation, who started the management process, but now they should let the process flow instead of guiding it. But LNROA still wants control over the process and claims more power in decision-making than it supposed to has.
Without technical and management knowledge LNROA wants to be involved in purely technical questions. For example concerning the sewage plant they want to appoint a manager and oversee the operation. This function should be entirely the task of the Municipal Council.
A positive point is that LNROA has been lobbying for mutual interest, which overlaps with the interest of LNROA but also covers the interest of different sectors (the local people, citizens, tourism, etc.). Restoration of the sewage treatment plant is a good example where improved public health is one of the main objective.

They do not want to expand the Implementation Committee, because - they say - the bigger is a committee the slower is the decision-making. Big membership would cause delay. Thus, still not everyone is presented in the Implementation Committee only the ones invited/selected by LNROA. For example the pastoralists are still not presented in the Implementation Committee. Maybe this will make the committee dynamic, but quick progress can be stopped again as it happened before.
In the beginning the Fisheries Society was not represented neither. Later the secretary of the Society was invited to the Implementation Committee. The tourism sector was not involved neither, only after the clash.
LNROA has learned from the lesson and try to involve more stakeholders to the process. But participation is still not complete.
The LNROA members are easy to reach and communicate with. Other groups like the pastoralists are more difficult to reach and to inform. But these marginal groups are the real challenges, these people must be involved in the decision making, too. It is better to examine and look into the problem thoroughly and achieve mutual agreement, than make quick progress in decision making without certain groups.

The interference of KWSTI was a good strategic step. It pushed forward the process out from the pitfall. However, conflicts were not fully eliminated on the stakeholder meetings. There is still communication problem between the chair of LNROA and the chair of LNGG. Although LNGG officially returned to LNROA, LNGG still consider itself as a separate group. 1 member from LNGG sits in LNROA. LNGG still have a denying attitude towards everyone who wants to tell what they can abstract. They keen on a realisation of a reliable hydrological study.

On the Implementation Committee meetings the plan is constantly renewed. Almost all changes are proposed by LNROA, and those are minor compositional changes without any influence on the content of the plan.

Environmental education is very important to raise awareness of residents about the importance of the catchment area and how it must be protected. An environmental education program appeared in the plan, but nothing was done on this field.

The concept of the Code of Conducts:
It is more likely that the stakeholders will read their own sectoral CoC's than that they will search for the relevant points in a thick integrated management plan. It is practical to have separate CoC's, though it does not promote integration of the sectors. If the CoC's are not written in total isolation, but are adjusted to each other, the proper allocation of the available resources can still be managed.

Enforcement mechanism:
Enforcement and authority is the crucial questions of implementation. Authority is a pertinent issue: which authority is to enforce the plan`s measures? In the beginning the available enforcement mechanism was peer and market pressure. Without jurisdiction and back-up from governmental agencies the implementation of the plan (monitoring, research, enforcement) is problematic and not feasible. This fact has been recognised by LNROA, and members of the Implementation Committee put big effort in lobbying for governmental approval.
The CoC audit manager - if employed - cannot enforce the measures and neither would the Implementation Committee. The CoC manager would not have jurisdiction over private land property. Any subscriber to the CoC can drop out when he wants.

The writing of the CoC's is proceeding, although there is no full commitment. At the end of this year all sectors will be able to show a CoC. The geothermal energy exploitation is clean production, they don't need CoC, a few pages will do it, what can be an extract of their EIA.

The Fisheries Society was not represented in the Implementation Committee but later the secretary of the Society was invited to the Implementation Committee.

7. CONCLUSION

Participation in environmental management can reduce the costs of decision-making and conflict resolution, enforcement of regulations and operation and maintenance expenditure, and will improve decisions through drawing on local knowledge.
Participation can mean anything from provision of information to "beneficiaries", through various levels of consultation, counselling, and therapy aimed at inducing acceptance of decisions made, or controlled, at higher levels, through to citizen empowerment.
Participation and democratisation advocacy begs the question of how and whether minority, or poorly articulated interests will be effective in public decision-making.
The Naivasha case as a pilot project for locally initiated management showed good example for the importance of public involvement. There was no hidden agenda, inexperience was the reason of problems in the management process. Participation of the different stakeholders was poor, partly because of passiveness of certain groups and partly because active lobbying was lacking from the side of LNROA. In the beginning LNROA was a closed society, the membership was opened only for the riparian owners. This closed society started the management process and also wanted to lead the process. This had a consequence of not involving other actors into the decision making process. The lake is a resource, it is used by LNROA AND others. This was not realised by LNROA.
LNROA looked at the problem from their point of view. They relied on inputs of their members and consultants. The source of information was filtered and was restricted to literature and inputs from the members of LNROA.
On the other hand the precautionary principle of LNROA (without scientific ground for any concern) was laudable and was a wise and preventive step.

„More governmental involvement, less enthusiasm". This concept was changed, it was understood, that enforcement through peer and market pressure is not viable.

The management should be co-ordinated more neutrally.

Since the pastoralists are not presented in the Implementation Committee they should be represented in one of the sub-committees.

A management plan should not deal only with the close surrounding of the lake but should cover the whole catchment.

There is good community spirit among some farmers within LNROA, but it can not be said about the whole membership of the Association, and definitely not about the other stakeholders. It should be realised that environmental awareness is very poor among the riparian farmers and also among other stakeholders. Exception is the core of LNROA.

Arguments and discussions have been keeping the plan and the process alive. Decisions should emerge from complex bargaining, confrontations, and complementarities between various individuals. These healthy reactions ensure progress and mutual final agreement.

The Fisheries Office has clear interest in increasing lake levels, but there are not active in lobbying for this.
The poachers are not involved, nobody tries to communicate with them.
Concerning the plan, the definition of the problems and issues was completed, but no solutions were given to solve the problems, no specific management measures were recommended.

BACKGROUND/ IDEA	DEFINE THE ISSUES/ IDENTIFICATION	ADDRESS THE ISSUES
Why is management necessary?	What are the threats and what is not sustainable?	mitigation measures on a daily basis

Concerning the concept of Code of Conducts: the majority conform, but there are still a minority who either through ignorance or a don't-care attitude have not yet adopted these codes. This problem of "non-adoption" should be broadened into an attempt to understand why land users do what they do, why do they deny co-operation.

"Second-best policies, if well implemented, are preferable to unenforced perfect policies." The attitude of LNROA is maybe not adequate, but it is still better than the unenforced governmental policy.

The terms of references of the technical sub-committee is not realistic and very extensive

Concerning the relation between the Maasais and the KWS, LNROA: „There is enough room for the friendship to grow."

8. RECOMMENDATION

To be able to write a CoC, the sectors (pastoralists, tourism) should be educated, so they understand what it should contain, why it should be written and why it is relevant, important to them. For example somebody should explain the value of CoC to the Maasais, how they affect the environment and what is the carrying capacity.
The sectors should help to each other by providing transport means and other facilities to each other. Expectations towards the Fisheries Office are far beyond its resources. The sectors should also constantly learn from each other, they should learn by doing it. In the process, everybody should provide information to, and should learn from each other. For example LNROA should learn about the ideas of the Maasais culture and vice versa, the Maasais should be educated. The same goes for the poachers. It is necessary to communicate with the poachers and get to know their perception of the situation.
Education, extension should first aim the most uneducated sectors.

Monitoring should be a combination of internal and external monitoring:
Internal monitoring by stakeholders.
External monitoring by competent authorities (KWS as responsible)

The management process should be opened for public and should be co-ordinated by LNROA.
The EIA of KPC should be available for the public.

In future an inter-regional, integrated plan should be written for the whole catchment. If currently the CoC's are attached, special emphasis should be put on resource allocation. CoC's should be definitely compatible with the guidelines of the management plan. New CoC's should be a product of continuous consultation with the concerned individuals.

An independent CoC audit manager should be employed with legal power. The task would be regular environmental auditing of the farms.

The management process is well documented so far. This practise should be continued (minutes of the meeting, draft and final plans and reports).

The Fishery Society, the pastoralists and other sectors need a forum where they can express their feelings and concerns. Regular meetings should be organised by the District Officer or by LNROA (plenary and sectoral).
The plenary meeting should be a kind of platform held on the same day or just before the Implementation Committee meeting. This platform can be organised twice as often as the Implementation Committee is held. The representatives of the stakeholders should participate here to balance the conservation needs and the resource exploitation.
Sectoral meetings should be organised for the different sectors, respectively. Specially for the fishermen and for the Maasais these sectoral meetings can be held on site, close to the living or working place. For the fishermen it can be held at the

fish banda (see page 20), for the Maasais it can be held at the Council Hill (see page 25). Sectoral meetings can be organised as often as the Implementation Committee meeting is held. During these meetings first hand knowledge will be passed to the District Officer or to LNROA.
Minutes should be written on these meetings to have written records on what was agreed upon.
The benefits of these meetings:
The stakeholders are no longer operating as individuals or as more or less autonomous groups but start acting as a team. The stakeholders will feel that they are actually involved and have a say in the process. They become committed to what was agreed upon and will try to execute the measures.
The representative of the pastoralists should be invited to one of the sub-committees. („get on board")

The terms of references of the sub-committees should be defined clearly and should be realistic. The TOR's should be co-ordinated by the Implementation Committee, so there will not be any overlapping.

The communication problems with the representative of the maasais should be solved by proper translation.