

Lake Naivasha

EXPERIENCE AND LESSONS LEARNED BRIEF

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1. Introduction

Lake Naivasha (Figure 1) is a shallow basin lake, situated 80 km northwest of Nairobi in the Kenyan Rift Valley. The recent developments around the lake constitute an interesting case for natural resource management that is discussed in this brief.

The lake contains freshwater supporting a rich ecosystem, with hundreds of bird species, papyrus fringes filled with hippos, riparian grass lands where waterbuck, giraffe, zebra and various antelopes graze, dense patches of riparian acacia forest with buffaloes, bushbuck and other creatures, beautiful swampy areas where waterfowl breed and feed and, at the same time, magnificent views of the nearby volcanoes. Local fishermen depend on the lake for fish and crayfish. Although the lake is situated in a semi-arid zone, after the rainy seasons, the fragile soils of the surrounding hills and the valley bottom produce grass where the pastoral Maasai bring their herds for dry-weather grazing, thereby depending on the lake and its various watering points.

Situated west of the main lake is Lake Sonachi, a small paradise on its own. Sonachi (or Crater Lake as it also is known) is in the caldera of a small volcano, with its own microclimate. A dense forest covers the steep walls of the crater. High biomass production has been recorded in this highly alkaline lake, which often hosts flocks of flamingos.

Lake Naivasha has no surface outlet, with the natural water level changes over the last 100 years being more than 12 meters. The water level can change several meters within just a few months, causing a shift of the shoreline of several kilometers. These dynamics add an extra dimension to the riparian ecosystem, as well as complicating the water resource management issues.

In the colonial days, large cattle ranches occupied the bottom of the Rift Valley. There was a large sisal plantation located south of Lake Naivasha. The lake water was used only to irrigate small acreages of fodder crops, provide water for cattle, and grow vegetables. Large areas of papyrus were cleared and converted into agricultural land. When the water levels were receding between the 1930s and 1950s,

the Colonial Government was reluctant to approve water abstraction permits.

In 1929, the Naivasha landowners organized themselves into the Lake Naivasha Riparian Owners Association (LNROA). The land below the arbitrary chosen lake level of 6,210 ft asl (1,892.8 m asl) was put into the custody of the landowners in 1933, under the LNROA, although no permanent structures were allowed to be built on this land. This proved to be a wise move, since it has protected the riparian/shore line from degradation. In the late 1950s, when the lake water levels started to rise, after a couple of decades of falling levels, the Administration began designing complex diversion schemes: Water was to be transferred to Lake Elmenteita (also commonly spelled Elementeita) to the north, and to Kedong valley to the south. Fortunately, these plans never came to fruition. Around 1990, the LNROA became more proactive and, in 1998,



Figure 1. The Lake Naivasha Basin.

changed its name to the Lake Naivasha Riparian Association (LNRA) and opened itself to a wider membership by instituting associate membership. In 1999, the LNRA's 70th anniversary, the organization received the prestigious Ramsar Wetland Conservation Award in the NGO category for its conservation work on the lake.

The first large abstraction of the lake occurred when a pipeline from the Naivasha basin to Gilgil and Nakuru Town became operational in 1992. During the 1970s, there was little irrigation, mainly fodder crops. In the early 1980s, however, one vegetable grower decided to switch crops, successfully, to the production of cut flowers. This decision has profoundly changed the rules of the game.

The permeable and fertile soils, low rainfall, reliable supply of good quality water, good climatic conditions, availability of cheap labor, and easy access to Nairobi Airport, are the ingredients of a booming flower-dominated horticultural industry around the shores of the lake. Since the first flower farms started in the early 1980s, there has been a fairly constant increase in the area under flowers. In the late-1990s, the flower farms started to mushroom; this process is still continuing, causing considerable concern regarding whether or not the lake can sustain this increase.

The horticultural developments caused a shift in the landownership and population around the lake. Before the horticultural developments, the population was comprised mainly of people born along the lake shores, or who were attracted by its peace and beauty. Since the 1980s, entrepreneurs have moved in, bought or rented land, and started growing commercial flowers for export. Those who had lived all or most of their lives in Naivasha, however, realized that the paradise might be lost if the lake was not properly managed. The LNRA became the vehicle that started the lake management process in the late-1980s. The energy, diplomacy and stamina of two LNRA members, the Chairman and Honorary Secretary, have been instrumental in starting and continuing this process. During this period, a rather dormant stakeholder organization with a long colonial history was transformed into an active organization interested in sustainable development of the lake. The LNRA started sensitizing their members and others on environmental issues, compiled and summarized research that had been carried out over the years into one document (Goldson 1993), encouraged researchers to investigate the lake, started to develop a management plan and sectoral codes of conduct, and started to network and lobby in order to achieve their goals, with the old riparian agreement becoming a powerful instrument for protecting the government-owned riparian zone.

The large commercial growers felt that the direction the LNRA had taken was not consistent with their commercial interests. As a result, a small group of large flower farms established the Lake Naivasha Growers Group (LNGG). Conflicts between LNRA and LNGG arose and were subsequently reconciled, which is all part of the consensus-building process and movement

toward a more institutionalized form of management, with the result being that both groups are now working together for the benefit of the lake and the economy.

The first important achievement in this process was the designation of Lake Naivasha as a Ramsar site in 1995. As a result, the Kenya Wildlife Services (KWS), custodian of Kenyan Ramsar sites, became an important and influential partner with the LNRA. In 1996, the stakeholders agreed on the Management Plan, with the Government of Kenya officially approving it. This was the start of the implementation phase of the Plan. The Lake Naivasha Management Implementation Committee (LNMIC) was then formed, being the body to execute the plan, drawing its members from various relevant government and non-government stakeholder organizations.

The LNMIC has no executive powers, and no budget allocated to it. It has to work through, and with, official government institutions with some limited support of wetlands-oriented projects and NGOs. At the same time, the number of problems to be addressed is manifold, with many important parameters still unknown.

The population has increased tremendously around the lake, resulting in a proliferation of unplanned settlements, which lack basic amenities such as water, sanitation and waste disposal programs. The lack of water in these settlements forces residents to go to the lakeshore for domestic water, laundry and livestock watering. As a result, the area is being denuded of trees for firewood and over-grazed by livestock, thereby promoting erosion. There is a major issue of bush meat and human/wildlife conflict, and wildlife is being snared on a large scale for meat and skins.

The rapid developments resulted in many speculations on the complex relationships between resources and resource users, and subsequent disputes. Conservationists argued that commercial farms are ruthlessly emptying the lake, whereas commercial growers counter that the lake levels were much lower in the 1950s, before agricultural activities began. Although the lake is intimately linked to a very productive aquifer, the inter-relationships are complex. Farmers pumping groundwater claim that they do not exploit the lake. Many unsubstantiated claims are made about the volume of water abstractions, the effects of deforestation, the river sediments accumulating in the lake, the effects of agrochemicals used by the horticultural farms and smallholders in the upper catchment, the unplanned urban and slum development, the effects of cattle watering at the lakeshore, the relationships between agrochemicals, overfishing, introduced species and biodiversity, the effects of untreated sewage discharged into the lake, the effects of the geothermal plant just south of the lake, and many more issues.

In 1996, the LNRA asked the Ministry of Water Development to study the lake's water balance and the water-related environmental impacts. This study was carried out in close collaboration with ITC-International Institute of Geo-

Information Science and Earth Observation, in the Netherlands, with the collaborative studies continuing to the present. The Ministry has stationed a hydrologist in Naivasha to monitor the water resources. Leicester University/Earthwatch have studied the aquatic ecology of the lake since 1985. The lake also has been the focus of research by many Kenyan scientists from local and overseas universities, the Kenya Marine and Fisheries Research Institute (KEMFRI), KWS and Kenya Agricultural Research Institute (KARI).

The problems of disseminating the results of scientific work among laymen, and integrating scientific knowledge in the management process, are well known, not being unique to Kenya. Nevertheless, the research on the water, environment, socio-economy and ecology has helped resolve a number of resource disputes and conflicts, allowing the LNMIC to make rational decisions.

The main issue however, regarding how a multimillion-dollar, booming horticultural economy can exist within a Ramsar site, became more quantifiable. Over a long period, Kenyans ruthlessly and unsustainably exploited their natural resources, long-term planning was virtually absent, and law enforcement was poor. Somewhere around the year 2000, however, the tide changed, with an enabling environment for natural resources management beginning to emerge.

The Environmental Management and Co-ordination Act (1999) and the Water Act (2002) provided for the National Environmental Management Authority (NEMA) and the Water Management Authority (WMA). The first Authority is now operational, whereas the latter is still in the process of being established, and the concept of Integrated Water Resources Management (IWRM) is being incorporated. The LNRA took a more holistic approach, realizing that the RAMSAR site could not be protected without addressing the problems in the entire lake basin. It involved more and more stakeholders and sectoral Codes of Conduct operationalized in the Management Plan. The LNGG, who originally were mainly concerned about access to water and land for horticultural production, also began to appreciate that natural resources are finite, and that their over-exploitation would damage the entire flower industry. Furthermore, in their main European export market, environmentally-friendly production is an asset. The LNGG adjusted its earlier position and became a more active partner in lake management, working together with LNRA on resource issues, including land tenure, abstraction rates, agrochemical control, and water availability. The LNGG employed a horticultural expert, who actively promotes water conservation and environmentally-friendly production techniques, and the importance of water abstraction monitoring, among its members. Many (large) farms have now voluntarily installed water meters.

Several commercial growers realized that innovative techniques and better irrigation management could reduce water usage. They have started such activities as applying computerized irrigation systems with soil moisture sensors, moving away

from overhead sprinklers to more efficient drip irrigation systems, using coco-peat to improve soil characteristics, using geothermal energy to increase CO₂ and climate control of greenhouses, storing roof runoff, and constructing artificial wetlands to treat wastewater.

The LNRA started to compile an inventory of its resources, in close cooperation with officials of various Ministries. A politically important achievement was a temporary ban on fishing, which was enforced with the cooperation of the commercial fishermen—a previously unheard of activity.

At present, the Ministry of Water Development and Management is re-assessing abstraction permits, and water pricing is being seriously discussed. Both LNRA and LNGG have concluded that no new abstraction licenses should be issued at present.

The Chairman of the LNRA wrote: “I believe that we were also fortunate to have the ideal conditions of climate, soils and water for flower-growing. For all its potential to destroy the lake, the industry is contributing greatly to sustainable utilization of such a valuable resource. In absence of the industry, I believe more abuse and more fragmented development would have occurred and would have been more difficult to contain” (Enniskillen 2002).

The management of Lake Naivasha is complex, and many issues remain to be addressed and resolved. However, if the management process begun some 10 years ago maintains its present direction, Lake Naivasha may become a famous example of Integrated Water Resources Management, one illustrating that a profitable economy and a Ramsar site can co-exist.

2. Background

2.1 Biophysical features

2.1.1 General Setting

Lake Naivasha (0.45° S, 36.26° E), altitude 1,890 m asl, lies on the floor of Africa’s Eastern Rift Valley, covering approximately 140 km². It is the second-largest freshwater lake in Kenya, and one of a series of 23 major in the East Rift Valley—8 in central Ethiopia, 8 in Kenya, and 7 in Tanzania—spanning latitudes from approximately 7° N to 5° S. The overall climate of the Eastern Rift Valley is semi-arid.

2.1.2 Geology, Soils, Groundwater

Only a few properties with direct relevance to managing Lake Naivasha are discussed in this section.

The volcanic formations in the Rift Valley generally have a high sodium (Na) content. The soils around the lake are developed on volcanic ashes, mainly composed of fine pumice grains, and pumice layers are abundant. The interaction between volcanic deposits and water in the lakes causes the genesis of zeolite minerals.

Due to their high pumice content, the soils around the lake are very permeable, with a very low water-holding capacity. As a result, irrigation water seeps quickly to depths below the plant rooting zone. Very frequent (some farmers claim 10 times daily) irrigation activity is necessary, with all excess irrigation water seeping down to the groundwater. The soil properties are also important in regard to defining the path agrochemicals are likely to follow; because of the high permeability and gentle slopes, surface runoff rarely occurs and most agrochemicals are transported toward the groundwater.

Groundwater plays an important role in the hydrology of the Lake Naivasha system. The leakage from the lake is part of the groundwater system, and exact identification of this mechanism could provide for a better exploitation of groundwater resources. Although groundwater is the recipient of most agrochemicals used around the lake, the water flow is generally away from the lake. Thus, the chance that agrochemicals will end up in the lake is low. The aquifers around the lake have very high yields, and all irrigation north of the lake is based on groundwater.

Because of the alkaline nature of the volcanic rocks, the soils and groundwater have a high sodium content. This causes a problem for growing high-quality crops, since the soil structure is unsuitable. In general, groundwater in the area south of Lake Naivasha is not very suitable for irrigation. Mixing groundwater with surface water could prove a viable option. The abundance of pumice is going to play an important role in the hydroponic irrigation systems, since pumice is a perfect sub-stratum for hydroponic culture.

The presence of zeolites also is recognized, but not well-researched. Zeolites play an increasing important role in organic farming and modern land management. They have very high soil water retention capacities, and extremely high Cation Exchange Capacities (CEC). They are able to capture ammonia (NH₄), an important fertilizer. Thus, more research on the potential of zeolites in the floricultural industry around the lake is highly recommended.

2.1.3 Climate

The drainage basin lies within the range of the Intertropical Convergence Zone (ITCZ). Mount Kenya and the Nyandarua Range capture moisture from the monsoon winds, casting a significant rain shadow over the Lake Naivasha basin. The rainfall distribution has a bi-modal character, with long rains during April-June and short rains during October-November (Figure 2).

The long-term spatial rain distribution varies from about 600 mm at Naivasha Town to some 1,700 mm on the slopes of the Nyandarua Mountains. The Kinangop Plateau experiences an annual rainfall between 1,000-1,300 mm. The open water evaporation of Lake Naivasha is approximately 1,720 mm/year.

2.1.4 Hydrology and the Water Balance

The lake is fed by two perennial rivers, the Malewa and the Gilgil Rivers, discharging 80% and 20%, respectively, of the total inflow. The Karati River drains the area east of the lake, being ephemeral and flowing approximately 2 months per year. The area south of Lake Naivasha does not produce much runoff reaching the lake. The drainage from the Mau Hills and Eburu to the west infiltrates before it reaches the lake.

Both the Malewa and the Gilgil Rivers yield water of excellent quality. The Electric Conductivity (EC), a proxy for Total Dissolved Solids (TDS), may change very rapidly in a few hours, although the mean EC for both rivers is around 100 µS/cm. Like all natural water in the area, the sodium content is relatively high.

The lake fills a shallow water basin with gentle slopes. Thus, both the area and the water evaporation increase with rising lake levels. The lake exhibits a dynamic behavior. Its water level follows the long cycles of wetter and dryer periods with the amplitude of about 12 m over the last 100 years.

The lake's water level fluctuations have attracted the interest of both scientists and water managers. In 1948, Mr. Tetley (an Hydraulic Engineer in Nairobi) wrote: "The lake reached its next highest peak in 1917 and since that year (1917) to April 1946 the level had a drop of about 37 feet; its area shrank from say 86 square miles to less than 33 square miles and it lost about fifteen sixteenth of the volume of water all in 29 years."

Verschuren et al. (2000) studied the lake levels over the past 1000 years, identifying 4 periods when the lake almost went dry, as well as periods with higher water levels than present.

Lake Naivasha actually consists of three lakes. The Crescent Lake, the deepest part of the lake (18 m depth) can be connected to the main lake, depending on lake levels. Oloiden is a smaller lake at the south end of the Lake Naivasha and, depending on lake levels, can be distinct from the main lake.

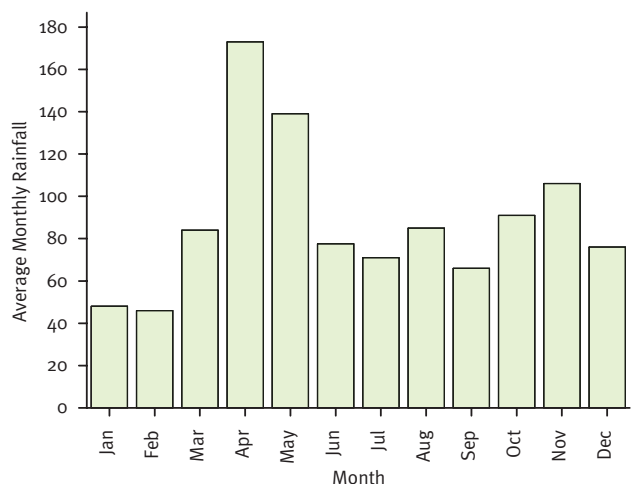


Figure 2. Average Monthly Rainfall Distribution for Lake Naivasha Region.

The main lake is shallow (max. 8 m). Additionally, Crater Lake or Sonachi is located near the southwestern part of Lake Naivasha, but it is independent from the main lake.

Although the lake has no surface outlet, it still has good water quality, with an EC value of approximately 300 $\mu\text{S}/\text{cm}$. It has been recognized for a long time that only underground outflow could explain the freshness of the lake water. The groundwater levels, and the isotopic composition of groundwater, indicate that this flow is both to the north and the south. A small part of the groundwater evaporates, and will escape in the form of fumaroles in the geothermal areas. The remainder flows into Lake Magadi and Lake Elmenteita, taking thousands of years for the water to arrive at these lakes.

The lake itself can be considered a groundwater outcrop of a very good shallow aquifer that drains into a deeper aquifer system, which carries the water towards the terminal lakes (Magadi and Elmenteita). The groundwater system around the lake is complex, with important management implications that will be discussed later. The water generally flows away from the lake, with the exception of the western direction, where an inflow from the Ndabi Plains enters.

The water balance of the lake has been calculated with a water balance model (Mmbuie 1999). The water balance is calculated for the period 1934-1983 (Table 1), therefore representing the period before large-scale water abstractions began.

2.1.5 Biosphere

Little natural vegetation is left in the catchment. The headwaters of the Malewa River, the lake's main water source, are situated in the Aberdare National Park and adjoining gazetted forest. The vegetation consists of humid Afro-mountain forest and bamboo. Fog frequently occurs, and may play a role in the water balance. Although the Kinankop and Bolosat Plateau were large grassland plains in the past, an estimated 30% is now covered with maize or vegetables, and many fast growing tree species. The upland areas are largely covered by tree-savannah landscape and dryland forest, and remnants of this forest can still be seen on the escarpment. In the past, the bottom of the Rift Valley was an open savannah landscape.

Lake Naivasha supports unique habitats, particularly the fringing papyrus swamp and associated freshwater biodiversity. As previously noted, the ecosystem comprises three chemically distinct water bodies, the main freshwater lake, a more alkaline and sometimes-connected lake (Oloidien), and a crater lake (Sonachi).

Table 1. Lake Naivasha Water Balance, 1934-1983
($10^6 \text{ m}^3/\text{month}$).

Rain	Surface water inflow	Evaporation	Groundwater outflow
95	220	260	55

The littoral zone is inhabited by macrophytes that provide suitable habitats for fish feeding and breeding, and mulch for invertebrates. Although the species composition has changed over time, the dominant floating species are *Cyperus papyrus*, *Eichhornia crassipes* (exotic), *Pistia stratiotes*, *Salvinia molesta* (exotic), *Wolffia arrhiza* and *Nymphaea* (water lilies). Submerged plants include *Potamogeton schweinfurthii*, *P. pectinatus*, *P. octandrus*, *Najas pectinata*, *N. caerulea*, *Ultricularia reflexa*, and *U. gibba*. Although the areas of submerged macrophytes vary considerably, the littoral zone comprises about one third of the lake. This habitat exerts great influence on the lake's biology and chemistry, and the plants also are responsible for the richness of the bird population.

Water lilies almost disappeared in the 1980s, thought to be caused by the introduced crayfish and accidentally-introduced Coypus. The papyrus is considered the most important plant of Lake Naivasha, occurring in the shallow water of the lake edge, and on land where the sub-surface soil was saturated. It almost completely surrounds the lake, forms floating islands in the lake and can be found up to 5 km up the Malewa River. It acts as an efficient silt and nutrient filter, and is capable of recycling excess nutrients. It also forms an important habitat for fish (where submerged or floating) and wildlife (e.g., birds, hippos, buffalo) which use it as safe refuge and feeding area. The quantity of papyrus in the lake has varied tremendously as a consequence of fluctuating water levels, fires and, in some cases, human encroachment.

One hundred and forty-three (143) phytoplankton taxa have been recorded in the lake, including the species *Microcystis*, *Lyngbya*, *Oscillatoria* and *Melosira*. The photosynthetic rate is about 5 mg $\text{O}_2/\text{m}^3/\text{d}$ in the open lake (50 mg $\text{Chl-}a/\text{m}^3$). Most productivity occurs in the top 3 m of the lake. The more alkaline Oloidien and Sonachi lakes are more productive, with *Spirulina* significantly present. The main zooplankton genera are Cladocera, Copepoda and Rotifera. The zooplankton biomass is positively correlated with the chlorophyll-*a* (algal) concentrations, since zooplankton feed on the phytoplankton. Twenty-eight taxa of invertebrates have been recorded, associated with macrophyte beds.

The small-toothed carp (*Aplocheilichthys antinorii*) and *Barbus amphigramma* were the only fish species in the lake before 1925 (the paucity of species probably due to historical episodes of lake desiccation). The *A. antinorii* species had disappeared by 1962, likely a direct result of the introduction of the largemouth bass. The present fish population comprises introduced species, including largemouth bass (*Micropterus salmoides*), introduced from the United States in 1927, 1951 and 1956, *Tilapia zillii* (1956 from Lake Victoria: the introduction also contained *Oreochromis leucostictus*, now the most numerous fish, ahead of bass), and other tilapiine species not encountered today. Three cyprinodonts, *Gambusia*, *Poecilia* and *Lebistes*, were introduced to control mosquitoes. The exotic rainbow trout (*Onchorhynchus mykiss*) occasionally strays into the lake from the Malewa River, while *Barbus amphigramma* migrates between the lake and the river.

The Louisiana red swamp crayfish (*Procambarus clarkii*) was introduced in 1970, as a food source for the bass.

The main food source for fish fry is zooplankton (60%) and chironomid larvae, followed by algae and detritus. Larger bass feed on crayfish, fish fry and frogs. Juvenile fish exert predation pressure on the zooplankton in the littoral zone, whereas the zooplankton remain relatively untouched in the open waters. The fish are a source of food for numerous piscivorous birds (e.g., fish eagles, ospreys, cormorants, kingfishers, herons, pelicans), and also comprise an important fishery that is a source of income and animal protein for the human population around the lake and in nearby towns.

The Naivasha Thorn, or Yellow Fever Tree (*Acacia xanthophloea*) is the dominant terrestrial tree species, forming the woodland around the lake. It is an important habitat for birds and other wildlife, and the undergrowth provides an important buffer against erosion and helps prevent the transport of silt and nutrients to the lake. Many animals are found on the shores of the lake, in the acacia woodlands and the neighboring national parks and sanctuaries, including hippopotamus (a population of over 600), waterbuck, buffalo, giraffe, eland, zebra, Thomson's and Grant's gazelles, bushbuck, duikers, mongooses, otters, various snakes and rodents, and the occasional leopard. The Malewa River delta comprises Acacia woodland, before giving way to papyrus swamp.

Lake Naivasha regularly supports congregations of more than 20,000 water birds, with a mean of 22,000 (1991-1997). The riparian, papyrus and littoral macrophyte zones provide safe haven, foraging and breeding ground for many resident and migrant bird species, and other wildlife such as the hippo, waterbuck and buffalo. The woodland within the ecosystem provides habitat for the globally-threatened grey-crested helmet-shrike (vulnerable). Another globally-threatened bird found in this location is the Basra Reed Warbler (near-threatened), a winter visitor and passage migrant whose exact status is unknown. There also are regionally-threatened species, both as regular visitors and residents (e.g. great crested grebe (critical), Maccoa duck (endangered), African darter, great egret, saddle-billed stork, white-backed duck, Baillon's crane and African skimmer (all vulnerable)). The riparian/papyrus habitat supports certain endemic species, such as papyrus gonolek and white-winged swamp-warbler. The large mammals, especially the hippos, may play an important role in phosphorus recycling around the lake.

2.2 Political and Socio-economic Feature on Development and Conservation

The Lake Naivasha basin covers two districts, Nyandarua and Nakuru. Activities of many Government Ministries are decentralized to the district level, thereby complicating an integrated catchment approach. Development plans are written for districts (District Development Plans), but these districts cross-cut basin boundaries.

The lake has had Ramsar Convention status since 1995, with most land within the Ramsar site being privately owned. The land below the riparian boundary is government land, given in custody to the riparian landowners. No permanent structures are allowed.

The Lake Naivasha drainage basin largely occupies traditional pastures of the pastoral Maasai. However, the basin became part of the so-called white highlands after colonialization, areas where only European settlers were allowed to own land. The higher parts were mainly used for wheat and cattle, the bottom of the Rift Valley for cattle, and around Lake Naivasha sisal, Lucerne and vegetables were grown. After independence, mainly members of the Kikuyu tribe occupied the parts suitable for rain-fed agriculture. Because the land tenure in the bottom of the Rift Valley remained largely unchanged, much of the land around the lake is still owned by Kenyans of European origin. The fishermen community is mainly Luo.

There has been irrigated Lucerne north of the lake, used as fodder for dairy cows since the 1940s. The area between Lake Naivasha and Lake Nakuru (80 km to the northwest) is mainly used as cattle and game rangeland. Open rangelands are south of the lake, where the Maasai graze their livestock during the dry seasons. Closer to the lake edge are many irrigated floriculture ventures. The areas to the west and east of the lake, which receive higher rainfall, are occupied mainly by smallholders growing maize, vegetables and pyrethrum. There also are some larger grain farms.

As a result of introduced fish species, a fishing industry has sprung up, with black bass, tilapia and crayfish being commercially exploited. Recently, as a result of excessive fishing pressure, the fish stock became so depleted that a year-long ban had to be imposed to redress the situation and an annual closed season is now in force during the fish breeding season.

Lake Naivasha is a tourist destination, although not a major one. There are two small national parks (Hells Gate and Longonot) in the vicinity of the lake and nearby Aberdare National Park. The area's beauty, the extent of the bird and wildlife, its proximity to Nairobi, and the many hotels, home-stays and campsites at all budgetary levels, attract many visitors, both local and overseas. About 40,000 tourists visited the lake and its surroundings in 1998.

The KenGen Ol Karia geothermal power plant, situated 7 km south of the lake, became operational in 1982, producing 45 KW of power. An independent power producer started production in an adjacent area in 2002, producing 12 KW of power, and a second KenGen generation station was commissioned in 2004, producing 575 KW of power.

The first flower farm started in the early-1980s and, over a period of twenty years, the flori- and horticultural area has increased from close to zero to some 4,000 ha. Growers now produce at least 25 varieties of flowers (roses, spray

carnations, gypsophila, alstroemeria, eustoma, etc.) and vegetables (peas, baby corn, beans) for the export market, all of which are irrigated with lake, river or groundwater. The economic return per cubic meter of water applied on a crop varies tremendously, with the values in Table 2 based on an analysis carried out in 2000 by ITC.

Table 2. Economic Return per Cubic Meter of Water Use.

Crop	US\$/m ³
Flowers (indoors)	1.58
Flowers (outdoors)	1.25
Grass	0.04
Fodder	0.18
Macadamia nuts	4.86
Vegetables	0.72

The industry employs some 25,000 people directly, with a similar number also indirectly dependent, both as dependants and service providers. Based on the 1999 census, the Central Bureau of Statistics reported the population of the Naivasha urban core as 32,000 and the whole of Naivasha Municipality as 115,000 persons. According to a demographic internet source (www.library.uu.nl/wesp/populstat/Africa/kenyag.htm), the population of the urban core had increased from 6,900 in 1969 to 11,500 in 1977 and 35,000 in 1989.

The changes in land use patterns, especially north of the lake, are rather dynamic, and a differentiation between vegetables and fodder production is not always possible.

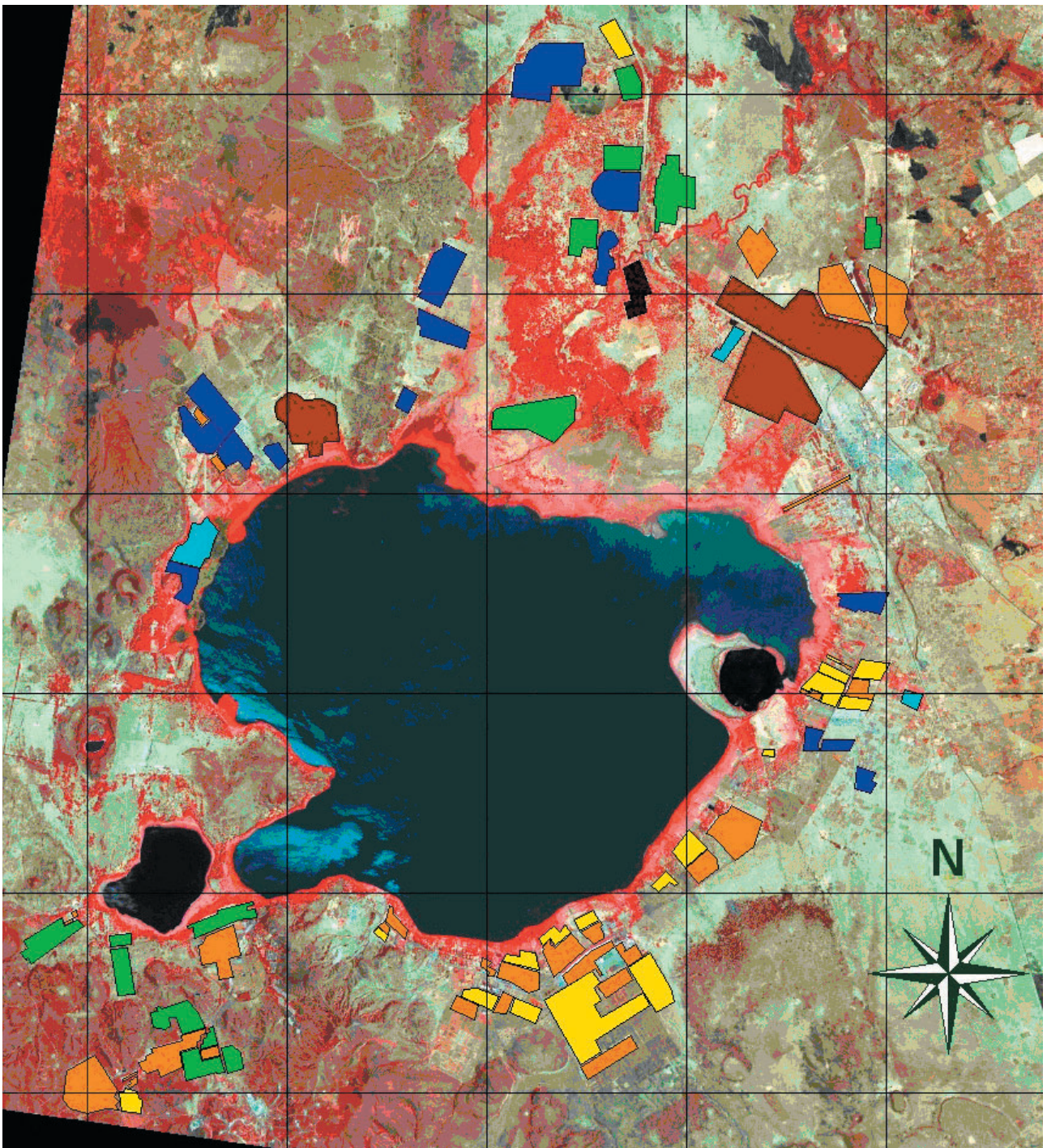
A number of observed trends include the following: movement of the flower industry from outdoors to indoor; fodder production replaced by vegetable production; irrigated land being abandoned; and the total area under irrigation being rather stable over the past 10 years. Table 3 and Figure 3 show area and location of the different types of irrigated farms as well as abandoned land.

Table 3. Irrigated Farms.

Crop	Area (ha)
Abandoned	814
Flowers (indoors)	1,191
Flowers (outdoors)	704
Grass and fodder	128
Macadamia nuts	63
Vegetables	937
Vegetables and fodder	943
Total Irrigated Area	3,966

The booming horticultural industry's influence on the local economy has never been studied in detail. What is certain, however, is that the floricultural business has attracted many people. Social tensions exist in relation to wages, social

security, trade union membership, sexual harassment and health issues related to exposure to agrochemicals. Trade organizations and trade unions play a prominent role in such issues and naturally try to organize farm workers, whereas farm owners/managers naturally prefer an obedient and quit workforce. Most, if not all, farms pay more than the legal minimum wage. The larger farms also provide housing, free medical services, schools for children of farm workers and social and sport facilities. Overall, the explosive development around the lake is nevertheless associated with many conflicts and disputes.



- | | |
|---|--|
| ■ Abandoned | ■ Macadamia nuts |
| ■ Flower (indoors) | ■ Vegetables |
| ■ Flower (outdoors) | ■ Vegetables and fodder |
| ■ Grass and fodder | |

Figure 3. Irrigated Crops around Lake Naivasha.

3. Biophysical Environment

3.1 Water Balance

In the late 1990s, ITC was engaged to develop a simple, spreadsheet-based water balance model of the lake and its basin. The model used data from a variety of sources—government and private sector—for a period from 1932 to the present day. If a groundwater outflow of 4.6 million m³ per month was allowed for, then the model was able to reproduce the observed lake level from 1932 to 1982 with remarkable accuracy (Figure 4). Over this period, 95 percent of all observed monthly lake levels differed from the modeled levels by 0.52 m or less. This accuracy makes the growing discrepancy between the observed and the modeled lake levels after 1982 all the more striking. By 1997, the observed level was 3-4 m below that predicted by the model.

The onset of this decline in water level coincided with the commencement of horticulture in the area in 1982, and there was a close match between the annual water deficit by 1997 (60 x 10⁶ m³) and the estimated water use based on the area of horticulture and the crops grown. If the 1940s climatic conditions recur, then the lake surface area will be reduced to 30 km², compared to the present 120 km².

In addition to the spreadsheet model, a groundwater-modeling program (ModFlow) of the U.S. Geological Survey was also used. Although the predictions from ModFlow were not better than for the spreadsheet model, it allowed for studying the effects of groundwater abstractions on the lake levels. It also can be linked to groundwater quality models, in order to study the transport of pollutants around the lake.

Overall, groundwater plays a more important role than realized by the stakeholders and management, because it: controls the irrigation efficiency; contains as much water as the lake; transports pollutants; affects the lake levels; feeds the geothermal system; and causes the lake to be fresh. How much of the groundwater outflow flows towards the north (Elmenteita) and how much southwards, has been long

debated. A water balance study covering the southern Rift Valley, from Lake Magadi to Lake Nakuru, indicated that some 15 million m³ flows toward the north.

The water outflow from Lake Naivasha toward the south causes over-irrigation to be a net loss with pollutants moving away from the lake. In the north, where groundwater recirculates due to groundwater exploitation, the excess irrigation will recharge the aquifer, and also bring pollutants to the groundwater. Overall, the large groundwater reservoir causes inertia of the system, necessitating long planning horizons.

3.2 Water Quality, Aquatic Ecology, Sediment Load

Several authors have previously reported on the lake's water quality. The oldest (though not complete) analysis dates back to the 1920s. The natural water quality is influenced mainly by solute inputs and lake level variations. The Total Dissolved Solids (TDS) increase in times of receding lake levels, and decrease after floods. Irrigation from the lake decrease the TDS concentration, whereas irrigation from the rivers increases TDS concentrations. No disturbing trends, however, have been detected so far.

Total phosphorus (T-P) is one of the elements controlling the lake's tropic status, and the following data (Table 4) have been collected from Abiya (1996) and Kitaka (2000).

Table 4. Total Phosphorus Concentrations in Lake Naivasha.

Date	T-P (ppm)	Source
01 Jun 1984	89	Abiya
01 Jun 1988	73	Abiya
01 Jun 1990	10	Kitaka
01 Jul 1997	110	Kitaka
01 Sep 1997	150	Kitaka
01 Nov 1997	70	Kitaka
01 Mar 1998	50	Kitaka
01 Jun 1998	40	Kitaka

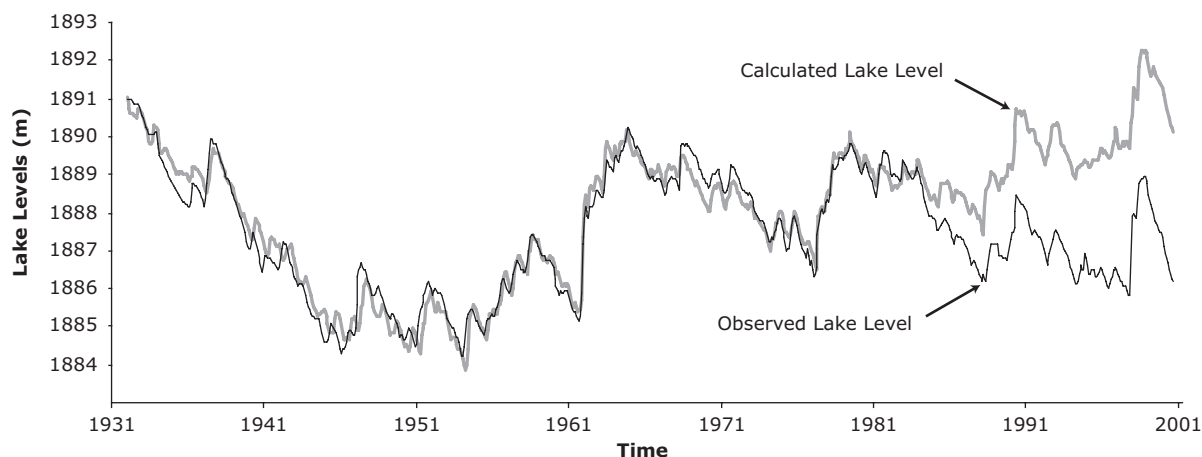


Figure 4. Long-term Water Level Change in Lake Naivasha.

The high values of 1997 are explained by that year's high runoff. Although Kitaka (2000) took a series of samples over several months in 1990 (with a mean T-P concentration of 10 µg/L), the source of Abiya's data is unknown. Time series data on nitrate (NO₃) and ammonia (NH₄) are not available.

A data set collected by ITC in 2001 shows a considerable temporal and spatial variation in the soluble phosphorus (PO₄) and nitrogen data. The two surveys, both with over 100 points well spread over the whole lake, were done only one week apart (Table 5).

The concentrations of chlorophyll-*a* increased from around 30 µg/L in 1982, to 110 µg/L in 1988, reaching 178 µg/L in 1995 (Unpublished LNRA Internal Report). McLean (2001) used 8 chlorophyll-*a* values obtained from Hubble in 1998 (cited in McLean 2001), with values ranging between 0.01-0.08 µg/L. The large difference likely can be attributed to the reporting units (i.e., factor of 1,000 between µg/L and mg/l). Harper et al. (1990) reported an increase from 20 µg/L in 1982, to 130 µg/L in 1987. The N/P ratio is 2.1 (McLean 2001), suggesting that nitrogen is the algal biomass limiting nutrient.

The large horticultural farms, and the many smallholders in the upper catchment, clearly have an effect on the lake's water quality. Nevertheless, the trophic status of the lake is still acceptable. Kitaka et al. (2002) classified the lake as eutrophic (1998-99), becoming hypertrophic after the El Niño floods (1997-98), and stated that the lake's trophic status can

be explained solely on the basis of the Malewa River nutrient input. A mathematical model, simulating agrochemical runoff, also showed that the major nutrient input originates in the upper Malewa River (Berrihun 2004).

Water transparency (Secchi depth) varies with site, ranging between 5-150 cm. It is lowest in the north swamp area, where suspended sediment is brought in by the rivers. Low transparency also can be caused by algal growth, and algal blooms have been observed, albeit infrequently.

Very few analyses are available on the pesticide levels in the lake. Gitahi et al. (2002) reported that organochlorines could be detected in black bass and crayfish, although no organophosphates were detected in the same samples. The total load to the lake has been calculated on the basis of farm data.

Everard and Harper (2003) have shown that the reduction in the lake's papyrus fringe has been dramatic (Figure 5). Also, the fish catch has varied substantially over the last 40 years, with relevant data compiled by Hickley et al. (2002) and LNRA, as shown in Figure 6.

An issue of major concern is whether or not an "ecological switch point" exists. This phenomenon is meant to denote where an ecosystem (irreversibly) switches from one stable state to another. Aquatic ecologists speculate that this point for Lake Naivasha was passed a long time ago, when alien species were introduced in the lake. The introduction of the Louisiana crayfish especially has changed the original submerged macrophyte-dominated ecosystem into a rather poor macrophyte ecosystem. Smart et al. (2002) concluded that *P. clarkii* (crayfish) could well have caused the observed elimination of native plant species in Lake Naivasha. The cyclical nature of populations of submerged plant species and of *P. clarkii* in inverse proportion to each other suggest the hypothesis that *P. clarkii* is a "keystone" species in the lake ecosystem. Under the present lake stresses, however, the occurrence of the next switch point is unlikely.

Table 5. Temporal and Spatial Variations in the Soluble-P (PO₄) and Nitrogen Data.

Nutrients	First Survey	Second Survey
	Mean concentration (ppm)	Mean concentration (ppm)
PO ₄	0.31	0.54
NO ₃	0.74	1.00
NH ₄	1.81	0.73

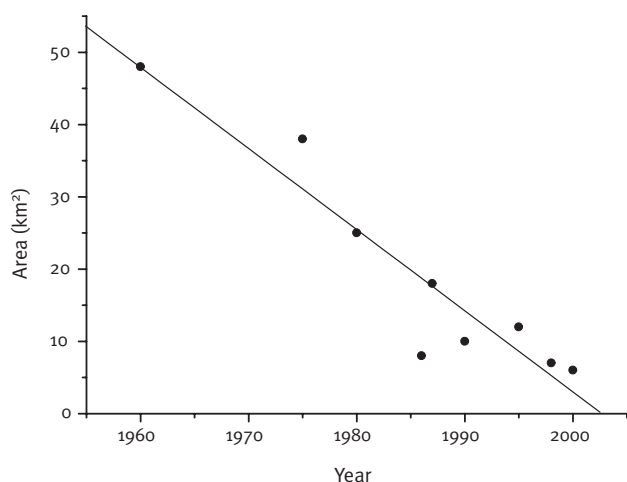


Figure 5. Lake Area under Papyrus.

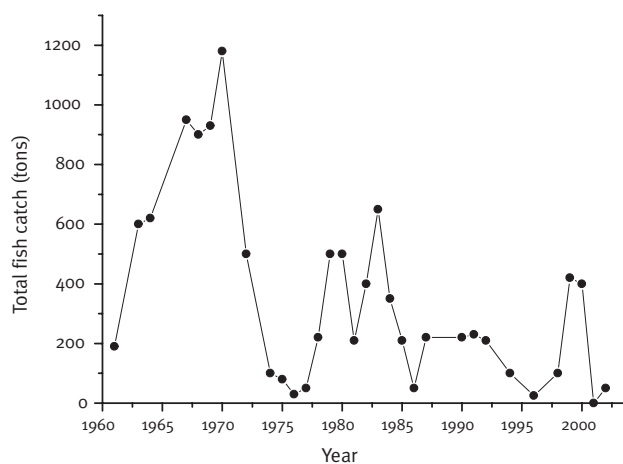


Figure 6. Total Fish Catch.

A new threat may emerge from the accidental introduction of common carp to the lake in 2001. Britton (2002) concluded that further work is necessary on the fish population, to monitor whether or not *C. carpio* successfully reproduces and becomes established in the lake. If this does happen, monitoring of the fauna and flora of the entire lake will need to be continued, since the species can be very destructive in its foraging activities among the lake benthos. Because of its native impacts on water turbidity and macrophyte growth, *C. carpio* is considered a pest species in many countries, including Australia and South Africa, and there are eradication programs designed to completely remove it from aquatic ecosystems.

Many stakeholders consider siltation of the lake to be a large threat. The existing three sources of sediment to the lake include: the Malewa and Gilgil River catchments (the upper catchment); dust deposition from the atmosphere; and direct transport through ephemeral streams surrounding the lake, and from the riparian zone into the lake. The land use changes have certainly increased the sediment load from the upper catchment. Nevertheless, assessments by ITC in 1998 indicate no serious erosion hazards exist.

Rupasingha (2002) processed the 1927, 1957 and 2001 bathymetric data and sediment samples from the Malewa and Gilgil Rivers. Based on accurate bathymetric surveys, a total input of 7 billion kg, equivalent to a layer with an average thickness of 0.21 m (0.5 cm/year), has been calculated. Analysis of the sediment data for the Malewa River explains 35% of the input. Thus, the remainder is from the Gilgil, from the shore and small channels, and from the atmosphere. Verschuren et al. (2000), who studied sediment cores of the lake for paleoclimatic research, calculated a sedimentation rate of 1 cm/year over the last 40 years. Adams et al. (2002) concluded that the papyrus fringe is an effective sediment trap for riparian sheet erosion.

A three-week experiment by ITC on atmospheric deposition, using a series of water-filled plastic basins distributed around the lake, suggested the atmospheric input may be considerable (up to 20%). The primary nutrient associated with sediment transport is phosphorus, with Kitaka (2000) concluding that the main phosphorus input is from the upper catchment.

4. Management Environment

4.1 Lake Management Program and Processes

To understand the management environment of Lake Naivasha, it is necessary to discuss the many formal stakeholder and informal stakeholder groups, and their mandates, objectives and interrelationships, as well as the many more obvious and less visible conflicts, disputes and disagreements.

4.1.1 Stakeholders

Lake Naivasha Riparian Association (LNRA). The Lake Naivasha Riparian Owners Association (LNROA) was founded in 1929 by

the riparian owners, with several descendants of the founding members still living around the lake. The LNROA signed the Foreshore Rights of Riparian Owners with Government in 1932, giving the owners the right to use the exposed land below the boundary, always provided that the ordinary occupation in these premises shall be deemed to mean only the right of access to water, the right of grazing, and the right of cultivation. This boundary still plays a very important role even over 70 years later. Persons buying or owning land around the lake automatically became Association members. The Association was not particularly active until 1986, when a new and dynamic Chairman was elected. The members then started to realize that the newly booming floricultural developments had the ability to jeopardize the future of Lake Naivasha.

The LNRA started a process of lobbying, awareness building, networking and data collection to counter the degradation of the lake by the ongoing activities. A report was commissioned in 1993 by the LNRA, summarizing the knowledge on the lake (Goldson 1993). In those days the "Foreshore Rights" was the only legal document protecting the immediate lake surroundings. In 1993, the LNRA started the process of drawing up a Management Plan for the lake, which would have the support of all sectors, and which was based on voluntarily-adopted sectoral codes of practice under an overall management strategy. The Management Plan was adopted by the membership in 1996, subsequently by the District Development Committee in Nakuru, and thereafter by the Government as the official Management Plan for Lake Naivasha.

As a result of initiatives by the LNRA, the Kenya Government (GoK) nominated Lake Naivasha as its second Ramsar site in 1995, although it only comprised the area within the road around the lake. The GoK reaffirmed the LNRA's Management Plan as being the Government's official Management Plan for its Ramsar site. The Kenyan Wildlife Service (KWS) is the custodian, on behalf of the Government, of wetlands in general, and Ramsar sites in particular. Accordingly, this process received its full backing and support. The Management Plan is to be implemented by the Lake Naivasha Management Implementation Committee (LNMIC) (see below), under Terms of Reference established and agreed with KWS. The Committee consists of local and national organizations, including one international group (IUCN). The LNRA, having initiated the management process and playing a central role throughout, remains a key member. The LNMIC membership is intended to be representative of stakeholders' interests, consistent with administrative and decision-making efficiency, while at the same time being a firmly locally-based initiative.

The LNROA changed its name in 1998 to LNRA (deleting the word "Owners"), becoming more open to stakeholders other than the original landowners by allowing associate membership. It is still, however, primarily an association of individuals or companies which hold land title or legal responsibilities in the area. The LNRA celebrated its 70th anniversary in 1999, and received the prestigious Ramsar

Wetland Conservation Award, presented at the 7th Ramsar Conference of Parties in Costa Rica. The LNRA presently has some 140 individual and corporate members. If employees, other workers, and dependants are included, the LNRA can be considered to represent at least some of the interests of perhaps 100,000 people. Because the membership fee is kept low (to allow more persons to become members), the organization is continuously short of funds. It receives some support from conservation-oriented NGOs, and employs one full-time person with an background in aquatic ecology, as well as having one Peace Corps volunteer. Small projects are executed if the funding allows.

Lake Naivasha Growers Group (LNGG). The LNGG was founded 10 years ago by a small group of large commercial flower growers, thereby possessing considerable influence and unofficial power. The membership fee is based on the number of employees, and with about 25,000 persons employed by LNGG members, generates a steady income flow. The LNGG began as a response to the LNRA's conservation ambitions, but has since changed its stance. The large farms are now concerned that they will be negatively affected over the long term by over-exploitation of the lake's resources. They also realize that their European customers want "clean" or "eco-products" coming from a protected environment. Labor and social conditions, including working environment, health and safety factors, and gender equity, also are increasingly of concern to European customers. The Kenya Flower Council (KFC) has responded to this concern with establishment of a Code of Practice. The LNGG employs its Code of Conduct for its members, and also is included as part of the lake's Management Plan. A part-time horticultural consultant has been employed to advise farms on social and legal issues, conservation measures, better pest control, and irrigation management. The group carries out audits among its members, to ensure they comply with the Code of Conduct and the Lake Naivasha Management Plan. Several larger farms have looked at ways to improve their impacts on the environment, including using integrated pest management to reduce pesticide use and constructed wetlands to treat their wastewater.

Kenya Wildlife Service (KWS). As an owner of riparian land, KWS has been a long-time LNRA member. It also is the official custodian of all Kenyan Ramsar sites, as well as manager of the area's National Parks.

Lake Naivasha Fishermen's Co-operative Society. This society represents the small-scale commercial fishermen on the lake, working in conjunction with the Fisheries Department (also see fishery discussion in Section 4.2).

The Government of Kenya and Local Administration. The Government, via several ministries and local authorities, has a legal and constitutional stake, as well as legitimate interest, in Lake Naivasha. The Fisheries Department is responsible for managing the fish stock, with the Ministry of Water Development & Management responsible for water management issues. Local Authorities at the District and

Divisional level include the Naivasha Municipal Council, Nakuru District Development Committee and District Environmental Committee.

Power Generating Companies. KenGen is a parastatal power company with operations just south of the Lake. OR Power is a new private power provider. Lake water also is used to recharge the geothermal field.

IUCN (World Conservation Union). The IUCN is a member of LNMIC, but has no further activities in the area.

Lake Naivasha Management Implementation Committee (LNMIC). The Lake Naivasha Management Implementation Committee (LNMIC) has the mandate to implement lake management efforts for KWS, but presently has no official status nor legal power, although the process of gazettelement under the Environmental Management & Coordination Act (EMCA) is well advanced. The membership comprises nominated representatives of various organizations and LNMIC subcommittees. The LNMIC has no formal budget.

Although the LNMIC has no direct jurisdiction, it can influence policy decisions and measures to a certain extent through its members. The full members include:

- Lake Naivasha Riparian Association (LNRA);
- Kenya Wildlife Service (KWS);
- World Conservation Union (IUCN);
- Ministry of Water Development and Management (MoWD&M);
- Ministry of Environment, Natural Resources and Wildlife;
- Ministry of Livestock and Fisheries Development, Fisheries Department;
- District Commissioner, Nakuru;
- Naivasha Municipal Council;
- Kenya Power Generating Company (KenGen);
- Ministry of Lands and Settlement;
- Ministry of Agriculture and Rural Development; and,
- Lake Naivasha Fishermen's Co-operative Society.

Co-opted members of LNMIC include:

- Water Bailiff; and,
- The Chairmen of the sub-committees for Tourism, Eburru Forest, Livestock, Biodiversity Monitoring, and Water.

In addition to the above-noted stakeholders represented in the LNMIC, other members include:

- The large farms—Most large farms are members of both LNRA and LNGG. As seen above, the interests of the two organizations are not always compatible. Moreover, some 5 large companies around the lake employ thousands of people, exporting products worth millions of dollars; as such, they can be seen to constitute a stakeholder group on their own. As previously noted,

several large farms also provide recreational, sports, medical and educational facilities (schools, hospitals) to their workers and families. The large farms also play an important role in facilitating the introduction of water- and environmentally-friendly technologies;

- The labor force employed by the large farms (and trade unions which represent some of them)—With about 25,000 employees, this is the largest stakeholder in terms of numbers of people. However, it proportionally has the least effective influence. No trade union, for example, is present in the LNMIC. The working conditions (salaries, exposure to pesticides, working conditions, etc.), however, are regularly discussed in the Kenyan press;
- Indigenous Biodiversity and Environmental Conservation—A rather vague group, mainly concerned with access to the lake;
- Upper catchment population—This group is highly significant, given that it is indirectly responsible for maintaining the inflow into the rivers, lake, and aquifers. The soil, woodland, and land management activities undertaken by the upper catchment dwellers will eventually affect the system hydrology. They utilise water for domestic water supply, livestock and farming, with sediments and agrochemicals from the upper basin ending up in the lake. This stakeholder group also is not represented in the LNMIC, except by GoK ministries and Local Authorities;
- Wood loggers—Legal and illegal logging activities affect the drainage basin's hydrological regime, increasing erosion. Even though many activities are illegal, many people nevertheless depend on forest products for their livelihoods;
- The (Maasai) pastoralists—Living south and west of the lake, the Maasai use the lake as a water point, especially during drought periods. This group also is not directly represented, and feels it does not benefit much from the area's developments. It also feels that its health and environment are affected by gases escaping from the geothermal power plants;
- Knowledge Institutes—Several universities and institutions (e.g., Egerton University, Moi University, Nairobi University, Kenya Marine and Fisheries Research Institute, Leicester University/Earthwatch, and ITC) regularly carry out research in the lake basin;
- Social & Environmental Certification Organizations—An example is MPS;
- Kenya Flower Council (KFC)—Advising their members on farm management, labor standards, and environmental policies, the Kenya Flower Council (KFC) has established a “silver standard”, covering workers' pay, conditions, and health, safety (to reach ILO conventions) and some environmental conditions, whereby their “gold standard” demands higher levels of environmental performance. The Fresh Produce Exporters Association of Kenya (FPEAK), focusing on vegetables and flowers, utilises weaker guidelines;

- International customers for flowers and vegetables (especially in Europe)—Increasingly purchasing not just eco-products (e.g., organically-grown vegetables), these customers also are concerned with “Fair Trade” issues, such as wage rates, working conditions (especially for women), child labor, health and safety for workers regarding pesticides, housing and social standards, etc;
- Media inside and outside of Kenya—This group especially includes environmental journalists;
- Agro-companies—Mainly companies concerned with such agricultural needs as seeds, agro-chemicals, etc;
- Tourist Industry—Although not a major stakeholder in the area, there are two small National Parks in the vicinity of the lake and the Aberdare National Park on the eastern watershed, and a number of hotels, home-stays and campsites; and,
- Internationally influential environmental and civil society organizations—These include the World Wildlife Fund (WWF) and the above-noted World Conservation Union (IUCN).

An important consideration, not always openly aired, is the cultural and ethnic differences between stakeholders. A large proportion of the commercial farms is operated and owned by Europeans. The white people can be further divided into descendants of originally-colonial landowners, and more recent entrepreneurs attracted by the area's business opportunities. The large dairy enterprises and meat farms, for example, are run by old UK-Kenya aristocracy and Italians. By the end of the 19th century (the start of British colonial times), the pastoral Maasai populated the area. However, the major proportion of the population in the area is Kikuyu. The fishermen are Luo people migrated from Lake Victoria.

4.1.2 Conflicts

A summary of the most important conflicts is presented below, with a differentiation between technical conflicts (facts based) and institutional/social conflicts (conflicts of interest and relational issues).

Technical conflicts. These conflicts are related mainly to disputes over the interrelations between natural resources, the allocation of these resources, and the humans exploiting them. Many factual disagreements in the past have been resolved by research findings, and the issues below can be seen as priorities for further research and analyses.

Factual disagreements include the following:

- Disputes about the effects of water abstractions on lake levels, and how much water can be safely abstracted;
- The size of the irrigated area, and the total water abstraction occurring thereof;
- Lake pollution by agro-chemicals (claimed by some environmental groups);
- Disagreements on the contribution of pollutants from the upper catchment versus the large farms;

- Extent of upper catchment water abstractions (thought to be considerable by some lake water users);
- Reduced lake levels caused by abstractions that decrease the catch, agro-chemicals reducing the catch, and fish (fry) being pumped out of the lake during water abstraction (claimed by fishermen);
- Lack of definition of sustainable water exploitation by the involved parties;
- Growers using groundwater claiming they are not over-exploiting the lake's water resources;
- Uncertainties regarding who has legal abstraction permits and who does not (it is speculated that many users abstract more than allowed by their permits);
- The riparian land delimited by the riparian boundary is government property, under the custody of riparian landowners. No permanent structures are allowed inside the boundary, although there is some dispute as to what constitutes permanent structures. The boundary is defined by the 6,210 ft asl (1,892.8 m asl) lake level contour, although some doubt exactly where this boundary is located;
- Disputes over the relationship between the lake levels and their dynamics;
- Disputes over the ecological functioning of the lake and its surroundings; and,
- The effects of geothermal plants on the environment (including lake levels, water quality and effect of emitted gases on the environment and people).

Institutional and social conflicts. These conflicts are of a legal, administrative, financial, social, or institutional order such as relational issues including:

- Water users blame the Forest Department and (illegal) wood loggers for mismanaging the forest reserves, thereby diminishing water yields and increasing erosion, and causing accelerated filling of the lake;
- Existing game and cattle corridors have been closed by agricultural land, and access to the lake generally has been closed;
- The labor force claims it is exploited and underpaid;
- Whether or not the LNRA Management Plan really considers the interests of all stakeholders, or is it more the product of a group of environmentally-sensitized white people (Wazungu)?
- Conflicts between the media and stakeholders, with the news on Lake Naivasha being more often negative than positive; and,
- Some farms do not respect the official riparian zone.

Conflict of interest. There also are conflicts between different socio-economic groups pursuing different goals, including:

- A major conflict exists between environmental groups who want to protect the lake and its catchment from over-exploitation, and commercial growers intending to maximize their output;

- Nakuru Town wants more water for its urban water supply, which could critically damage the lake;
- The tourist industry desires a natural landscape setting;
- The Maasai tribesmen claim historical traditional rights to the area, including access to the lake to water their cows;
- The large cattle farms claim that they have used the local natural resources in an environmentally-friendly manner, producing meat and milk for millions of Kenyans, instead of destroying the environment like it is claimed the flower growers have done;
- Fishermen consider the large-scale horticultural industry, using agro-chemicals, as a threat to their livelihoods;
- Whether or not the ordinary Kenyan or the Kenyan state generally benefits from this economic boom, or is it only a happy privileged few in the area; and,
- If water is priced, would the government or local stakeholders, or both benefit from the revenues?

4.1.3 Programs and Processes

There has never been a government project or program directly addressing the management of the lake. The LNRA and the GoK have received small grants from various organizations for this purpose, but the investments in the lake management are limited at the present time.

The responsible government organizations lack funds, means, and sometimes the interest, to seriously address the lake's problems. Until very recently, in fact, water and environmental law was basically a copy of that established during colonial days, and was unable to cope with modern land and water management issues.

Although a water abstraction permit has always been required, many users are either abstracting without a permit, or above limits set by the permit. Two new laws have recently been passed by Parliament, however, include the Environmental Management and Co-ordination Act (1999) and the Water Act (2002). The National Environmental Management Authority (NEMA) and the Water Management Authority (WMA) have the mandate to implement and enforce the new laws.

It was the combination of the many above-noted problems, and lack of Government intervention (thereby creating a management vacuum), combined with the visionary and strong leadership of LNRA, that allowed it to emerge as a strong stakeholder organization addressing the lake's many pressing issues. This 15-year process saw the evolution, from a small group of LNRA members concerned with the future of the lake, through a process of drafting the long-term vision, lobbying, networking, solving disagreements among stakeholders, consensus-building, awareness-raising, and reconciliation, to the present form of lake management.

The milestones in this process included:

- A report on the scientific knowledge and outline of “the way ahead” (1993);
- Preparation and official adoption of the Management Plan (1995) and, consequently, installation of the LNMIC;
- Reconciliation between the LNRA and LNGG (around 1999);
- Co-hosting a scientific conference on shallow tropical lakes (1999);
- Declaration of the Lake Naivasha as a Ramsar site (1995); and,
- Temporary ban on fishing, indicating that policies can be enforced (2002).

The cornerstones of the lake’s present management are the Management Plan and the implementing and executing organization, the LNMIC.

Lake Naivasha Management Plan. The Management Plan was written by a Steering Committee consisting of LNRA members, and representatives of the Government and NGOs. It is a dynamic document, already updated twice (carried out by the LNMIC) since its inception, as knowledge of the lake increases and the circumstances and laws change.

The primary objective of the Management Plan is to manage existing human activities in the lake ecosystem through voluntarily-adopted, sustainable, wise-use principles to ensure the conservation of this freshwater resource and its associated biodiversity. Secondary objectives include:

- Promoting and encouraging the major contribution made to the national economy by the lake;
- Maintaining, conserving and, where necessary, restoring the lake’s natural beauty and biodiversity;
- Achieving consensus via an understanding of, and support for, the Management Plan through voluntarily-adopted codes of practice and dialogue;
- Facilitating public access, tourism and research activities, while also respecting private ownership of the surrounding land; and,
- Immediately adopting practices on which there is consensus, based on current knowledge; and adopting other practices as the Plan is updated in the light of new information from the monitoring program.

The Sectoral Codes of Conduct (CoCs) incorporated in the Management Plan include LNGG, Power Producers (KenGen), Lake Naivasha Tourist Group, Fisheries Industry, Livestock and Dairy Industry, Wildlife, and Naivasha Municipal Council.

The Present Management Process. The LNMIC, responsible for implementing the Management Plan, meets every six weeks on average, and agreed action points are delegated to individual members. The direct contact for day-to-day business, visitors, enquiries, etc, is the active Honorary Secretary, while the Chairman handles higher-level contacts.

Because the LNMIC has no executive power, it can only exert its decisions through its members. The LNMIC can put pressure on the members representing the Government to enforce laws, or to take action, but the final authority remains with the various government institutions. It can also motivate members to adopt certain practices, although measurable targets are not yet part of the process.

The officers of the key Government Departments (e.g., Fisheries, Forest, Water) are supported to execute their duties. Subcommittees address the problems in special sectors, such as Biodiversity, Water, and Horticulture (LNGG). Technical information is provided by the subcommittees, Ministries, LNGG, researchers or individual specialists. The LNRA, with the support of LNGG, facilitates the LNMIC with a Geographic Information System (GIS) with provision of a detailed photographic coverage of the Ramsar site, riparian boundary, and cadastral map linked to a database containing details of the landowners.

The LNGG sub-commissioned a Hydrological Status Report, which provides a fairly-complete overview of water related issues, data availability, and advice on water resource management issues and policies (Rural Focus 2002). A user-friendly version of the Water Balance Model of the lake was developed by ITC and is now in local ownership. A regular newsletter also provides news, etc., to interested parties.

4.2 Reduction of Lake Stresses

The reduction of lake stresses is taken very seriously, being one of the key duties of the LNMIC. Much credit goes to LNGG and to some of the large farms. LNGG members consider that it is very important that the profit level of the well-managed farms is sufficient to make social and environmental investments.

Farms also are implementing or experimenting with new technologies and management practices, including:

- Hydroponics—closed circulation systems, using the locally available pumice as substratum;
- Use of coco-peat and compost to improve soil characteristics;
- Biological pest control and biodegradable pesticides;
- Artificial wetlands for natural wastewater treatment;
- Storage of roof runoff from greenhouses;
- Sophisticated irrigation systems, with soil tension meters and the latest irrigation technology;
- Use of geothermal steam to heat greenhouses during the night, to enhance plant growth using CO₂ and H₂S, and for sterilizing crops and the growth medium without the need for fumigation;
- Monitoring water abstractions;
- A shift from open-field crops to shaded growth or greenhouses, thus reducing water evaporation losses;
- High temperature incineration of dangerous wastes;
- Plastic recycling;

- Multiple use of crops, including baby corn for export and the stems/leaves as fodder;
- Reducing the area under cultivation, while intensifying output per area; and,
- Providing hospitals, schools, housing, social clubs for the employees.

These large, innovative pioneer farms play an important role in illustrating the possibilities and advantages of these innovations to other farms. Technical innovation may serve an economic and environmental purpose. The extra capital investments needed for hydroponics are regained within a very short period via higher productivity, no fumigation and lower agrochemical inputs.

The LNMIC/LNRA and LNGG have also been engaged in the following stress-reducing activities:

- Preservation of the riparian (shoreline) strips;
- Promoting use of safe, degradable pesticides;
- Controlling water uptakes;
- Minimizing fertilizer use;
- Preventing the introduction of alien species;
- Proper urban planning and development;
- Promoting sustainable tourism;
- Monitoring of resource status and development activities;
- Forest conservation, erosion control, watershed management; and,
- Environmental Impact Assessment and environmental audits.

To reduce the sediment and agrochemical load to Lake Naivasha, the LNRA has been sensitizing the inhabitants of the upper catchment on good farming practices, although this activity have been very low-key, due to inadequate funding.

Salvinia has existed in the lake since 1962; it became a major ecological problem by the early-1970s, covering a large portion of the lake. After chemical control failed, a biological control agent (*Cyrtobagus salviniae*, a host-specific insect), was introduced to the lake and, by the early-1990s, had effectively reduced the Salvinia cover to insignificant levels. Although water hyacinth was noted on the lake in 1988, the lake conditions are not conducive to its rapid spread. Two host-specific biological control agents (*Neochetina bruchii*, *N. eichhornia*) have been effective in containing the weed.

The Naivasha Municipal Council is in the process (with German and Japanese assistance) of reducing the nutrient load to the lake by upgrading the sewage network and plant.

KenGen is injecting condensed steam back into the geothermal reservoir. These authors reject the (persistent) idea that the geothermal exploitation has any effect on the lake levels.

The Ministry of Water Development & Management (a) has carried out a detailed water abstraction point survey; (b) has

stationed an hydrologist and a Water Bailiff in Naivasha to monitor resources and demand; (c) is training a water police force to prosecute illegal water abstractors; (d) is actively supporting hydrologic and environmental research; and (e) has upgraded the monitoring network.

The issues related to overfishing, and the consequent regulation, has received much attention in the national press and on the Internet. This issue provides an example that can be assessed in more detail to show how management of Lake Naivasha works in practice. As shown in Figure 6, the fish catch has been very low over the last couple of years. There is much speculation over the high variation and overall decline of the commercial catch. Many issues have been mentioned in the resulting disputes, including variations in lake levels, declining levels of riparian vegetation (papyrus and other macrophytes and floating vegetation), pollution (pesticides and fertilizers), sediments changing the water transparency, fish fry being pumped out by water intakes, an incomplete foodweb, overfishing and the use of excessively-small gill-nets, and no recovery time during spawning. Theoretically, the fish catch from the lake could be much higher, with various studies on the theoretical fish yield suggesting mean yields between 300-1,200 tons/year (Hickley et al. 2002).

The two main fish-related conflicts involve:

- Fishermen versus the flower farms—The fish catch is believed to be declining because irrigation lowers the lake levels, and the farms pump out the fry and pollute the lake; and,
- The environmentalist/LNRA versus the fishermen—Fish stocks are declining due to overfishing, poaching, undersized gill-nets, and no recovery periods, as well as no control/management of the quantity of fish caught.

The main stakeholders in the fish sector are the legal (and illegal) fisherman, the Lake Naivasha Fishermen's Co-operative Society, Kenya Marine & Fisheries Research Institute (KMFRI, with a research station in Naivasha), the Fisheries Department, and LNRA.

The LNRA has considered the declining fish catch as a sign of environmental degradation, teaming up with KMFRI and the Fisheries Department to reverse the trend. Since the catch has become very low, the fishermen had little to lose, and the licensed fishermen would certainly benefit from better management and law-enforcement.

These conditions were ripe for implementation of a fishing ban and during the year before an actual ban was imposed, the Fisheries Department held regular meetings with the legal fishermen, Kenya Marine & Fisheries Research Institute (KMFRI), LNRA, fishmongers, a representative of the illegal fishers, and the local authorities, and all aspects of the fishing activities in the lake were discussed. The fishermen were concerned that they were not catching sufficient fish to survive, and wanted the official net size to be reduced (even

though they admitted they were already using reduced net sizes and still not catching sufficient fish). KMFRI carried out research which confirmed the lake was being overfished, and that if something was not done to address this issue, the fishing industry would collapse. The original rules laid down for commercial fishing on the lake were based on research, and concluded that only 30 boats should be permitted to fish the lake, and that the net size should be 4 inches and greater. The number of boats, however, had increased to 130 over the years, and, as noted above, the net size used had (illegally) been reduced to 2 inches or less (some illegal fishermen were even using shade netting).

After lengthy discussions, the fishermen concluded that their only chance of sustaining their livelihood on the lake was to cease fishing for some time, and so agreed the lake should be closed to fishing initially for six months. However, when it was clear that the fish stock had not recovered sufficiently during this initial period, another six months was added to the ban. The fishermen accompanied and assisted the researchers, thereby seeing for themselves how the fish stock was recovering during the ban period.

Because the Fisheries Department does not have sufficient facilities to effectively patrol the whole lake, some of the fishermen offered to help police the lake during the ban period. There was also an initiative amongst the local landowners, whereby they funded and facilitated a group of 15 fishermen (called the Task Force) to help police the lake. This was reasonably effective in that, although the illegal fishers were still quite active during this period, their activities were considerably reduced.

The LNRA established a “liason office” to find jobs for fishermen on the flower farms. The LNRA also provided a sum of money to pay for the education of fishermen’s children so that they would not suffer during the ban period. Not all of the fishers took advantage of these initiatives, however, with many moving back to Lake Victoria from whence they had originally come. Just before the ban was lifted, the LNRA funded and organized a workshop with the fishermen to ensure they were fully aware of the rules.

When the ban was lifted it was decided, again in a public meeting, that the number of fishing boats on the lake had to be reduced, agreeing to a total of 43 boats. Although it was a difficult task deciding who should have a license, it was ultimately determined on the basis of how a fisherman had behaved in the past; if he had stuck to the rules, he got a license. The fishers also were warned that if they were caught flouting the rules, they would be permanently banned from fishing the lake. Several fishermen subsequently were caught using small net sizes and were banned; their place has been taken by other fishermen on the “waiting” list.

The practice of illegal fishing, using “seining” with very small mesh nets, has not ceased, and is still damaging fish breeding activities, particularly since it takes place in the shallows,

which constitute the fish breeding areas. This has affected the recovery of the fish stock and so, again after consultation with the fishermen, it was decided there should be an annual closed season of four months, to give the fish a chance to breed undisturbed. While the idea is good, it will not have the desired effect if the illegal fishing cannot be stopped. Although the fishermen have again been involved in trying to stop these illegal activities, the illegal fishers have now armed themselves, with a few nasty incidents occurring. The fishermen have lobbied politicians and the media very well, however, and many articles have addressed conflicts in which the poor fishermen were the victims of the powerful flower farms.

This is again an example whereby the availability of capital helped resolve the conflict: the LNRA has assisted the Fisheries Department to execute its duty (i.e., enforce the law), KMFRI has been supported to monitor the stock, and fishermen have been given alternative employment and school-fee grants. The long-term fish yield of the lake will certainly increase, which is beneficial for the fish-sector as a whole.

4.3 Environmental Status

Overall, Lake Naivasha is still in a relatively healthy state, and the water quality parameters are in acceptable condition. The spatial and temporal dynamics of the water quality parameters, and the unknown details of historic data, however, make the detection of trends difficult.

The main stresses on the lake are summarized as:

- Water abstraction;
- Agrochemical and sewage pollution;
- Destruction of riparian habitat (papyrus);
- Over-fishing; and,
- Erosion/siltation.

In regard to water abstractions, and pollution of the lake, there is an ongoing discussion of the relative contribution of the floricultural industry versus the other water users in the basin (see Section 3.1).

The recent introduction of sophisticated irrigation systems and better irrigation management has definitely led to a reduced water use. This is partly offset, however, by an increase of the area under irrigation for flowers and horticulture. The basin-wide water abstractions have caused a reduction of the mean lake level by approximately 2.5 m.

Due to the physical conditions surrounding Lake Naivasha, the risk of agrochemicals ending up in the lake is limited. The change to environmentally-friendlier pest control, and better irrigation management, has definitely had a positive effect on the lake’s water quality. However, the agrochemical contribution of the hinterlands to the lake is higher than the contribution of the farms around the lake. To reduce the sediment and pollution loads from the upper catchment, much work is

necessary in educating farmers in watershed conservation techniques and IPM (integrated pest management), although very little work has been carried out so far.

The improper use of riparian land is being reduced. Transgressors of the riparian boundary have been summoned to stop their activities. In one part of the lake, papyrus burning remains a problem. Overfishing has recently become a major concern. However, a fishing ban has already been issued twice in the last 2 years and, therefore, the fish stock is likely to recover.

The siltation of the lake is resulting from 3 sources, including sediment inflow through the main rivers, flash floods in the semi-arid area around the lake, and atmospheric deposition. In some areas south of the lake, wind erosion also is a serious problem, due to overgrazing and improper land management, with part of the wind-blown material being deposited in the lake. Thus far, however, there is no evidence the lake is seriously threatened by siltation.

4.4 Enabling Environment

4.4.1 *The LNMIC and LNRA*

The lake management institution (LNMIC) is operational, the result of a 10-year process of lobbying, networking, awareness and consensus building, as well as much energy of a few individuals working hard without the assistance of an “financed project”. The institution is likely to be sustainable, given that it is strongly linked to an organization (LNRA) founded more than 70 years ago. However, the financial situation of both the LNRA and LNMIC is poor, given that no structural support exists, and the membership fees of the 140 members are not sufficient to carry out the organization’s ambitions. The LNMIC is only weakly supported by a team of professionals who advise on developments and environmental threats by collecting and analyzing data. As a result, management of the lake is rather ad-hoc and not based on in-depth analysis of the system.

The main stakeholders seem to be firmly embedded in both the LNRA and LNMIC. Among the average Kenyan (Wananchi), however, the organization still has still the image of a “white”, elite club of conservationists and big businesses. The inclusion of the main non-represented stakeholders (e.g., Maasai pastoralists, upper-catchment population, workers and employees of the farms) would be necessary to introduce these stakeholder needs and concerns, thereby changing this image. The WWF will most likely soon begin a project in the upper-catchment and, through the project, ensure that portion of the population may get a voice in the process. The project will focus on both Lakes Naivasha and Nakuru. The following Naivasha-related activities are foreseen in the draft proposal:

- Water-awareness campaign;
- Halting illegal logging in the Aberdare Range and Mau Escarpment;
- Economic development and improved land-use on the Mau Escarpment and Aberdare Range;

- Rehabilitation and extension of the Nakuru and Naivasha water supply systems (this module could be split to cover Nakuru and Naivasha separately);
- Rehabilitation and enlargement of the sewerage system at Nakuru Municipality, Naivasha Town and their environs;
- Improving the solid waste disposal system in the Nakuru Municipality, Naivasha Town and their environs;
- Collection, treatment and disposal of industrial and agricultural chemicals, effluents and solid waste in Nakuru and Naivasha; and,
- Controlling and improving sand mining along tributaries of Lakes Nakuru and Naivasha.

Better relations with the press also could help change perceptions. It is noteworthy that stories always address the same issues in a negative way; namely, the floricultural industry emptying and poisoning the lake, causing low fish stocks and underpaying their labor force. Another negative image of LNMIC is that the meetings are not public and the records are confidential. The LNRA Newsletter only vaguely covers the real management problems faced by the committee, usually addressing less-important issues (e.g., a new bird species has been seen; the arrival of a new staff member in one of the Institutes). A positive activity would be to more effectively communicate the management process, their goals, success stories and failures to the general public.

4.4.2 *The Management Plan*

The main weakness of the Management Plan, and also the new Water Act, is that they do not quantify sustainability, nor define sustainable abstractions. The Management Plan does stress the importance of an accurate water balance, and the water balance model is sufficiently accurate for management purposes. However, it cannot provide an accurate answer to determining the sustainable abstraction of the lake. There is no doubt that every abstraction from the basin will result in a lowering of the mean water level in the lake. How much drawdown is socially, economically and ecologically acceptable, however, is an economic and political, rather than hydrological, question.

4.4.3 *Policy Context and Monitoring*

The new Government of Kenya, in office since the beginning of 2003, appears to be taking water issues seriously. The new laws on water and environment provide a good framework for Integrated Water Resources Management (IWRM). The two new institutions, the National Environmental Management Authority (NEMA) and the soon-to-be Water Management Authorities (WMAs) should have close links to the LNMIC, something that is not yet the case. For many years, the LNMIC has asked to be gazetted as a member of the Water Apportionment Board, but so far without success.

Once the WMA is in place, it is likely that water users in the Lake Naivasha will pay for their abstractions. These funds could lift the lake’s management efforts to a higher level. Because of cooperation between the government, LNRA/LNMG

and research institutes, the lake is reasonably well monitored; and the monitoring situation is certainly much better than in other parts of Kenya. The monitoring system, however, is not systematic and structural, and improvements are necessary. The technical aspects of water resource management are a costly affair. Collection of water data currently is carried out by MoWD&M, universities and research institutes. The formal Government policy regarding data is that the user pays. Notwithstanding that data collection is expensive, selling it at too high a price will result in the data not being used at all. The official price of the hydro-meteorological data set is about \$50,000, resulting in the data not being optimally used.

4.4.4 Research and Data for the Lake Basin

The quantity of data and research on Lake Naivasha and its drainage basin is rather overwhelming. Lake levels have been regularly monitored since 1909, and a few older observations also exist. The rainfall for Naivasha Town is available since the beginning of the 20th century. The area is well covered with rainfall stations (35 of the total 65 stations are operational). Other climatic variables (pan evaporation, radiation, wind speed, temperature, etc.) also are available.

The discharge records of the Malewa River (main inflow) begin at 1932. Several upper basin discharge stations also monitor flows. Hundreds of rain, surface, lake and groundwater samples have been taken and analyzed for chemical, biochemical, suspended sediments and isotopic composition. The oldest lake water analyses date back to 1923. The bathymetry of the lake was measured in 1923, 1958, 1983, 1991, 1997 and 2001. An aerial survey was carried out for the first time in 1948, and several times thereafter. A series of satellite images, beginning in 1976, illustrates the land cover changes and land use developments in the drainage basin. The geology has been mapped out in detail for the geothermal projects, and some 80 deep wells (>1,000 m) have been drilled in the geothermal areas. Many wells around the lake have been drilled, providing information on the shallow hydrogeological conditions and groundwater quality. Detailed inventories exist on water abstraction points and water consumption, and researchers have collected data on vegetation cover, biodiversity, aquatic ecology and fish stocks.

Early research was carried out primarily by the colonial administration. From the 1960s on, however, the lake has attracted a steady stream of researchers, producing hundreds of articles, Master and PhD theses, reports and posters.

MoWD&M, KWS, KMFRI, KenGen, LNRA, and Kenyan and foreign universities are actively involved in research on the lake, and there is generally a good spirit of cooperation and data sharing among these organizations. Research is being sponsored mainly by Earthwatch, Shell, Kenyan Ministries and Institutes, and local farms.

The total research investment over the last 10 years must be on the order of \$400,000, with part of this budget being used for monitoring that should have been carried out by the

responsible Government institutions. The research has been disseminated using various media, and theses are distributed among main stakeholders, via articles in scientific and popular magazines, and lectures at workshops and in local stakeholder communities. The research community has resolved a number of key conflicts and misconceptions, the most notable being the water balance, the effects of irrigation on lake water levels, the quantities of water being used by whom, the main polluters, and the environmental status (health) of the lake.

The effective use of research in the management of Lake Naivasha, however, is hampered by two factors. As previously noted, the professional staff supporting the LNMIC in the management process is missing. Further, most of the LNMIC members do not have the time and background to fully appreciate the relevant scientific work or to use the results in management decisions.

Universities often have different agendas than lake managers. For a university, the research topic must be scientifically interesting, whereas the relevance of this criterion for lake management is a secondary concern. In order to maintain needed financial support, trade-offs often must be made, and applied research seems to be more relevant for lake management than fundamental research. Nevertheless, research carried out by universities turns out to be very cost-effective, compared to projects in which research is carried out within the project itself.

One of the applied research questions of tremendous significance that has not yet been solved is the lake's discharge mechanisms. If the seepage takes place in a concentrated outflow zone, this water may be exploited. It may be concluded that LNRA's policy of stimulating research around the lake has had important impact on resolving lake problems. Some aspects of the systems behavior are obviously too complex to easily translate in laymen's terms. However, many other results have assisted in resolving factual disagreements, the best example being the effects of irrigation on lake water levels. Whereas this constituted an emotional discussion in 1997, it is no longer an issue. The effects are now known and accepted by all stakeholders (see Section 3.1).

5. Lessons Learned and Recommended Initiatives

One does not necessarily need a project to introduce the need for effective lake management. A few committed individuals may initiate the process and keep it going. Moreover, a management vacuum amongst the different officially-responsible authorities has created the opportunities for local (management) initiatives in the case of Lake Naivasha.

The presence of a healthy economy in a regional context seems to have influenced the protection of the lake in a positive way. The financial capital needed to introduce environmentally-friendly water conservation measures is available. Due to the large capital investments in horticulture, which are tied to the

Kenyan economy, the private commercial sector has developed a strong interest in sustainability. Technically-innovative production techniques and systems are both economically and environmentally interesting.

The two main lake stresses of water abstraction and agrochemical pollutant loads are associated with two different stakeholder groups. The irrigation water abstractions are attributed almost exclusively to the floricultural industry, whereas the nutrient load (and likely also the pesticide load) to the lake is attributed to the upper catchment population practicing rain-fed agriculture. The Ramsar status/designation also has helped enhance awareness on the need to conserve natural resources.

In many other project-supported lake management programs, large sums of money have been spent on data collection and analysis. This activity can be carried out more cost-effectively if lake managers team up with Ministries and knowledge institutes. However, the dissemination of scientific information, and the use of such information in lake management, remains problematic.

Although research can help solve many technical issues concerned with data interpretation, as well as some of the institutional conflicts, the underlying conflicts of interest may still remain. Thus, community participation is a vital element, particularly for a lake like Naivasha, where most impacts emanate directly from competition over the use of resources, and human settlements. In general, there is need to entrench the policy on community involvement into resource management.

Consensus building is essential in such community-driven conservation programs, in order that all stakeholders can move in the same direction. At the same time, consensus building takes a long time, and often can significantly slow the management processes needed to deal with urgent problems. However, even if the need for community participation and consensus building is acknowledged, enforcement of the new national laws incorporating modern environmental and water management concepts is an absolute requirement.

Funding remains a major challenge for community groups interested in wetland/lake basin conservation. The fact that there are many wealthy enterprises around the lake that dependent on the sustainability of its resources may negatively affect the willingness of donor agencies to finance lake management projects.

Having an accepted and ratified Management Plan, and an Implementation Committee, is not sufficient to carry out complex lake management. For example, the LNMIC is composed of relatively senior representatives of various stakeholders spending only limited time on their Committee duties. The organizational layer below the Committee also is absent. There is no operational team of professionals in the fields of water resources management, natural resources

management, regional planning, and aquatic ecology working full time to collect and analyze data to support the management process, set priorities and measure results—this is an important omission.

Structural and strategic discussions on what is sustainability, how the water should be allocated between different farms and sectors, how to optimize economic output and at the same time conserve the environment, how upstream-downstream relations could involve the upper catchment population, or what do if a series of serious drought years occurs, are issues too complex and too political to be addressed by the LNMIC at present.

Some specific research-related lessons include:

- A willingness to cooperate, trust, and share data and resources is more important than signing MoUs and agreements;
- Pooling resources is cost-effective; and,
- Dissemination and communication of research results to the stakeholders and decision-makers is difficult, therefore ensuring that old myths concerning the lake system are persistent.

Recommended initiatives. In spite of the official nature of the Management Plan, it is still necessary to institutionalize the Plan and its Implementation Committee under the Environmental Management and Co-ordination Act (1999). This will enable the Implementation Committee decisions to carry more weight for improved management effectiveness and, if the principle of voluntarily-adopted practices fails, it will allow them to enforce their decisions through the established legal mechanisms. Thus, it is essential that the LNMIC becomes a full member of the Water Apportionment Board.

One of the priority activities should be the introduction of water charges, with the revenues being used for basin management, rather than as extra income for the government. The pricing mechanism should focus on lake management, including minimizing environmental damage, while also maximizing social and economic outputs and an equitable distribution of resources. Issuance of new abstraction permits should also consider the large differences in the economic returns of different irrigated crops. Tradable water rights may be considered as a future option. Introduction of water pricing, however, also encompasses a danger. Control over the revenues obtained from pricing may introduce power struggles between the many organizations claiming a stake in the lake management, thereby paralyzing the progress in integrated lake management towards its sustainability goals.

Ideally, the whole process of data collection, updating databases, analysis and interpretation, and the use of simulation models and GIS, should be transferred from research institutes to local ownership. A Lake Naivasha Management Centre, where officials of different government institutions and scientists work together and share equipment,

data and knowledge to the benefit of the LNMIC and the Rift Valley WMA, could be a new goal. The revenues of the water charges could be used to establish and maintain such a center, the establishment of which would mean a considerable capacity building and education investment. This lake basin, with its interesting conflicts and good data, constitutes an ideal training case for lake and IWRM management. Research on the lake and its drainage basin should become more embedded in the curricula of local universities, and research by local and foreign institutes should become an integral and financed part of lake management efforts.

Over the last 30 years the Government, and Kenyan and foreign researchers have collected a tremendous quantity of data, a large part being available at the LNRA's Documentation Centre. However, given the variety of topics and the large quantity of material, it is impossible to overview or appreciate its full content. The LNMIC could be assisted in this task if a Scientific Committee was attached to LNMIC to advise on relevant policy matters. This committee could be composed of researchers seriously studying the lake, as well as a few experts in lake and wetlands management and/or IWRM.

The lake managers should start the process of land planning. A land zoning with designated land uses (agriculture, rangeland, settlement, conservation) could be agreed upon and enforced, via the issuing of water permits.

6. Summary

A unique set of conditions is found around Lake Naivasha, including:

- A highly-profitable and booming horti- and floricultural industry that depend on a protected lake/wetlands;
- A well-established and strong stakeholder organization, an accepted Management Plan and an Implementation Committee;
- An abundance of scientific research on various aspects of the ecosystem and the socio-economy;
- A generally environmentally-conscious stakeholder community and enterprises that do not want to put their future at stake by overexploiting the lake and its resources;
- A positive change in attitude by the government regarding management of natural resources;
- The large farms not being opposed to water charges, as long the process is transparent and at least part of the revenues are re-invested in the lake basin;
- Cooperation between LNRA/LNMIC, LNGG, Government institutions and research institutes;
- The lake as a Ramsar site; and,
- Management of the lake and its basin receiving much national and international interest.

All the necessary conditions are in place for Lake Naivasha to become one of the first basins in Africa with a lake managed for its sustainable use, in accordance with World Lake Vision

(World Lake Vision Committee 2003) and IWRM principles. The present actors in the management process deserve support in attempting to hurdle the last institutional, technical and financial barriers to achieving this goal.

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