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IS-108 Reykjavík, Iceland

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APPRAISAL DRILLING OF GEOTHERMAL WELLS IN OLKARIA DOMES (IV), KENYA – BASELINE STUDIES AND SOCIOECONOMIC IMPACTS

Pacifica F.A. Ogola
Kenya Electricity Generating Company Ltd. - KenGen
Technical Assurance Division
P. O. Box 47936, Nairobi
KENYA
pochieng@kengen.co.ke.

ABSTRACT

Socioeconomic impact assessment has become a critical component of project implementation and feasibility. The socioeconomic studies of Olkaria Domes appraisal drilling in Kenya is aimed at supplementing technical and other environmental studies that have been done in the project area. This report is based on findings and analyses from field study and is limited to the socioeconomic aspects of the project impacts. Subsequently, the following topics are discussed: project description, baseline condition of the study area, stakeholder analysis, socioeconomic impacts of the new projects, anticipated environmental risks and a monitoring plan. It is apparent that there is rapid expansion of agriculture and population growth in the area, not matched by adequate infrastructure and proper natural resource utilization. The drilling project, which will only take one year, is not expected to significantly alter the current socioeconomic setup. Impacts caused during drilling will be minimal and short term. A full and detailed EIA will be undertaken upon completion of production drilling and before implementation of the power plant.

1. INTRODUCTION

The social and economic impact assessment plays an important role in project development of many countries. For several decades, this role has not been integrated in project planning and as a result, most receiving communities have not seen tangible benefits from the project around them. The project is located in Kenya, one of the geothermal fields (Figure 1) within the rift valley in Naivasha division of Nakuru district. In the wake of the new Environmental Management and Coordination Act 2000, and other international legislations, the importance of socioeconomic studies before project implementation has been emphasised. It is out of this realization that the implementing agency (Kenya Electricity Generating Co. Ltd) decided to undertake a full socioeconomic study of the area to compliment other studies and to comply with the new regulations.

Several investigations on reservoir engineering, geophysical, geological, geochemical surveys and aspects of environmental considerations have been done in detail for the entire Olkaria geothermal

field and Olkaria Domes. Despite this, a full socioeconomic impact study of the area had not been undertaken to complement the technical studies. These studies were only limited to the immediate surroundings of the project and especially the Hells Gate National Park. The main aim of this study therefore was to collect baseline information of the study area, assess the current socioeconomic status and evaluate possible impacts of the appraisal drilling and testing of Olkaria (IV) Domes geothermal projects.

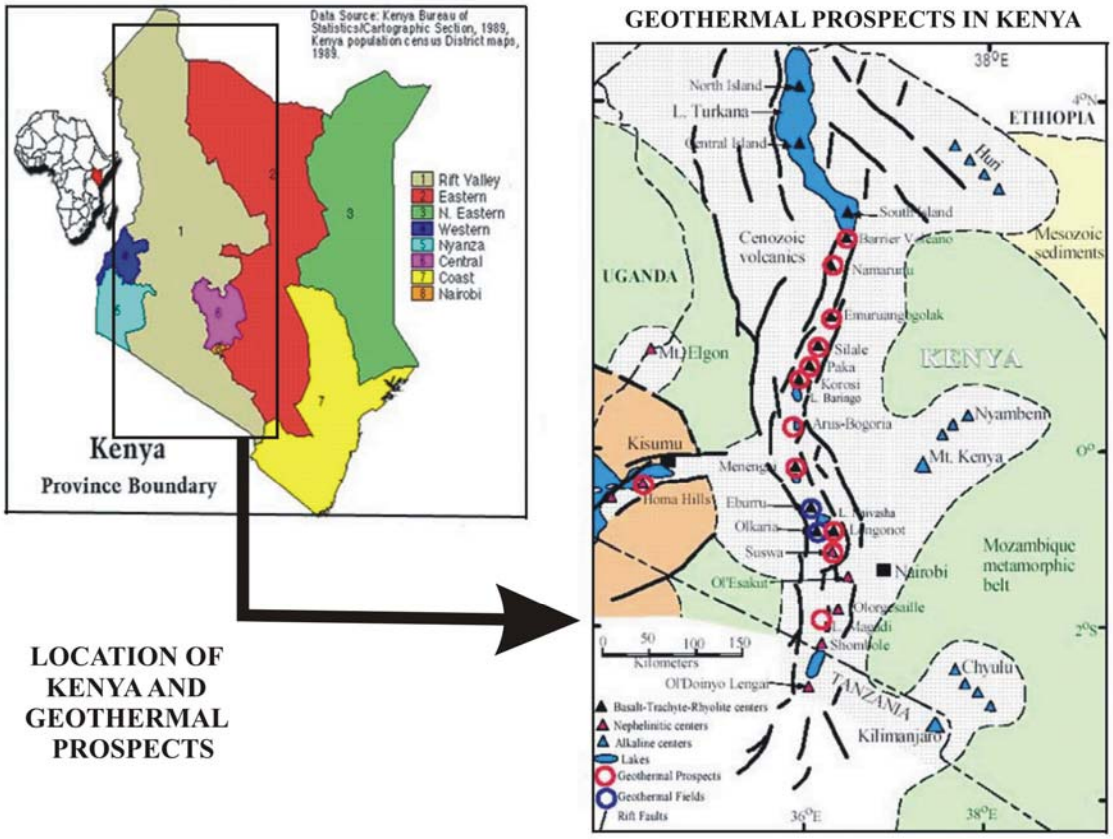

FIGURE 1: Map of Kenya and location of geothermal resources

1.1 Legal and institutional framework

In early 2000, Kenya enacted a new Environmental Management and Coordination Act (EMCA) as an overall legal instrument for managing environmental issues. Previous legislation with sectoral policies scattered in 77 different resource specific laws often led to regulatory competition. Under the Act, institutions like the National Environment Council (NEC), National Environment Management Authority provincial and district environment committees, and the Public Complaints Committee have been formulated. Within each of these administrative structures, provision is made for public participation.

The National Environment Management Authority (NEMA) is the principal government institution responsible for implementing all regulations relating to the environment, including overseeing the Environmental Impact Assessment. A new Environmental Impact Assessment (EIA) regulation and draft guidelines have been released in which the project proponent is expected to undertake EIA at his own expense and submit a draft report to NEMA. Environmental guidelines on mining and energy sectors provided by national environmental regulations for Kenya were also used in scoping the terms of reference for the proposed project.

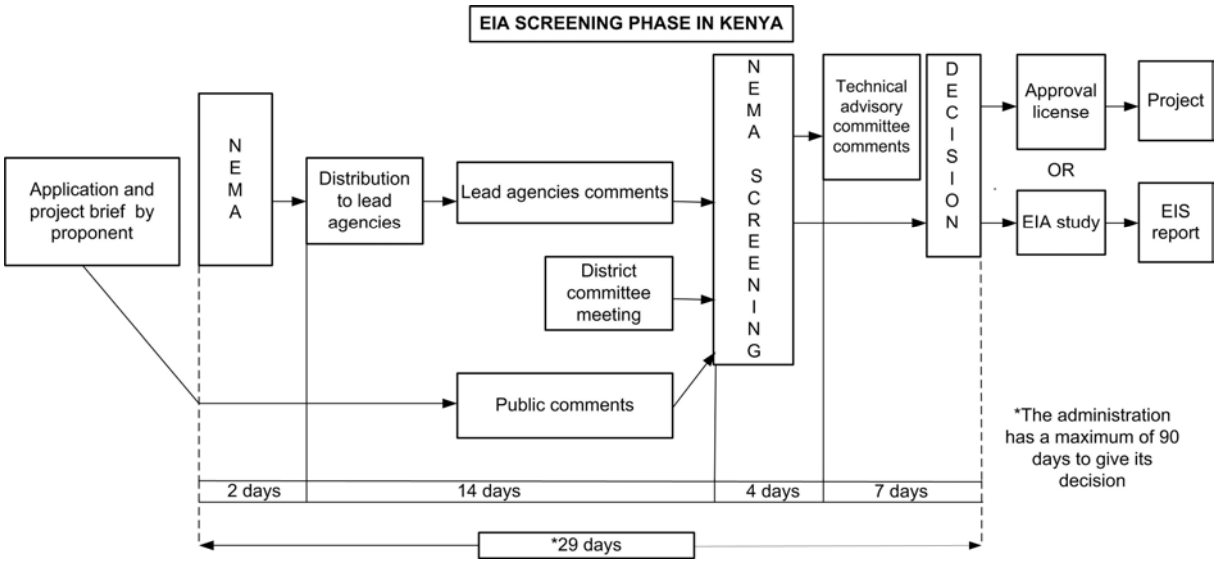

FIGURE 2: EIA screening/scoping phase in Kenya

One of the key aspects highlighted in the act is the impact of the project on the local people and interested parties. According to this act, the project must first undergo a screening. In this phase, the proponent submits a report to NEMA for screening and scoping of terms of reference for EIA. The screening process stipulated in the act is described in Figure 2. A project brief was submitted to NEMA on the Olkaria Domes project.

The second phase of the environmental law requires that after screening has been completed, projects in the second schedule of the ACT must undertake an EIA. This project falls within the second schedule of the Kenya's Environmental Management and Coordination Act (Republic of Kenya, 1999). All projects in the second schedule must undergo a full EIA Study. After completion of the EIA study the reports are submitted back to NEMA for further comments and further mitigation proposals and final approval of the project. The entire process of screening and EIA approval should take at least 90 days. During this process, the act gives a provision for the public to comment on the Environmental Impact Statement (EIS). The EIA review process is illustrated in Figure 3. The project proponent is also expected to submit a detailed Environmental Management Plan (EMP) and carry out environmental monitoring and audits which form the third phase of the application of the law.

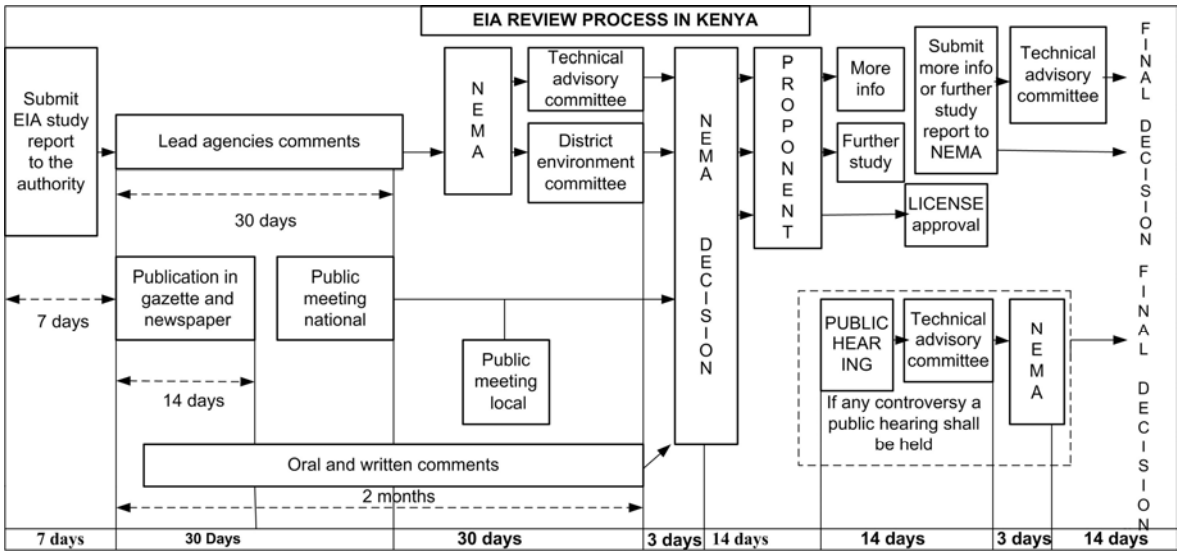

FIGURE 3: EIA (EIS) review process in Kenya

Other national legislation relevant to this project will be applied. These include the Water Act Cap 372, Irrigation Act Cap 374, Kenya Power and Lighting Act Cap 48, Fisheries Act No 5 of 1989, Public Health Act Cap 242, Lakes and Rivers Act Cap 409, Land Planning Act cap 303, River Authorities Act Cap 443, Local Government Act, Way Leaves Act Cap 292, Forest Act Cap 385, Antiquities and Monuments Act Cap 215.

Since one of the key financiers of the project is the World Bank, the study integrated the World Bank requirements with the national requirements. The study was also carried out in accordance with operational directives of the World Bank source book. The project falls within World Bank category A of study for environmental assessment "OD 4.00 – Annex A, World Bank (1989). According to the World Bank legal requirements described in Figure 4, the project is in preparation phase under feasibility studies. Generally, appraisal drilling falls under feasibility studies.

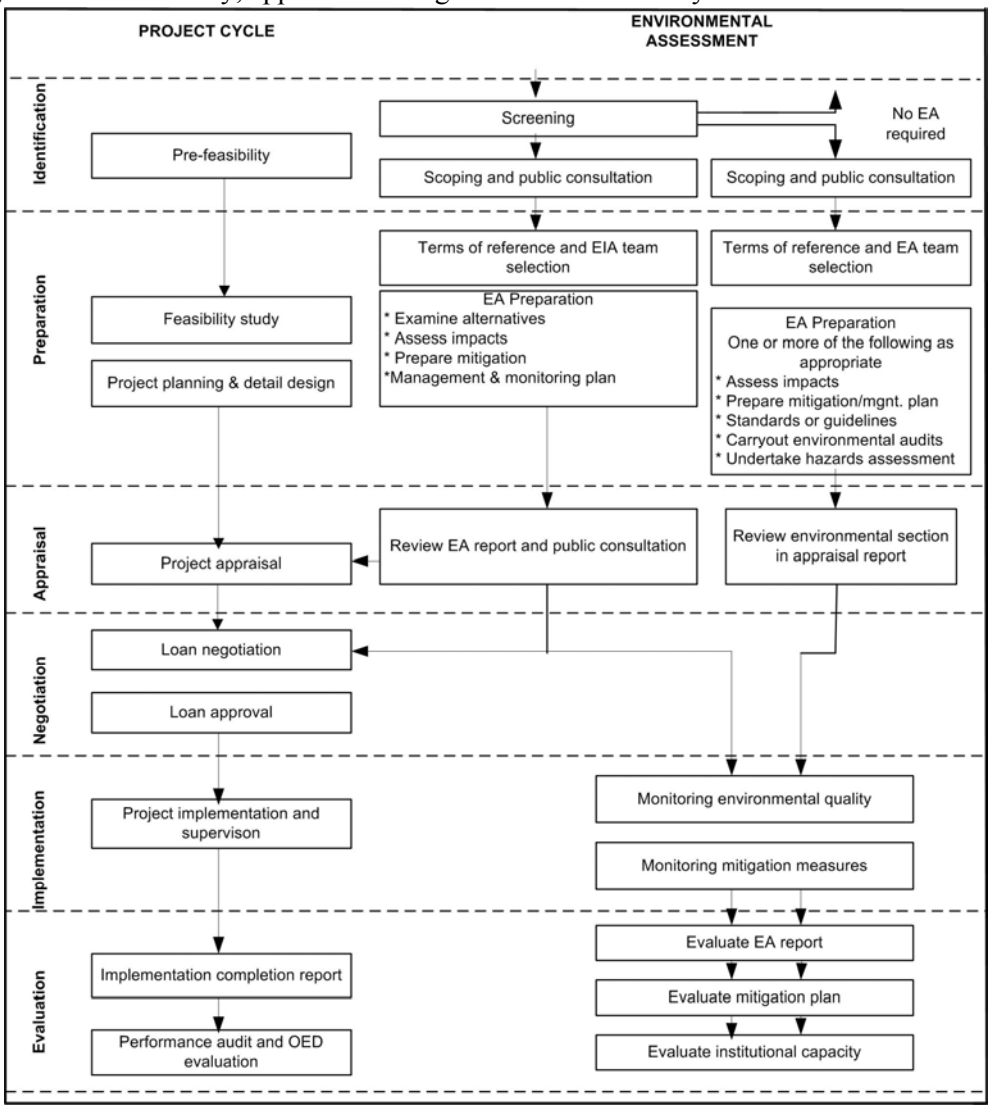

FIGURE 4: World Bank EIA process

1.2 Objectives of the study

The objectives of the study were to

- Collect baseline information on all socioeconomic activities, physical resources, infrastructure and services and evaluate their utilization and current status;

- Analyse stakeholder characteristics and expectations;
- Assess socioeconomic effects of potential drilling project on the area;
- Briefly assess other environmental risks associated with the project and their socioeconomic context; and
- Suggest a feasible environmental mitigation and monitoring plan.

1.3 Methodology

The study followed a normal research strategy as illustrated in Figure 5.

The development of terms of reference was guided by Kenya's national environmental legal requirements, World Bank and other relevant international requirements. Primary data acquisition was obtained from the field using the following methods:

- Brainstorming sessions with stakeholders;
- Semi structured interviews where checklists were used to guide the discussion while allowing other issues to arise and be pursued;
- Questionnaires to stakeholders;
- General observation.

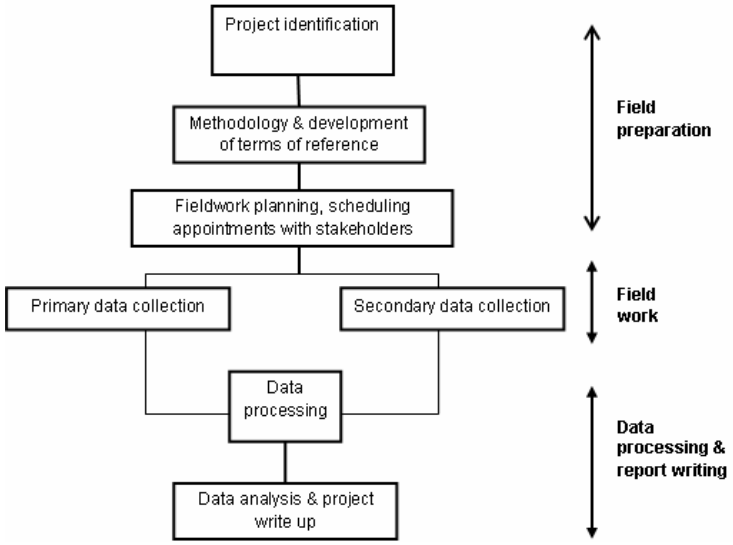

FIGURE 5: Study structure

Secondary data collection of literature and reports was also done during the survey. The stakeholders were divided into groups of different economic interest and sampled within the strata. The respondent rate was 95% even though most of the respondents had no actual figures.

The main component of the report is divided into the sections described below the same method has been used by Eythórsson et al. (2003).

1.3.1 Project description

This gives a brief overview of the new project and its components. These include the project location, size and input. The project components give a general magnitude of the project that is being introduced in the already established socioeconomic setup.

1.3.2 Baseline description

The baseline information in this report gives a general overview of the study area and mainly describes the type and utilization of natural resources, economic activities, physical and social infrastructure, general population, economy and labour characteristics of the study area. The issues discussed under this section have a direct influence on the social and economic status of the study area and form the basis for current status evaluation. Once the baseline is established, the impact of future changes can be compared and assessed.

1.3.3 Impact assessment

An evaluation and analysis of foreseen socioeconomic impacts of the project is done based on the information obtained from the baseline study. Additional information on similar studies and reports is obtained for comparison. All issues of concern are identified and possible mitigating measures relevant to the status of the area are proposed.

1.4 Assessment boundary/scope

The geothermal field is located about 120 km from Nairobi. Administratively, the project is located within the rift valley province, Nakuru district, Naivasha division, Hells Gate location. The actual project site is located within the Greater Olkaria geothermal area (GOGA) on the eastern arm of the East African Rift Valley on Kedong ranch. The ranch is adjacent to the Hells Gate National Park. This will be the first geothermal project to develop outside the park. Access to the site is from the Moi South Lake road through the Hells Gate National Park into part of Kedong ranch (on the edge of the park) beyond which is a vast area of wildlife grazing land and Mt. Longonot National Park.

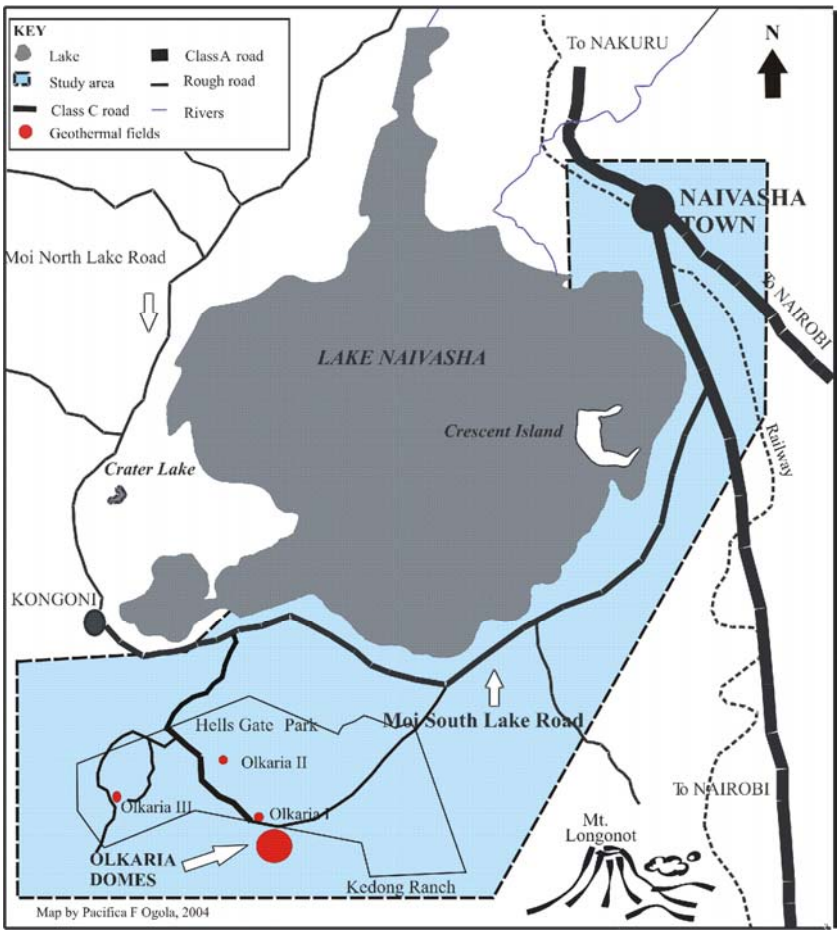

FIGURE 6: Assessment boundary limits

The study was therefore based on socioeconomic aspects and natural resources along the Moi south lake road because most stakeholders and economic activities are clustered along this road. The road will also be the main route for transportation of project materials since there is no alternative road to the site. The study area covered a radius of about 25 km from the project site to Naivasha town, and other additional areas outside the Moi South Lake road which the project might have some influence on. The project site and study area are shown in Figure 6.

This study is limited to socioeconomic impacts of drilling and testing of the six appraisal wells of Olkaria Domes. Additional studies and a full Environmental Impact Assessment will be done upon production drilling completion and before construction of the power plant. Therefore a full EIA with all disciplinary branches is out of the scope of this document. The results of this study are also expected to influence production drilling since the wells will be drilled within the same site.

2. DESCRIPTION OF THE PROJECT

2.1 Project background

The Greater Olkaria geothermal area (GOGA) shown in Figure 7 currently serves three power plants Olkaria I, II and III with a total installed capacity of 128 MWe. The geothermal field has been divided into blocks which include Olkaria East serving Olkaria I power plant, Olkaria Northeast serving Olkaria II, Olkaria West serving Olkaria III and Olkaria Domes (IV) which is the project of this study.

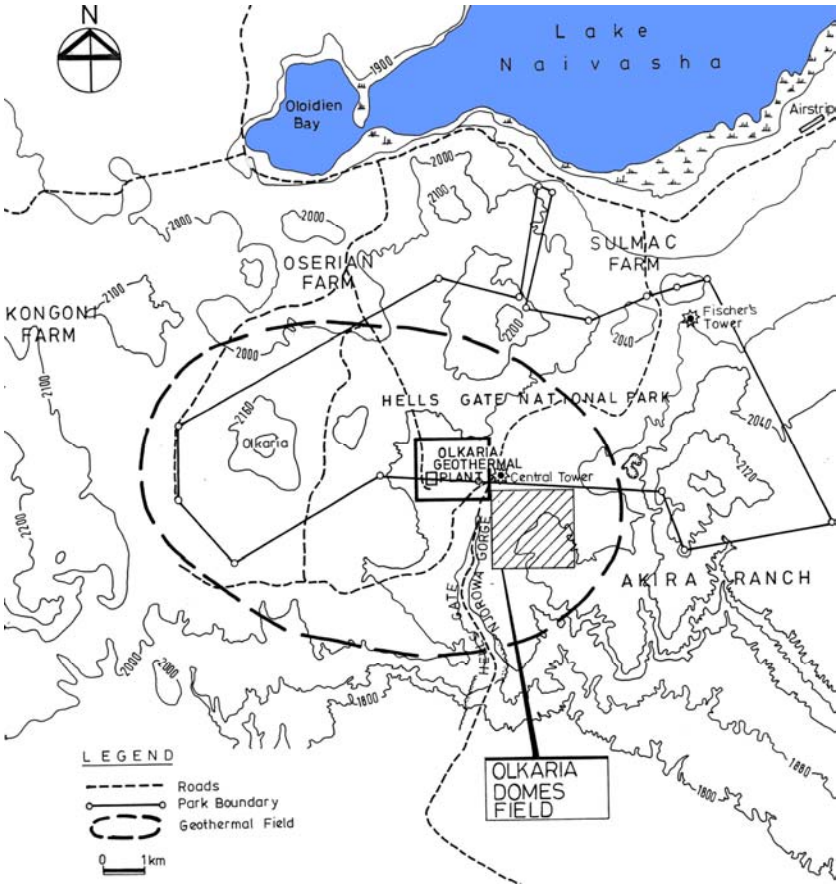

FIGURE 7: Olkaria geothermal field

Exploration work of the project started in 1998 followed by exploration drilling of OW 901, OW 902 and OW 903. Results from exploration drilling indicate that wells OW 902 and OW 903 are not consistent in their productive capacity except for OW 901. OW 903 fluctuates while 902 is unproductive and may only be used for reinjection or monitoring. Plans to drill six appraisal wells by October 2005 are underway. The wells may be vertical or directional with an estimated well output of about 2.5 MW per well. Later on 22 directional and vertical production wells are planned with an output of 5 MW per well with 4 reinjection wells. The wells will be drilled to a depth of 2000-3000 m below surface but this will also depend on the elevation.

2.2 Project size

The project area may expand after successful drilling of the appraisal wells, however, this study is limited to the current project area whose details are listed below.

- The current total area of the Domes is 4 km^2;
- Drilling of one well takes about 60 days, therefore drilling six appraisal wells will take approximately one year. One well is expected to consume 100,000 m^3 of water in 60 drilling days and therefore 6 wells will consume a total of 600,000 m^3 of water in a year assuming there is no delay in drilling;
- Each well pad will occupy a maximum area of 50 m × 100 m;
- The ponds at the drilling site will occupy an area of 20 m (length) × 5 m (width) × 2 m (depth);

- Proposals to use geothermal brine for drilling instead of Lake Naivasha water are being considered; if the geothermal brine is used for cooling, the brine storage reservoir will be approximately 30 m (length) × 50 m (width) × 2 m (depth);
- A 4 km long, 6 m wide access road with a number of 500 m roads branching from it into the well pads;
- A total of 36 people, 13 people per shift working 4 shifts. The working hours will not exceed 40.5 hours a week. KenGen staff and contractor will do the drilling. No temporary camps will be required as the field is within close proximity to Olkaria I and II where most of the staff are housed. The contractor will also use the available accommodation in the area;
- Testing of wells after drilling will take three months.

2.3 Project input

The drilling project input includes the items listed below. It is important to highlight the project input as a requirement of Kenyan environmental laws and to determine how the input will influence the environment.

- *Capital:* The cost of drilling the six appraisal wells alone is estimated at USD 5.9 million.
- *Land:* Drilling will take place within the Olkaria Domes area, which covers an area of 4 $km^{2.}$ The land acquisition is still under negotiation with Kedong ranch owners.
- *Materials:* Construction material and heavy equipment will be sourced from outside and transported to site by contractors.
  - Service equipment e.g. rig move trucks, drilling tools, heavy trucks, water supply equipment (temporary), radio communication, earth moving equipment
  - Support services, e.g. labour, transport, safety and medical services, mobile kitchen and toilet
  - Materials, e.g. Class A cement, drilling detergent, concrete, drilling mud, sand, gravel, rig fuel and lubricants for drilling and cement additives, steel, electric cables, timber, steam pipes and cladding material for power plant and steam pipeline. The signed contract between the proponent and contractor on project design and the quality of input and safety regulation will be adhered to.
- *Labour:* KenGen has capacity for drilling and has a fully fledged drilling department. Therefore, the contractor from the hired rig company will work alongside the KenGen staff. There is no local capacity in this field around the study area.
- *Transport:* Access road to the site has been constructed and will be upgraded. Transportation for labour force and heavy equipment will be provided. Environmental considerations will be made during transportation, delivery and use of all projects input. Details on this will be obtained in the progress reports.
- *Water:* Each well is expected to consume about 100,000 m^3 of water for the 60 drilling days. Since transportation of water to the site is expensive, considerations to use brine fluid instead of fresh lake water are being made.

3. BASELINE DESCRIPTION OF THE STUDY AREA

3.1 Stakeholder composition

Naivasha division and especially the South Lake area is very unique and so are its stakeholders. The stakeholders range from Maasai grazing animals to big multi-billion institutions with houses ranging from Maasai manyattas, shanty towns to castles owned by some of the highest European families. The stakeholders are not only diverse in social class but also their origins which makes the area very

cosmopolitan. It is, therefore, very difficult to identify the area with one big community sharing the same cultural or ethnic traditions as is common in many parts of Kenya. In this very unique complex are also very unique stakeholders, the wild animals, whose interests are championed by the Kenya Wildlife Service and conservationists.

The stakeholder composition of the area includes KenGen, flori/horticultural farms, Kenya Wildlife Service, hotels and conservation centre, ranches (e.g. Kedong ranch), fisheries, Orpower, Maasai community, local residents, associations e.g. Lake Naivasha Growers Group (LNGG), Lake Naivasha Riparian Association (LNRA), Lake Naivasha Tourism Group (LNTG), and government agencies like the municipal council, Ministry of Education, Ministry of Labour, Ministry of Agriculture and Ministry of Water.

Most of the stakeholders in the region are very cohesive and belong to one or more association. KenGen is a member of the Lake Naivasha Riparian Association and works closely with the other associations. These associations have formed a good conduit for information sharing, thrusting out key problems affecting the region and giving some financial contribution towards social responsibilities. A good example of this cohesion was witnessed during the repair of a small part of the Moi South Lake road, the formulation of the Lake Naivasha Management Plan, and establishment of the code of conduct by the LNGG´s and associated environmental audits of their activities. KenGen and Kenya Wildlife Service (KWS) hold meetings to discuss the environmental issues according to the Memorandum of Understanding (MOU) between the two institutions. KenGen has also collaborated with the Maasai community by providing social amenities such as water, transport, schools, etc. KenGen and KWS and the Maasai community also hold regular meetings to discuss fires in the dry season, among other issues. The Maasai community has greatly benefited from the existence of the geothermal project in the area.

The challenge goes to those who do not belong to any association and do not give back to the region after harvest.

3.2 Description of physical resources

3.2.1 Land resources

Before the colonial government, the land was traditionally grazed by the Maasai who lived a pastoral way of life. The Maasai grazed from Kajiado and Narok to the northern and eastern parts of Kenya. For centuries, land was communally owned and still is in some cases and used for grazing. In 1905, the colonial government moved the Maasai to the reserves. The land including the land around Lake Naivasha was subdivided in big parcels and acquired by individuals. The land tenure system changed from traditional Maasai communal ownership to freehold private ownership with title deeds. As a result of this, land has been sold from one person to the next with appropriate title deed. The land within the Naivasha township area is on leasehold. Though the area has been annexed by the council, the land in the study area is still freehold. The value of land varies with the location. The value of land next to the lake is approximately USD 12,500 per acre while the land across the Moi South Lake road will cost nearly half or less of the amount per acre depending on the location and view. The land which has been subdivided and sold out for low income housing costs about USD 1,250 per acre.

The land where some of the KenGen facilities are located is used for conservation; it was gazetted as a national park after the implementation of Olkaria I geothermal power plant. KenGen and KWS have signed a MOU to govern the operations of the company in the park

The immediate neighbours therefore are KWS, Kedong ranch, Ngati farm and Oserian. Kedong ranch where the Olkaria Domes will be located is currently owned by a group of individuals who bought the land from a settler. The ranch closely borders the park.

3.2.2 Water resources

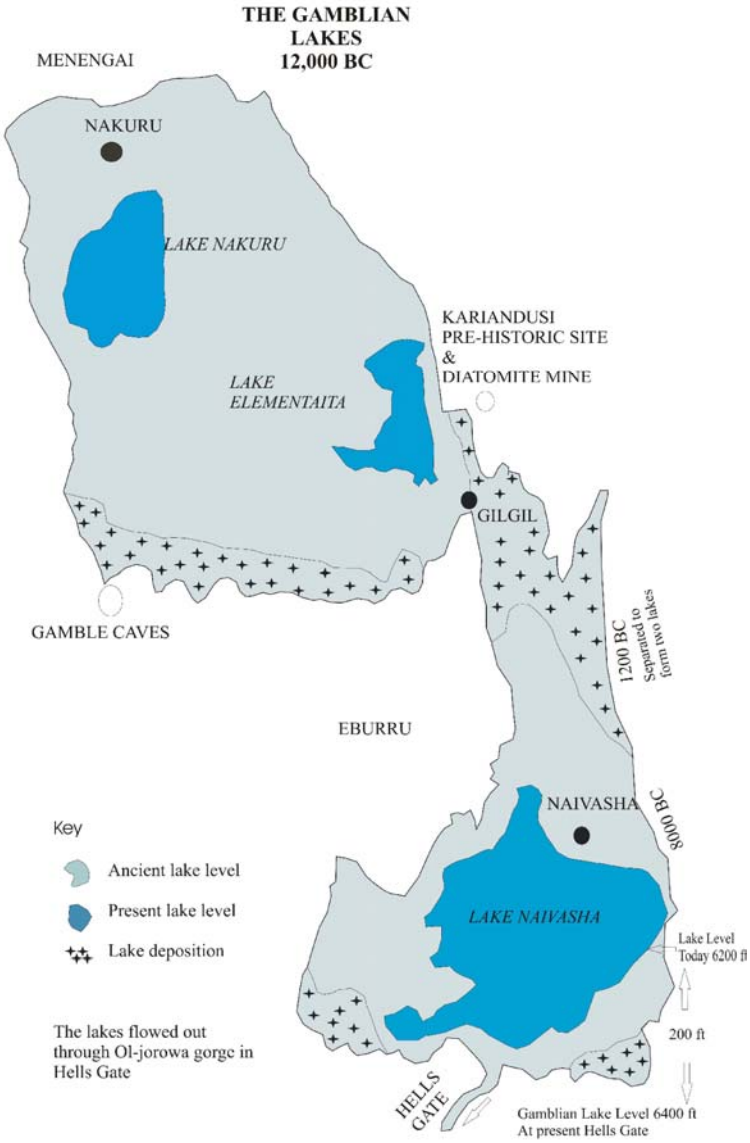

FIGURE 8: The Gamblian lakes

Lake Naivasha is a shallow freshwater lake located at an elevation of about 1890 m above sea level. It was once a relic lake, which was a part of a large fresh water body comprising Lake Naivasha, Elementaita and Nakuru (Figure 8). Though the lake has no visible surface outlet, it has not become saline despite the high potential evaporation rates, thus indicating a subsurface outflow. The state of this outflow has been a major subject of speculation. The lake catchment's area is around 3200 km^2 and it is one of the biggest bird sanctuaries in Africa. The lake receives water from two perennial streams, Malewa river from Aberdares in Nyandarua and the Kinangop with a drainage area of 1739 km^2, and the Gilgil river from the north with a drainage area of 420 km^2. The Malewa contributes 90% of all surface inflow (LNRA, 1999). Karati river also drains into the lake but is seasonal. The lake is also recharged by rainfall, surface runoff and subsurface drainage. There is a possibility of underground outflows. It is believed that between 50 and 90% of the lake outflow is directed to the south from the north (Darling et al., 1990). In the northern part of the lake, a delta had been built by sediments mainly from Gilgil and Malewa rivers. The level of the lake is not dependent on surface runoff from storm water and rivers, but by the underground drainage system, which is not clearly understood.

The lake has a very flat bottom with major increase towards the shore but deepens at Oloiden and Crescent lake. The depth survey of this lake was made as early as 1927. Later in 1983, a second depth survey using Lowrence X-15 echo sounding technique was made and compared to the 1927 survey. At this time, the level was 3 m lower than 1927 and changes in the bottom topography may also have occurred. According to the survey, the maximum depth was 17 m at Crescent lake, and Oloiden bay at 9 m. The deepest point in the rest of the lake is 9 m measured at Hippo point, with a mean depth of 4.7 m (Ase et al., 1986).

Groundwater resources include the deep geothermal aquifer, which is not directly linked to the lake, and the upper aquifer, which is believed to have a direct link to the lake. The lake is like a small pan, several kilometres above the geothermal resource and recharged by different hydrological systems.

3.2.3 Geology and soils

The study area embraces two flanks of the Gregory rift valley with the Kinangop plateau on the eastern side and the Mau escarpment on the western side. The main faulting stages of the rift valley occurred during the Miocene or early Pliocene and in the Pleistocene-Holocene epochs (Ase et al., 1986).

The geology of the study area has 80 scattered craters forming the Olkaria volcanic complex which covers an area of about 240 km^2 south of the lake and west of Longonot volcano. The surface rocks in Olkaria complex are comendite, or peralkaline rhyolitic with most of the surface features comprised of steep-sided domes formed from lava and pyroclastic rock or thick lava flows. The pyroclastics are mainly tephra and tuff layers deposited during eruptions of Mount Longonot. In some areas, the domes coalesce, forming arc-like ridges or large hills rather than discrete domes. The Olkaria Domes enclose almost a circular depression which is obscured in part by the Olobutot ridge. The depression is dissected by the 16 km long and narrow Ol Jorowa gorge which was formed by the outflow of water from Lake Naivasha. Subsurface rocks mostly comprise sub-aerially erupted rhyolitic, trachytic and basaltic lava and associated pyroclastic rocks. The soils are loam clay, loam friable stony and calcareous in nature (Atkilt, 2001).

3.2.4 Vegetation

The semi arid climatic conditions and porous volcanic rocks influence vegetation. The vegetation is mainly diverse species of grassland and shrub land dominated by leleshwa and several species of acacia. In Kedong valley, the main vegetation is cactus, *euphorbia candelabrum, acocanthera schimperi*. The area around the lake has yellow fever tree (*acacias*) on the outer extreme of the lake, papyrus reeds, water lilies (extinct), macrophytes and *silavania molesta* weed, respectively. Generally, the area has a dry savannah look.

The amount of papyrus reeds in the lake has also been threatened by the fluctuating levels of the lake, fires and human encroachment. The papyrus forms an important sediment and nutrient filter for the lake. Its roots form an important habitat for fish and wild animals such as hippos, birds and buffalo that use it as a safe feeding ground (Ramsar, 2002). Studies by Lopez (2002) indicate that the area under papyrus has been declining since 1967. According to the study, in 1967-1984, the rate of papyrus loss was at 129 ha./year, 1984 to 1995 the loss was at 38 ha./year with a total cover loss of 422 ha. However, in 1995-2000, there was some slight recovery of 135 ha. due to conservation measures put in place. The loss of area under papyrus cover is presented in Figure 9 from raw data obtained from Lopez (2002).

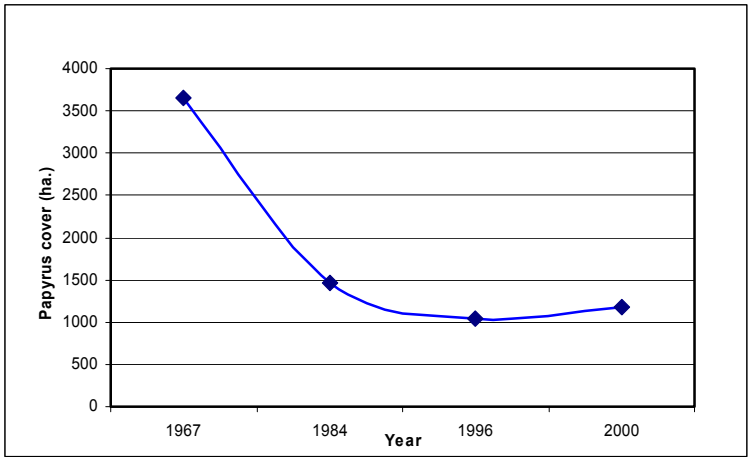

FIGURE 9: Loss of area under papyrus cover

The *silvania molesta* weed has continued to flourish in the lake since 1962 and sometimes becomes a major ecological problem when it covers most of the lake surface. The weed inhibits primary production because it reduces light penetration into the water especially on breeding grounds. Attempts to reduce the weed by chemical control failed but biological control by use of *cyrtobagus salviniae* and *samea multiplicatus* was successful in reducing the weed to current levels.

3.2.5 Climate

The climate of the area is semi arid with mean monthly temperature of 18°C with a maximum of 27°C. The average annual rainfall is about 600 mm with evapo-transpiration of 1360 mm/year which creates a water deficit for plant growth. The precipitation is concentrated in two rainy seasons April to May and October to November, with two intervening dry seasons. The rainfall in the area is influenced by relief. The region is in the rain shadow of the Kinangop and Mau escarpments. Though evaporation shows small deviations of ca. +/- 50 mm, precipitation varies strongly from one year to the next (Ase et al., 1986). Winds are generally weak with the strongest occurring during October and August, between 5-10 m/s, and blowing from varying directions.

3.3 Description of economic activities

The study area is endowed with different kinds of economic activities with the main ones being tourism, wildlife and biodiversity conservation, pastoralism, farming (horticultural and livestock), accommodation, fishing, power production (geothermal), trade and business. For easy and quick identification, the economic activities have been ranked in terms of output and size in acreage as shown in Tables 1 and 2. From the analysis, horticulture is the leading economic activity in the area in terms of size and revenue earnings. Geothermal activity is the major second revenue earner in the region with a small aerial coverage in comparison to horticulture. Details of each economic activity are discussed below.

TABLE 1: Activities rank in size in terms of economic revenue

Activity	Relative income (%)
Horticulture	37
Geothermal	28
Hotels/catering	14
Small business	9
Livestock production	6
Wildlife conservation	3
Fishing	2
Other	1

TABLE 2: Activities rank in land coverage in revenue

Activity	Relative size (%)
Horticulture	43
Livestock production	19
Wildlife conservation	12
Hotel & catering	9
Small business	7
Geothermal	5
Fishing	4
Other	1

3.3.1 Tourism

The South Lake area has many tourist attraction sites, namely the Hells Gate National Park, Green Park, Mt. Longonot, Lake Naivasha, Crater Lake, geothermal, Maasai cultural centre and private game sanctuaries. Hells Gate National Park is the main tourist centre covering an area of 68.25 km^2 and is about 90 km from Nairobi. The park received a total of 346,000 visitors in the years 1998-2000 with the annual average visitors being 75,000, after the decline in tourism due to the 1997 terror attack on Nairobi. The main tourist activities in the park include: camping, campsites at Oldubai, Naiburuta and Endacha, picnic sites and nature trails at Ol Jorowa gorge, Fisher's Tower, Central Tower, Hell's kitchen and obsidian caves. Access to the park is by 3 gates, the main gate along the Moi South Lake road, Olkaria gate and the Narasha gate. The Olkaria gate where access to the geothermal plants is located, has also earned the park the highest revenue through visits from schools around the country. The power plant receives over 100 visitors per month who have to pay park revenue. The park earns a total revenue of about Kshs 13 million per annum (USD 162,500, at the rate 80 Kshs to one USD).

The tourism circuits in the area are not well developed. Efforts to connect the national park with the Maasai Mara have been futile because members of the 'big five' (e.g. buffalo, elephant, lion, leopard

and rhino) cannot be photographed en route within minutes of lodges. The lake is definitely an asset to the tourism industry. Some of the tourist activities include bird watching, rock climbing, boating, biking, wildlife viewing, fishing and exploration. Sport fishing cannot be sustained due to a decline in fish production which resulted in a ban on fishing. The Lake Naivasha tourism group markets the region being only one hour away from Nairobi, the area providing easy get away recreation for local and international tourists.

Other than for tourist purposes, several films have been produced in the Hells Gate national park due to its picturesque landscape. These include King Solomon's Mines, Magambo, Where no vultures fly, Born free, Sheena, queen of the jungle and The verraux eagles (Carnelly, 1993). This is a potential resource that can earn the park and country a lot of revenue in the future.

3.3.2 Accommodation and catering

There are about 18 hotels, lodges and campsites for accommodation along the Moi South Lake road. The hotels range in class, size, and specialization from large commercial chains to small camping conservation sites. Accommodation rates range from USD 50 to 700 per night. The turnover from the hotels and accommodation on the South Lake area in terms of occupancy rate, annual returns, labour force, tax revenue from employees, expenditure etc. could not be obtained. The 18 hotels in the South Lake area could be employing a maximum of 1000 employees.

3.3.3 Wildlife and biodiversity conservation

The area surrounding the Domes is very rich in biodiversity of both floral and faunal nature. The fauna ranges from reptiles like cobra and python, insects and arthropods like grasshoppers, butterflies, bees and termites, about 400 species of birds, to mammals, like baboon honey badger, buffalo, African bushbuck, caracal, African wild cheetah, African civet, Kirk's dik-dik, hunting dog, duiker, eland, fox, bat-eared, grant's gazelle, Thomson's gazelle, large-spotted genet, small-spotted genet, giraffe, African hare, spring hare, hartebeest, hippopotamus, buffaloes, hyenas, hyrax, impala, jackal, black-backed, klipspringer, leopard, lion, marsh mongoose, white-tailed monkey, black faced vervet, clawless otter, porcupine, rat, African mole, reedbuck, bohor, reedbuck, chanler's serval, bush squirrel, striped ground squirrel, steenbok, warthog, waterbuck, and common zebra. The animals move away from open grassland to cool bush areas during the day and graze in the early morning and evening. Most of the vegetation in the park is undisturbed.

Wildlife conservation is mostly done in the park, private ranches and private sanctuaries. These include: Hells Gate national park, Elsamere Conservation and Study Centre, Kedong ranch, Kongoni farm, Oserian, Longonot ranch, Ostrich farm, Crescent Island. Most of the Lake Naivasha riparian land owners practice biodiversity and wildlife conservation within the riparian area. Lake Naivasha supports a large water bird community, fish and many large mammals. Lake fish have been threatened by decreasing lake levels and overfishing.

The increase in development activities and land subdivision has led to the clearance of large chunks of land to pave way for new developments. Most of the animal corridors have been illegally annexed and sold. Currently, the only animal corridor to the lake is through the Oserian farm. Outside the park, vegetation cover especially the *leleshwa* tree, is endangered due to over exploitation for charcoal burning.

3.3.4 Pastoralism

The Maasai believe that they came from the sky with their livestock at the dawn of human existence and have grazed and watered their stock in a nomadic lifestyle for centuries in the area. In the early 20th century with the coming of the British, the land was subdivided into large ranches for British farmers and later in 1970s crop irrigation was introduced. Despite the change in land use and

subdivision, the Maasai, being pastoral by nature, still herd their animals on the private land and the national park. The animal composition includes cows, sheep and goats in the hundreds. For centuries, they have coexisted with the wildlife and have continued coexisting with the new development in the area despite difficulties in accessing private land to water and graze their animals. The area is still a major pastoral route from Suswa to Gilgil despite the private acquisition of land. The Kenya Wildlife Service has given the Maasai free passage through the park because of their ability to understand and co-exist with the animals. Livestock is kept for milk, blood, meat and cultural reasons. Maasai herds range from tens to hundreds of livestock, an indicator of wealth.

3.3.5 Farming

Farming in the division includes large and small scale commercial farms, ranches and subsistence agriculture. On the upper catchments, the main food crops grown include maize, beans potatoes and some green vegetables and fruits. The cash crops include flowers, wheat and barley. Most of the farms are dependent on boreholes, lake or its catchment water. The boreholes are also connected to the lake through underground drainages. The farm sizes are presented in Table 3 below as they were before the year 2000. The most common agricultural activity in the South Lake area is commercial flori-/horticultural farming.

TABLE 3: Farm land categories in Naivasha

Farm size	No. of farms	Total size (ha.)
Small scale	20,540	49,084
Medium scale	1,336	10,782
Large scale	31	37,196
Total	**21,905**	**97,062**

Source: Naivasha Municipal Council (2000), Development plan for 2000-2004

Horticultural farming
In the late 1970s, horticultural farming was introduced around the lake (Figure 10) and has since grown to large commercial farming for export. Before independence and shortly after, the irrigated agriculture around the lake was mainly for fodder crops for the local market and to a little extent the European market. Kenya is currently second after Israel in cut flower export and horticultural products. Naivasha supplies about 75% of the total export and earns the country approximately USD 110 million per annum. Horticultural export from the country in the last 5 years is presented in Figure 11, indicating a general increase in the sector (CBS, 2002). Irrigated horticulture and flower growing is rapidly expanding around the lake at an alarming rate over the past 20 years.

FIGURE 10: Greenhouses around Lake Naivasha (LNRA, 1999)

Farming is mainly oriented for the European market. The growth in farming has led to a complete change in land use from ranching and wildlife grazing to commercial irrigated agriculture. The

total area under irrigation in 2001 was about 1560 ha. on the Moi South Lake road, but has since increased tremendously to over 2000 ha. with a rapid increase in greenhouses according to most studies and LNRA. According to Sayeed (2001) using satellite image of the area, the total area under irrigation in the whole division is estimated to be about 5000 ha. and could be more due to increasing expansion in agriculture. Precise information on this could not be obtained from the Ministry of Water bailiffs who issues the water abstraction permits to the farmers based on farm size. The area under irrigated agriculture could have increased to more than the 5000 ha. by 2004. This industry has been attracted by the availability of abundant fresh water from Lake Naivasha, big tracks of land (which can be leased), favourable climatic conditions, labour and proximity to Nairobi.

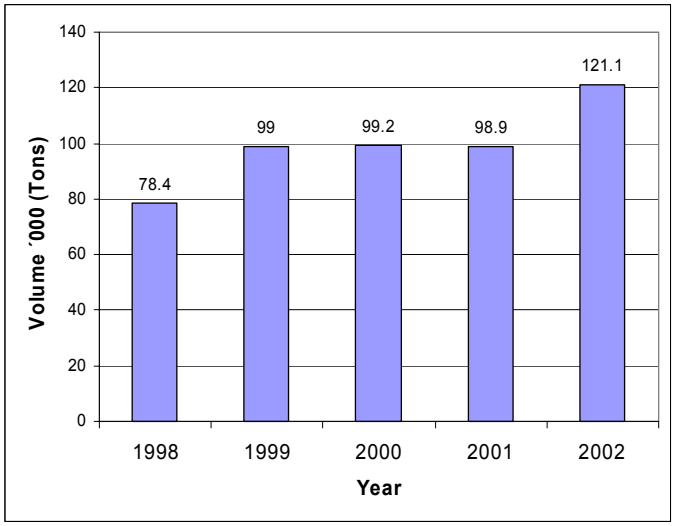

FIGURE 11: Export of agricultural products (CBS, 2002)

Small scale farming of food crops like maize, beans and potatoes grown in farms ranging from 0.5-5 ha. is also practiced on the upper catchments. However, this kind of farming is minimal along the Moi South Lake road and practically non existent within the Olkaria Domes site. In the early 1920s though, sisal plantation of about 20,000 acres was planted by MacCrae (on Kedong ranch), which was later abandoned and the land turned into a ranch after several trials and failures.

Livestock production

This is another major source of income and also a key sector in the region. Currently, an area of about 19.2 km^2 of land is under livestock production (Naivasha Municipal Council, 2000). These include dairy/beef cattle, goats, sheep and associated products like skin, hides, meat and milk. Current data on livestock production and population could not be obtained during the study. Therefore, estimates from livestock numbers based on averages obtained from 1994 to 1998 were used to estimate the average population. The estimation indicates that there are approximately 57,580 cattle, 20,000 sheep and 5,166 goats in the division. Data on dairy and beef production for the South Lake area and the division as a whole could not be obtained. It's all scattered on different farms and also classified. Wildlife species like ostrich, giraffes and zebras are also raised for game meat.

On the South Lake area and around the Domes, ranching is practiced on the Kedong, Longonot, Kongoni, Ngati ranches and a few flower growers keep both livestock and wildlife. The Kedong ranch is one of the largest ranches in the area rearing animals purely for beef. The ranch has acted as a buffer zone, protecting the park and also accommodating wildlife. The ranch was previously owned by a British settler who later sold it to a group of local owners. The area also supports large herds of Maasai livestock kept for subsistence and limited commercial use. Most of the Maasai herd is usually either in transit to Suswa and Narok or raised on private ranches like Kedong and Ngati farms.

3.3.6 Fishing

Fish in Lake Naivasha is artificial having been introduced from different places. In 1962, some endemic species were spotted which disappeared due to predation pressure. The types of fish include:

- Two types of Tilapia - *oreochromis leucostaictus* and *tilapia zllii*. These were introduced in 1956 from Lake Victoria by the Fishery Game Department.

- Large mouth bass, *micropterus salmoides,* was introduced from North America in 1929, with a re-introduction in 1940s and 50s. The large bass is mainly for fishing. It feeds on other fishes. The above three form the backbone of the fisheries.
- Guppi, *lebistus rediculata*, is of no commercial value. The date of introduction is unknown but it was introduced to control mosquito larvae.
- Adel, *barbus amphigramma*, is 10-11cm, and of riverine origin coming from Malewa and Gilgil rivers. The fish goes up the river during breeding season.
- Common carp – *cyprinus carpio*. This species was established when the lake was closed for fishing in the year 2001. Previously, it was recorded as low. It comes from the central province brought by the Malewa River. It inhabits muddy rivers and lake shores and destroys the nest and eggs of Tilapia and Large Mouth Bass. It grows to about 6-7 kilos.
- Cray fish – *procambras clarkii*. It was introduced to diversify the fishery and used to form the basis for the export market until EU banned fish export during the El-Nino.
- Rainbow trout, *onchorrycus mykiss*. The species is occasional because it cannot stand very high temperatures and requires clean water. They stray from the Malewa river. Occasional catches of about 5 fish in a year have been recorded.
- Nigra, *Orochromis spirulus,* was introduced in 1925 from Athi River but disappeared due to hybridization (crossbreeding with other fishes).
- *Orochromis niloticus*. This species was introduced around 1967 but it disappeared again.

Fishing in the lake was banned in 2001 due to over fishing but in 2002, partial fishing was allowed. As a result of the ban, fishing boats on the lake were reduced from 200 to 40. The fishermen lost their source of livelihood and in compensation were given alternative jobs in the flower farms. Despite this, poaching is still a major threat to the lake's fish population because wages from the farm cannot sustain the fishermen. The poaching activities are currently concentrated along the shores inhibited by macrophytes that provide a suitable habitat for fish feeding and breeding. Data on annual fish production by species, though important, could not be obtained. Pressure experienced by the industry includes:

- Fluctuating lake levels, which is a major concern to the Fisheries Department. Fish production is dependent on the lake level. When the level recedes, production goes down, and when the level goes up production goes up. During the El-Nino period 45–50 tons a month of fish would be caught but by 2001, only 5 tons a month. The lake is currently receding very fast. Annual fish production is presented in Figure 12.

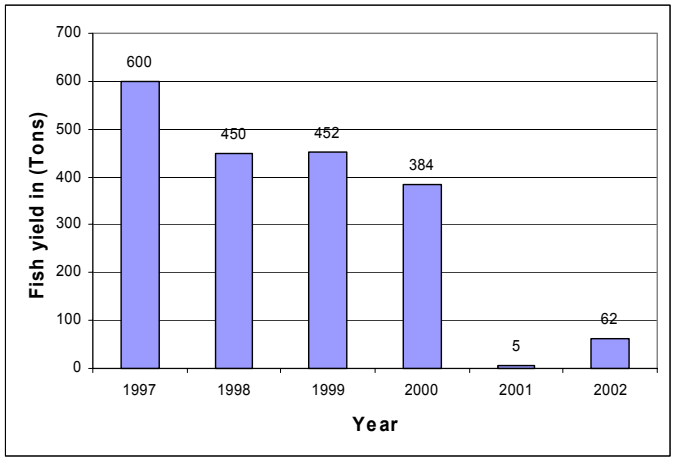

FIGURE 12: Annual fish production in Lake Naivasha

- The ministry does not have adequate resources and the personnel needed to protect the lake from poaching. Increase in population along the Moi South Lake road due to the increase in development has increased the demand for fish and hence poaching. The lack of adequate staff or equipment to guard the resource has forced the Fisheries Department to depend on well wishers who are mostly riparian land owners to shoo away the poachers and seize their boats. A protection unit chaired by the District Officer to make management decisions on the problem and resource recovery at a committee level has also been formed.

- Water abstraction from the lake using pumps located along the breeding grounds have led to suction of fish eggs and small fry. Most individuals and institutions have water pumps around the lake. The institution and individuals have now been advised to put a wire mesh at the end of the pipe to act as a barrier to protect the eggs and small fry. Despite this, the fish is still subjected to pressure from suction.
- Poor fishing methods like fishing on the breeding grounds, use of undersized nets and trawling have led to harvesting of fry (young fish).
- Water pollution from economic activities and sewage systems. The economic activities of the area have also had a significant impact on the aquatic vegetation. In 1980s the water lilies almost disappeared as a result of introducing cray fish and coypus into the lake.

Fish in the lake have been on the decline. A ban on fishing was the most sensible way to allow a recovery of the fish population to an appropriate level for sustainable fishing. There is no doubt that the resource will recover if the ban is properly enforced.

3.3.7 Geothermal power generation

In the early 1920s, the resource was first exploited by Colonel Murray who distilled wild lemon grass for essential oil using natural steam jets near Hobley´s Volcano and sold it to Grasse, in France.

Currently, the resource is utilized by KenGen (115 MWe) and Orpower (13 MWe). The geothermal resource in the area occurs in deep aquifers and was formed as a result of tectonic movement and volcanism. Geothermal exploration for electricity production started in the late 1950s. The first power plant was commissioned in 1985. This is the second country in Africa to harness geothermal energy after Ethiopia. The Olkaria geothermal fluid is steam-dominated and only exploited for high-temperature utilization. The company intends to expand exploitation of the resource within the same field to ensure optimum utilization of the resource before investing in other fields. Orpower is currently generating 13 MWe and has a reserve capacity of 36 MWe.

The Oserian horticultural and flower farm plans to utilize the resource in greenhouses to guard against infective pests and minimise the use of fertilisers. This will be the first direct utilization for commercial purpose and easily meets the European market standards on the use of biocides.

Hells Kitchen (within Hells Gate National Park) is an area of thermal manifestation that is used as a picnic site. Currently, the area is located in the Hells Gate park. In the mid 20th century, the hot rock was used by visitors to fry eggs and make tea, according to Peter Robertson.

3.3.8 Trade and business

The main business centre in the region is Naivasha town, the central business district which occupies about 30 km^2 of the old town (Ministry of Lands and Settlement, 2002). Several small businesses and trading centres have grown to serve the population on Moi South Lake road in the past 10-15 years with the expansion in horticultural and flower farming. These include small retail shops, food canteens, vegetable stalls, and chemists amongst others. The small business units have met the daily requirements of the flower farm labour force and other low-income earners. This has also ensured that all the basic needs within the area are met as opposed to spending money and time on trips to Naivasha. 'Matatu' (van public transport) business is also increasing in the area unlike before when the residents were purely dependent on institutional transport. However, people still prefer to go to Naivasha town for major shopping.

The Maasai community also runs a cultural centre where the cultural history of a Maasai family is displayed to tourists who are visiting the park. The community members also sell cultural artefacts like necklace, bracelet, 'shukas', Maasai head gear, etc. The cultural centre is located on Kedong ranch. There is also trade in livestock in various local markets on market day.

3.3.9 Education and scientific research

Lake Naivasha has attracted individuals and institutions due to its unique nature since 1920s. Some of the institutions include "earth watch" from Leicester University who studies the limnology and ecological studies of the lake and has continued every year since 1994. The ITC of Netherlands has been studying the hydrological and geological aspects of the lake and its catchment since 1996. Presently, there is a German group planning to study the characteristics of the lake bed. KenGen has done a lot of extensive research on the geothermal phenomenon and geological characterisation of the area. Some of the studies recorded include geology, geochemistry, and geophysics of geothermal aquifer flows among others. The Elsamere Field Study Centre has programmes for school children and teachers from all over the East African region.

3.4 Infrastructure and services

The rapid population increase in the area has not been matched by the available infrastructure. In Hells Gate location alone, the population has increased tenfold in 20 years. This has exerted a lot of pressure on the natural resources and infrastructure of the area.

3.4.1 Water use and provision

The main water sources for domestic, livestock and agricultural use are the lake, supplemented by boreholes and rainwater. The South Lake Road and the Domes area fall within the Olkaria ward of Naivasha Municipal council. Despite this, the council has not been able to provide water and sanitation to individuals and institutions. Most institutions are pumping water directly from the lake or from boreholes. There is an eminent conflict between conservation and a high rate of consumption. Lake water is mostly used for irrigated floricultural and horticultural farms, geothermal plant operations and drilling activities, domestic and hotels among others. Borehole water is used for cooking and drinking due to the deteriorating quality of lake water. Rainwater supplements the borehole water during the rainy season. Borehole water is also deteriorating in quality due to high fluoride and salts contents. The fluoride content has been recorded by the council as 8-20 mg/l, which is above the World Health Organization (WHO) limits for drinking water (Rural Focus, 2002). There are currently over 120 boreholes in the division. The permits for borehole water are given as set by the Water Act Cap 372 and must be at least 800 m from an existing borehole, a rule which has not been observed.

The water abstraction permit is issued by the Naivasha water bailiffs' office. The issuance of this permit is based on acreage and type of use. Permits for domestic water have a renewable lifespan of 10 years while those for agriculture have 5 years. Most of the stakeholders have acquired the permits; some, however, do not meter their water consumption. Field studies by the bailiffs' office have shown that most people consume below the limit allowed in the permit. Locations of boreholes and abstraction points are shown in Figure 13. Some of the problems associated with the provision of water and threats facing the lake are illegal water connections, misuse

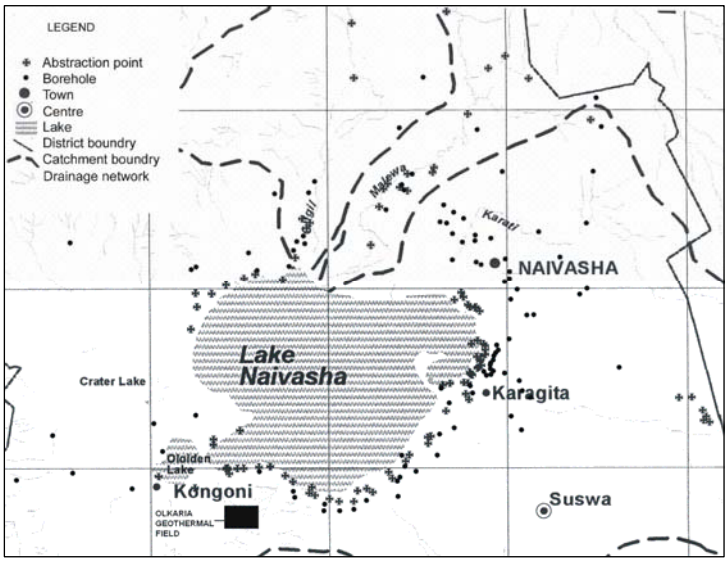

FIGURE 13: Location of water abstraction points and boreholes

(since the water is free), the high fluoride content, the Naivasha municipal sewage system, individual domestic sewerages, pit latrines, pesticides, poaching, un-metered abstractions, encroachment into the riparian land, siltation from the upstream, domestic washing and bathing (Kwa Muyaa and Kamere), and abstraction of borehole water around the lake.

3.4.2 Water consumption

An interview with Lake Naivasha Riparian Association (LNRA) revealed that there is no database on rainfall, water level of the lake, evaporation, inflows and outflows. Some of this information is available though scattered in different documents in different institutions. Currently, there are efforts to collect and collate the data, an initiative spearheaded by Lake Naivasha Growers Group (LNGG) and supported by the riparian association.

LNRA has no actual data on water consumption of the riparian members. It was also not possible to tell how many of the riparian members meter their water consumption, an issue which though critical, is very touchy in the area. Most of the water users have obtained their water permits, which some obtain directly from Nairobi without consulting the local water board.

More flower farms are coming up on the North Lake area that will require more water for irrigation. Despite the fact that some of the farms will use borehole water for irrigation, this is a major concern for LNRA since the borehole could be linked with the aquifer that drains into the lake. The LNRA has no mandate to control any type of development that could affect the level of the lake. The use of Malewa river and Gilgil for irrigation on the upstream is also a major concern.

According to the studies by Sayeed (2001), the area under irrigation is 1560 ha. and according to a different study by rural focus, the area under irrigation was close to 2000 ha. in 2004. It was not easy to estimate the total area under irrigation and water consumption. The water bailiffs' section which issues the permit based on the size of irrigated plots could not avail this information.

According to the Water bailiffs office, a non-commercial irrigation farm draws 10 m^3/day/acre while a commercial farm draws 25-30 m^3/day/acre depending on the type of crop or flower and to some extent irrigation methods. Some of the farms have adopted drip irrigation which is more water conserving than the overhead irrigation.

Water use for KenGen is mainly for power plant operation and domestic use. KenGen also supplies Orpower and the Maasais with piped water as a social responsibility. The total water consumption for KenGen is 59,000 m^3/year for power station use and about 1000 m^3 of water per day during drilling. However, drilling is an activity that cannot make a significant difference in the lake level. Water consumption for powerhouse use is negligible compared to the 300,000 m^3 used for irrigation per day. The water used for drilling is also recycled. KenGen may supplement the water with geothermal brine. This has not been done before in Kenya, as it would lead to drilling complications.

Institutions like hotels and ranches are also key water consumers, etc. The hotels mostly use lake water for irrigating the lawns, flushing toilets and showers, general cleanliness and use borehole water for cooking and drinking. Most hotels do not meter their water consumption rates. The water use for livestock and wildlife is pumped into water troughs and the general consumption is relatively low and can be estimated at 280 m^3 per day.

The expansion in agriculture and economic activities has resulted in a faster drawdown of the lake. Though the lake levels have been known to fluctuate, simulations done by Sayeed (2001) indicate that there has been a significant drawdown since 1985, as illustrated in Figure 14. The lowest level ever recorded was at 1883.9 m above sea level in 1954, while according to Carnelley (1993), the highest level was in 1908 at 1892.9 m a.s.l. which is also considered to be the riparian mark. The 1964 level of 1890.7 m a.s.l. indicates the highest peak in the second half of the century. Other peaks recorded

were at 1888.7 m in 1979 and 1888.9 m a.s.l. in 1998. All these peaks are associated with floods with the 1998 one being the El Nino floods. The reading in 2000 was at 1886.3 m a.s.l. The latest readings were not available from the LNRA office during the study. The downward trend in the lake levels calls for conservation. The lowest levels were recorded before intensive development of the area occurred. Over-abstraction would reduce the shoreline and hence breeding grounds for fish.

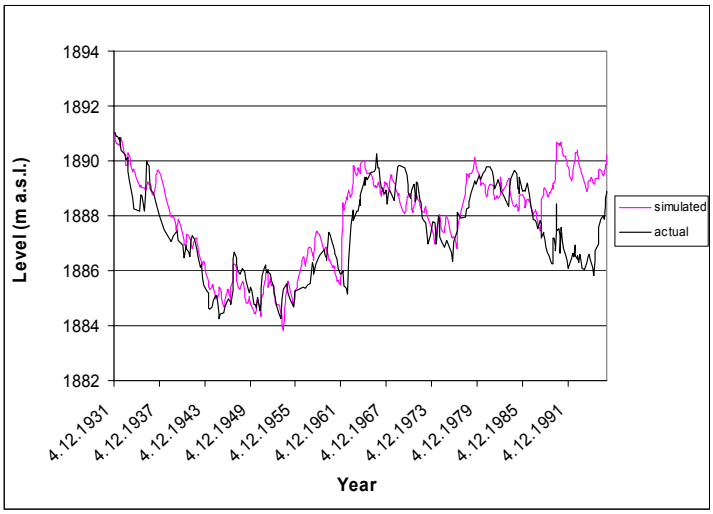

FIGURE 14: Simulated and actual lake levels

The LNRA has developed a water management plan and submitted it to NEMA for gazettement. If NEMA (National Environmental Management Authority) passes the plan, the LNRA officials will have control over the abstraction levels of the lake. Under the water act, there are no abstraction limits on lake water resources, unlike rivers.

The LNGG have employed a consultant to start a database, which will be managed by LNRA and accessed by all members. It is being proposed that all institutions with a high potential of polluting the lake should test their wastewater and make the result available on demand.

Water quality monitoring should be done more regularly and consistently by the LNRA with assistance from members who have laboratories like Kenya Wildlife Service Training Institute, WWF-Nakuru, KenGen, Oserian and Home grown.

3.4.3 Housing and settlement

The settlements and farms along the South Lake road are concentrated along the road and hence defined by it.

There are different categories of housing in the area. The high-class housing type is mainly on the riparian land consisting of large old houses on vast acres of land overlooking, or on the shores of the lake. These housing units are privately owned and are not quite visible from the South Lake road. The second or the middle class housing is typical of Orpower and KenGen Lake side housing and the Lake view estate, which were constructed with modern planning and finishing. The other housing units are one room houses for farm labourers by growers, and low class unplanned housing structures constructed by businessmen to meet the increasing housing demand in the area. Lastly, beyond the park and Moi South Lake road are scattered Maasai manyattas on Kedong ranch and Ngati farm.

The Naivasha council does not have a town planner. Land subdivision on the South Lake road has led to unplanned crowded housing units coming up. These are Karakita, DCK, Kamere and Kwa Muyaa among others. The current general trend of housing development is unplanned despite the fact that the area was recently annexed by the municipal council.

The area has mushrooming slums, which have grown as a result of an increase in the area under irrigated agriculture and expansion of other developmental activities. A number of flower farms have made an effort to provide housing for their staff, however, they cannot meet the housing needs of the kind of labour force they require. This need has been met by businessmen who constructed several unplanned residential housing units to accommodate them.

The provision of low class housing by private landlords has not been followed by the provision of clean water and sanitation facilities. This has also led to an isolated concentration of low class housing either neighbouring open spaces or irrigated farms for greenhouses along the Moi South Lake road. These types of housing have also led to a lack in distinct neighbourhood character with one moving from a well kept tourist hotel to greenhouses to slum dwellings.

3.4.4 Energy

The main source of energy for lighting in the area is electricity. Most institutions and residential houses have been connected to the grid. However, some of the unplanned low income housing are not connected. In KenGen staff houses, electricity is the main source of energy for cooking while in the upcoming low class houses which form the majority, the main source of energy for cooking include kerosene and wood fuel. Most of the charcoal is from Maela and Eburru forest. The increase in population is a major threat to the forestry resource in these areas. The pastoral community uses wood fuel for cooking.

3.4.5 Education

The schools in the area fall under the Maela education zone according to information obtained from the Ministry of Education. Despite the increase in population, the government has not invested in schools in the area. There are a total of 18 public primary schools with a total of 11,096 students, 77 nursery schools (private and public) with a total of 5,027 preschool children, 2 secondary schools with a total of 340 students as per the 2004 enrolments.

The above statistics indicate a sharp contrast of 10,756 between the primary and secondary school enrolments. The low enrolment to high school could be attributed to the following factors:

- High rate of school dropouts due to an inability to pay school fees since most people in the region are low income earners;
- Single parenthood;
- Some parents do not take seriously the need to educate children, especially girls, especially among the Maasai´s;
- Early marriages due to economic hardships;
- Shortage of secondary schools.

The government has not been able to build schools and therefore most of the schools above have been built by institutions around the Lake to offset the high demand for primary schools especially in the farming industry. Other institutions in Naivasha town are secretarial and computer colleges, 'jua kali' training for informal industry like dressmaking, auto repair, research institutes and the wildlife and fisheries training institutes.

3.4.6 Transport

Roads. Moi South lake road is a class C loophole road providing access to Olkaria geothermal power plants, flori/horticultural farms, hotels and accommodation and to Hells Gate National Park and residential areas. The transport system is shown in Figure 15. In the 1940s while building the artillery camp, the Italians constructed a quarter of the mile of the South Lake road (Carnelley, 1993). The road was rough until early 1991, when it was tarmacked by the geothermal project under the World Bank fund. This led to the opening up of the area and tremendous growth of horticultural activities on the South Lake road. In the northern part of the lake, the road continues as a rough road after Kongoni.

The main road users include 'matatus' (public transport vans) who make several trips a day back and forth to Naivasha town, public buses (morning and evening) ferrying flower farm workers, heavy

trucks transporting power-house and greenhouse construction materials, tourist vans, commercial vehicles transporting flowers to and from Nairobi, private cars and cyclists (mostly by farm workers and hiking tourists).

The traffic volume decreases from town to the geothermal or Kongoni. This can be attributed to the number of farms, which have grown between the South Lake road junction from Naivasha town to the geothermal residential housing. The road between housing and geothermal power plants is much better despite complaints by people that it is the construction of the power plant that destroyed the road while transporting heavy equipment to site.

Part of the road is currently under grading from the money donated by the Lake Naivasha Riparian members with KenGen giving the biggest donation.

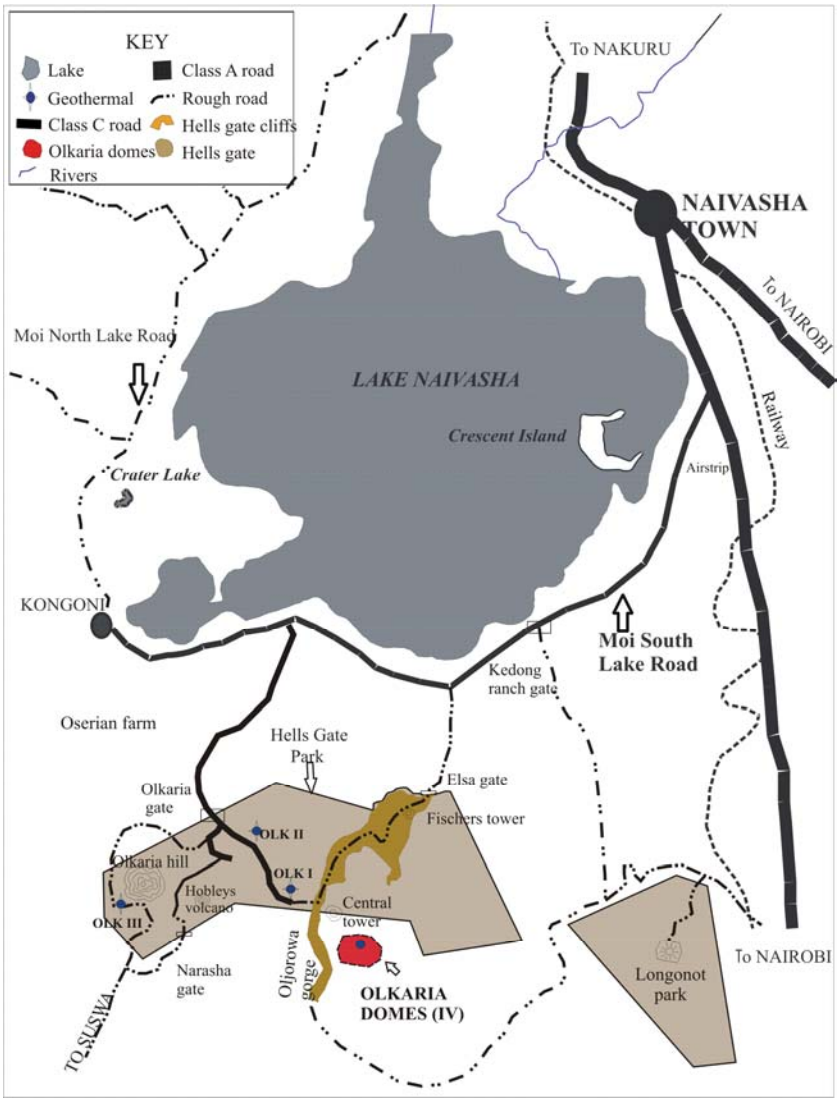

FIGURE 15: The transport system in the South Lake area

Airstrips. There is one public air strip within the jurisdiction of the municipal council. The airstrip is not frequently used due to poor maintenance. Other than that, there are private air strips owned by individual riparian lands owners with private aircraft.

Railroad. This is part of the Kenya-Uganda railway line. It arrived in Naivasha in 1899 and marked the beginning of the growth of Naivasha as an important economic centre. The railway is only being utilised for transportation of cargo. Passenger services stopped due to the poor condition of the coaches.

3.4.7 Health facilities

There are eight government hospitals in the municipality. These include Naivasha district hospital, Karakita dispensary, Rocal dispensary, Karati dispensary, Nyamathi dispensary, Maraiguchu dispensary, NYS, DDS, and prisons. There is a district hospital run by the municipality of Naivasha with a capacity of 100 beds. These health facilities are not adequate for the population. The most prevalent diseases in the district, according to the public hospital statistics in order of rank are respiratory, malaria, skin infection, diarrhoea, eye infection, intestinal worms, unrinary tract infection, ear infection, rheumatic pain and HIV aids. The percentages are presented in Figure 16.

The health statistics cannot be indicative of the actual cases because many sick persons do not visit the hospital. Some prefer to either adopt "a wait and see" attitude, buy medicine, use traditional medicine or go to private doctors.

Institutions in Hells Gate have small dispensaries for their staff. These clinics cannot handle major cases which they most often refer to the district hospitals or Nairobi. Health and sanitation in the area in the low-income housing is on the decline due to poor sanitary conditions and access to clean drinking water. This may lead to an increase in water borne or water related diseases.

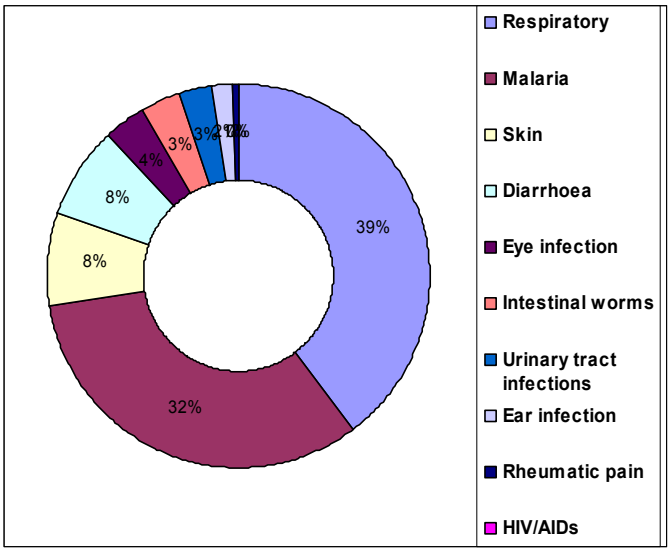

FIGURE 16: Top ten diseases in Naivasha Municipal Council in 2000

3.4.8 Sewage and sanitation

Sewage and sanitation in the Hells Gate location is not in the municipal system because it is located outside the town setup. The location was not part of the municipal council until recently and hence the council had less influence on the infrastructure. Most of the stakeholders in this region have their own sewerage systems which are mostly soak pits, septic tanks and pit latrines.

Only 10% of Naivasha town residents are connected to the sewage system with approximately 1200 connections. The rest of the residents are using pit latrines or septic tanks. The sewage system includes modern mechanical aeration ponds with stabilization lagoons. Currently, the sewage system is not functional and the council is looking for funds to repair it. During the rainy season, the floodwater from the sewage is drained into the lake. The estimated cost of rehabilitation of the sewage is about Kshs 6,759,500 (USD 84,500). The municipal council cannot meet these costs because it operates on an annual budget of Kshs 70 million (USD 875,000). The council has made an appeal to the stakeholders for assistance and is still awaiting response (Naivasha Municipal Council, 2000).

The rehabilitation of the sewage will help in reducing biological pollution of the lake and improve the general welfare and health of the people living around the facility.

3.4.9 Recreational facilities

There are no public recreational facilities along the Moi South Lake road. All facilities are either private or beyond the reach of the majority of the residents because of high costs. These are tourist facilities and in some facilities, entry at the gate is restricted. However, some institutions have started clubs for their employees, such as KenGen, Oserian, Sher agency, Orpower and a few others. The Oserian flower farm has a football pitch and a team in the national league. The majority still do not have access to recreational facilities.

In Naivasha town the stadium was allocated to a secondary school by a presidential decree and hence there is none at present. Delamere farm has donated 26 ha. of land towards the construction of a new stadium. The design of the new stadium has been made but there are no funds for construction (Naivasha Municipal Council, 2000).

There is a community hall with a sitting capacity of 200 which is grossly under utilized because it has no facilities and requires urgent renovation and fencing. There are no parks within the town area. The council plans to collaborate with the riparian land owners to open access to the lake to the public.

3.5 Population characteristics

Figure 17 depicts the 2004 population projections based on the 1999 population census. The census estimated the population of Naivasha at 103,701 persons. Projections done for 2004 by the Nakuru district statistical office estimated the population in 2004 to be at 200,640 at a growth rate of 5.68%. Several studies have quoted 250,000 using different projection factors. This growth rate is not only based on normal growth within the district but migration factors. The average population growth rate in Kenya is at 3.8%. This is a typical population structure of a developing country. The life expectancy in Kenya is 47-59 for males and 48-63 for females (Ministry of Planning and Development, 1998). A high fertility rate of 7, low expectancy rate, and high child mortality rate are the main factors for the trend seen in Figure 17.

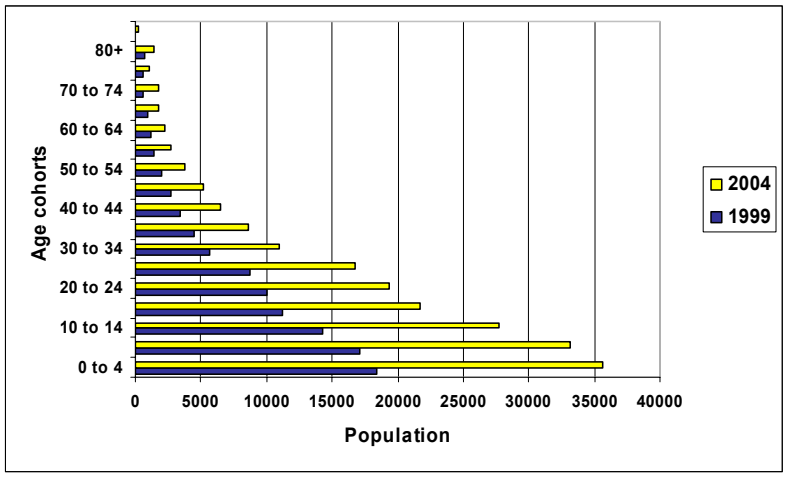

FIGURE 17: Population projection by age cohort

Immigrants of diversified mix live in the area. These include whites who are mainly farm/property owners or executives, Asian businessmen, diverse ethnic communities like Kikuyus who are mostly doing business, Luos, Kisiis, Kambaas, Luhyas and others who form the majority of the flower farm labourers, and finally the Maasais who are staying on private land without authorization. The area's population has risen from 20,000 to 250,000 in the last two decades. The rise in population is mainly attributed to migration of people seeking work in the flower farms due to an increase in flower and horticultural farming. It is obvious that the small settlements mushrooming are not solely occupied by flower farm workers who constitute 90%, but also small traders, hotel workers, a very negligible ex-labour force from Olkaria II project, etc.

The labour composition is mostly from Luo, Kisiis and some Kikuyus ethnic communities. Most of the labour force that comes from the western part of the country has a tradition of living with extended families. The rise in population has not been matched by an improved infrastructural development.

The rise in population has created booming business for Naivasha town, which has a symbiotic relationship with the Hells Gate location. The population boom has impacted on the area in the following manner:

- Increase in theft and robbery cases;
- Increase in solid waste and especially litter along the road;
- Pressure on land carrying capacity in terms of persons per square kilometres and clearance of vegetation for fuel wood;
- Pressure on physical infrastructure;
- Degradation of property value due to overcrowding and growth of slums;
- Increase in traffic volume and matatus (van public transport) to meet population transport requirements;
- Increase in lake and borehole water abstraction;
- Pollution of both lake (washing and bathing at the lake) and groundwater (due to increase in pit latrines).

3.6 Economy

Agricultural development and catering and accommodation are the key sectors along the Moi South Lake road. It was not easy to give a specific value to all the economic activities of Hells Gate location and more specifically in terms of VAT, employment opportunity, employees' salaries and taxes paid from the salaries, etc. The data could not be obtained from the relevant ministries.

Horticultural and floricultural export is the major foreign exchange earner for Kenya accounting for about 12% of Kenya's income. The horticultural export has grown from about 1400 tonnes in 1968 valued at 2.5 million Kshs, to about 85,000 tons in 1996 valued at 8.8 billion Kshs.

The region employs 30,000 workers on the farms who have at least five or more dependants. The growth of Naivasha town is a result of the Lake which has attracted foreign investment in flower farming. The area directly and indirectly supports a population of over 500,000. Flower growing has overtaken coffee and tourism as a source of foreign exchange for Kenya and ranks second only to tea, according to the Kenya Flower Council. Last year, Kenyan sales of cut flowers abroad were worth USD 110 million (£77million), or 8% of export earnings.

In power production, KenGen has about 400 employees, and generates revenue to the government from the sale of 277 GWh of electricity per year. The implementation of Olkaria II with 70 MWe increased the output to 682.75 GWh in the July 2003 - June 2004 fiscal year. Orpower has approximately 15 employees and is currently generating 13 MWe.

The revenue from tourist activities, e.g. hotel accommodation, park entry earnings have also contributed significantly to the region.

3.7 Labour force

Statistics on the labour force could not be obtained from the Ministry due to a lack of data. However, an estimate of 20,000 farm labour force alone was given by the LNGG representative during the interview. This figure could be indicative of the labour force of the LNGG members and does not cover the non-LNGG and new growers. According to the Naivasha council development plan, the area supports a total of 30,000 people in farming. LNGG has 25 members out of the known 40 farms. In view of this, the labour force estimated by the Nakuru district statistical office using population age groups between ages 15 and 59 is used as an indicator. The estimates shown in Table 4 below are based on a comparison between the 1999 census and 2004.

TABLE 4: Population of the labour force - age group 15-59

	Male	**Female**
2004	48,157	47,608
1999	23,408	21,733

Though the comparison does not give the specific category for the study area but the division as a whole, it can be used as a general indicator of the demand for a labour force in the area which has doubled due to an increase in agricultural activities in the South Lake area, which is the receiving area. The labour force on commercial farms is mostly composed of women who work on a casual basis while most of the men get permanent jobs. Most of the labour force type is unskilled. The women are preferred because of their ability to handle the product carefully and give attention to the crops. The general income of the labour force is less than USD 50 per month for unskilled labour to over USD 5000 for a foreign executive. The unskilled labour requirement fluctuates between high and low seasons. The rest of the people in this age group based on the table above are self-employed, running

private businesses, working in hotels and conservation centres, working for KenGen and KWS among other small activities, including non-employed.

A breakdown on the labour force in the South Lake area based on estimate figures is presented in Table 5. As explained above, the labour force is not indigenous and hence immigrants are of both local and international origin. Hours of labour vary with the type and season of employment, however, in most cases, employees work in shifts if and when required. According to the estimates, agriculture has the highest labour force while the rest of the activities is only 18% of the total labour turnover in the area.

KenGen labour composition is both technical and non-technical. This has been categorised into two groups, management and union. The management is composed of highly technical staff and support staff. The company's Olkaria branch has about 400 employees running the two geothermal power plants and carrying out geothermal resource assessments. The non-agricultural employment category based in the Naivasha urban setup is summarized in Table 6.

TABLE 5: Labour estimates in the South Lake area

Activity	Labour force estimates
Farming	30,000
Hotels	1,000
KenGen	400
Ormat	15
KWS	50
Livestock production	150
Small trade	5,000
Fishing (official)*	40
Total	**36,655**

TABLE 6: Non-agricultural employment in Naivasha town

Occupation	%
Professional	2
Administrative	3
Retail trading	50
Service industry	20
Manufacturing	10
Small business, artisans, construction work	10
Transport	5
Total	**100**

Source: Naivasha Municipal Council, 2000

3.8 Public safety

There is an increase in insecurity with the increase in population. Crimes like car jacking, robbery with violence, burglary, rape and petty theft are on the increase. The nearest police station is Kongoni to the southwest and Naivasha town, both of which are on the extreme ends of the location. Complaints about drug and alcohol (illicit brew) use and abuse in the area were also mentioned during the field work. This poses a danger to the residents of the area and will increase the juvenile delinquency rate if not abated in good time.

The increase in traffic volume, both vehicular and bicycles, have increased the rate of road accidents. The cyclist accidents can be attributed to a lack of well developed and defined cyclist paths. The majority of the unskilled labour force use bicycles as a cheap mode of transport. Hardly any human-wildlife injuries are reported.

3.9 Naivasha Municipal Council

Currently, the municipality covers an area of 941 km^2 of which 700 km^2 is land and 241 km^2 lake area. This makes it the biggest municipal council in Kenya in terms of land coverage. The town was founded as a result of the construction of the Kenya – Uganda railway which reached the area in 1899. It then grew as a white settlement and was made Naivasha district. Some milestones are:

- In 1963 Naivasha lost its district status due to federal boundary redefinition;
- In 1979 it became an urban council with 6 elected and 2 nominated councillors;
- In 1980 the town was made a town council by presidential decree;
- In 1982 the town was gazetted and its boundaries extended from 250 km^2 to 941 km^2;
- In 1993 the town was elevated to a full municipal council status with a Mayor, and the jurisdiction of the council was extended to the neighbouring agricultural land and the Hells Gate National Park.

The council has 212 employees with over 90% in low-grade employment. There are four major departments, the town clerk, town treasurer, town planning, works and conservancy and social services, education and housing departments. Though the council covers an area with great economic output, the council has suffered a shortfall in its budget and lacks the capital to improve the infrastructure in the area. Revenue collection is poor and not well organised. Most of the stakeholders have met their own infrastructural needs especially along the Moi South Lake road and hence the council may not have a basis for revenue collection. However, the stakeholder should support the council's projects.

4. SOCIOECONOMIC IMPACTS OF THE PROJECT

4.1 Overview

Based on the above socioeconomic conditions without the project, this chapter evaluates the possible socioeconomic changes resulting from an appraisal of the Olkaria IV (Domes) geothermal project. All stakeholders interviewed felt strongly that the power (drilling) project is of national interest and should override all other concerns. Despite this, the power project should take into consideration the needs of the stakeholders. This is not the first project to be implemented by KenGen in the area. The company has so far implemented two geothermal projects Olkaria I (45 MW) and Olkaria II (70 MW). During the implementation of these projects, the company met several social responsibilities, e.g.:

- Provision of Orpower with an average 150 m^3 water per month for power station use;
- Construction and maintenance of Mvuke primary and nursery schools which are open to all stakeholders;
- Construction of Moi South Lake road and was recently the biggest contributor towards its repair;
- Provision of pipe water to the Maasai community at the Kedong and Narasha, including other ad hoc but necessary services like transport and access to Mvuke primary school;
- Extensive research on the land resources and characteristics;
- Provision of decent housing carefully planned for its employees which has improved the areas general outlook;
- Donation of seedlings to the region and the rift valley province.

All stakeholders agree that KenGen has immensely contributed towards social responsibility in the area and has stayed in the lead in this regard.

Since the three projects will be on the same geothermal field with a reasonable infrastructure and development, negative impact will be temporary and may not change the ambiance of the area in view of other existing development. However, before the evaluation of the impacts, the stakeholders' needs and fears were assessed and highlighted in Table 7. The socioeconomic assessment has been done in consideration of these needs and fears. This analysis provided the framework of the stakeholders' expectations of KenGen. The anticipated socioeconomic impacts of Olkaria IV drilling project are discussed below.

TABLE 7: Summary of primary stakeholder needs and fears

Primary stakeholder	Underlying needs	Underlying fears	Current status
Maasai community	o Land security and recognition as the natives of the area o Freedom of passage to grazing & watering points o Basic amenities	o Relocation or loss of settlement by private land owners	o Occupation on private land.
Kenya Wildlife Service	o Enforce conservation policy o Conservation and minimal disturbance of flora and fauna o Revenue earning from tourists groups o Re-vegetation of the park o Provision of geological info about the park by KenGen	o Loss of grazing land o Soil erosion o Modification of the physical landscape o Loss of animal corridors o Possible animal accidents	o KenGen and KWS have a MOU governing KenGen activities in the park o Additional revenue earned by KWS from power plants visits
Kedong ranch	o Land ownership litigation with Maasai settled o Compensation based on current economic land rates o Some compensation for the geothermal resource	o Opening up of the area will encourage more unauthorised settlements.	o Land acquisition ongoing. o Pending court case of eviction of Maasais' squatting on the land
Lake Naivasha Riparian Association	o Preservation of the riparian land and ecosystem o Water pollution o Minimal abstraction of Lake water	o Loss of riparian land due to over abstraction and increasing development	o KenGen is a member o No water pollution is expected o Short term water abstraction limited to drilling months
Hotels/Lake Naivasha tourism group	o Preservation of the park o Market Naivasha as a tourist destination o Maintain a safe and relaxing atmosphere for tourists	o Degradation of the area due to many developments	
Lake Naivasha growers group (LNGG)	o Sustainable use of lake water o Less heavy vehicular use of the Moi South Lake road. o Adequate labour force	o Expansion, development and population growth in the area. o Increase in lake water abstraction o Damage of road by heavy vehicles during drilling and power plant construction	o Code of conduct o Depend on the road for quick transportation of flowers to Nairobi. o 25 members
Non LNGG growers	o Access to water resources o Labour force	o Unknown	o Don't belong to any group in the area o Not governed by LNGG´s code of conduct and operate freely
Fisheries	o Protection of fish breeding grounds	o Fish poaching o Heavy suction water pumps on breeding grounds o Water pollution from riparian members	o Imposed ban of fishing since 2002 o Lacks adequate personnel to monitor poaching
Conservation groups	o Minimum destruction of wildlife habitat	o Expansion of development	o Wildlife and ecological conservation

4.2 Population

Since the geothermal drilling project is not expected to be labour intensive, the project will not bring about any change in the population status of the area. The contractors' team will be accommodated in the KenGen housing facilities or local hotels and will demobilise after the completion of the project. The rest of the project workers who are mainly KenGen stuff already reside in the area.

The project is not expected to disrupt the social routine and network of the population in the area. The access road from Olkaria 1 to site, as discussed below, is not expected to cause any population influx in the area or open it up (as is common with new roads) because the road passes through the park and ends in Kedong ranch which is a private property.

4.3 Education

There will be no increase in school enrolment as a result of the project because it is neither expected to bring additional people into the area nor last beyond a year. KenGen has already constructed a primary and nursery school which is open to all children from the region. The drilling project, just like Olkaria 1, is likely to attract academic interest and hence serve as an opportunity for learning for schools and other institutions of higher learning.

4.4 Labour force

Three categories of labour force will be used in the project. These are contractors from the rig company, KenGen staff and some casual workers for the civil jobs. The income for each category will be different. The contractor will be paid according to the signed agreement in the contract and mode of payment, KenGen staff will not receive any special remuneration and will depend on regular salary. If any casual labour force is needed, the remuneration will be based on the regional casual labour rates. These are subject to the current market rates.

The project will not create any significant job opportunities due to its technical and short term nature. A total of 36 people will be expected to work in shifts in accordance to the labour laws. The lifespan of the project is one year and could be less with a better drilling rig. Drilling of the production well may not take place soon after appraisal drilling. It will be determined by the success of the appraisal wells and availability of funds.

4.5 Land and compensation

Negotiations on land acquisition are still going on with Kedong ranch and compensation will be made as soon as both parties close the negotiations. The sale of land will be an additional income to Kedong ranch which owns a vast track of land. The land under negotiation is only grazed by wildlife and some Maasai livestock. There are a few semi-permanent Maasai manyattas on Kedong ranch. The dispute of the land between Kedong ranch and the Maasai´s is still unresolved.

Since crop production activities are located about 5 km from the project, no agricultural land will be lost and hence no crop loss and hence no compensation is expected. The economic cost of land to be acquired and modes of compensation are still being determined.

The project will not cause additional stress on the land carrying capacity of the study area beyond which harm will occur. The project will not lead to population increase. Hence, the land will not be stretched beyond its tolerance limits due to a demand for infrastructure within the project area.

4.6 Tourism/recreation

The proposed project is adjacent to the park where most tourists visit as a form of recreation. Some of the major tourist attraction sites like the Ol-Jorowa gorge and Central Tower are within proximity of the Domes. Current access to the Domes from Olkaria 1 passes through these scenic sites. There are

no game lodges in the project site (Domes area) and no indication of future plans as the land is reserved for grazing by the ranch.

Truck traffic during the months of construction, drilling and well testing activities for each of the Olkaria Domes wells may impact on recreationists. The potential conflicts would most likely occur during the high recreational periods.

The tourist perception of the area could be altered from a natural setting to one with a developmental look. However, tourists have continued visiting the park despite the existence of three power plants. The general public and tourists should appreciate both the need for recreation and development.

There is no doubt that previous geothermal projects have resulted in increased business in catering and accommodation services in the area. The current project is expected to have a similar impact on the area.

4.7 Roads and traffic safety

The key roads for this project are Moi South Lake road and the access road to the Domes. Though the site can be approached through Elsa gate, Kedong ranch main gate, the access road from Olkaria 1 will be used. The access road is an earth road from Olkaria 1 power plant through the Hells Gate National Park into Kedong ranch. Only part of the access road has been developed. Upon completion, the road is expected to be 4 km long and 6 m wide, with a number of 500 m branches into the well pads. The upgrading of the access road will improve access to tourist sites and the Kedong property.

Assuming all of the proposed well sites and roads will be constructed as specified, an estimated 30 acres of vegetation will be removed. The construction, operation and maintenance of the road and well site will have a long-term impact. The area has a high risk of water and wind erosion even without the project. Impacts would be minimized, but not eliminated, through drainage control measures during construction and maintenance.

The actual impacts will be determined by the number of trips per day to and from the site from Olkaria I and from Naivasha town. This will depend on project requirements and inputs and the length of the project. There is obviously going to be some increase in vehicular movement to the site through the park and hence some change is expected. The vehicular movement from Naivasha town to site will not be frequent since all the drilling material will be brought and stored in Olkaria 1 and hence no impact is anticipated in terms of traffic volume on the Moi South Lake road.

The vehicular movement from Naivasha to Olkaria 1 will not cause any changes in the already existing air quality. However, movement from Olkaria 1 to the site may create some dust because the road is made of earth and has loose volcanic soils. This will not cause any significant impact to anybody since the area is inhabited, but may cause some nuisance to rangers. Noise generated by vehicular movement will not cause a psychological nuisance to anybody since the access road is kilometres away from residential and agricultural areas. The more likely areas to be affected are the post of the gorge rangers and view points. Other areas like Oldubai and Nabruita campsites will not be affected by traffic noise and dust. To avoid the above impacts the following needs to be considered:

- The traffic will be expected to abide by the speed limits and by the laws of the area;
- Movement of heavy construction traffic must be planned appropriately;
- Prevention of soil erosion during upgrading and use of access road and, by regular watering to avoid impact of dust. Maintenance responsibilities must be established and it ensured that rehabilitation takes place as soon as possible.

4.8 Agriculture and livestock production

There is no crop cultivation at the project site and hence there will be no requisition of a farm land. However, the area along the Moi South Lake road has large commercial farms. Several studies and experiments done on the impact of geothermal activities on crops indicate that the geothermal resource and H_2S do not cause problems. This has been confirmed by activities in places like Iceland where geothermal water is used in greenhouses for heating. The Oserian flower farm is planning a geothermal project for utilization of geothermal energy in the greenhouse in order to control humidity to stop fungus infection and reduce use of fungicides, subsequently meeting the European market standards on the use of biocides.

The drilling operations would be a temporary disruption to livestock operations. A total of over 50 acres of livestock forage would be lost if all planned production wells were drilled.

4.9 Energy and economy

The project will not reap immediate benefit in terms of electricity production. In the long term, the project will contribute additional 70 MWe to the national grid. Currently, only 15% of Kenyans have access to electricity from the current installed capacity of 1218 MWe. Geothermal only contributes 11% of the total with an installed capacity of 128 MWe. Energy is a means to development. This will bring a positive net benefit by reduction of the use of petroleum fuels which are non-renewable and subject to high price fluctuations, and consequently a reduction of pollutants emitted into the atmosphere through combustion of the fossil fuels.

Diesel generators will be used at the drill site. The transportation and storage of these will be handled according to the relevant safety requirements. The amount of emission from combustion of the diesel on site will be insignificant in relation to the ambient air quality of the area and the short duration of use. The figures on actual emission reduction will be calculated once the resource and its capacity have been confirmed.

4.10 Aesthetic/Visual impact

The Visual Absorption Capacity (VAC) of the Domes and surroundings is very high due to the vegetation cover and hilly nature of the terrain. Additionally, using equipment with neutral, non-reflective colours that blend with the surrounding rocks or trees would reduce the visual impacts of the drilling facilities. The drill rig and drilling operations for the Domes wells would be a temporary visual impact to park visitors. Dust from the air drilling operations would be visible to the KenGen workers at Olkaria I and II and Orpower, KWS, Kedong ranch, Nabruita, Ol Dubai camp sites, View points, Gorge rangers post, Maasai cultural centre, Maasai pastoralists and some private landowners.

The water pipeline running along the slope in the area would also have a visual impact. KenGen has ensured that the colour of the pipe will blend in well with the colour of the ground to minimize the impact. The cost of minimising visual impact should be determined.

4.11 Archeological/historical/cultural sites

To comply with the national museums act and the national environmental management and coordination act, impacts on archaeological, historical and cultural sites must be documented. An inventory of archeological / cultural artefacts is recorded in Appendix 6.10 of the EIA report for Olkaria II project (KPLC & Sinclair Knight Merz, 1992). During field work, no archaeological, historical or cultural sites have been identified within the Olkaria Domes project site or anywhere in

the vicinity of the project. The Maasai cultural centre is a manyatta started for business purposes and is located on Ngati farm and hence unauthorised. There is still pending a dispute between the farm and the manyatta owners. The project will not extend to the cultural centre.

However, the KWS should engage a professional archaeologist or historian to try to identify such resources and evaluate their value to the area and society at large. The most important sites in Hells Gate are geological formations like the Central Tower, Fischer's Tower, Ol Jorowa gorge, obsidian caves and areas of thermal manifestations, none of which the project will interfere with.

4.12 Summary of impacts

From the above, an impact matrix based on temporal, spatial and severity scale has been developed as shown in Table 8, using the following criteria:

a. Scale and/or significance of the impact?
b. Probability and/or frequency of occurrence?
c. Duration of the impact?
d. Potential regulatory or legal exposure?
e. Difficulty and/or cost of changing the impact?
f. Effect of change on other activities and processes?
g. Concerns of interested parties?
h. Effect on the public image of KenGen?

TABLE 8: Impact matrix, developed for the Domes project

Temporal scale	**Duration (years)**
Short term	0-5
Long term	5-20
Permanent	20+
Spatial scale	**Matrix**
Household/individual	1
Hells Gate location	2
Municipality	3
Regional	4
National	5
Severity scale	**Matrix**
Large positive impact	+3
Moderate positive impact	+2
Slight positive	+1
No impact	0
Slight negative impact	-1
Moderate negative impact	-2
Large negative impacts	-3

The summary of the socioeconomic indices and associated impacts is displayed in Figure 18 and in Table 9. The values on the X-axis in Figure 18 represent the spatial scale as shown in Tables 8 and 9, while the values on the Y-axis represent the severity of the impact as illustrated in Table 9. The severity is presented on a scale between -3 to +3, the maximum impacts (negative and positive). From the above summary, it is clear that positive impacts, though short-term, outweigh negative ones.

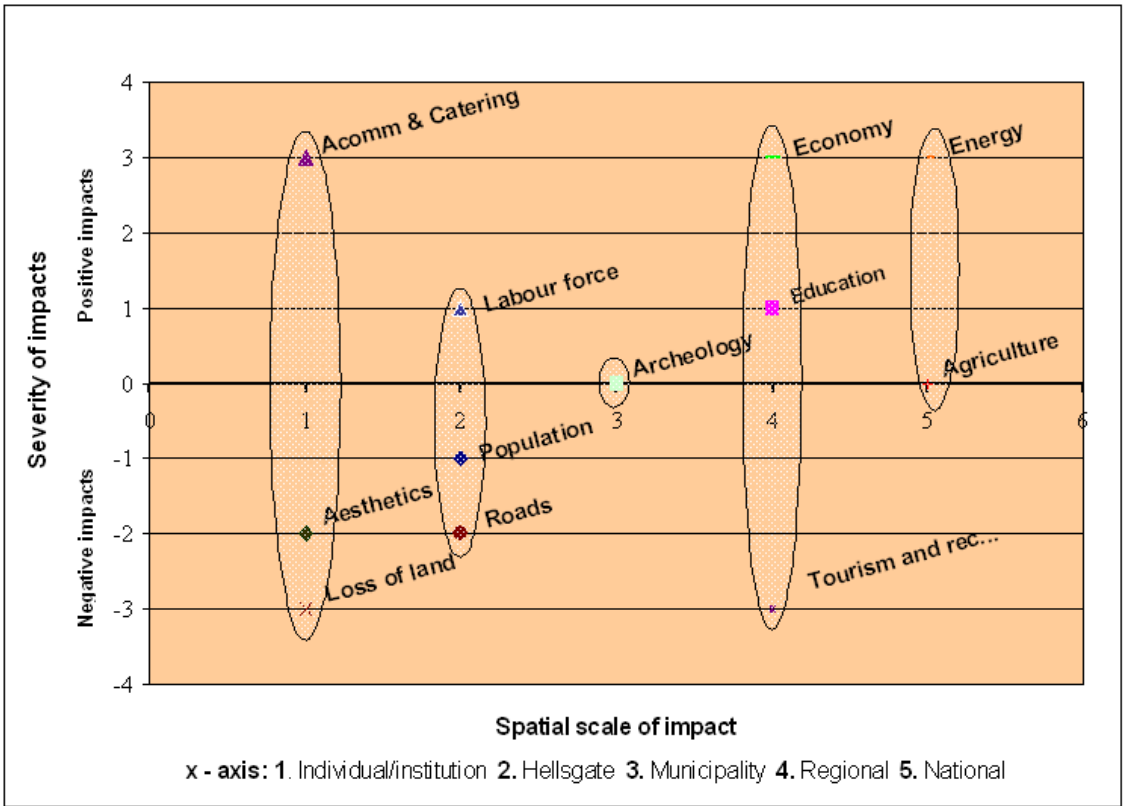

FIGURE 18: Summary of impacts

TABLE 9: Results of impacts for the Domes project, based on the matrix defined in Table 8

Indicator	Spatial scale	Severity scale	Temporal scale
Population	2 and 3	-1	Short term
Education	4	+1	Long term
Labour force	2	+1	Short term
Loss of land	1	-2	Permanent
Tourism and recreation	1 and 4	-3	Permanent
Roads	1 and 2	-2	Long term
Agriculture	5	0	0
Energy	5	+3	Long term
Economy	4	+3	Long term
Aesthetic/visual	3	0	Long term
Archaeological/historical/cultural	3	0	0

4.13 Social responsibilities of other institutions

Some institutions and individuals have contributed by constructing class rooms, educating girls or through the payment of teachers. One such institution is Orpower. Oserian built 3 primary schools, a shopping centre and health facilities for its 6,000 workers. Members of the LNGG have also contributed generously towards construction of schools and health facilities and by making contributions to the Naivasha Street Children's Home among others. Several institutions have contributed generously to different causes but all the contributions cannot be highlighted in this study. One of the most outstanding individual contributions is by Peter Robertson and it goes beyond physical and financial values. Mr. Robertson is not only constructing a new permanent classroom building for the Narasha primary school but ensures that teachers reach the school in good time by providing transport, and also to visit the school children and assess their progress.

5. ENVIRONMENTAL RISKS OF THE PROJECT TO NATURAL RESOURCES

5.1 Risk to water resources

Drilling will require fresh water from the lake of up to 1000 m^3 per shallow well and 3000 m^3 for deep wells. The lake has no outlets and has shown a large variation in levels without significant abstraction over the years and is expected to show similar variations in future even in the absence of a power station and socioeconomic activities in the area. Drilling mud, additives, cuttings, cement, oil and grease will be passed through a sump system where drill cuttings and mud particles will settle down and the viscous drilling fluid be recycled back into the system.

No significant change will be expected since drilling activities will only last for about one year. During drilling, KenGen will abstract steam from a deep aquifer at an approximate rate of 8 kg/s per 3.5 MW. The steam field is not connected to the lake and is not expected to affect the water balance of the lake. The lake is like a small pan several kilometres above the deep aquifers and hence has no direct relationship. Studies by Arusei (2001) reveal that groundwater flows from the northern part into the lake while the resource is located in the outflow zone. However, farming activities springing up in the north and using borehole water may affect the lake level because the lake is recharged from the north. KenGen also plans to have re-injection wells ready once production starts, to recharge the aquifer.

In order to limit degradation of the resource, simulation of reservoir performance at different exploitation capacities has been done. Sustainable management of the reservoir by maintaining an adequate balance between geothermal fluid withdrawal and recharge of disposed fluid will be carried out once operation begins. Re-injection wells will be drilled after monitoring reservoir flow patterns to avoid cooling of the resource and excessive hydrothermal pressure. There is risk of water pollution from heavy metals like As, B, Hg, Zn, Pb, Cl, Li, etc. from geothermal fluid. Reinjection is, however, the most effective means of controlling the release of heavy metals into the environment.

The fisheries' concern was that water suction would also pull young fry and eggs; KenGen has a wire mesh at the abstraction point to avoid this.

KenGen is a member of Lake Naivasha Riparian Association (LNRA) with other stakeholders who own riparian land. LNRA has a community-based management plan - Lake Naivasha Management Plan (LNMP), for sustainable use of the lake. All the requirements of the management plan and other water resources will be taken into consideration.

5.2 Risk to soil resources

The potential for soil erosion in the area is high. Soil erosion may increase during construction and drilling phases of the project. However, drainage control and soil conservation measures will be provided. The erosion will not affect the sedimentation yields of Lake Naivasha due to adequate vegetation cover around the area and the drainage direction from the field. The costs of soil prevention measures and reforestation should be included in the total project cost.

5.3 Risk to air quality and noise

The main risks to air quality include emissions of non-condensable gases and dust. If bedrock is encountered during construction of a reserve pit and blasting is required there would be noise from the explosives and increased dust from the explosion. Dust would also be generated during the drilling of shot holes for the charges and by traffic movement.

The noise from drilling and testing operations would have a short-term impact lasting approximately one year. Noise levels measured during exploration drilling at different sites around the site are summarised in Table 10.

TABLE 10: Noise level during exploration drilling of Olkaria Domes

Site	Noise level (dB)
Drilling site	80-96
Nabruita	40
Oldubai camp	45
View point	52
Gorge rangers post	35
Maasai cultural centre	45

Source: Data from Olkaria Environmental section

The major offenders of geothermal non-condensable gasses are H_2S and CO_2 while minor ones are CH_4, Hg, Rn, NH_3 and B. Emission of H_2S, CO_2 and other gases is of concern to KenGen workers on site and wildlife. Adequate measures to control accidental leakages must be put in place by the drilling team. The workers should not be exposed to H_2S concentrations above the occupational exposure limits of 10-15 mg/m^3 (7-10 ppm). Exposure to the community will be a minor nuisance since there are already three power plants in the area as well as emissions from natural thermal manifestations. H_2S in ambient air in concentrations on the order of the odour threshold does not have any significant biological impact on man or animals. Effects of H_2S are summarised in Table 11.

TABLE 11: Effects of H_2S on humans and wildlife

Concentration (ppm)	Effect
1-10	Offensive odour
10-20	Occupational exposure limit
20-100	Ceiling of occupation exposure limit, a worker must wear breathing apparatus
100-200	Loss of sense of smell in 2-15 minutes. May burn throat and chest, and cause headache and nausea, coughing and skin irritation
200-500	Loss of reasoning and balance, respiratory disturbance in 2-5 minutes, prompt resuscitation required
500-700	Immediate unconsciousness with one sniff. Causes seizures, loss of control of bowel and bladder. Breathing stops and death will result without resuscitation efforts
700-1000	May lead to immediate unconsciousness. Death or permanent brain damage may result unless rescued promptly
1000-2000	Immediate collapse with respiratory failure

Source: KenGen, report no. Geo/8/009b

Measurements of H_2S concentration in ambient air are a part of routine monitoring. During drilling, measures to prevent gas leakages will be enforced. Air pollution modelling within the area has been carried out. Protective equipment such as gas masks and ear plugs will be used. Gas analysers and noise meters will be used to measure ambient air pollution levels.

Annual CO_2 emission from geothermal plants is not high compared to oil-fired plants. This makes geothermal power the preferred option with regard to environmental and health aspects.

5.4 Risk to wildlife and biodiversity

The Hells Gate and Longonot National Parks were gazetted in 1984, three years after commissioning Olkaria I Power Station. This imposes constraints on operation management of the power station and park. An environmental impact (EIA) study was made according to World Bank operational directive 4.0 for proposed development in Olkaria II, which concluded that geothermal development is feasible within Hell's Gate Park.

KenGen and Kenya Wildlife Service (KWS) signed a Memorandum of Understanding (MoU) in 1994 which outlines the harmonious operations of the two parties for the mutual benefit of the country. Envisaged environmental impacts and mitigating measures to be undertaken, and areas that require collaboration between KenGen and KWS to ensure that no conflicts arise during operations, are clearly stated in the agreement. The chairmanship of MoU meetings is rotational between KenGen and KWS divisional heads depending on the venue of the meeting. The MoU document is always attached to the tender document issued by KenGen for geothermal projects in order to inform contractors of environmental obligations within the Park. KWS is currently reviewing the MoU document especially with regard to incoming IPPs such as Or Power in Olkaria III.

Though the current project is outside the park, KenGen will uphold the conservation and protection value of both flora and fauna. The proposed well locations are within a general area which provides habitat for a variety of wildlife species including birds, mammals and fish. The cliffs provide nesting grounds for birds and especially for vultures.

The primary impacts that could result from the proposed action are direct loss and alteration of approximately 1.5-9 acres per well and the displacement of wildlife due to increased human activity and noise. Impacts would last from 3 to 5 years (time required for re-vegetation), if a well was drilled and then abandoned. The duration of impacts for producing wells could be 20 years.

Habitat disturbance would result in direct loss of smaller, less-mobile species such as small mammals and reptiles. More mobile species such as Kongoni, Zebra, Thompson's Gazelle, Giraffe, Eland, Reedbuck, Warthog, Impala, Dik dik, Stein buck, Klipspringer, buffalo, wildebeest, waterbuck would be displaced. Because of the high fecundity of small mammals and reptiles, their populations would be expected to recover quickly following reclamation.

A settlement pond will be constructed on each drill pad for storage and disposal of drill fluids. It is possible that birds and wildlife might consume the water or drown in it. At the end of drilling operations and prior to reclamation of the reserve pit, the pit should be fenced and the top of the pit covered or fenced to prevent access to birds and other wildlife.

There are no listed endangered species of plants or animals in the area.

5.5 Occupational health and safety risks

The most probable occupational heath and safety risks associated with geothermal drilling include small accidents, accidental gas emissions, induced seismicity, hydrothermal eruptions or landslides. In order to prevent these, the site contractor will adhere to local and international safety drilling regulations. Blowout prevention equipment will be used on-site and adequate emergency plans put in place. This will be included in the bid document as a prequalification. Other risks include subsidence.

6. ENVIRONMENTAL MONITORING PLAN

Due to the small magnitude of the project and its minimal implications on the socioeconomic status of the area, most socioeconomic variables like population, labour force demand, education, services and infrastructure will be monitored. KenGen expects to be ISO 9001:2000 certified by December 2004. All ISO requirements in regard to quality management will be effected. Procedures on environmental monitoring have been developed. An environmental monitoring plan includes the following:

Pre-project monitoring: Stakeholder consultations and disclosure. Ambient air quality monitoring, wildlife movements and soil erosion monitoring is on-going in the entire Greater Olkaria geothermal field and in the Olkaria Domes.

Project implementation monitoring: Monitoring of environmental variables during drilling and testing to determine changes which may have occurred as a result of the project. These will include traffic movement, community complains, soil erosion and management strategies, labour force requirements, accident cases, impact on wildlife resources, water use, solid and liquid waste management, and air quality.

Post project monitoring: This will involve continuous monitoring and measurements to ensure that the required legal requirements and standards are met and strictly adhered to. Environmental audits will be carried out as part of the KenGen routine audits in accordance to the National Environmental Management Authority Regulations and will be submitted to the authorities for scrutiny.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Geothermal projects do not cause adverse socioeconomic negative impacts. Therefore the Olkaria Domes (IV) drilling project will not cause any long term negative impacts. KenGen, through Olkaria I and II, has adequately met the key socioeconomic responsibilities and any benefits from the current project will be an added bonus to the region. A full EIA will be conducted upon completion of production drilling in preparation for the steam field development and power plant construction.

The study area has undergone tremendous social and economic revolution in the last two decades. The rate of economic development does not match the land and natural resource carrying capacity nor the rate of infrastructural development. The lake water is the most critical attraction for economic activities. Fishing has been exploited beyond sustainable means; population has increased beyond infrastructural development and services; and agricultural expansion has gone beyond land capacity.

Stakeholders have formed associations to manage and conserve the resources in the area and have a mutual coexistence/relationship with each other. The success of these associations will obviously depend on the determination of the stakeholders to conserve and save the area. Most of the inhabitants are not indigenous. Sustainable development of the area should be reinforced by all stakeholders and well-wishers. Mutual coexistence should be based on moral principles, values and environmental ethics. The stakeholders should not just be recipients of the project benefits but should also be accountable and accommodate interests and needs of each other including the project proponent's in this case KenGen. The degree of involvement and responsibility of each and every stakeholder should be very clear, not mere rhetoric. Benefits accrued should be obvious and of value to the region or recipients. The government should also intervene to ensure sustainable use of resources.

Further recommendations are discussed below.

7.2 Recommendations

7.2.1 Government

The infrastructural facilities in the study area have been developed by stakeholders without contribution from the government or the council. The government should do the following;

- Provide more infrastructure and social amenities with expansion of developmental activities in the area.
- Enforce environmental and water use regulations to ensure sustainable use of the resources in the area.
- Control developmental expansion in the area and relocate horticultural activities to other suitable and new places.
- The Moi South Lake road has not been upgraded since its construction. This should be done by the Ministry of Public Works every five years. Thus the government would support the stakeholders.
- The water bailiffs office should do random checks of water abstraction levels in the area to ensure that all developers are drawing water within the limits of their permits.
- Due to an increase in population and the rise of insecurity in the region, there is need for another police post in the area. This should be placed between the road to Mai Mahiu and the Kamere residential area.

7.2.2 KenGen

During the study, the following stakeholder concerns became apparent;

- Kedong ranch and the park have a lot of hills and gorges which should not be modified, as the area depends mostly on its unique physical/geological attraction. Stakeholders feel that any development undertaken by the institution in this location should not alter the physical landscape and therefore no bridges should be constructed.
- The stakeholders appreciate KenGen´s contribution in improving the general infrastructure in the area, especially the construction of the Moi South Lake road and the Mvuke primary school. However, during construction of projects, heavy vehicles and transportation of heavy equipment back and forth pose a danger to the road and its use. The road was constructed by the company in 1991 through a World Bank fund as a part of the project development.
- About 80% of stakeholders interviewed feel that KenGen should stop giving handouts to the Maasai community as it has created a dependency syndrome from which it cannot break free. The company should clearly define its social responsibilities and deliver it with caution. This should be done from the onset of the project in its role as a power generating company, not as a government development agency. Some stakeholders feel that KenGen should not provide the social responsibilities or disputed land.
- The KWS main concerns include loss of habitat, possible wildlife accidents including exposure to poisonous gases, roads and water pipes passing through the park near vulture cliffs and the Central Tower.
- KenGen should, in future, consider using green coloured roofs instead of red ones, for the benefit of stakeholders across the lake. Red roofs give the area a developed look.

7.2.3 All stakeholders

- All stakeholders have the ability to pull resources together and improve the infrastructure. Stakeholders should plough back a small percentage of their income into resource conservation and infrastructural development.

- In order to minimise the misuse of lake water, all users should meter their water consumption and employ water conservation techniques.
- Stakeholders can create a community road fund managed by the LNRA by establishing a toll station on Moi South Lake road as a self help community project.

LIST OF ABBREVIATIONS

EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
KENGEN	Kenya Electricity Generating Company Limited
KWS	Kenya Wildlife Services
IPPs	Independent Power Producers
LNRA	Lake Naivasha Riparian Association
LNGG	Lake Naivasha Growers Group
LNTG	Lake Naivasha Tourism Group
MoU	Memorandum of Understanding
NEMA	National Environmental Management Authority
NSSP	Naivasha Strategic Structure Plan

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