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ENVIRONMENTAL BASELINE STUDY FOR GEOTHERMAL DEVELOPMENTS: CASE STUDY ARUS-BOGORIA GEOTHERMAL PROSPECTS, KENYA

G.N. Wetang'ula[1], B.M. Kubo[1] and J.O. Were[2]
[1]Geothermal Development Company
P. O. Box 100746, Nairobi 00101
KENYA
[2]Kenya Electricity Generating Company Ltd. (KenGen)
P.O. Box 785, Naivasha
KENYA
gwetangula@gdc.co.ke, bkubo@gdc.co.ke, jwere@kengen.co.ke,

ABSTRACT

Arus and Lake Bogoria geothermal prospects are located North of Menengai and South of Lake Baringo within the Kenya Rift. Geothermal phenomena in form of fumaroles, hot pings, steam jets, geysers, sulphur deposits and high geothermal gradient expressed by anomalously hot ground and groundwater water characterized by temperatures above ambient in the area. As an effort to explore the geothermal potential areas in the north rift, the Kenya Government, through the MoE and KenGen carried out surface investigations in the area to determine its geothermal resource potential. The survey was conducted from the 14th February 2005 to 8th July 2005 and was co-funded by the Kenya Government and KenGen. An environmental survey to collect and compile baseline data was undertaken to ensure that any possible environmental concerns that can arise could be predicted well in advance. Results of the study indicate that anticipated environmental impacts could be significant within LBNR. However, social impacts are insignificant in magnitude. The impacts, however, could be effectively mitigated during civil works, drilling and testing of geothermal wells and power plant construction and operation

1. INTRODUCTION

1.1 Study objective and scope

The study objective and scope of the environmental baseline study included surveys on the following environmental and social aspects of Arus-Bogoria geothermal prospect:

- Socio-economic issues such as land use and tenure systems, population, natural resources, infrastructure, public services, transportation, historical sites of social significance, energy usage and demand.
- Flora and fauna of the prospect area including any rare or endangered species for conservation purposes; and
- Water resources, their quality and general drainage trends; and

- Climate and ambient air quality

1.2 Justification

The study objective was mainly to collate and analyse existing socio-economic and environmental baseline data for Arus-Bogoria geothermal prospect.

In addition, the baseline information would be used during full-fledged Environmental Impact Assessment (EIA) for the subsequent geothermal energy utilization. This would ensure that any developments undertaken are environmentally sound and socially acceptable as stipulated in the Environmental Management and Coordination Act, EMCA (1999), and operational guidelines issued by geothermal energy development partners.

1.3 Study methodology

The social and environmental baseline data for the prospect area was acquired through site assessments and consultations with public officers, representatives of Non-Governmental Organizations (NGOs) and local community leaders.

2. BIOPHYSICAL ENVIRONMENT

2.1 Climate

Baringo and Koibatek Districts are arid and semi-arid. Two seasons of rainfall are experienced. The long rains start at the end of March to the beginning of July, and the short rains from the end of September to November (Figure 1). The rainfall is about 50% reliable. The rainfall varies from 300-750 mm in the Rift Valley floor near Lake Bogoria to 1200 mm in the highlands near Eldama Ravine town. The monthly rainfall recorded at Loboi station near Lake Bogoria as shown in Figure 1.

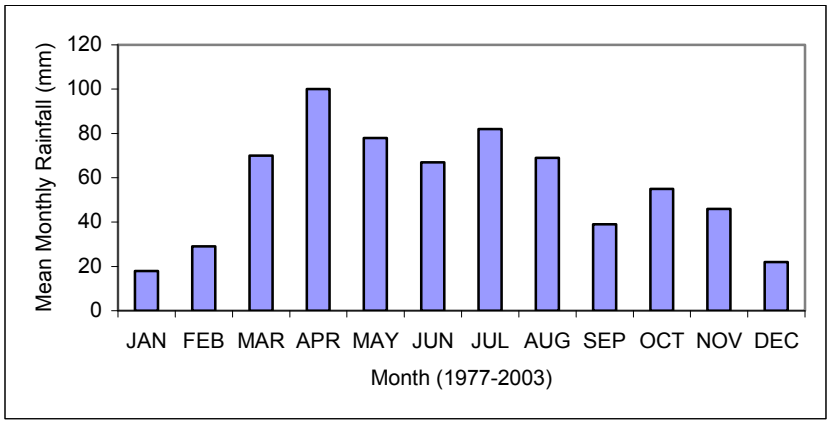

FIGURE 1: Lake Bogoria mean monthly Rainfall at Loboi Station from 1977-2003

Temperature varies from 15ºC to 35ºC and follows the rainfall pattern. The temperature is relatively cool from June to October and hot from December to March. The average temperature is about 28ºC for the most part of the year. The temperature and rainfall regimes in the vicinity of Lake Bogoria National Reserve combine to give Lake Bogoria a hot, arid to semi-arid climate. The evaporation in the area varies from 1,800 mm to more than 2,200 mm per year. The mean annual evaporation is estimated at 2,020 mm per year (JICA/MOARD, 1999).

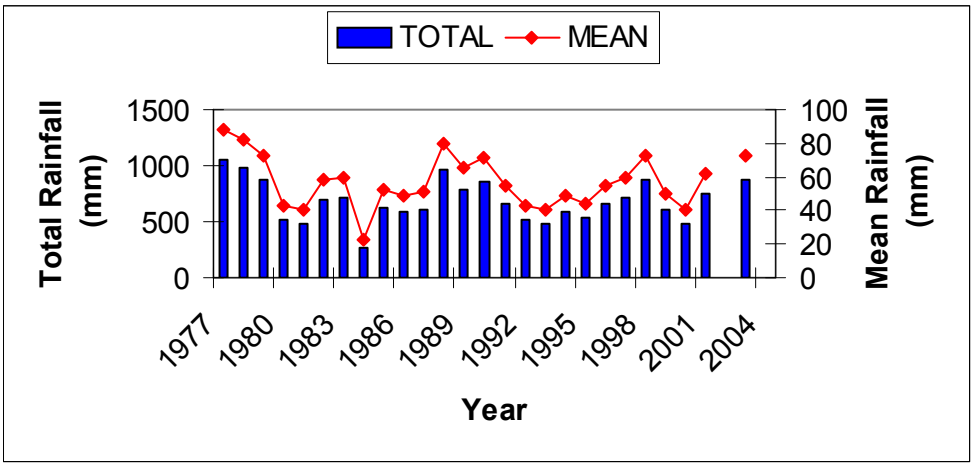

FIGURE 2: Lake Bogoria total and mean annual Rainfall at Loboi Station from 1977-2003

2.2 Soils

The soil types and distribution in the prospect area have been influenced by the topography. The steep slopes and rolling hills have soils developed from volcanic rocks, which are well drained varying from deep to shallow depths. Soils in these low-lying area (lowlands) have developed on volcanic rocks and alluvial. In most areas the bedrock is basaltic and some pyroclastics. This has weathered over time under dry climatic conditions to give rise to sandy loam soils in texture. They are well drained, moderately deep to very deep, brown to dark loams, sandy loams or clay loams and very erosive (Figure 3).

FIGURE 3: Erosive nature of soils around Mugurin

Mogotio and Kisanana areas, soils are very shallow and at times extremely gravely to extremely stony. The soils vary in colour from mainly brownish to reddish brown depending on the mineral contents. Sandstones and conglomerates are common in Simotwet, Kamar and Koibos locations making them to be rich in sand. There are pockets of sedimentary rocks mainly shale and silt in depressions especially where streams enter swampy areas. Around Mugurin and Molo Sirwe, soils have low water holding capacity, very shallow and extremely gravely clay-loams. At the escarpments soils have moderate water holding capacity, shallow depth, stony, gravely clay loams. Thick clay loam of alluvial origin is found around Marigat.

2.3 Land use

The prospect area supports both crop and livestock production. The semi arid zones of the prospect area are mainly used for livestock production (Figure 4). Large livestock numbers can cause threats like, land degradation and loss of biodiversity due to over grazing if not checked. Such practices are however gradually declining as more people settle down permanently around water points and arable land. There are pockets of irrigation agriculture along rivers like Perkerra, Molo, Wasseges and Loboi (Figure 5).

FIGURE 4: Livestock production within the prospect area

FIGURE 5: Sections of irrigation agriculture around Loboi

2.4 Water resources

The surface water resources in prospect area are scanty. The largest water body in the prospect area is Lake Bogoria which about 33 km^2 and highly saline. The main river that feeds this lake is Wasseges. It collects most of its stream flow from tributaries on Laikipia escarpment. In dry periods, the river dries up near Sandai before reaching the lake. From western side the lake is fed by some hot springs and seasonal tributaries including Emsos.

The surface water quality of selected streams in prospect area is good (Table 1). Surface water resources have also been developed by construction of Dams and Pans to provide water for domestic use and livestock watering. The largest operational scheme is found in Marigat (Perkerra Irrigation Scheme) and the Sandai scheme, located northeast of Loboi. There are many small irrigation schemes towards Lake Bogoria. It is only in the streams, which are fed by Hot Springs, increased fluoride concentrations are found.

TABLE 1: Water quality of selected streams/rivers in the prospect area (mg/L except for pH)

Item	**River Emsos**	**River Ararae**	**River Molo**	**River Narosura**	**Canadian Drinking water quality guidelines**
pH	8.2	7.6	7.9	7.1	6.5-8.5
Mn			0.439	0.425	0.05
Ca	4	7.2	8.8	5.6	200
Mg	1.92	14.59	Nil	Nil	50
Cl-	14	11	12	8	<251
F-	1.26	0.83			1.5
NO^-_3	0.06	0.1	1.9	2.9	45
SO^{2-}_4			6.0	7.0	500
TDS	260	180	113	74	<500

There are several water supplies and boreholes in the prospect area (Table 2). Unfortunately, most of the boreholes produce water of low drinking quality due to high levels of fluoride and sometimes manganese (Table 3).

TABLE 2: Water supplies and boreholes within prospect area

Division	No. of W/supplies	Type of water (gravity/pumping)	Source of water (surface/borehole)	Remarks
Mogotio	5	4 are pumping, 1 is gravity	4 boreholes, 1 river source	4 are community managed & 1 is GoK run
Kisanana	12	All pumping	All are boreholes	All are community managed
Emining	9	All pumping	7 boreholes, 1 river	All are community managed
Marigat	-	Pumping	17 boreholes, 1 river source	-
Mochongoi	-	Pumping	8 boreholes, 6 productive	-

TABLE 3: Water quality of selected bore holes (mg/L except for pH)

	Koitebes Borehole	Kures Borehole	Rosaga Sch. Borehole	Nyalibuch Borehole	Nguberetti Borehole	Canadian drinking water quality guidelines
pH	6.0	6.8	8.0	7.9	7.55	6.5-8.5
SiO_2	25.0	20.0		25.0	40.0	-
Mn	3.7	1.2	1.2	1.0	0.1	0.05
Na	101.8	101.8		24.9	137.5	200
K	32.8	37.7		17.0	16.8	-
Fe	0.2	0.03	0.13	Nil	0.05	0.3
Ca	18.0	24.0	58.4	20.0	76.0	200
Mg	16.8	19.0	14.88	5.2	23.0	50
Cl-	8.0	15.0	15	4.0	54.0	<251
F-	4.0	5.0		0.6	0.6	1.5
NO^-_3	Nil	1.1	3.0	Nil	Nil	45
SO^{2-}_4	30.0	10.0		0.8	112.5	500
TDS	450	450	450	175	670.0	<500

2.5 Floral composition

Natural vegetation comprises of several species of acacia and grasses characteristic of a dry savannah. The areas comprising Radat, Kimose, Saos, Molo Sirwe, Emining, Mukuyuni, Wassegese and Maji Moto vegetation is deciduous and semi deciduous bushland (Figure 6). Around Mugurin, Ngendalel, Mogotio, Kisanana and around Lake Bogoria vegetation is a combination of evergreen (Figure 7), deciduous and semi deciduous bushland. The area around Loboi, Sandai and Logumgum vegetation is a combination of deciduous Shrubland (Figure 8), deciduous shrub grassland (Figure 9), seasonally flooded grassland (Figure 10) and acacia woodland (Figure 11). Common tree species include: *Acacia tortilis, A. seyal, A. nilotica, A. brevispica, A. mellifera and other Acacia species*. Other species include *Balanites aegyptica, Tarconanthus comphratus and Terminalia. Grasses include Cynodon, Digitaria, Hyperhenia and Cenchrus sp.*

The only endangered plant species in the area is Aloe Vera plant species (Figure 12), which is currently being overexploited because of its medicinal value. Funds have been secured from the European Union and plans are underway to construction a factory for sap extraction at Koriema (pers. comm. with residents involved in Aloe Vera project).

FIGURE 6: Deciduous and semi deciduous bushland

FIGURE 7: Deciduous shrub-grassland

FIGURE 8: Evergreen bushland

FIGURE 9: Seasonally flooded grasslands

FIGURE 10: Deciduous Shrub land

FIGURE 11: Woodland

2.6 Fauna

Lake Bogoria and part of its catchment area is rich in fauna hence has been protected as Lake Bogoria National Reserve (LBNR) and covers an area of 107 km^2 (Figure 13). It was gazetted in 1973 and is currently managed by Baringo and Koibatek County Councils. Recently the LBNR was designated as

a third Ramsar site after Lake Nakuru and Naivasha. The lake is saline and covers an area of 34 km^2. It is rich in biodiversity, hosting about half of the world's population of lesser flamingos (*Phoeniconaias minor*). It is also a habitat to other bird species including greater flamingos (*Phoeniconaias rubber*), black-necked grebe (*Podiceps nigricollis*), ostriches, fish eagles and several migratory species. Due to its avifauna richness, it has been designated as an Important Bird Area (IBA). The mammalian fauna in LBNR include zebras, gazelles, buffaloes, several primates and the only relatively accessible population of greater kudus. In addition to its rich biodiversity, Lake Bogoria has numerous hot springs.

FIGURE 12: Aloe Vera project at Sandai primary school

FIGURE 13: Flamingos in Lake Bogoria National Reserve

2.7 Biodiversity value of Lake Bogoria

Microorganisms

A bacterial population of over 10^6 bacteria/ml of the Lake Bogoria water has been recorded. Numerous bacteria have been isolated from this lake but are yet to be characterized. In a recent study, a new novel genus of *actinomycetes*, *Bogoriella caseilytica* has been described. The phytoplankton community is dominated by a cyanobacterium, *Spirulina platensis*, yet on occasions this species has almost been absent.

The hot springs environment is characterized by thick green or orange algal mats which are the primary producers of a quite complex micro-ecosystem. Some of the green-orange algal mats are known to be *Chloflexus-synechococcus* association but many other are still undetermined in terms of species composition. The zooplankton community is relatively abundant with *Brachionus plicatilis* and the benthos mainly consists of chironomid larvae.

Macrophytes

The Waseges-Sandai River enters the lake through a large freshwater wetland, the Kesubo Swamp, dominated by cattail, *Typha domingensis*. The Greater Loboi Swamp to the north of the lake is dominated by papyrus, *Cyperus papyrus*, and cattail (a marsh plant), *Typha domingensis*. There are no submerged macrophytes in the lake. The open shore, often littered with lava boulders is dominated by the salt-tolerant grass species, *Sporobolus spicatus* together with the sedge *Cyperus laevigatus* around the hot springs.

Terrestrial vegetation

The terrestrial vegetation is mainly thorny bushland dominated by the species of *Acacia*, *Balanites* and *Commiphora* with patches of riverine woodland containing *Ficus capensis*, *Acacia xanthophloea* and *Acacia tortilis*. In the lower slopes of the Siricho Escarpment, *Combretum* and *Grewia* thickets

dominate. The areal coverage of the different vegetation types in the Lake Bogoria catchment is shown in the Table 4.

TABLE 4: Vegetation types in Lake Bogoria catchments

Vegetation types	Area (km^2)
Acacia mixed	62.054
Acacia mixed (A. mellifera, dominant sp.)	8.369
Acacia mixed (dense)	8.122
Aloe Euphorbia	19.501
Ficus forest	1.502
Swamps	0.053
Mixed bushland	293.410
Scrubland	26.911
Open ground	2.667

Source: Njuguna, 1999.

Herpetofauna and fish

Lake Bogoria has no fish, however, around the mouth of Wasages-Sandai River and in both Greater Loboi and Kesuba Swamps fish species of the genus *Protopterus* has been reported. Crocodiles and monitor lizards are found in the wetlands associated with Lake Bogoria.

Birdlife

Lake Bogoria is internationally important as a main feeding ground for a large percentage of the world's population of the lesser flamingo (*Phoeniconaias minor*). The high productivity of the blue-green algae, *Spirulina platensis*, coupled with the presence of freshwater at several places results in a concentration of the lesser flamingo in large numbers, at times over two million, to give the appearance of large shimmering pink sheets across the lake. Kenya holds between a third and a quarter of the total world population of the lesser flamingo.

Recently, Lake Bogoria was reported to have a flamingo population estimated at Two Million, believed to be the largest number of flamingos converging on a single water body at any one time. Lake Bogoria is recognized as one of the 60 Important Bird Areas (IBAs) in Kenya. It is also one of the 13 lakes listed for the internationally important number of migratory birds they hold (Nature Kenya, 1999). In July 1994, a ground count of flamingos yielded an estimate of 1,579,000 flamingos. The following year, in March 1995, the flamingos were estimated at 248,499 birds with the greater flamingos, *Phoeniconaias ruber*, (6,143) only making 2.3% Palearetic waders totalled 3,143 birds in 1995, the vast majority being the ruff, Philomachus pugnax (2,327). An impressive number of the black-necked grebe, Podiceps nigricollis (1,832) was recorded. One greater painted snipe, Rostratula benghalensis was also found. The lake is also important for other bird species, for example, the Steppe Eagle, African Fish Eagle, Tawny Eagle, and Marabou Stork. The lesser flamingos fall prey to Marabou Stork, baboons, monitor lizard and warthogs. Ostriches are also common in LBNR especially in the Sandai area to the north of the lake.

Mammals

There are no mammals inside Lake Bogoria but a small variety of animals exist in the adjacent areas. They include the rare Greater Kudu (*Tragelaphus strepsiceros*) and many other antelopes such as gazelles and impala. Other mammals found in LBNR are zebras and buffaloes. The Greater Kudu population is reported to be on the decline, as a result of the demand on their horns, which are used by the locals for ritual purposes. The zebra population is reported to have increased tremendously in the recent past. There is an urgent need for an animal census.

3. SOCIO-ECONOMIC ISSUES

3.1 Administrative set of the prospect area

The prospect area is situated partly in Baringo District and partly in Koibatek District. It traverses Marigat and Mochongoi Divisions in Baringo District and Emining, Mogotio and Kisanana Divisions in Koibatek District (Table 5). This is a marginal agro-ecological zone IV-semi arid zone suitable for livestock production, wildlife habitat and dryland agriculture with little rainfall and high temperatures.

TABLE 5: Administrative units of Arus and Lake Bogoria geothermal prospect area

District	Division	Area (km^2)	Locations	Sub-Location
Koibatek	Mogotio	538.2	6	11
	Kisanana	236.4	7	25
	Emining	401.6	5	9
Baringo	Marigat	641	9	18
	Mochongoi	329	3	7

3.2 Land tenure system

In terms of land holding system, most of the lands in the prospect area are communal land (trust lands) but land adjudication is on going to facilitate private ownership. Land adjudication and surveying is on going and several land adjudication sections have been established and include Maji Ndege area (Loboi, Mbechot, and Kapkuikui villages), Maji Moto, Koitumet, Cheparandi (Emining) and Wasseges (Kisanana) adjudication sections. In Mogotio Division, much of the land is under sisal farming under private ownership. No livestock group ranches exist in the prospect area. Currently, no map regarding land ownership is in place as land registration is still in progress.

3.3 Population and demographic characteristic

The Arus and Lake Bogoria geothermal prospect area's population is projected to have increased from 76,708 people in 1999 with a population density as shown in Table 6 to **107,590** at the end of 2004.

TABLE 6: The 1999 population of Arus-Lake Bogoria by sex, households, area and density

Division	Male	Female	Total	Households	Area (km^2)	Density
Kisanana	3263	3435	6698	1262	236.4	28
Emining	6944	7122	14066	2818	401.6	35
Mogotio	9054	8876	17930	3613	538.3	33
Marigat	13285	13638	26923	6356	1224	44
Mochongoi	5745	5346	11091	2413	329	19

3.4 Agricultural activities

The prospect area is classified as lowland in terms of agro-ecological zones with little rainfall and high temperatures. The land is used for animal grazing and furrow irrigation agriculture. Pockets of rain-fed and irrigated crop production can be found especially along the river course and lowland. Crop failure prevails in both rain-fed agricultural and irrigation areas because water is limited in this lowland. There are small-scale irrigation schemes in the area that are served by both permanent and

seasonal rivers, streams and swamps. Reliable sources of rivers and streams include Perkerra River, Molo River, Wasseges and Loboi. Swamps include Loboi and Kapkuikui. Soil erosion in the area is also widespread. This has been aggravated by reduction in vegetation cover and by overstocking of livestock leading to land denudation and formation of large gullies.

Crop production statistics

There are pockets of crop producing area in this lowland. The main food crops are maize, millet, beans and Irish potatoes. The prospect area is a perennial food deficit. Despite the area producing a little food to feed her population, most of the food (60%) is sold for cash requirements thus occasioning frequent food shortages. The poverty level in the prospect area is more than 50% as much of the cultivated area is put under low value food crops.

Livestock production

Livestock keeping is one of the most important economic enterprises in the prospect area. Under the semi arid conditions that prevail, traditional raising of indigenous livestock breeds is managed under pastoral and nomadic systems. Livestock production is depressed due to lack of adequate water and insufficient pasture as a result of prolonged droughts, epidemic disease outbreaks and lack of breeding systems for better productivity.

3.5 Health and sanitation

The top ten diseases are as indicated in Table 7 with Malaria and URTI being the most prevalent diseases in the five Divisions of the prospect area. The high prevalence of these top diseases are attributed to factors such as presence of diseases vectors mostly mosquitoes; weather changes (for URTI); low latrine coverage (intestinal worms and diarrhoea); inadequate water supply; poor housing and unprotected sex.

TABLE 7: Disease prevalence in 2004 by Divisions within the prospect area
(Value in parenthesis is disease rank)

Disease	Divisions				
	Kisanana[1]	Mogotio[2]	Emining[3]	Marigat[4]	Mochongoi[5]
Upper Respiratory Tract Infection (URTI)	1427 (1)	3156 (1)	4932 (2)	10263 (2)	5847 (1)
Malaria	828 (2)	2832 (2)	5760 (1)	12745 (1)	2083 (2)
Diarrhoea	567 (3)	480 (3)	960 (3)	244 (9)	684 (5)
Intestinal worms	383 (4)	218 (5)	111(4)	849 (4)	365 (9)
Skin diseases	-	333 (4)	-	2156 (3)	1094 (4)
Pneumonia	-	-	-	849 (4)	1299 (3)
Rheumatism	-	-	-	257 (8)	465 (6)
Accidents*	-	-	-	593 (5)	432 (7)
Urinary Tract Infection (UTI)	55 (5)	-	15 (8)		
Ear Infection	3	36 (6)	20 (7)	294 (7)	237 (10)
Gonorrhoea	40 (6)	2 (10)	3 (9)		
Malnutrition	20 (7)	-	-		
Eye Infection	-	33 (7)	31 (6)	414 (6)	400 (8)
Chickenpox	6 (9)	15 (9)	56 (5)		
Mumps	9 (8)	16 (8)	-		
Amoeabiasis	-	15 (9)	-		
Measles	3				

Source: Department of Public Health, Baringo District Hospital-Kabarnet & Koibatek District Hospital-Eldama Ravine. * Include injuries such as burns etc.[1]-Olkokwe dispensary & Kisanana Health Centre, [2]-Mugurin & Maji Moto dispensaries, [3]-Emining Health Centre, [4]-Marigat Sub-district Hospital,[5]-Mochongoi Health Centre

HIV/Aids prevalence in Baringo District side of the prospect area is about 4 %, which is low compared to the current National prevalence level of 7%. Marigat area within Arus-Bogoria prospect in Baringo District, however, presents a unique scenario due to large numbers of casual workforce engaged at Perkerra Irrigation Scheme. The majority are low-income earners residing in a slum area within Marigat centre known as "Kampi Ya Turkana". Most of them are social refugees from Turkana ethnic group, hence the name "Kampi Ya Turkana". The group's inability to meet the basic social-economic needs forces them into sexual relationships with multiple partners and therefore vulnerable to HIV/ Aids infections. According to the Public Health Officer in-charge of HIV/Aids Programmes in Baringo District, 80% of people living with HIV/Aids (PLWHA) in Marigat Division are from "Kampi Ya Turkana" area.

For Koibatek side of the prospect area (Mogotio, Kisanana and Emining), data for the 4th quarter of 2004 indicate that HIV/Aids Antenatal clinic (ANC) and sexually transmitted diseases (STDs) prevalence was 7.7% and 18.2 % respectively. No HIV/Aids data was available for Voluntarily Counselling and Testing (VCT) Centres. The current health facilities within Arus-Bogoria geothermal prospect area is as indicated in the Table 8.

TABLE 8: Health facilities (hospitals, dispensaries and health centres) within the prospect area

Division	Mogotio	Emining	Kisanana	Marigat	Mochongoi
Health facilities	2	1	2	12	4

Source: Department of Public Health, Baringo District Hospital-Kabarnet & Koibatek District Hospital-Eldama Ravine.

3.6 Tourism

Tourists and visitors to the Reserve are stakeholders, in search of recreation, education and research. They include both local, national, and international tourists and visitors. According to records in the Lake Bogoria recording station, over 50,000 school children visit Lake Bogoria annually to understand and appreciate the unique physical geography of the Rift Valley (Figures 14 and 15), an important topic in the geography syllabus in Kenyan schools. Researchers who come to seek knowledge are among this group.

FIGURE 14: Lake Bogoria with its hot springs

FIGURE 15: Unique landscape of the Great Rift Valley

The number of visitors to LBNR fluctuates very much according to season with the peak being between the months of July and September (Figure 3) and the lowest between months of January and May.

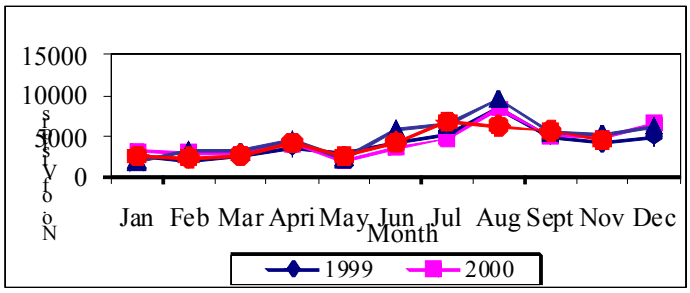

FIGURE 16: Visitors to Lake Bogoria National Reserve

3.7 Employment profile

In estimating employment, it is worthy noting that some people engage in multiple activities like farming, retailing while at the same time they could be employed in the public sector. The largest employer in the prospect area is the small farm sector (e.g. rain-fed and irrigated crop farming, and bee keeping) and livestock keeping. There is also migrant seasonal labour, rural self-employment and urban self-employment. Urban self-employment includes small-scale business (wholesale and retail trades, hotels) and informal sector enterprises (e.g. welding and carpentry) in urban and market centres. In general, most of the labour force within the prospect area is unskilled and semi skilled and is mainly engaged in small farm sector, livestock keeping and rural self-employment. Labour force in the public sector is skilled and is mostly from outside the prospect area. The main sources of casual employment are NGO's and Corporations that support various community-based projects.

3.8 Physical infrastructure

Roads

The area is criss-crossed by quite a number of all weather roads and motorable tracks, which can be classified as roads of Class B (National trunk roads), Class E (Special purpose and Minor roads) and a few unclassified roads. The classified roads include the D365 Mogotio Lake Bogoria road (58 km) and the E460/D365 Loboi-Makutan-Tangulbei road (80 km). The non classified roads include Molo Sirwe-Oteri road (25 km), Lake Bogoria/Maji Moto road (17 km) and the Marigat-Mochongoi road (57 km).

The Ministry of Public Works and Roads through its Roads Maintenance Department in the two districts, has endeavoured to keep most of the roads and tracks in motorable state including the ones within Lake Bogoria National Reserve. The Contractor that was awarded the contract of gravelling Marigat-Arabal-Mochongoi (C51) abandoned the Contract after logistical delays. There were also plans of constructing a new loop to connect Nakuru-Marigat-Mochongoi-Nakuru to improve communication in the area after completion of the Marigat-Arabal-Mochongoi road project.

Postal and telecommunication

There are post offices at Mogotio and Marigat and a sub post office at Emining. There are plans to extent services to areas not covered such as Mugurin and Maji Moto near Lake Bogoria.

The prospect area is relatively served with telephone lines with Mogotio division having more than 50 telephone lines. There are manual telephone exchange facilities located at Marigat, Kampi Ya Samaki, Kisanana and Emining. Areas lacking telephone facilities are Olkokwe and Mugurin. Marigat's total capacity of the telephone exchange facilities is 300 lines and only 90 lines are utilized. Therefore, there are 210 telephone lines for new customers around Marigat, Loboi, Kapkuikui, Loboi and Sandai locations at a cost of Ksh 8,200 per line. In addition to the above network, a wireless line has been extended from Kabarnet Exchange to Loboi and Mochongoi Centres through radio systems. Ms

Celtel has also commissioned a base transmission station at Marigat. This has improved communication network in the area.

Power

Only a few areas within Arus-Bogoria prospect are connected to the electricity power grid. These are mainly the trading centres located along the power distribution grid. Main ones include Mogotio, Emining, Marigat, Loboi and Mochongoi. The power connection by KPLC has been limited only to the people who are able to pay. For example at Marigat the capacity of the Transformer installed is 1.5 MVA and the actual consumption by connected consumers is about 0.5 MVA. This leaves a surplus of 1.0 MVA for new connections around Marigat, Loboi and Kapkuikui among other locations in the vicinity of Marigat Centre.

3.9 Educational profile and facilities

Educational facilities in within Arus-Bogoria prospect are as shown in Table 9. Schools are few and lack basic requirements such as classrooms and desks and laboratories in comparison to the schools in highland areas. Similarly, enrolment in both primary (29,992) and secondary (2,076) schools is low. The hostile semi-arid environment, effects of disease outbreaks particularly malaria and URTI, cultural practices particularly early marriage and pastoral lifestyle and high poverty levels are among many other factors responsible for the low enrolment rates. However, interventions from World Food Programme (WFP) through World Vision ADP and the GoK through free school-feeding programs sustain enrolment of pupils in these lowland schools.

TABLE 9: Educational Profile and facilities in Arus-Bogoria prospect in 2005

Division	Pre-Units	Primary Schools	Secondary Schools	Enrolment in Pri. Schools	Enrolment in Sec. Schools
Mochongoi	27	27	1	6151	140
Marigat	33	33	4	9498	687
Emining		24	2	4948	583
Kisanana		13	1	2809	241
Mogotio		24	5	6586	425
Total		**121**	**13**	**29992**	**2076**

Source: Education Department, Baringo District-Kabarnet & Koibatek District, Eldama Ravine

3.10 Mineral resources

Ruby deposits have been discovered at Kaplengoi and Kurintoi in Mochongoi division. The current prospecting site is East of Lake Bogoria around Mbechot area and West of Marigat. Corby Company Ltd has been issued with prospecting licenses for three areas at Mbechot in Mochongoi Division. Trona deposits on the shores of L. Bogoria are mined on a small scale by pastoralist community for their livestock.

4. ANTICIPATED ENVIRONMENTAL AND SOCIAL IMPACTS AND MITIGATIONS

Environmental impacts arising from geothermal development in Arus-Bogoria prospect area will largely depend on a specific location where development will take place. The subsequent section is therefore a summary of generalized impacts that might be anticipated during development. The potential impacts have been modelled on similar projects that have been implemented else where e.g. Olkaria

4.1 Environmental impacts

Flora
The opening of the area for drilling will involve removal of the original vegetation for road construction and drill pad preparation.

Recommended mitigation
- Reduction of pad size to a minimum as far as practicable to ensure minimum disturbance of natural vegetation;
- Immediate seeding of the affected area with indigenous perennial grass species such as *Cynodon dactylon, Cenchrus ciliaris, Cymbopogon sp., Themeda triandra, Sporobolus ioclados, Chloris roxburghiana;*
- Re-injection of drilling effluents and waste brine to minimize impacts on flora in the surrounding environment;
- Vegetation monitoring programme to assess the possible potential long-term effects of effluents on natural vegetation is recommended.

Fauna
Major impacts could be realized if major developments will be undertaken closer to Lake Bogoria and its surroundings which is a key habitat both fauna and avifauna. Of importance to note is noise pollution during drilling and well testing which has been considered as a negative impact on avifauna because it is thought that it can make animals move away from preferred habitats. The LBNR being an Important Bird Area (IBA) and a designated ramsar site close developments need to be undertaken with caution.

Water resources
Drilling of geothermal wells and construction of geothermal utilities and operation require large amounts of water for both domestic consumption and industrial uses.

Recommended mitigation
- Consider alternative sources of water for geothermal well drilling like drilling new boreholes.
- Adopt modern drilling techniques using minimal amounts of water during drilling and with recycling capability.

Soil
Removal of vegetation and opening of ground during geothermal well drill pad preparation and construction of geothermal utilities may lead to soil degradation through wind or storm water induced erosion.

Recommended mitigation
- Rehabilitation of drill sites through planting of fast growing plant species such the indigenous perennial grass species like *Cynodon dactylon, Cenchrus ciliaris, Cymbopogon sp., Themeda triandra, Sporobolus ioclados, Chloris roxburghiana*; and
- Monitoring of soil quality to assess the magnitude of short and long-term impacts.

4.2 Socio-economic impacts

Land use
Land would be required for access roads, geothermal well drill pads and subsequent development. The land is held under trustee by Koibatek and Baringo County Councils.

Population and settlement
Development of geothermal resource would lead to an increase in population due to people coming to the area in search of employment. The main impact anticipated could be change in social stratification among the local inhabitants

Infrastructure and other public utilities
The anticipated social impacts from geothermal development activities in this Prospect area may include opening up of the area and improved road network through upgrading of existing roads.

Tourism
Lake Bogoria National Reserve (LBNR) is already attracting many local and foreign non-paying visitors. Therefore, the planned construction of geothermal utilities in the area is anticipated to attract both local and foreign people due to its unique feature as is the case with geothermal developments in Olkaria field within Hells' Gate National Park, which has become major attraction. The area's potential to generate revenue from visitors will increase especially with revenue that will accrue from accommodation facilities that are coming up.

Energy consumption and demand
Development of geothermal, which is a cheap, reliable and environmentally clean source of electric power in Arus-Bogoria Prospect area, will halt any further degradation of vegetation resources and enhanced public access to electric power thus improved living standards.

5. CONCLUSION

The anticipated environmental impacts could be significant within LBNR. However, social impacts are insignificant in magnitude. The impacts, however, could be effectively mitigated during civil works, drilling and testing of geothermal wells and power plant construction and operation.

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