Environmental and Socio-Economic Issues of Geothermal Development in Kenya

by Martin N. Mwangi
GeoSteam Services Ltd.
P.O. Box 4 - 20117, Naivasha, Kenya
mmwangi@safaricom.com

Abstract Geothermal energy plays a very important role in the clean energy supply of the world. The impacts of geothermal development are often positive. The socio-economic effects are also important, especially in neighboring communities. However it is imperative the environmental issues associated with geothermal are identified and addressed very early on in the development and operation of geothermal projects. The use of Environmental Impact Assessment methods and the establishment of an Environmental Management System are useful in this regard. Altogether Kenya has developed about 167 MWe of geothermal power in the Olkaria Geothermal Field within the Kenya Rift Valley, most of which is located in a game park. The environmental and socio-economic issues managed in the development are discussed here.

Introduction

Kenya’s geothermal resources are associated with the Great East African Rift System transecting the eastern part of the African continent (Map 1). The area has about 14 known geothermal sites, many of which are associated with central volcanic centers (Map 2). Geothermal resources at these sites occur as steam jets, hot springs, geysers, and altered hot ground.

A comprehensive exploration of these resources began in 1970 and currently Kenya generates about 167 MWe, accounting for about 12% of the effective-installed capacity. Kenya Electricity Generating Company Ltd. (KenGen) has two power stations, Olkaria I and II, with a total capacity of 115 MWe. Orpower 4 Inc.
Geothermal in Kenya

**MAP 1. The East African Rift System.** Drawn by Toni Boyd and reproduced from Stories from a Heated Earth, Our Geothermal Heritage, Raffaele Cataldi, Susan F Hodgson, and John W. Lund, editors. Published by the IGA & GRC.

---

The Great East African Rift System
by John W. Lund

The East African Rift System runs parallel to Africa’s eastern coast for 5,600 km (Stager, 1990). This furrow—formed from a series of cracks in the earth’s crust and the resulting highlands—has two branches. The western branch starts in Mozambique to the south and runs north along the border of Zambia and Tanzania, through Burundi and Rwanda, and into Uganda. The eastern branch starts in Central Tanzania and runs north through Kenya and Ethiopia, ending on the continent at Djibouti and Eritrea at the Afar Triangle, bordering on the Red Sea and Gulf of Aden.

Enormous troughs, up to 2 km deep and 90 km wide, form along these cracks. Elongated lakes, also formed by the rift system along the western branch, include Malawi, Rukwa, Tanganyika, Kivu, Edward, and Albert. Shallow saline lakes along the eastern branch include—among the larger—Eyasi, Natron, Turkana, Abaya, Abbe, and Assal. Massive Lake Victoria lies between the two branches. The volcanoes Kilimanjaro, Africa’s highest peak at 5,895 m, and Mount Kenya at 5,199 m, stand adjacent to the rift near the center.

Hot springs, many at boiling temperatures, lie all along the rift. Most are assumed to have been present in the past. Sixty-four hot springs are reported for Kenya, varying in temperatures from 22 °C to 98 °C, and all are associated with the rift system (Kamondo, 1988).

**Selected References**


---

generates 48 MWe (Olkaria III), and the Oserian Development Company generates 3.8 MWe. KenGen is a public-private company generating 74% of Kenya’s power. Orpower 4 is an Independent Power Producer, while the Oserian Development Company is a farming company, generating power for its own use. All the geothermal power originates from the Olkaria Geothermal Field and all of Kenya’s geothermal experience comes from this field.

Besides producing power for farm use, Oserian is a leader in the region for growing cut flowers. Currently, Oserian is using
**Geothermal in Kenya**

geothermal heat and CO2 in 50 hectares of greenhouses for the production of cut flowers for the export market.

Olkaria Geothermal Field is located in the central part of the Kenya Rift Valley, south of Lake Naivasha and 120 km northwest of Nairobi. The field is divided into seven sectors for management purposes. These are the East Field, Northeast, Northwest, Southwest, Southeast, Central, and Olkaria Domes (Map 3). Geothermal exploration work started here in the early 1950s when two wells were drilled at Olkaria. The Olkaria East Field supports a 45 MWe Olkaria I geothermal power plant, fully commissioned in 1985. An important consideration for environmental management in this area has been the existence of Hell’s Gate National Park, established in 1984, which supports wildlife species such as buffalo (*Syncerus cafer*), zebra (*Equus burchelli*), Grant’s gazelle (*Gazelle grantii*), Thomson’s gazelle (*Gazelle thomsonii*), Coke’s hartebeest (*Alcephalus buselaphus*), and Maasai giraffe (*Giraffa reticulata*), among others (Map 4).
Outside of Olkaria Geothermal Field, exploratory drilling has occurred in Eburru Geothermal Field (Map 2), about 50 km north of Olkaria. One exploratory well is suitable for power generation and KenGen is tendering to install a pilot binary plant before drilling more wells—to use its full potential.

Geothermal development at Olkaria has created environmental challenges and inspired vibrant economic activities, particularly from KenGen’s environmental and social-responsibility initiatives, which are discussed here.

Environmental Issues

**Background**

Kenya’s experience in geothermal development has been concentrated around the development of Olkaria Geothermal Field and, to a lesser extent, Eburru Geothermal Field (Map 2). In addition, some experiences have occurred during detailed-scientific studies undertaken at the surface in about six geothermal prospects beyond Olkaria and Eburru. This discussion details the experiences at Olkaria—intended for replication in other regions, with modifications based on local settings and improvements learned along the way.

The environmental-management initiatives undertaken by KenGen were triggered by the fact that a large part of Olkaria Geothermal Field was established as Hell’s Gate National Park by the government in 1984, when Olkaria I power station had already been commissioned (Map 4). At the same time, the World Bank became interested in the further development of Olkaria’s geothermal resources and was lending funds for further exploration and development. Under the lending terms, the World Bank required that its Operation Directive OD 4.00 – Environmental...
Geothermal in Kenya

### Olkaria III Expansion

On February 17, Ormat Technologies, Inc., announced its project subsidiary had signed a letter of intent with the off-taker, Kenya Power & Lighting Co. Ltd., for a further expansion of its Olkaria III Power Plant by up to 52 MWe (from 48 MWe to up to 100 MWe). The expansion will occur in two phases. Phase I includes 36 MWe within 3.5 years after finalizing the amendment to the existing Power Purchase Agreement—with an option for Phase II of 16 MWe within 4.5 years from the commercial operation of Phase I.

The existing 48 MWe Olkaria III Power Plant itself was built in two phases. The first phase of about 13 MWe began commercial operations in August 2000 and the second phase of about 35 MWe began operations in January 2009.

Assessment Guidelines be used for future-geothermal developments (World Bank, 1989). Based on these matters, KenGen decided to create a section in its geothermal project organization that dealt with environmental management on a daily basis. As the environmental management of the project developed, the results could be seen in the design differences between the Olkaria I and Olkaria II power stations. In addition, KenGen now operates an Environmental Management System under the ISO14001:2004.

The environmental impacts associated with the Olkaria geothermal project are typical of those involving geothermal resources found elsewhere in the world, but the ways they are addressed differ by magnitude, location, knowledge base, laws, and regulations.

### Laws and Regulations


Other regulations do not refer specifically to geothermal development but, due to their implications, affect geothermal development at various stages in various ways. These include: the Energy Act 2006, Forest Act, Water Act, Factories and Other Places of Work Act, and the Wildlife Conservation and Management Act. This list of legislation may not be exhaustive, but it includes some of the important legislation affecting geothermal development in Kenya.

Besides the legislation, there are Kenyan and international policies and regulations governing the development of geothermal resources, most especially the ones tied to conditions for funding geothermal projects—for example, the World Bank Operational Directive OD 4.00.

Initially, KenGen based its environmental initiatives on the World Bank’s Operational Directive OD 4.00 during the development of Olkaria II. The directive requires a fully fledged Environmental Impact Assessment (EIA) be undertaken for any power-station development project. Therefore, such an assessment was undertaken from 1992 to 1994 for the development of Olkaria II. Based on the EIA results, a Memorandum of Understanding was signed between KenGen and the Kenya Wildlife Service (KWS) for developing geothermal resources within the Hell’s Gate and Longonot National Parks. Other processes, for example the use of water from Lake Naivasha, have driven other initiatives. Olkaria III and the two Oserian power stations were developed much later when the EMCA was already in force and they, therefore, used the Act.

The EMCA of 1999 came late in the development of geothermal energy in Kenya. It is an overall legal instrument for managing environmental issues and has created several institutions for this management—the key one being the National Environmental Management Authority (NEMA). The EMCA provides for establishing appropriate legal and constitutional frameworks for sustainable management of the environment and natural resources in Kenya. The EMCA outlines EIA procedures, environmental audits, monitoring procedures, and transmission and environmental-quality standards. The government enacted the EMCA to address the ever-growing negative environmental concerns of human activity on the environment. Generation and use of energy is a factor contributing to atmospheric pollution, land degradation, and global warming.

The EMCA also provides for establishing
Geothermal in Kenya

provincial and district environmental committees and a Public Complaints Committee. The law, therefore, gives the public voice and a chance to participate in matters related to the environment. NEMA requires all power projects—before a license is issued—to undergo an EIA and conduct public disclosure involving all the stakeholders. In addition, an Environmental Management Plan and regular environmental monitoring and audits are required.

Under the EMCA, the Energy Regulatory Commission (ERC) is recognized as the lead agency for the enforcement of environmental and safety regulations in the electric power sub-sector, the functions of which are conferred by the Energy Act of 2006. The EMCA requires the ERC to take into account the need to protect the environment, conserve natural resources, and protect the health and safety of service users and the public at large when reviewing applications for licenses.

Environmental Impacts

Surface disturbances

Olkaria Geothermal Field is located within an area of gently rolling hills, mostly covered with thick layers of pyroclastics and deposits of volcanic ash from numerous volcanic eruptions. The topography here is quite diverse, with volcanic masses and scarps formed by faulting and erosion. The Ol Njorowa Gorge has sheer faces carved from sheets and plugs of intrusive comendite, and volcanic masses occur on the Central and Fischer’s towers. Small areas of plains exist to the northeast. Three major biological zones exist—depending on the terrain, vegetation, and wildlife use (Kenya Wildlife Service, 1992).

The plains are part of the Ol Njorowa gorge and the dominant plant species are *Cynodon dactylon*, *Digitaria scalarum*, leleshwa (*Tarchonanthus camphorates*), and acacia shrubs. Hills and mountains encompass the geothermal development area toward the Olkaria gate. Olkaria Hill, with an elevation of 2,240 m above sea level, is within the region. Here the dominant vegetation associations are *Tarchonanthus* / acacia shrub land and *Cymbopogon* / *Themeda* / *Digitaria*, which do not constitute important food sources for the animals—hence the low animal concentrations. Cliffs, walls, and towers form the main walls of the gorge and the Fischer’s and Central towers. The area is rocky and the vegetation scant.

Parent soil materials are predominantly volcanic. There is porous volcanic ash derived from lavas, pyroclastic rocks, and lacustrine lake deposits (Clarke, 1990). The volcanic ashes are very vulnerable to water erosion when the ground is graded for drilling pads, roads, and power-station construction. To mitigate impacts, infrastructure sizes are controlled and only what is absolutely necessary is cut. Rehabilitation is also done by planting local star grass, leleshwa, and *Acacia Sp*. The steam pipelines often are painted to blend with the landscape. Once the use of a road has been discontinued, the top soil is returned; otherwise, roads in developed fields are tarmaced to minimize erosion.

Solid-waste management

Geothermal development produces significant amounts of solid waste; therefore, suitable disposal methods are needed. Because of heavy metals—particularly arsenic—contained in geothermal waters, these solid wastes are often classified as hazardous. Geothermal drilling produces wastes, such as drilling mud, petroleum products from lubricants and fuels, and cements. Drilling mud is either lost through circulation in the well or ends up in drilling sumps as solid waste for disposal. Since a lot of fuel and lubricants are used when a single well is drilled, product storage and transport usually follow
Geothermal in Kenya

Sound environmental practices, as stipulated in the KenGen Environmental Policy and the Environmental Management System. Cements are not normally considered hazardous, although some constituents—like silica—may be so. During plant operation activities, KenGen has special provisions for the safe storage of lubricants and fuels.

Other important solid waste includes cooling tower sludge (may hold mercury) and construction and normal-maintenance debris. All are transported safely to designated disposal sites or landfills periodically monitored and audited for environmental compliance.

Noise

Sources of noise include an operating drilling rig, well testing activities, and power-station operations. In only a few instances do rig equipment noises exceed 85 dB. The highest noise (up to 120 dB) occurs during the vertical discharge of wells during start-up, before they are discharged through a separator. The period of vertical discharge has been reduced to not more than 30 minutes to clear cuttings and other debris from the well. Horizontal discharge through separators reduces noise to below 85 dB. Initially, wells were put on horizontal discharge for about a year. Now, wells are discharged for shorter periods, not exceeding two months. Today better-designed separators are in use. These dampen noise more effectively and reduce water carry-over, which can cover plants with well solids that temporarily affect their growth.

Noise around the Olkaria power stations is associated with non-condensable (NCG) gas ejectors and air receivers and turbines. Because of this noise, the NCGs for Olkaria II station are designed to discharge through the cooling towers—which dampens the sound. The turbines have fairly low noise levels by design specifications, and much of the other noise is generally trapped by putting the turbines in a building instead of leaving them in the open. Still it is important for workers to use ear protectors during drilling, discharge tests, and plant operations.

After an extensive survey, a number of noise monitoring sites were selected to determine potential-noise sources in the project area (Kubo, 2001). Thirteen sites were designated as noise monitoring sites or stations. Noise-level measurements are taken twice a week in all the monitoring sites and stations. Noise occupational health and safety criteria in Kenya, regardless of hearing protection, is 85 dB in a work place for an employee working an eight-hour day. Other than the power station and the rig during drilling, noise levels fall below the recommended exposure limit.

Brine

In Olkaria, wells generally produce 75% steam and 25% water and dry up as the well continues to discharge. The brine component has harmful chemical substances, is hot, and can burn humans and animals. From a study done by Wetang’ula and Snorrason (2005) and from some wells at Olkaria I, it was discovered the trace-element concentration levels in wastewater from most wells fall within the international-water quality criteria for protecting plants and animals (mammals) against any potential ecotoxicological risk, except for arsenic, boron, and molybdenum in wastewater from a few wells. Geothermal wastewater could be a potential ecotoxicological hazard due to these trace elements without a proper disposal strategy. The fluoride level in wastewater from all the wells is high, typical of the Kenyan Rift waters.

Initially Olkaria I brine from wellhead separators was collected in open concrete channels leading into fenced-off conditioning ponds, which allowed the silica to polymerize on cooling down. The conditioned brine from these small ponds was collected from various wells and placed into a large pond. Some brine infiltrated into the ground and the rest evaporated. Today, the conditioned water is continuously reinjected cold into disused wells. In another part of the Olkaria I Field, the separated hot brine is reinjected before cooling. Cooling tower blow-down water is also mixed with the separated water from the wellheads and reinjected into deep wells. Ponds are generally fenced off to prevent both wild and domestic animals from entering to drink the water—and possibly drown, especially during the dry spell when water is scarce in the park. Alternative drinking water points for animals have been provided at strategic locations for this purpose. The reinjection of waste water is an environmentally friendly way
of managing the waste water and also replenishes the reservoir, increasing its productive life.

Based on reinjection experiences from Olkaria I, all the separated water from the Olkaria II Field has been reinjected hot into four infield wells. The power station blow-down water is reinjected in two wells located some distance outside the producing field, to avoid cooling the reservoir.

In 2001 during the construction of Olkaria II and after 20 years of Olkaria I operations, KenGen received complaints from local pastoral peoples that the brine was killing their cattle and making their women miscarry. The allegations could not be verified by the complainants and it was learned later the complaints had no basis and were meant to draw attention for more jobs and as an attempt to seek some form of compensation.

**Gas emissions**

Olkaria steam has 1% non-condensable gases. Of these, 92% is CO₂, 3% H₂S, and the rest methane, nitrogen, and hydrogen (Opondo, 2002). Discharging wells emit these gases over a limited period of time. However, there is a continuous emission from the power-station ejectors at Olkaria I station at the top of the station building. At Olkaria II, pumping these gases to the cooling tower and releasing them at an upwards velocity through the cooling tower fans is a more effective means of disposal.

Hydrogen sulfide gas emission is the major gas concern, due to the unpleasant smell and toxicity at moderate concentrations. Measurements at the power plant have recorded 1-minute concentrations not exceeding 1.25 ppm. Monitoring is done three times a week at most locations around the power station and at least once in a week for sites further away. There are 10 main monitoring sites, distributed to cover residential areas, occupational workplace areas, and park entry points around Olkaria. The occupational exposure limit of H₂S in workplaces is 10 ppm for an average 8-hour day. The H₂S levels at Olkaria are far below the occupational-exposure limit. The maximum value recorded is 4.40 ppm at the power station.

When the Oserian farm started growing flowers, the farmer thought gases discharged by KenGen were affecting his crop. Fortunately this happened only once. Later, it was discovered a disease the farmer had not known about—because he was then inexperienced in growing flowers—had affected the crop. To address the matter conclusively, a joint experiment was conducted by KenGen and the farmer (Kollikho and Kubo, 2001). The flowers were grown in two plots located 600 m and 1,200 m from the Olkaria I station in the direction of the strongest wind, and at the same time similar flowers were grown at the main farm about 7 km away, as a control. The trials were done over a period of a year during 1994 and it was proven the gaseous emissions were not affecting the flowers because the concentrations were too low (<1 ppm).

Today the Oserian Development Company actually uses geothermal gases in their greenhouses, especially carbon dioxide, to boost the growth of their roses. In the greenhouses, fresh water—heated with geothermal water through heat exchangers—keeps the temperatures high at night, thereby reducing the humidity to below 85%. This both lessens the need to use chemical sprays for diseases and reduces production costs. The heat and carbon dioxide also increase the rate of flower growth, resulting in a better crop.

**Steam gathering system**

The cross-country steam lines can affect the free movement of animals in the park. To overcome this problem, animal migration routes are mapped before the lines are constructed and
are taken into consideration during the design. Sections of pipelines are raised to a height suitable for giraffes to pass beneath comfortably—giraffes are the tallest animals in the area. In some places, the pipes pass through underground culverts so the animals can pass over the pipes. The color of the pipes is selected to blend with the environment.

**Power-transmission lines**

Power-transmission lines require an EIA to avoid visual impact and collisions by birds. The Olkaria II 220 kV line was routed with the help of personnel from the Kenya Wildlife Service to avoid crossing scenic cliffs, the Hell’s Gate gorge and the Fischer’s and Central towers that form important breeding and nesting grounds for various bird species, such as the Verreaux’s Eagle, Rüppell’s Vulture, and the rare Lammergeier, or Bearded, Vulture. Planning has allowed the birds to avoid power-line collisions and electrocution.

**Water usage**

The water used for both domestic and geothermal development comes from Lake Naivasha. It has been designated as a Ramsar site under the Ramsar Convention due to the national and international interest in the ecology of the lake environment as a wetland habitat. There is a high demand for lake water for the ever-expanding flower growing business, human settlement in the town of Naivasha, future shopping centers, the tourism industry, and by the pastoralists, mainly the Massai. Geothermal development uses fairly small amounts of water for power-station startup, drilling, and domestic purposes. Recycling is practiced during drilling to minimize water usage.

KenGen is a member of the Lake Naivasha Riparian Association (LNRA)—whose members are stakeholders owning the riparian land, and the community-based management plan (*The Lake Naivasha Management Plan*) for sustainable use of the lake. The LNRA involved all the Lake Naivasha stakeholders in developing the management plan, and the stakeholders have developed codes of conduct to govern their activities with respect to the lake. For the energy sector, KenGen developed a comprehensive code of conduct and all power producers operating in the vicinity of the lake are expected to adhere to it. The association also self regulates in the use of riparian land, which has a potential for polluting the lake.

### Socio-Economic Issues

#### Water

Lake Naivasha is the only source of water for the Olkaria area. For a large distance south of Lake Naivasha, the well boreholes are either dry or discharge steam. Coupled with the fact that rainfall is low, the local pastoral peoples suffer a lot from lack of water for domestic use and for the animals. KenGen, therefore, provides
water pumped from Lake Naivasha to about seven points throughout the year to the local community. Some other water is provided to the Kenya Wildlife Service staff and the wild animals. Water is also provided to the Eburru communities, who originally depended on rain water or condensed steam from the naturally occurring steam jets. During a severe drought, KenGen trucks in water to communities much further from Olkaria.

**Roads**

Between 1985 and 1990, KenGen used tarmac to pave the Olkaria-Naivasha Road (40 km) and the well field access roads, opening the entire area to agriculture, tourist hotels, and assisted easy access into Hell’s Gate National Park. Consequently, the horticultural industry has created many jobs in the area and some of the large farms employ about 6,000 people. The flower industry along this road is second in Kenya only to tea for foreign sales. Several new hotels have been built here and more and more people visit Naivasha and Hell’s Gate National Park for business and recreational purposes. The area supports, directly and indirectly, more than 500,000 people.

KenGen also assists the Kenya Wildlife Service to maintain roads in Hell’s Gate National Park. A large number of tourists come to the park to visit the Olkaria Geothermal power stations. In fact, geothermal development has become one of the major tourist attraction sites in Hell’s Gate National Park.

**Labor**

The power stations employ about 500 permanent staff. However, services like cleaning and guarding are outsourced through contracts with the local communities. A large amount of the other labor is outsourced to communities on a casual basis during times of power-station construction and maintenance.

**Education**

KenGen has constructed nursery and primary schools for the children of its employees and the local community. Currently these two schools average 480 pupils, more than half from the local...
Geothermal in Kenya community. The company bus brings in pupils from the local communities, some living about 15 km away.

Every year KenGen, under its social responsibility programs, sponsors three additional students who attend secondary schools and two students who attend national universities—and the company plans to increase these numbers.

Jointly KenGen, Orpower 4 Inc., and Oserian have helped construct classrooms in some schools further away from the Olkaria Field, and Orpower 4 has provided teachers for some of the schools. KenGen is planning to spend monies from the Community Development Credit Fund for this purpose (see side bar for fund details on carbon capture). The monies also will be used to expand the water supply and dispensary initiatives.

Health

A dispensary constructed for KenGen staff is open to the local community for limited treatment. KenGen and Orpower 4 have continued to organize health camps, bringing services closer to communities around Olkaria.

Transportation

The area south of Olkaria has no public transport. For this reason, KenGen and Orpower 4 provide free rides to the community. In particular, KenGen provides a bus on Saturdays all year long for the local community to use as transportation for shopping. Transportation is also provided to local communities during inoculation or other governmental health and education initiatives.

Complaints

Some local communities very close to the geothermal field complain KenGen is not doing enough for them. People here reside in ownership-disputed land. Although KenGen would be willing to assist these communities, KenGen would not want to be involved in land disputes, as land issues in Kenya are sensitive. KenGen only wants to be involved in community projects located in areas without disputes.

Social Afforestation

Initially, KenGen’s tree nursery was meant to germinate seedlings for rehabilitation within the geothermal projects. Currently, about 100,000

Community Development Credit Fund

by Martin N. Mwangi

In August 2006, the World Bank agreed to purchase Certified Emission Reduction credits from KenGen for six power-generation projects. Among the projects was the 35 MWe Olkaria II third-unit, geothermal-project-extension—now under construction and planned to be commissioned in May 2010. This project was estimated to reduce about 176,000 tons of carbon annually. Under the World Bank Carbon Finance Agreement, additional funding of $1 per ton of carbon will be made available annually to KenGen under the Community Development Credit Fund (CDCF) to be used for community projects around Olkaria over the period of the agreement. KenGen carried out a survey of the priority projects the community wished funded by the CDCF. They included schools, water, health, and cattle dips.

Beatrice Kipng’ok, from KenGen, and Noreen, from the World Bank, visit a Maasai woman’s group. Beatrice works with the Massai to identify the areas of assistance and Noreen handles Community Development Credit Fund activities. Souvenirs for sale are displayed on the cloths in the foreground. PHOTO BY M. MWANGI.
Geothermal in Kenya

Kenyan Geothermal Traditions
by Cyrus W. Karingithi
Assistant Manager, Resource Development, KenGen

Mt. Ol Donyo Lengai, in northern Tanzania near Lake Natron, is called “God’s Mountain” by the pastoral Maasai living around it. This is the only constantly active volcano in the southern area of the East African Rift System.

Around Kenya’s Olkaria Geothermal Field, south of Lake Naivasha, the Maasai use red ochre clays gathered from altered, hot steaming grounds as a paste for beautifying both hair and face. The Maasai say their gods live in the hot steaming grounds. Water condensed from the steam is drunk by the Maasai and their animals.

Acknowledgments
The KenGen management is thanked for approving the publication of this essay. The author would also like to record his gratitude to all those who provided information, comments, and other forms of assistance during the preparation of the work.

Selected References

Conclusions
The possible environmental impacts from geothermal development include surface disturbances, including physical effects due to heat, chemical emissions, and socio-economic issues. All can be minimized. Putting into place monitoring and control programs can check the unforeseen impacts that only appear in the operational phases of geothermal development. The Olkaria geothermal project has not led to the environmental degradation of Hell’s Gate National Park; in fact, it has enhanced park tourism. Socio-economic impacts are important and can be minimized with the involvement of local communities in effective, corporate social-responsibility policies.