

ABSTRACT

The pressure to shift from energy sources causing global warming and ozone depletion is top agenda on the global environmental debate. As a result, geothermal energy is among the underexploited options under consideration due to its controllable environmental impacts, un-fluctuating fuel (steam) prices and fluctuating weather conditions associated with thermal and hydro. Social and environmental considerations and applicable laws in geothermal utilization should therefore be clearly understood for it to effectively compete with other alternative sources especially in developing countries that have not met their energy requirements and have a reserve of the resource. The overall project development benefits would be realized if the local communities are integrated from initial stages and have clear knowledge of what they can accrue from such projects.



INTRODUCTION

- Geothermal energy utilization as an alternative source is gaining momentum in both developed and developing countries around the world in the age of higher environmental awareness. Though biological and physical impacts of geothermal siting are well understood, socioeconomic impact is still the missing link. In order for geothermal resource to achieve popularity, as a renewable energy alternative, there is need to clearly identify the social and environmental impacts of its development. This is achievable through environmental and social impact assessments/monitoring from project initiation to operation phase. The integration of social concerns into the decision making, planning and management of any geothermal project is required by international agreements/protocols, national laws, policies of bilateral agencies and international financing institutions. Internalizing the cost of social and environmental benefits in the overall project cost would be one way of enhancing the competitiveness of geothermal energy against other alternative sources.
- Most geothermal resources in the world are located in remote scenic, wild and protected areas. The key socioeconomic impacts associated with developing these resources include opening up and modernization sites, loss of wildlife habitat, visual intrusion in scenic tourist areas among others.

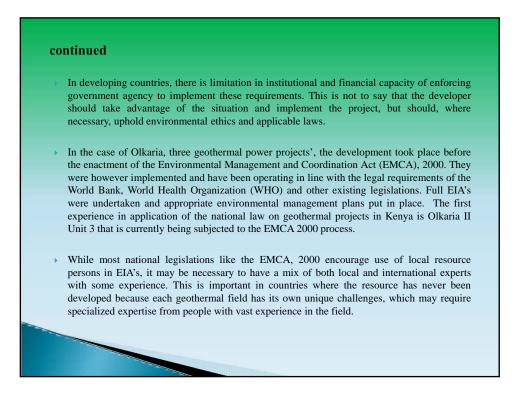
LEGAL ENVIRONMENTAL FRAMEWORK

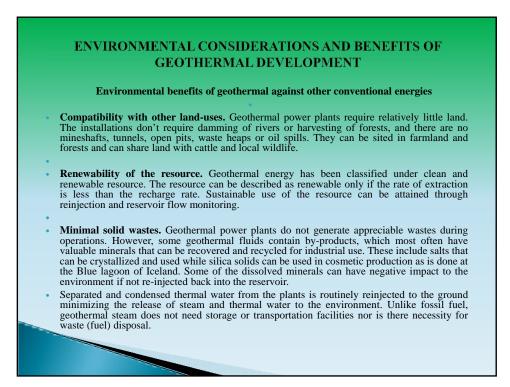
The sub-Saharan African countries depend on their immediate environments for economic and social needs than any other parts of the world. Due to this dependency, public awareness and concern on how new projects are impacting on the socio-economic environment is becoming an important factor among decision makers. Though geothermal energy is relatively new to most countries in the continent, it is not an exception to this rule. In Kenya, geothermal development at Olkaria has resulted in greater environmental and social benefits to the local communities and the region as a whole due to manageable environmental and social impacts

Before implementation of any project, the national and international environmental legislation relevant to its implementation must be understood. In geothermal power development, it is important to understand these legislations in relation to exploration, drilling, power plant construction, operations and decommissioning. These legislations often specify standards with which the project must comply and sometimes may delay implementation due to lengthy licensing process or public consultation requirements. Implementing agencies should guard against any environmental liabilities as they may have adverse financial implication on the total project cost. Some of the legislations that must be understood include;

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- Environmental Impact Assessment regulations (National legislation and guidelines, WB Operational policy (OP) 4.01, OP/BP/GP 4.02, Environmental Action Plan; OP 4.07).
- ▶ National and donor emission standards for air, noise and water quality requirements (WB guidelines on air and Noise emissions, WHO water quality requirement, National and local bylaws requirement, Water Resources Management; OP 4.09, Conventions on climate change)
- Local and international legislation in relation to biodiversity conservation incase the project is located in the park. (WB OP/BP/GP 4.04, Natural Habitats, Convention on Biological Diversity.
- ▶ National and international policy on resettlement/relocation and compensation of people if necessary. (WB OP/BP 4.12, Involuntary Resettlement, National Resettlement Policy.
- Identification of key stakeholders and public consultation and disclosure methods within the national environmental legal framework (OD 4.20, Indigenous Peoples; and OPN 11.03, Cultural Property, National disclosure methods).
- Occupational health and safety rules related to geothermal development.
- ▼ Local council bylaws.





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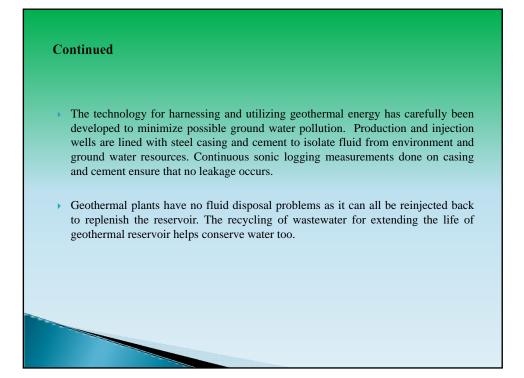
TABLE 1: COMPARISON OF CO2 EMISSION BY POWER SOURCE

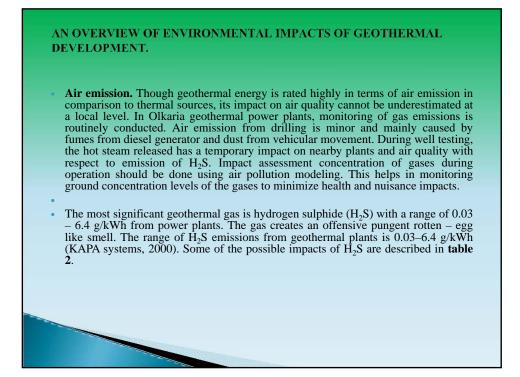
SOURCE: INTERNATIONAL GEOTHERMAL ASSOCIATION (IGA), 2002

Power source	CO2 Emissions (g/kWh
Geothermal 35% efficiency	122/kWh (weighted average)
Coal @ 35% efficiency	915/kWh
Fuel oil @ 35 % efficiency	760/kWh
Natural Gas combined cycle @ 60% efficiency	315/kWh

Continued

- The amount of Non Condensable Gases that may be released into the atmosphere is determined by the nature of the reservoir and the type of technology. For instance, binary plants emit virtually no gases because it's closed loop system using heat exchange method. Dry steam and flashed steam plants emit water vapor containing these gases. However, the process of reinjecting the geothermal fluids back into the reservoir diminishes the possible release of gases into the atmosphere.
- In low temperature utilization, CO₂ found in geothermal fluids could prove beneficial in direct use greenhouse applications as a growth stimulant. Studies have shown that increase in CO₂ from normal level of 300ppm to approximately 1000ppm can raise crop yields by up to 15% (Dunstall and Graeber, 2004).
- ➤ As a result of these environmental benefits, geothermal energy easily qualifies as one of the candidates for Clean Development Mechanism (CDM) of the Kyoto protocol, which would be an added incentive to the development of the resource. The CDM concept allows developed countries to offset their GHG emissions by investing in emission reduction projects in developing countries. It enables emission reduction targets to be achieved cost effectively while developing countries receive sustainable development and technology transfer benefits (Michaelowa, 1997).
- Minimal surface and ground water pollution. Unlike most fossil fuel plants that release waste heat into water bodies, geothermal power plants use cooling towers to emit heat into the atmosphere.





Effect of Hydrogen sulphide on human beings	
Concentration in ppm	Effect
1-10	Offensive odour
10-20	Occupational exposure limit
20-100	Ceiling of occupation exposure limit. Worker must wear breathing apparatus
100-200	Loss of sense of smell in 2-15 minutes. May burn throat and chest. Causes headache and nausea, coughing and skin irritation
200-500	Loss of reasoning and balance. Respiratory disturbance in 2- 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 if no resuscitation is done
700-1000	May immediate unconsciousness. Death or permanent brain damage may result unless rescued promptly
1000-2000	Immediate collapse with respiratory failure

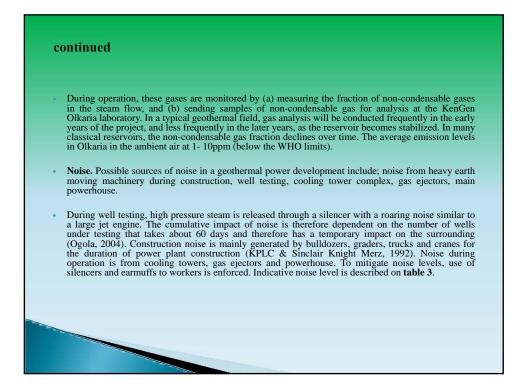


Table 3: Indicative noise levels during drilling and construction

Operation	Noise Level (dB)
Air drilling	85-120
Mud drilling	80
Discharging wells vertically (to remove drilling debris)	Up to 120
Normal well testing through silencers	70–110
Diesel engines (to operate compressors and provide electricity)	45–55
Heavy machinery (e.g., for earth moving during construction)	Up to 90
Power plant operation (Olkaria II)	65 - 70

The world-bank noise level requirements are shown in table 4 below. Table 4: World Bank requirements on Noise Level (World Bank, 1998)

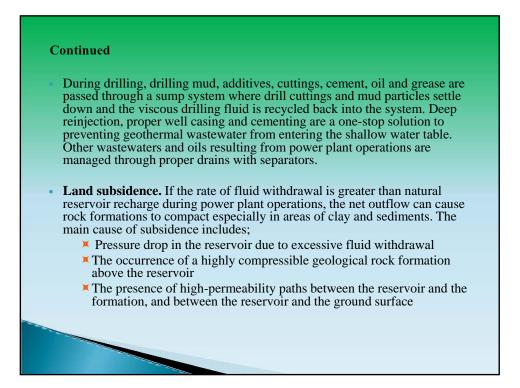
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and Education 55 45	Receptor	Day time (07	00-2200hr) Night (2200-0700	
	Residential.Institution	onal		
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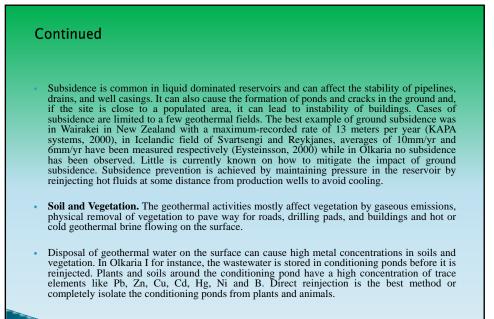
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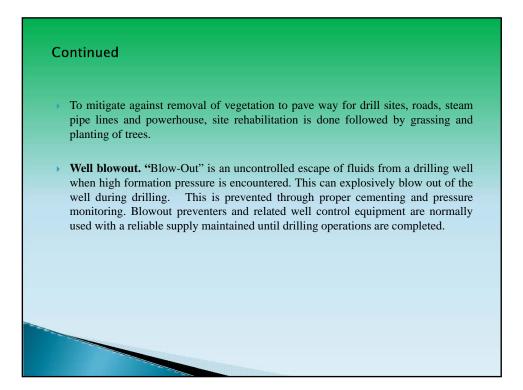
Waste water. The main geothermal wastewater is brine. In Olkaria I, the disposal of brine was via gullies and natural drainage, but in Olkaria II, wastewater disposal is done by deep reinjection. Though brine is not considered toxic by any standards, it may pose health risk depending on the geothermal fluid chemistry. The brine also poses risk on water pollution if it has heavy metals like As, B, Hg, Zn, Pb, Cl, Li. Some of the international standards (WHO) that may be used in monitoring these heavy metals and other pollutants in geothermal and other projects are listed on table 5.

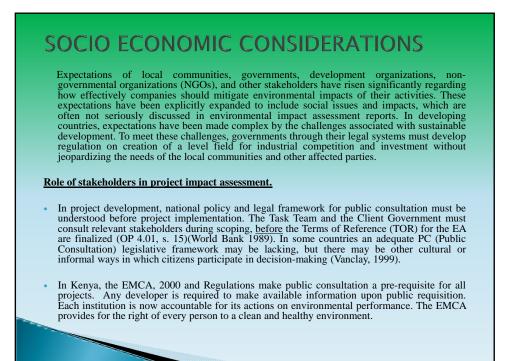
Wastewater	Maximum
Parameter	Concentration (mg/l)
Biological Oxygen Demand (BOD)	50
Chemical Oxygen Demand (BOD)	250
Total Suspended Solids (TSS)	50
Oil and Grease	10
Heavy metals (Total)	10
Total Chromium as Cr	0.5
Total Copper as Cu	0.5
Total Iron as Fe	1.0
Total Zinc as Zn	1.0
Total Chloride as Cl	0.2
Total Arsenic as As	0.1
Total Lead as Pb	0.1
Total Mercury as Hg	0.01
Total Nickel as Ni	0.5
pH	6 – 9 u <u>nit less</u>

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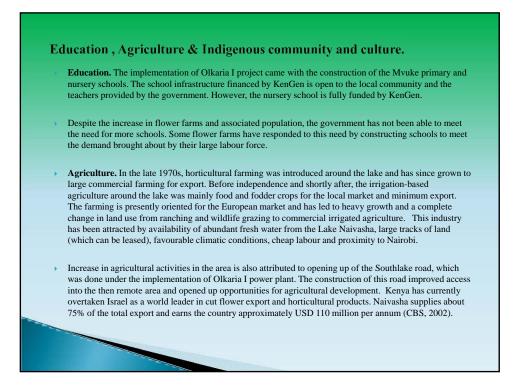
- It also makes it the obligation of every person to protect and manage the environment. The developer is therefore expected to adhere to the three principles of sustainable development; polluter pays principle and precautionary principle (Republic of Kenya, 1999). Evidence of the developer's good intentions and environmental governance can be made known through public consultation and disclosure. This is done during EIA, environmental audits and monitoring during project implementation and operation.
- All stakeholders should be identified and consulted at the initiation stage of the project. Means of contacting influential stakeholders and the non-influential ones should be devised and the effectiveness of the consultation process evaluated.

Socioeconomic impacts of developing geothermal projects - The Olkaria experience.

• The Greater Olkaria Geothermal Area is influenced by historical factors, which has influenced its current socioeconomic set-up. The area has undergone tremendous land use changes with accelerated changes experienced in the last decade. Unlike many parts of Kenya where the stakeholders are local communities bound by similar culture, language and race, this area is cosmopolitan. Therefore the socio economic impact of development would not be a typical reflection of what happens in any rural set-up in Kenya. Some of the key socioeconomic impacts as experienced in Olkaria are discussed below;

Tourism and Wildlife Conservation

- There is a debate as to whether geothermal resource development and wildlife conservation are compatible. The Olkaria power plants located in Hells gate National Park are a classic example of such compatibility of the two land uses. This area was gazetted as a park in 1984 after construction of Olkaria I power plant. This has been perceived as the best decision made by the conservationist at that time in view of the fact that the area was going to be opened up following the construction of a power plant. Since then, Kenya Wildlife Service (KWS) and KenGen developed a Memorandum of Understanding (MoU) to govern geothermal power operations within the park. The MoU also covers Orpower 4 (an independent power producer). The KWS and KenGen are currently working on the revision of the MoU following the commissioning of Olkaria II in 2004, which is also within the same park. The main concerns of the Kenya Wildlife Service and other conservationists include; effluent disposal, emissions, animal accidents (traffic), loss of habitat, harassment of animals, blockage of seasonal animal migration routes, noise and odour.
- In order to minimize impacts caused by geothermal development activities in the park, several studies were carried out. These studies included establishment of animal migratory routes, breeding grounds, tourist circuits and protected plants and wildlife species. The plant operations have maintained conservation of unique scenic features and wildlife species within the park. Steam pipelines on major animal routes were looped to provide easy movements for the wildlife such as giraffes within the park.
- High voltage lines and silencers are a potential danger to birds and as such they were constructed to avoid right angle crossing of known bird flying routes. To avoid animal accident in the park, a speed limit of 40km/h is observed while game proof fencing is done to keep the animal away from brine pools.



- Several studies and farm experiments were done on trial basis by KenGen to assess the impact of cooling tower plume and gas ejectors on the flowers. The results of the study indicate that the plume and especially H_2S does not cause any hazard to the flowers and horticultural crops. This has been confirmed by activities in places like Iceland where geothermal water is used in greenhouses for heating. The Oserian flower farm has developed a system for utilizing geothermal heat and gases to heat > 30 hectares of greenhouses as a means of controlling temperatures and humidity to stop fungus growth and reduce the use of fungicides and subsequently meeting the stringent European market standards on residual plant chemicals. The farm is also injecting the geothermal CO_2 into the greenhouses increase the rate of photosynthesis and production with much success.
- Indigenous community and culture. The indigenous community of the Olkaria area are the Maasai's who are less than 100 people. The community lives in the vicinity of the park on surrounding private farms and therefore have no firm legal rights of occupation. The development of the power plants did not displace or directly affect any indigenous community and their culture. Though there is very limited interaction with the community interms of project operations and maintenance, methods of ensuring that they benefit from the project have been devised. Some of the benefits the Maasai's community has enjoyed from the project include, provision of piped water at the Kedong and Narasha, access to Mvuke Mvuke primary school, transport provision for shopping every weekend and assistance to put up a new primary school called Iseneto.

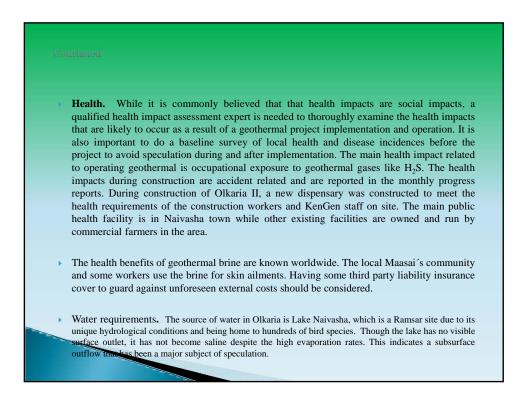
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The expansion of geothermal development in the areas immediately outside the park may however affect the Maasai's if KenGen was to acquire the land from the private farms.

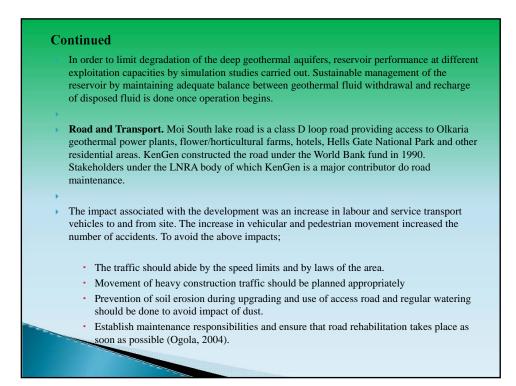
- Aesthetics and visual impact. The construction of geothermal plants in a tourist set up can cause visual intrusion if not carefully planned. The Visual Absorption Capacity (VAC) of an area should be clearly understood right from the planning stage. The Olkaria area has a high visual absorption capacity due to topographical nature of the area. Using equipment with neutral, non-reflective colours that blend with the surrounding rocks or trees have reduced the visual impacts. For instance, the Olkaria II powerhouse is coloured in light brown and green to blend with the surrounding environment. In Olkaria II, separated water is not released into the atmosphere like in Olkaria I hence have no visual impact of plumes. During drilling and construction of powerhouse, the visual impact may be temporary, though notable. Costs and means of minimising these impacts must be determined prior to implementation.
- > Labour. Just like any development project, geothermal development stimulates creation of additional economic activities, indirect jobs and generates tax and revenue. The geothermal industry provides a wide range of employment opportunities from exploration, drilling, manufacture of turbines and operations. Through the economic multiplier effect, salaries earned generate additional incomes and jobs in the local and regional economy. A general rule of thumb is to maximize the use of local labour.

During the plant construction stage, there is an influx of workers that require camping facilities such as X2 camp during Olkaria I construction. Other social impacts relate to the interaction of locals with the construction workforce. The construction phase of a geothermal plant involves far more workers than the operation maintenance stage, and because appropriate infrastructure and management procedures are often not in place, the impacts at this time can be higher than during the operation stage. Though the construction of Olkaria II came with an influx of construction workers, the plant operational staff were internally relocated from Olkaria I and Kipevu thermal. The increased labour force requires an increase in transport, rental houses and leads to pressure on existing social infrastructure. The temporary labour force during construction of Olkaria II was estimated at 920. It is however important to note that this increase cannot be matched to the phenomenal increase in permanent labour force brought about by expansion in flower and horticultural farming.

- Energy and economy. Energy is a means to development. The increase in energy leads to growth of development activities and eventually poverty alleviation. Currently, only 15% of Kenyans have access to electricity from the country current installed capacity of 1218 MWe. Geothermal only contributes 11% of the total with an installed capacity of 129 MWe. The gross revenue generated from geothermal in 2004/2005 was about Kshs 1.7 billion. In most African countries, the local communities especially in the rural areas do not directly benefit from the electricity generated as it is taken to the national grid.
- Some of the local economic benefits include increase in trade and business, income from rent and transport services, improved access to essential services etc.



- Ground water 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 kilometers above the geothermal resource and are recharged by different hydrological systems.
- Water requirements for the power stations, residential houses, and other occasional activities like construction and drilling must be established before resource exploitation. Currently, the water use for KenGen is mainly for power plant operations and domestic. KenGen also supplies Orpower 4 (IPP) and the Maasai's with piped water as a Corporate Social Responsibility. The total water consumption for KenGen is 59,000-m³/year/station use and about 1000 m³ of water per day during drilling. However, drilling is an activity that happens in one year of a decade or more and cannot make significant difference in the lake level. Water consumption for powerhouse uses are negligible compared to the 300,000 m³ used for irrigation per day by the commercial farms. The water used for drilling is also recycled. KenGen may supplement the water with geothermal brine during drilling of Olkaria IV.
- There is a possible risk on water pollution from heavy metals like As, B, Hg, Zn, Pb, Cl, Li etc from geothermal fluid. Water quality monitoring is done more regularly and consistently by all stakeholders to determine its quality and impacts of surrounding agricultural activities on its ecosystem. The impact of these pollutants on availability of water for domestic and livestock use should be determined and prevented.





- An environmental monitoring plan is normally designed and included in the EIA report. Monitoring is done to identify and mitigate changes in the environment brought about by geothermal project development. This is done during exploration, drilling, construction and operation. The monitoring plan has all the identified possible impacts, their mitigations and the person responsible for implementation. A cost is also attached to all mitigation measures and possible alternatives analyzed.
- Participatory approach is encouraged in monitoring social issues (World Bank, 1994). Table 6 highlights some of the key environmental and social issues that are monitored in geothermal development.

ocial Monitoring Parameters	Environmental Monitoring Parameters
and use changes	Soil and vegetation elements concentration
Public health and safety	Water elements concentration
Water use and consumption	Ecosystem (plants & animals both aquatic and terrestrial)
Community complaints	Noise level
Employment and income	Air pollution and Precipitation chemistry
Resettlement (if application)	Soil erosion and control
Traffic volume	Subsidence
Business and services	Water and gas chemistry
Demographic changes (wildlife and human)	Ground water chemistry and levels
Tourism (if applicable)	Seismic monitoring
School enrolment and facilities	Geo-hazard monitoring

CONCLUSION

- The development of geothermal energy does not cause adverse impacts to the environment compared to other conventional energy sources. All the known environmental impacts resulting from geothermal development can be mitigated against. However, in developing geothermal projects, the costs of environmental and social mitigation measures should be factored into the total project cost. All the national and international legal requirements should be used to benchmark environmental management. Ultimately, the need is to balance between development that is brought by the energy resource and conservation of the environment.
- Most African countries have not met their energy requirements despite the vast resources in the continent. The countries with geothermal potential should seek for funds to develop these resources. There is also great need to have receiving communities identify with the projects from initiation stage to decommissioning and to ensure that they accrue direct benefits from such projects. Otherwise, if not involved, the communities can reject the project and blame all environmental degradation on the developer.

CBS, 2002: *Economic survey 2003*. Central Bureau of Statistics (Kenya) Nairobi, report, 239 pp. Dunstall, M and Graeber, G. 2004. *Geothermal carbon dioxide for use in greenhouses*. Geo-heat bulleting Vol.18, p 1–14. Eysteinsson, H. 2000: *Elevation and gravity changes at geothermal fields on the Reykjanes peninsula, SW Iceland.* Proceedings of World Geothermal Congress 2000 Kyushu – Tohoku, Japan, May 28 – June 10, 2000.

	ACRONYMS
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
KenGen	Kenya Electricity Generating Company Ltd.
KPLC	Kenya Power and Lighting Company Ltd.
Km	Kilometres
KWS	Kenya Wildlife Service
LNGG	Lake Naivasha Growers Group
LNTG	Lake Naivasha Tourism Group
MOU	Memorandum of Understanding
MW	Mega Watt
NEMA	National Environment Management Authority
NCG(s)	Non Condensable Gas(es)
ppm	Parts Per Million
TLV	Threshold Limit Value
UNEP	United Nations Environment Programme
WB	World Bank
WHO	World Health Organisation
g/kwh	Grams per Kilowatt Hours
CO2	Carbon dioxide
H ₂ S	instagen Sulphide