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BIODIVERSITY CONSERVATION AND GEOTHERMAL DEVELOPMENT

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ABSTRACT

Major geothermal prospects occur in fragile ecosystems constituting a rich tapestry of all forms of life and the ecosystems that they are part. Ensuring intra and intergenerational equity in geothermal development is critical for conservation of biological diversity. Relative to the variety of habitats, biotic communities and ecological processes in the biosphere, biodiversity is an important pre-requisite for all forms of life to exist as it provides valuable ecosystem services. Nevertheless, there exist several threats to biodiversity and biodiversity conservation including loss of habitat, overexploitation, pollution, and climate change. To mitigate this, several environmental concerns including binding, non binding and local agreements involved in achieving biodiversity conservation are reviewed in this paper with case examples from the Olkaria geothermal power project, situated within the Hells Gate National Park in Kenya.

1. INTRODUCTION

One of the key components crucial in economic and social development is energy. The current energy exploration and use has resulted in environmental changes with significant local and regional effects, a concern that caught the attention of many countries in the Earth Summit. Today, more than 1.6 billion people worldwide have no access to electricity and approximately three billion people depend on traditional biomasses as their energy supply for cooking and heating (Advisory Group on Energy and Climate Change Report, 2010), hence a challenge. Biodiversity loss and global warming threats continue to place an increasing demand for environmental compliance thus the need for environmentally sound energy systems to attain global prosperity. Presently, the shift is toward clean renewable energy sources among which geothermal power is the most attractive because of its relatively benign nature (de Jesus, 1997). Enhancing the sustainability of geothermal development will therefore ensure viable energy for the future whilst maintaining the integrity of the natural environment.

The Kenyan rift, forming part of the eastern arm of the African rift, harbours the great wealth of geothermal resources in fragile and critical habitats. A unique success is the continued existence of the Olkaria geothermal power project amidst a complex self sustaining biophysical functional unit; the Hells Gate National Park in Naivasha. The challenge facing the Kenyan government is to continue developing the geothermal resource for power generation whilst maintaining and sustaining the delicate biodiversity, however several environmental management measures have been implemented with continuous follow-up to enhance conservation.

1.1 Biodiversity conservation: benefits and losses

The manifestation of biodiversity is the biological resources (genes, species, organisms, ecosystems) and ecological processes of which they are part. Biological diversity is therefore essential in supporting human life, and is central to the relationship between man and nature. A number of ecological goods and services are directly and indirectly derived from biodiversity including air quality balance, determination and regulation of climate and biogeochemical cycles, environmental change indicators, environmental purification and protective services. Other biodiversity values include utilitarian for example, industrial raw materials and aesthetics.

In parallel with human development and economic expansion has come a greater reliance on products and resources originating from the world's biodiversity. However, this increase in the extent and range of use of biodiversity has generally not taken into account natural regeneration rates of biodiversity, and thus over-use has resulted in the degradation of natural systems and loss of components of biodiversity. The major cause has been human mismanagement of biological resources often stimulated by mis-guided policies and faulty institutions resulting in habitat destruction, overexploitation, invasive species, pollution, climate change, human over population, and overharvesting.

Optimal utilisation and development of natural resources ensures both intra and inter-generational equity hence environmental sustainability (Figure 1) and biodiversity conservation. The Brundtland Commission, 1987 defines sustainable development as development that ´meets the needs of the present generation without compromising the ability of the future generations to meet their needs´ (UNCED, 1992a). Sustainable development therefore is living within the Earth´s capacity at a given time and has been observed that economic policies that do not consider environmental concerns lead to deteriorated environments. On the other hand, environmental policies that ignore economic realities limit opportunities to raise resources for environmental rehabilitation and enhancement (International Chamber of Commerce, 1992).

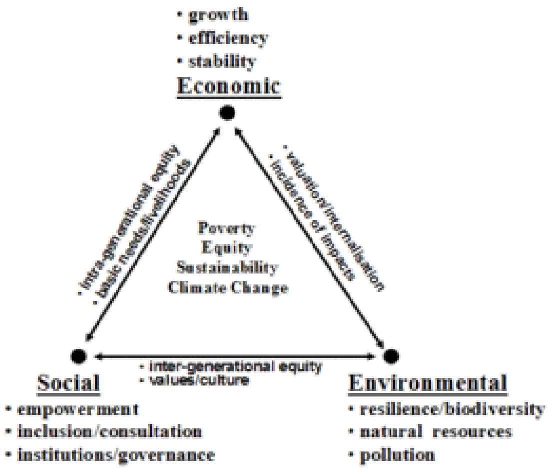

FIGURE 1: Sustainable development triangle (Modified from Munasinghe 1994a)

In this light, sustainable development is not a moral call. It is a necessity for human and natural survival. A safe, environmentally sound, and economically viable energy pathway that will sustain human progress into the distant future is clearly imperative. It will require new dimensions of political will and institutional cooperation to achieve it.

2. BINDING AND NON BINDING AGREEMENTS

Binding, non-binding international and local significant guiding principles need to be integrated in any kind of development to foster sustainability. It is critical to understand and observe strict adherence to vital environmental legislation in the course of geothermal development 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. In this context, key regulations that need to be understood and observed include:

- 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 critical habitats. (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.

In Kenya, the Olkaria I (45Mwe) and II (70Mwe) geothermal power projects' development took place before the enactment of the Environmental Management and Coordination Act (EMCA), 1999. They were however implemented and have been operating in line with the legal requirements of the World Bank, World Health Organization (WHO), EMCA, 1999 and other existing legislations. Full EIA's were undertaken and appropriate environmental management plans put in place. The first experience in application of the national law on geothermal projects in Kenya was the Olkaria III Project and Olkaria II Unit 3 (35Mwe) (Ogola, 2005).

2.1 Convention on Biological Diversity, 1992

The Convention on Biological Diversity is a binding agreement that was inspired by the world community's growing commitment to sustainable development. Signed by 150 government leaders at the 1992 Rio Earth Summit, the Convention on Biological Diversity (CBD) is dedicated to promoting sustainable development (Article 1). It provides a comprehensive document underlining the principles (Article 2) of biodiversity conservation and sustainable use at the global scale with the objective to ensure sustainable use and conservation of biological resources, as well as fair distribution of benefits related to biodiversity and genetic resources (www.cbd.int/convention, 2010). The Convention also highlights the relationships between conservation, sustainable use of natural resources and sustainable human development. In ratifying the CBD, the Parties to the Convention undertake a commitment to implement the Convention at a national level in contribution to achievement of its goals and objectives at a global level. Kenya ratified the Convention in the year 2000 (http://www.cbd.int/information/parties.shtml, 2010).

CBD and renewable energy
CBD has put a major emphasis on the need to factor sustainability into development choices to mitigate climate change, a significant threat to biodiversity conservation. According to the Inter-governmental Panel on Climate Change (IPCC), an average temperature rise of more than 1.5 to 2.5°C would put 20% to 30% species at risk of extinction. Renewable energy development is therefore encouraged due to its minimal effects on climate change, however CBD stipulates continuous mitigation and monitoring to minimise any likely effects on biodiversity (Secretariat for CBD, 2009).

2.2 Aim for conservation and no net loss of biodiversity

The biodiversity-related Conventions are based on the premise that further loss of biodiversity is unacceptable. Biodiversity must be conserved to ensure it survives, continuing to provide services, values and benefits for current and future generations. The International Association for Impact Assessment (IAIA), 2005 recommends the following approach application to help achieve *no net loss* of biodiversity:

- Avoid irreversible losses of biodiversity.
- Seek alternative solutions that minimize biodiversity losses.
- Use mitigation to restore biodiversity resources.
- Compensate for unavoidable loss by providing substitutes of at least similar biodiversity value.
- Seek opportunities for enhancement.

3. BIODIVERSITY CONSERVATION IN GEOTHERMAL DEVELOPMENT

The current environmental measures for geothermal projects minimize habitat destruction and therefore, the loss of biological diversity. The measures include: i) an environmental impact assessment prior to project implementation that already integrates biodiversity considerations; ii) avoidance of rare, endangered or threatened species in earthworks; iii) minimization of openings; iv) directional drilling that allows compact work areas which are standard practices in geothermal development and minimize impacts on habitats (De Jesus, 2007). The recent procedure of redirecting emissions during well testing to avoid brine spray and defoliation proved helpful for projects in forest locations and is highly recommended (Tuyor, et al., 2005).

Chapter 9 of the Rio Declaration of 1992 declared that geothermal is an environmentally advantageous energy option basically due to its benign emissions. It is against this background that geothermal can be considered a green energy resource as it addresses the following key environmental concerns

3.1 Climate change

Losses in biodiversity are highly attributed to climate change, a global catastrophe resulting from global warming due to green house gas emissions. Today, climate change is a universal concern closely linked to energy utilization and sustainable development. The goal of the UN Framework on Climate Change Convention (UNFCC) of 1992 is the "stabilization of Greenhouse Gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system… within a time frame sufficient to allow ecosystems to adapt naturally..." (UN, 1992). Carbon dioxide (CO_2) emissions represent the main GHG known to cause global warming. In 2005, according to the G8 Conference (2005) about 200 scientists from thirty (30) countries discussed the latest research on climate change. They confirmed the link between the concentration of GHGs in the atmosphere and the increase in global temperature levels. A change of 2°C (3.6°F) was defined as the threshold to avoid the serious effects of global warming. This translates to a ceiling of 550 parts per million CO2 equivalent by volume in the atmosphere (De Jesus, 2007). Among the known geothermal emissions, only carbon dioxide and methane are known to be GHGs. Their levels are however much lower from geothermal production compared to those of fossil fuels.

Kyoto Protocol, 1997 and Clean Development Mechanism (CDM)
The increase in deployment of geothermal energy will have a large net positive effect on the environment in comparison with the development of fossil fuels. This is in harmony with the Kyoto resolutions on global climate change. The convention requires developed countries and those in transition economies to reduce their GHG emissions by 5% of their 1990 level (UN, 1997). The agreement allows the joint cooperation of developed countries to abate GHGs and for industries to trade their emissions based on their permit ceiling. During production, geothermal power plants emit insignificant amounts of CO2, SO2 and absolutely no nitrogen oxides in comparison to thermal plants. These small quantities from geothermal plants are not emitted during power production as a result of combustion but are natural constituents of a geothermal reservoir. The gases would eventually vent

into the atmosphere under natural conditions although at much lower rates (Goff, 2000). The nature of the geothermal reservoir and technology employed determine the amount of Non Condensable Gases that may be released into the atmosphere. For instance, binary plants emit virtually no gases because it is a closed loop system using heat exchange method. Dry steam and flashed steam plants emit water vapor containing these gases. However, the process of re-injecting 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 indicate that increased CO2 concentration from the normal level of 300ppm to approximately 1000ppm can raise crop yields by up to 15% (Dunstall and Graeber, 2004). The Oserian Flower Farm in Kenya operating a geothermal plant with an installed capacity of 4Mwe and 16 Mwt, successfully injects CO2 in the greenhouses to increase the rate of photosynthesis and production.

CDM, a concept that allows developed countries to offset their GHG emissions by investing in emission reduction projects in developing countries enables emission reduction targets to be achieved cost effectively while developing countries receive sustainable development and technology transfer benefits. The Olkaria III Phase II 36MWe (Orpower 4) geothermal project in Kenya is a recipient of a CDM facility for the period 2009-2015 with an average emission reduction of 171,265 tonnes of CO2. With the expected capacity expansion plan for geothermal energy in Kenya, most of the earmarked geothermal projects are expected to be CDM or comply with the requirements of the next protocol (Ogola, 2010).

3.2 Critical habitats

Most geothermal resources in the world are located in remote scenic, wild and protected areas hence a challenge to developers. Current international opinion however indicates that authorities now recognize that development may be considered in protected areas. The International Union for the Conservation of Nature (IUCN) prescribes the exclusion or the declaration of special zones for areas that are needed to maintain services to human settlements (IUCN, 1986).

Geothermal development and wildlife conservation
Kenya’s geothermal resource is located within the Rift Valley. Some of the fields with geothermal prospects are in densely populated areas, while others are within national parks. The Olkaria power plants (area 80km2) located in Hells gate National Park (68km2) are a classical example of power development and wildlife conservation compatibility. 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. The land is characteristic of rugged terrain, volcanic hills, valleys, gorges, boulders and highly altered weathered rocks. Vegetation is mainly shrubs and short trees dominated by several species of Acacia and Euphorbia. There are also a wide variety of succulents in the area and some unique plants capable of withstanding high temperatures. Seen animals include Maasai giraffe (*Giraffa reticulata*), warthogs (*Phacochoerus aethiopicus*), zebras (*Equus burchellis*), Coke’s hartebeest (*Alcephalus buselaphus*), thompson’s (*Gazelle thomsonii*) and grants gazelles (*Gazelle grantii*) and buffaloes (*Syncerus cafer*). Others include water buck, baboons, monkeys, African jackal; hippopotamuses, and leopards with about 103 bird species including vultures, tawny eagles, verreaux's eagles, augur buzzards, secretary birds and swifts. The land is mainly used for geothermal activities, wildlife conservation and ranches. Lake Naivasha, a freshwater lake that gained international Ramsar recognition in 1989, and Mt. Longonot are major scenic sites within close proximity attracting both local and international tourism, education and research.

As part of the Environmental Impact Assessment recommendations, Kenya Wildlife Service (KWS) and KenGen have since then developed a Memorandum of Understanding (MoU) to govern geothermal power operations within the park. Orpower 4 (Independent Power Producer) also has a MoU with KWS. The Geothermal Development Company (GDC) Limited of Kenya which kicked off its geothermal development activities late 2009 is also seeking to establish a MoU with KWS and KenGen to facilitate conservation efforts against development in bid to develop the underway 140Mwe geothermal power plant at the Olkaria IV field. KWS and other conservationists major concerns due to geothermal development in the park include; effluent disposal, emissions, animal accidents (traffic), habitat loss, blockage of seasonal animal migration corridors, noise and odour. To minimize such impacts, several studies which included establishment of animal migratory routes, breeding grounds, tourist circuits, protected plants and wildlife species were carried out and implemented. Operations have maintained conservation of the unique scenic features and wildlife species within the park. Steam pipelines on major animal routes are 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 accidents 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.

In managing the park KWS personnel monitor the patterns of animal movement and carry out quarterly animal census in addition to their regular research. Environmental Audits are also conducted by KWS within the park and follow-up reports with mitigation measures to be implemented are sent to the KenGen environment offices for action. The geothermal power plants have not altered significantly the ecology of the surrounding National Park.

Generally, an average geothermal power plant is estimated to use between one to eight (1-8) acres of land per megawatt, compared to 5-10, and 19 acres per megawatt for nuclear and coal power plants respectively. On the other hand, large hydropower requires over 275 acres of land per megawatt for an adequate size reservoir (De Jesus, 2007). However, the effect of geothermal resource development on land depends on a number of interacting factors, namely characteristics of reservoir, type of extracted fluid, type of application, size of the plant and terrain. In addition, ancillary supportive infrastructure for geothermal resource exploitation such as access roads and power transmission lines imposes additional impact on the terrestrial environment.

The declaration of geothermal projects as ecotourism sites in Bacon-Manito, Albay-Sorsogon in the Philippines because of its heart of the geothermal field (De Jesus, 2007) is proof that the utilization of geothermal energy does not contribute to the earth’s deterioration. Other sites include the Hoshino, a resort in Japan using geothermal heating, the Great Geysir, the Surtshellir lava cave, the Deildartunguhver hot spring of Iceland and Rotorua of New Zealand, to name a few.

Concern for Toxic Wastes

The concern for toxic wastes and transboundary movements led to the signing of the Basel Convention (1989). Under this treaty everyone is encouraged to manage the wastes as close as possible to the source of its generation. Geothermal operation can be compliant with this international prescription as geothermal effluents in liquid dominated fields may be re-injected back into its reservoir, ensuring in situ waste management. Reinjection has been adopted for brine disposal in more than 44 fields (Stefansson, 1997). It is a standard practice that Kenya has started adopting to prevent contamination of the environment. The mineral extraction of silica, zinc, lithium, manganese, caesium, rubidium and rare metals has been studied in Salton Sea and Mammoth Springs in California, U.S.A. with some results (Bloomquist, 2006). Sorption membranes using resins to remove boron have been reported (Yilmaz et al., 2005). Hypersaline brines and supersaturated steam may contain high levels of chemicals that can generate solid wastes. These wastes may be reduced to soluble forms for reinjection. Thiobacilli is used as a bioremediation method to dissolve, separate or immobilize hazardous geothermal sludge (De Jesus, 2007). Countries utilizing geothermal energy also adopt best practices in the management of its solid wastes and no utilizing country has been reported to export wastes to other countries.

Displacement of people
Infrastructure projects have yielded global concern about dislocation of people and the related social costs. To address the socio-economic and physical dislocation in cases when these are inevitable, appropriate involuntary resettlement packages must be negotiated with the affected households, to include replacement of structures, amenities and livelihoods. De Jesus, 2007 avers that the objectives of resettlement are to: i) relocate houses to areas where residents are not exposed to physical, health, and security hazards; ii) ensure that affected households are fully and justly compensated for any crop and property damages; and iii) help the relocated households regain and improve their standard of living on the settlement sites. In negotiating with the affected population, the community is assisted in gathering facts and perceptions, understanding their situation, developing common solutions and agreeing on a mode of collaboration with the geothermal developer. Geothermal Projects in Kenya, have adopted the same practice with the involvement of government surveyors to assist in giving a baseline resource value upon which negotiations are open.

Respect for Indigenous People (IPs)
The people´s way of life and origin is vital in defining their identity and thus needs special attention based on international consensus. The UN Declaration on the Rights of Indigenous Peoples (IPs) affirms that IPs are equal to all other people and that the UN is convinced that the IPs have suffered historic injustices through dispossession of their lands (UN, 2007). Thus, the UN recognizes the urgent need to respect and promote the inherent rights of the IPs to their lands, territories and resources and their need to have control over the developments affecting them. Issues such as encroachment of geothermal projects into the ancestral lands of indigenous communities, desecration of their sacred sites and the destruction of IP traditional ways of life are due to the growing awareness of the IPs as distinct peoples who have the right to self-determination. The current practices in geothermal development and utilization are compliant with these prescriptions of the UN declaration. In Kenya, social benefits have been derived from geothermal development along with cultural conservation. The Olkaria geothermal project lies within the vicinity of the Maasai community who form the indigenous community of the area living at the periphery of the project on private land. Their cultural aspects have to a lesser extent been affected by geothermal operations due to their minimal interactions with the proponents. However, through corporate social responsibility implemented by the geothermal developers several benefits are accrued to the locals including piped water services, employment, education, transport, social afforestation and health facilities. The geothermal proponents foster a bottom – top approach where they engage the communities' voice in any kind of planning to ensure social acceptability of their projects, consequently encouraging participatory rural appraisal and cultural acknowledgement and respect.

4. CONCLUSIONS

Geothermal energy is an environmentally advantageous energy option basically due to its minimal environmental impacts. Understanding the nexus between biodiversity conservation and geothermal development presents a unique case of compatibility thereby promoting environmental sustainability. This is viable with appropriate integrated environmental advocacy including monitoring, mitigation measures and legislation with local and international support. With the global call for protection and conservations of the environment, investments in geothermal projects must be given support as they are the next best alternative to green the economy thus fostering biodiversity conservation.

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