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Kenya Electricity Generating Co., Ltd.

GEOTHERMAL TRAINING PROGRAMME

Geothermal Development Company

BIODIVERSITY CONSERVATION

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ABSTRACT

Biodiversity refers to the variety of all forms of life on earth, including the different plants, animals, micro-organisms, the genes they contain and the ecosystem they form. It is considered at three main levels including species diversity, genetic diversity and ecosystem diversity. Relative to the variety of habitats, biotic communities and ecological processes in the biosphere, biodiversity is vital in a number of ways including promoting the aesthetic value of the natural environment, contribution to our material well-being through utilitarian values, maintaining the integrity of the environment through; maintaining CO_2/O_2 balance, regulation of biochemical cycles, absorption and breakdown of pollutants and waste materials through decomposition, determination and regulation of the natural world climate, protective services, e.g. by acting as wind breaks and acting as indicators of environmental changes. Despite the benefits from biodiversity, today's threats to species and ecosystems are the greatest recorded in recent history and virtually all of them are caused by human mismanagement of biological resources often stimulated by misguided economic policies, pollution and faulty institutions in-addition to climate change. To ensure intra and intergenerational equity, it is important to conserve biodiversity. Some of the existing measures of biodiversity conservation include; zoological gardens, botanical gardens/arboretums, seed banks and national parks and game Reserves.

1. INTRODUCTION

1.1 Definition

Biodiversity refers to the comprehensive umbrella term for the degree of natures variety or variation within the natural system; both in number and frequency. In general, it refers to the variety of all forms of life on earth. The different plants, animals, micro-organisms, the genes they contain and the ecosystem they form.

The manifestation of biodiversity is the biological resources (genes, species, organisms, ecosystems) and ecological processes of which they are part. Biodiversity is therefore considered at 3 major levels:

- Genetic diversity.
- Species diversity.
- Ecosystem diversity.

1.1.1 Genetic diversity

This is the variety of genetic information contained in all of the individual plants, animals and micro-organisms occurring within populations of species. Simply it is the variation of genes within species and populations.

1.1.2 Species diversity

This is the variety of species or the living organisms.

Species Richness - This refers to the total count/number of species in a defined area. Various indices are used including the Mangalet index and Menhink index.

Species Abundance - This refers to the relative numbers among species. If all the species have the same equal abundance, this means that the variation is high hence *high diversity*, however if the one species is represented by 96 individuals, whilst the rest are represented by 1 species each, this is *low diversity*.

Taxonomic or phylogenetic diversity - This considers the genetic relationships between the different groups of species. The measures are based on analysis, resulting into a hierarchical classification representing the phylogenetic evolution of the taxa concerned.

1.1.3 Ecosystem diversity

This relates to the variety of habitats, biotic communities and ecological processes in the biosphere.

2. IMPORTANCE OF BIODIVERSITY

2.1 Ethical and moral values

Every form of life on earth is unique and warrants respect regardless of its worth to human beings; this is the ecosystems right of an organism. Note that every organism has an inherent right to exist regardless of whether it's valuable to human beings or not. Humankind is part of nature and the natural world has a value for human heritage. The well being of all future generations is a social responsibility of the present generations, hence the existence of an organism warrants conservation of the organism.

2.2 Aesthetic value

Human beings derive great enjoyment from natural environment. The shapes, structure and colour stimulate our senses and enrich our culture. This is illustrated majorly in the popularity of biodiversity conservation measures and the myriad of the many organizations which fight for the protection of different organisms. A lot of money is paid to conserve wildlife for their value in nature through so many organizations. Wild species enhance our appreciation and enjoyment of the environment through:

- Leisure activities e.g. bird watching and nature trailing;
- Spotting activities e.g. spot hunting, spot fishing, diving and mushroom picking;
- Hearing, touching or just seeing wildlife;
- Enjoyment as seen in art and culture e.g. dolls and teddy bears.

2.3 Utilitarian values

These contribute to our material well-being, besides our feelings and emotions, they are things that will give us satisfaction and include conservative and productive materials from biodiversity e.g. agricultural materials or food sources, medicine, industrial raw materials, educational values and scientific research.

2.4 Ecological values

Biodiversity maintains the integrity of the environment through:

- Maintaining CO_2/O_2 balance. It is through biodiversity that sequential balance of CO_2 and O_2 is maintained. The greenhouse effect is as a result of CO_2 accumulation in the atmosphere, ozone layer depletion also occurs overtime making the earth warmer and more prone to natural calamities.
- Regulation of biochemical cycles e.g. O_2, hydrological cycles etc. Biological resources are important media in biochemical cycles, without which the cycles are not complete.
- Absorption and breakdown of pollutants and waste materials through decomposition, e.g. in food webs and food chains where the flow of energy goes through production ⟶consumption ⟶ decomposition without which breakdown and absorption of materials will not be complete. In an ecosystem there is no waste as decomposition will take place to purify our environment by transforming the waste to other forms of biodiversity.
- Determination and regulation of the natural world climate whether local, regional or micro through influencing temperature, precipitation and air turbulence.
- Acting as indicators of environmental changes e.g. the green house effect as a result of global warming causes changes in weather seasonality and also affects crops among others.
- Protective services, e.g. protection of human beings from harmful weather conditions by acting as wind breaks, flood barriers among others.

3. LOSSES IN BIODIVERSITY

Today's threats to species and ecosystems are the greatest recorded in recent history and virtually all of them are caused by human mismanagement of biological resources often stimulated by misguided economic policies and faulty institutions.

3.1 Principal threats to biodiversity

A threat by definition refers to any process or event whether natural or human induced that is likely to cause adverse effects upon the status or sustainable use of any component of biological diversity.

3.1.1 Habitat alteration / destruction

Increased insatiable demand for resources results to land use changes hence loss to genetic diversity, species reduction and increased ecosystem changes such as random population changes, disease outcrops, habitat fragmentation among others resulting in biodiversity losses.

3.1.2 Overharvesting / over-exploitation of biological resources

This results when individuals of a particular species are taken at a higher rate than can be sustained by the natural reproductive capacity of the population being harvested. This can be through hunting, fishing, trade, food gathering etc. Overharvesting will lead to extinction of resources or the biological resources, eventually leading to loss of species. For species that are protected by the law and

overharvesting occurs, this is known as poaching, if the law allows for harvesting of a resource, this is known as cropping.

3.1.3 Pollution

Chemical or thermal pollution is a threat to biodiversity. Species in habitats are increasingly being harmed by industrial activities and pollution from excessive use of agro-chemicals such as DDT, oil spills, acid precipitation etc.

3.1.4 Introduced species / biological invasions

This can be intentional or accidental. Species introduced in an ecosystem will cause changes in the ecosystem. Introduced species are organisms arising in areas/ habitats in which they were previously not native. Such introduced species are usually referred to as biological pollutants. Some of the ecological impacts of the invasion include hybridization, out competition, disruption of original ecosystem, plant pathogenic influences, disease transmission, disruption of foodwebs and to some situations extinction. Species may be introduced intentionally for:

- Ornamental concerns;
- Agriculture;
- Hunting and spotting activities;
- Biotechnology for scientific research;
- Trade.

3.1.5 Climatic changes

This is of great concern especially when global CO_2 increases in the atmosphere resulting to global warming. Most species originate within a very narrow physiological limit; hence nature has a range of tolerance maintained for ecosystem stability. Changes may be gradual or abrupt such that if the limit is exceeded the upper or lower species suffers extinction.

3.1.6 Population

As the human population is increasing, there exists insatiable demand for raw materials which is bound to cause changes in biodiversity. It is therefore vital to control human population which will result in biodiversity conservation.

3.1.7 Institutional / policy failure

Some institutions are created to manage biological resources. However, the institutions/policy fail to internalize the values of biodiversity within the decision making process of their Nations and individuals. Such institutions/policies in place should have a holistic approach towards biodiversity conservation rather than part conservation.

4. BIODIVERSITY CONSERVATION

This incorporates the preservation, maintenance, sustainable use (conservation), recovery and enhancement of the components of biological diversity, where:

- *Conservation* - is the sustainable use of resources and encompasses protection as well as exploitation and;
- *Preservation* - is an aspect of conservation meaning to keep something without altering or changing it.

4.1 Sustainable development

This refers to development that meets the needs of the current generation without compromising the ability of future generations to meet their needs; it simply refers to intra and intergenerational equity. A balance between the environment, development and society results to sustainable development which ensures biodiversity conservation. This is only possible in the presence of good enforced and implemented policies/ conventions, environmental institutions (e.g. NEMA for Kenya) and political stability among others (Figure 1).

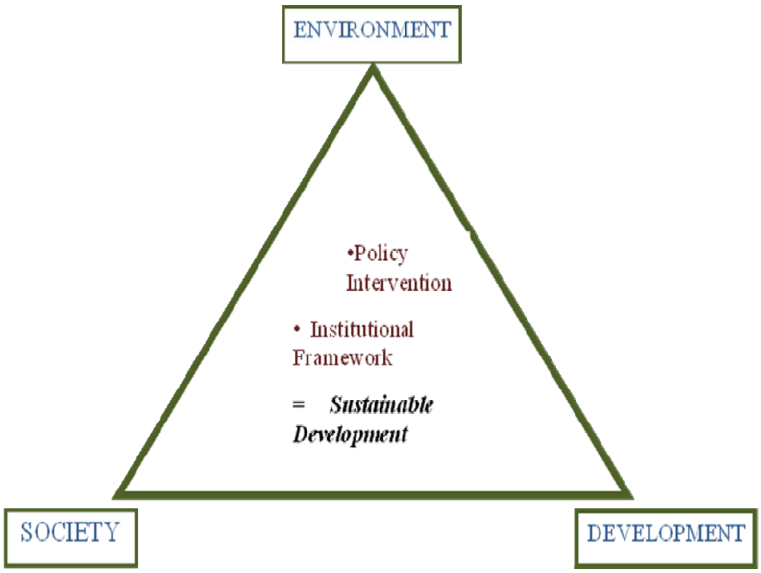

FIGURE 1: Concept of sustainable development

4.2 Conservation measures of biodiversity

Ex-situ conservation:

- Refers to conservation of components of biodiversity outside their natural habitats, e.g. zoos, museums, gene banks, botanic gardens/arboretums;
- Used for threatened and endangered species to avoid their extinction; also known as captive conservation.

In-situ conservation:

- Refers to conservation of ecosystems and natural habitats including maintenance and recovery of viable populations of species in their natural habitats.

4.3 Convention on biological diversity (CBD)

Conservation of biological diversity and sustainable use of its components came into the limelight in 1972 (United Nations Conference on Human Environment; Stockholm). In 1973, UNEP identified conservation of biodiversity as a priority area, hence there was need to get the legal mandate for conservation of world resources. There were negotiations for a legally binding instrument to address biological diversity and its loss to enhance fairness and equity in sharing of the benefits of biodiversity; this led to the opening of the Convention on Biological Diversity in 1992; Rio de Janeiro under the United Nations Conference on Environment and Development (UNCED)/ Earth Summit. The convention was inspired by the growing concern all over the world for sustainable development. The convention objectives were:

- Conservation of the biological diversity;
- Sustainable use of its components;
- A fair and equitable sharing of its benefits.

This was the first global comprehensive agreement that addressed all the aspects of biological diversity; genetic resources, species diversity and ecosystem diversity.

4.4 Other international biodiversity conventions and conservation organizations

- African Convention on Conservation of nature and natural resources.
- The Ramsar Convention on Wetlands of international importance.
- International Union for the Conservation of nature (World Conservation Union).
- Convention on International trade for endangered species (CITES).
- International Convention for the Protection on birds.
- International Board for Plant genetic resources .
- World Resources Institute.
- World Wide Fund for Nature.
- Convention on Conservation of migratory species of wild animals.
- International Convention for the Regulation of whaling .
- UNESCO programme on Man and biosphere .

4.5 Existing Measures for Conserving Biodiversity in Kenya

Zoological gardens - These are refuge areas for rare animals that could disappear without captive breeding e.g. zoos and aquariums. They are conservation areas for preservation of genetic stocks for re-introduction to the wild when conditions become favourable. They are also used for educational and scientific research.

Botanical gardens/Arboretums - These are areas for research and exhibition of plants, documentation of local flora, preserving samples of rare and endangered species and maintenance of specimen collections for future use. It acts like a museum for plants e.g. the East African Botanical Garden in Nairobi.

Seed banks - Ex-Situ approach where storage of conservation materials in form of seeds is monitored with regard to viability through germination tests and purity analysis. The objective is to ensure that genetic continuity is maintained.

National parks and game reserves - These are different from zoological gardens and are established on terrestrial and aquatic ecosystems with the objective to preserve wildlife that cannot co-exist with human beings and human activities. National parks are under the jurisdiction of central government while game reserves are managed by the local county council.

5. CASE STUDY - HELLS GATE NATIONAL PARK, KENYA AND GEOTHERMAL DEVELOPMENT

Hell's Gate national park covering an area of 68.25 km^2 lies south of Lake Naivasha in Kenya, NW Nairobi (Figure 2). It received the name "Hell's Gate" by explorers Fisher and Thomson in 1883 and was named after a narrow break in the cliffs, once a tributary of a prehistoric lake that fed early humans in the Rift Valley. Established in 1984 as a small national park, it is known for its wide variety of wildlife and for its scenery. The park is characterized by warm and dry climate. Two extinct volcanoes are located in the park; Olkaria and Hobley's, as well as obsidian forms from the cool molten lava. Within Hell's Gate is the Hells Gate Gorge, lined with red cliffs which contain two volcanic plugs: Fischer's Tower and Central Tower. Off of Central Tower is a smaller gorge which extends to the south and of which a path descends into hot springs.

There is a wide variety of wildlife in the national park, though many are few in number. Examples of little seen wildlife include Giraffes (Figure 3), Warthogs, Zebras, Antelopes, rock hyrax, gazelles, water buck, baboons, monkeys, African Jackal; Thompson’s and grants gazelles, Hippopotamuses, leopards, and cheetahs. However, the park has historically been an important home for the rare

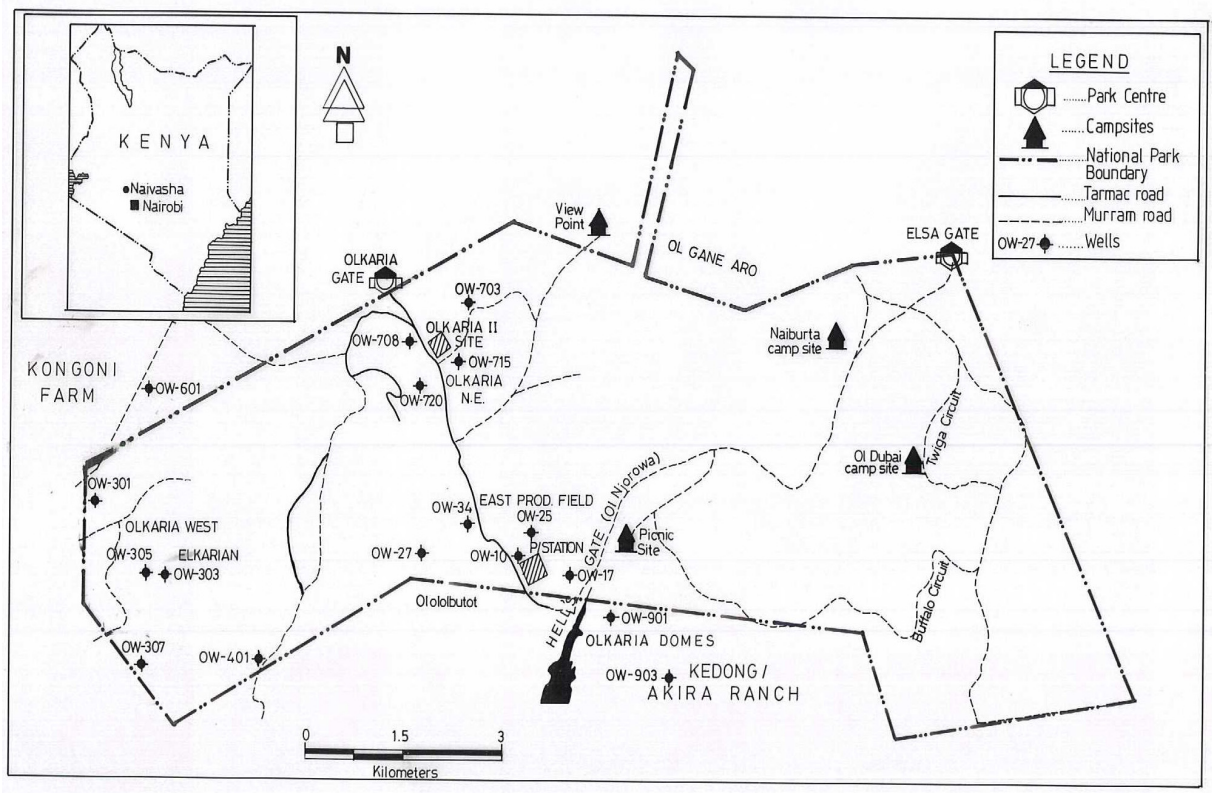

FIGURE 2: Location of Hell's Gate National Park. Source: KenGen Olkaria GIS Lab.

lammergeyer eagles. There are over 103 species of birds in the park, including vultures, Twany eagles, verreaux's eagles, Augur buzzard, secretary birds and swifts. The most dominant vegetation in the park is *Tarchonanthus camphoratus* commonly known as leleshwa.

In the early 1900s, Mount Longonot erupted, and ash can still be felt around Hell's Gate. The comprehensive Olkaria Geothermal Station, the first of its kind in Africa, was established in 1981 and generates geothermal power underneath Hell's Gate from the area's hot springs and geysers. Two other power stations exist in the Park namely Olkaria II and Olkaria III (Figures 2 and 4).

FIGURE 3: Giraffe, Hells Gate national park, Kenya.

FIGURE 4: Olkaria II power station, Naivasha.

5.1 Environment management aspects

To conserve biological diversity and ensure sustainable geothermal development in the park, the following environmental management aspects are implemented:

- Surface disturbance; rehabilitation and afforestation;
- Noise monitoring;
- Solid waste management;
- Wildlife population studies;
- Chemical discharge monitoring (wastewater, trace elements, gases);
- Gravity and seismicity studies.

Other geothermal power plants in popular tourist resorts worldwide include:

- Fang, Thailand (Figure 5);
- Zunil, Guatemala (Figure 6);
- Rotorua, Newzealand (Figure 7).

FIGURE 5: Geothermal power plant at Fang,

FIGURE 6: Geothermal power plant at Zunil, Guatemala.

FIGURE 7: Geothermal power plant at Rotorua, Newzealand.

REFERENCES

Spellerberg, I.F., and Hardes, S.R., 1992: *Biological conservation*. Cambridge University Press, 123 pp.

Swanson, T.M. (ed.), 1995: *The economics and ecology of biodiversity decline – The forces driving global change*. Cambridge University Press, 176 pp.

Tolba et al., 1992: *The world environment 1972 – 1992: two decades of challenge.* Chapman and Hall on behalf of the United Nations Environment Programme, 884 pp.

Wetangula, G., and Ajayi, J., 2002: *Power development and nature conservation – two scenarios*. University of Iceland, Iceland and Olkaria Geothermal Power Project, Naivasha, Kenya.