# ENVIRONMENTAL BASELINE SURVEY FOR GEOTHERMAL DEVELOPMENT: CASE STUDY KIBIRO GEOTHERMAL PROSPECT, UGANDA

Oris Ouma[1]

[1]Ministry of Energy and Mineral Development

P.O.Box 9, Entebbe, Uganda

oumaoris@gmail.com , oris.ouma@minerals.go.ug

***Keywords:*** *Geothermal, environment conditions, baseline data, mitigation measures.*

## ABSTRACT

The shift to environmentally friendly energy sources is one of the main items on the agenda of global environmental debates. Geothermal energy is one of the resources that often are located in remote, forested and wildlife areas, whose environment is a source of social and economic necessities for Ugandans. Therefore, in order for government and stakeholders to assess the impact of geothermal projects on the environment, the developer must prepare a detailed Environmental and Social Impact Assessment (ESIA) for the project. The current state of physical, social and economic environments is defined in baseline surveys before a project begins and are necessary for the design and assessment of any project. The potential impacts of a project cannot be determined without knowing the existing state of the environment. Baseline surveys will also be used to monitor the effects of projects during operation, such as physical, biological and socioeconomics aspects. The baseline data is built through collection and analysis of existing data, community consultation programs and specific field surveys. An Environmental and Social Impact Assessment (ESIA) is then carried out to discover early enough, if there would be any adverse effects on the environment and local ecosystems. An ESIA would ensure that any developments undertaken are environmentally benign and socially acceptable to stakeholders including geothermal energy development partners. In this article the Kibiro geothermal project serves as example. This project is anticipated to have both positive and negative environmental impacts based on baseline studies. However, the negative impacts can be contained through recommended mitigation measures.

## 1. INTRODUCTION

### 1.1 Background

Systematic geothermal energy exploration has been going on since 1993 with the aim to identify potential geothermal energy resources in the Western branch of the East African rift system in Uganda. Kibiro is one of the areas that have been studied in detail and is now ready for drilling. There are a number of stages required in geothermal energy development from the preliminary to the production. Geothermal energy is well known to be an environmentally friendly energy source compared to fossil fuels but this does not mean that it is completely friendly to the environment. Geothermal energy development has some impact on the environment and the aspects of this environmental impact have to be considered prior to any decision to develop a geothermal field, as well as possible mitigation measures (Goff & Goff, 1997). Undesirable effects may result from these geothermal activities on ecosystems such as air quality, noise, hydrology, soil, flora and fauna, land use, culture and archaeological settings, indigenous people, climate, terrain, aquatic organism, amenities and socioeconomics aspects. Therefore, stages of geothermal development must be carefully investigated to ascertain in a timely manner, if there would be any adverse effects on the environment and local ecosystems. Baseline data was collected on critical aspects of environmental conditions as they existed before any significant disturbance at Kibiro. It is hoped and planned that the environmental data set up by this survey will serve as baselines from which to measure changes which may be associated with geothermal development, not only in the area immediately neighboring Kibiro, but, with appropriate adjustments, for development which may occur elsewhere in the surrounding environment. Additionally, the baseline information will be used during full-fledged Environmental Impact Assessment (EIA) for drilling and operation phases. This would ensure that any developments undertaken are environmentally sound and socially acceptable as stipulated in the National Environmental Act, 2019, and operational guidelines issued by geothermal energy development partners (Torrance, 2012).

### 1.2 Study Area

#### 1.2.1 Regional Study Area

The regional study area has been defined as the Hoima District in Western Uganda where the Kibiro prospect is located. Secondary data is presented for the socio-economic conditions within these administrative areas.

#### 1.2.2 Local Study Area

The Kibiro geothermal prospect is located in Kigorobya subcounty, Bugahya county in Hoima district, Western Uganda, about 210 km NW of Kampala (Figure 1). The prospect area is at an elevation from about 620 to 1000 m asl on the SE shore of Lake Albert. The thermal manifestation at Kibiro are hot springs, which are situated on a fan delta of about 1.3 km x 0.6 km, limited by the lake shore and the foot of the ~300-400 m high escarpment forming the southeastern side of the rift. Additionally, a fumarole (45℃) has been located approximately 1Km SE of the hot springs. The environment affected by the development of the Kibiro geothermal prospect is basically the environment of Hoima district.


ISSN 2703-4275

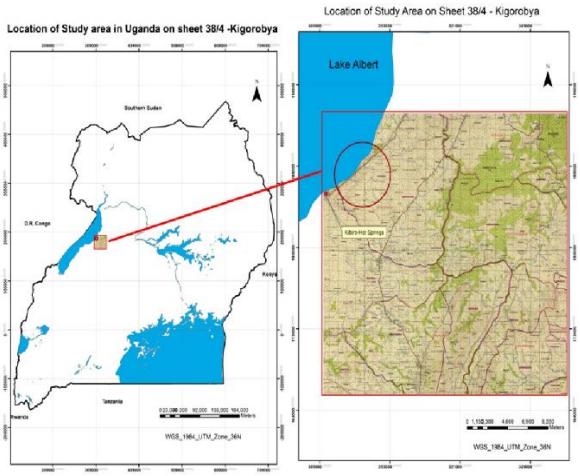


**Figure 1: Location of study area in Uganda and on sheet 38/4 (Mawejje et al.,2014).**

### 1.3 Objectives of the Study

The study objective of the environmental baseline survey is to review the following environmental and social aspects of Kibiro geothermal prospect:

- Physical environment such as geology, climate, water resources
- Biological environment
- Socio-economic conditions.

### 1.4 Legal and Regulatory Framework

The legal framework on environmental management in Uganda is provided for in a series of laws, including the Constitution of Uganda (1995). There are also a number of Acts, Statutes and Regulations that have been instituted. The overall objective for the legal and regulatory framework is to provide measures necessary to protect and preserve the environment from abuse, pollution and degradation as well as to promote environmental awareness. It is also geared towards achieving sustainable social and economic development, by ensuring that natural resources are harnessed and exploited in a balanced and sustainable manner for present and future generations. A section of the relevant legislation pertaining to geothermal development is presented in Table 1. It is a requirement that all aspects of an energy development project must comply with such policies, laws, treaties and agreements.

**Table 1; A section of the relevant legislation to geothermal development**

| |
|---|
| The Uganda Constitution, 1995 The Uganda Constitution of 1995 (Articles 39 and 41) |
| The National Environment Act, 2019 |
| The Water Act -Cap 152 (2003) |
| The Wildlife Act, (Cap 200) Of 2000 |
| Mining Act, 2003 |
| Electricity Act, 1999 |
| Land Act, 1998 |
| The Uganda Tourism Act (2008) |
| Local Government Act, 1997 |
| The Roads Act, 1964 |
| The Public Health Act (1964) |
| The Investment Code Statute, 1991 |
| The Town and Country Planning Act Cap. 30 |
| Donors and Financing Institutions e.g. The World Bank |

## 2. BASELINE CHARACTERIZATION

### 2.1 Physical Environment

#### 2.1.1 Geology and Topography

The Kibiro geothermal prospect is located at the foot of the escarpment of the western branch of the east African rift system. The escarpment rises over 300 m above Lake Albert. The area also consists of deep and steep valleys (fault zones), especially closer to the escarpment. The geology of the prospect is divided into two distinct areas. To the east, it consists of crystalline basement, characterized by granites, granitic gneisses, schists and quartzites, whereas there are sequences of thick sediments in the rift. The rocks in the escarpment are highly transformed by the fault movements. The hard rocks have been resistive to weathering while the soft rocks weathered and formed depressions. There are no volcanic rocks in the Kibiro geothermal prospect.

#### 2.1.2 Climate

The overall climate in Hoima district is stable with small variations in temperature, humidity and wind throughout the year. The district receives a total rainfall of about 700-1,500 mm per year. The wet months are April - May and September - October, with two dry spells occurring in June - July and December – January (Figure 2). Western areas bordering the rift valley are the driest and hottest. Temperatures are generally high ranging between 16 to 32˚C. The long-term wind speed records from the East African Meteorological Department (1975) indicate average annual wind speeds of 3 knots and 5 knots at 0600 hours and 1200 hours, for Hoima. The Kibiro geothermal prospect lies in the rain shadow and is hot and dry all the year round with few rainy days; the project is located in the driest area in the district.

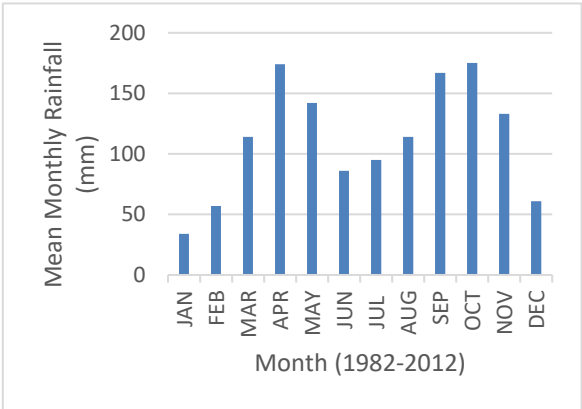


**Figure 2: Hoima Mean Monthly rainfall from 1982-2012 (Climate Data, 2015).**

#### 2.1.3 Soils

Hoima's soils are ferralitic and generally acidic. However, they have adequate organic matter especially on the lower slopes and in the valleys. The soils are typically loam and deep on the valley slopes but tend to be shallower on the upper slopes. Soil erodibility is low, rainfall erosion is generally moderate. The water table is high with soils frequently water logged. The soils of Hoima are defined by a number of parameters, which include parent rock, age of soil and climate. As already mentioned above the most dominant soil type is ferralitic soil. Productivity soils are scarce, therefore, fair and low productivity soils in Buseruka, part of Kigorobya, part of Kyabigambire, along the lakeshore and partly Buhimba must be managed effectively in order to sustain Hoima's agriculture.

2.1.4 Water Resources

Lake Albert is the main surface water source coupled with the small rivers from the hills. The permanent rivers include Kitawe, Kasensero, Kachuru, Waaki and Hoimo. However, some rivers are seasonal and only contain water during the rainy season. There exist wetlands and lagoons in some places (around Lake Albert). There is a supply of ground water available for domestic use due to rivers in the area. The composition of waters in selected rivers and boreholes are presented in Tables 2 and 3 respectively.

**Table 2; Composition of water in selected water sources within the Kibiro prospect**

| Item | Lake Albert | River Kachuru | River Waki falls | EA Standards (Mg/L max.) |
|---|---|---|---|---|
| pH | 8.93 | 6.84 | 7.61 | 6.5-8.5 |
| TDS | 338 | <50 | <50 | 1500 |
| Na | 72.3 | 12.3 | 5.4 | 200 |
| K | 49.4 | 0.8 | 1.7 | - |
| Ca | 9.75 | 11.5 | 5.5 | 150 |
| Mg | 27.3 | 6.5 | 3.1 | 100 |
| Cl- | 24.2 | 1.5 | 2.3 | 250 |
| F- | 0.83 | | - | 1.5 |
| SO4 | 19.3 | 2.1 | 2.8 | 400 |

**Table 3; Composition of water in selected Boreholes within the Kibiro prospect**

| Item | Ndalagi Borehole | Nyabago Borehole | Kijura Borehole | EA Standards (Mg/L max.) |
|---|---|---|---|---|
| pH | 6.72 | 6.03 | 8.1 | 6.5-8.5 |
| TDS | 680 | 16 | 112 | 1500 |
| Na | 50.6 | 4.8 | 10.7 | 200 |
| K | 7.5 | 1.8 | 2.0 | - |
| Ca | 138 | 1.0 | 13.5 | 150 |
| Mg | 39.5 | 0.6 | 8.1 | 100 |
| Fe | 0.72 | - | - | 0.3 |
| Mn | 0.034 | - | - | 0.1 |
| Cl- | 123 | 2.7 | 5.0 | 250 |
| F- | 0.12 | - | - | 1.5 |
| SO4 | 227 | 0.5 | 1.5 | 400 |

2.1.5 Air Quality

Air quality within Hoima district is generally good because it is located in the countryside with no industrial developments and very low traffic movements and virtually no air polluting industries to speak of. The area is not very dusty because of the grass cover in some areas; however, air is still mainly polluted by dust being blown by wind. Another source of air pollution is the smell of hydrogen sulphide gas from the hot springs.

**2.2 Biological Environment**

2.2.1 Fauna

No detailed count of the fauna has been carried out in the district but generally the wildlife fauna population is low. This is partly due to habitat loss for these animals through agricultural encroachment. The fauna is mainly concentrated in areas that have fairly heavy vegetation but are in many cases thinly populated. Monkeys, baboons, antelopes and pigs are known to exist. In other parts of the district, the fauna is confined to Lake Albert and the wetlands. Hippopotami are known to exist in the waters of Lake Albert while papyrus swamps are rich in birds both in terms of variety and numbers. Some bird species breed along the lake shores. Crocodiles also exist in Lake Albert (Figure 3).

**Figure 3: Some of the bird species at the shore of Lake Albert**

2.2.2 Flora

The Kibiro geothermal prospect is dominated by grassland, woodland and bushland. Grass savannah is derived from wooded savannah and thicket by repeated cultivation, grazing and burning. The escarpments are steep, rocky and hence hold no major plant life. The valley basins are flat and characterized by short grass. Geothermal grass surrounds the hot springs. The river valleys are forested due to water infiltration. Some vegetation act as cultural herbal medicine e.g. Aloe Vera, baobab tree and earth tulips.

**2.3 Land Use**

Agriculture is the main economic activity and source of income in Hoima district. The population produces both food and cash crops. Livestock farming is also practiced, mainly with local breeds such as Zebu and Ankole cattle. However, introduction of exotic breeds is expected to increase on the productivity in regards to dairy products. The main agricultural activity west of the escarpment in the rift valley at Kibiro and the neighbouring village of Kachuru is fishing and raring of chicken, pigs, and goats, and to a small extent cattle keeping. The area is not good for crop husbandry due to being in the rain shadow and dry all the year round. There is also salt farming which dates back to 900 years ago. It is commonly practiced by women (Figure 4, 5 & 6)

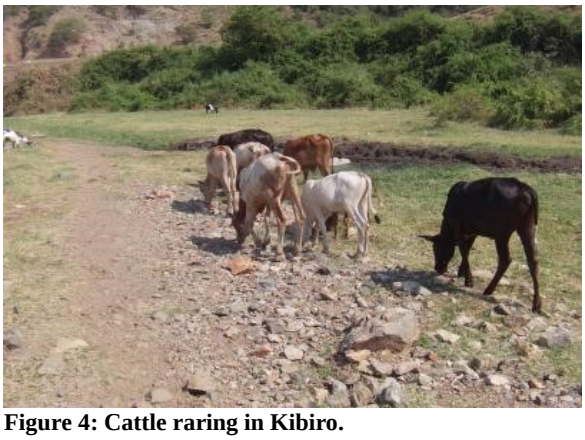

**Figure 4: Cattle raring in Kibiro.**


ISSN 2703-4275

**Figure 5: Salt mining.**

**Figure 6: Fish drying.**

### 2.4 Socio-Economic Conditions

2.4.1 The Administrative Structure

Hoima District is divided into three counties, Bugahya, Kigorobya and Buhaguzi, and one municipality. The counties are sub divided into 10 sub counties and 1 town council. Hoima Municipality comprises of four divisions: Kahoora, Bujumbura, Busiisi and Mparo. In total, the district has 43 rural parishes, 20 town wards, 457 villages and 149 cells.

2.4.2 Land Tenure System

The major land tenure systems in the district include customary, freehold, leasehold and public land. All protected forests and wildlife conservation areas are under public land form of tenure, in addition to areas accommodating government institutions and infrastructure. On private land, customary land tenure (both individual and communal) is the most widely practiced system. In Kibiro, customary land tenure is used.

2.4.3 Population and Demographic Characteristics

According to the National Population and Housing Census (2014) results, Hoima District had a total population of 573,903 people (Table 4). Results also showed that most of the people in Hoima District reside in rural areas 81.4% compared to 18.6% who reside in urban centers. The gender distribution was reported to be males: (49.96%) and females: (50.04%). At the time of the census, Kibiro village had a population of 9415 people.

**Table 4; Population distribution per County for the different gender.**

| County | Male | Female | Total |
|---|---|---|---|
| Bugahya | 68,061 | 65,720 | 133,781 |
| Kigorobya | 36,504 | 37,765 | 74,269 |
| Buhaguzi | 134,588 | 130,640 | 265,228 |
| Hoima Municipality | 47,552 | 53,073 | 100,625 |
| **Total** | **286,705** | **287,198** | **573,903** |

**(Uganda Bureau of Statistics, 2014)**

2.4.4 Local Community

Hoima ditrict has a multitude of ethnic groups with the indigenous Banyoro and Bagungu forming the dominant tribes. There are also other tribes such as Baganda, Banyankole, Bakiga, Lugbara, Alur and Jonam. The main inhabitants of Kibiro are the Banyoro, Bagungu, Alur, Balaalo and Congolese. They are mainly fishermen, who settled in this area with a motive of fishing. These people are quite social and ready to give any information as long as the right procedures are followed i.e. one has to first contact their Local Council chairman and declare the purpose of their visit.

2.4.5 Health

Hoima district has a total of 53 health units of which 44 are government aided. These include 1 Hospital, 3 Health Centre IV's, 33 Health Centre III's and 20 Health Centre II's at parish level. The health units are distributed in all sub counties across the district. Kigorobya County, in which the Kibiro geothermal prospect lies, has five health units at Kigorobya, Kibiro, Bombo, Kapapi and Kitana (Table 5). The common diseases in the district are malaria, followed by respiratory infections, anemia, AIDS, meningitis and dysentery.

**Table 5; Health units at Kigorobya County**

| Sub County | Parish | Health Unit | Level |
|---|---|---|---|
| Kigorobya Sub County | Bwikya | Bombo | HCII |
| | Kapapi | Kapapi | HCIII |
| | Kibiro | Kibiro | HCII |
| Kigorobya Town Council | Northern Ward | Kitana | HCII |
| | Eastern Ward | Kigorobya | HCIV |

2.4.6 Tourism

Hoima district has potential for the development of a tourism industry in the areas of the rift valley, the escarpment, the hot springs at Kibiro and Lake Albert. The Kibiro hot springs and the salt industry attract a number of tourists. The area also gives a good views of Lake Albert from the top of the escarpment at Kabiribwa, the rivers running through the fault lines, the different settlements, the hot springs and also the different activities taking place in the area. On the other hand, from the valley floor one is able to see the vegetation types, the hills and escarpments. All these are good tourist attraction features. Kibiro is not a gazetted protected area and therefore does not need an entry permit.

2.4.7 Literacy and Education

Hoima District Local Government embraces government initiated programs under Universal Primary Education and Universal Secondary Education since their inception in 1997 and 2007 respectively. The literacy rate in the district is about 76% for the age group above 10 years old.

2.4.8 Infrastructure and Services

*2.4.8.1 Roads*

The district's road networks are made up of trunk, rural feeder and community roads with a total length of 1,915 kilometers of which 261 km are trunk roads, 534 km district roads and 1,120 km community roads. The major roads include the 220 km Kampala-Hoima road connecting to the central and western region and Hoima-Kaiso Tonya road linking oil explorations areas to the rest of the country. Other busy roads in the district are the Hoima – Fort Portal via Kabwoya, Hoima – Kafu and Hoima – Masindi roads. At Kigorobya, there's a feeder road (Murrum) that leads to Kibiro through the escarpment at Kabiribwa.

*2.4.8.2 Telecommunications*

Hoima district is connected to the national telecommunications infrastructure and enjoys the services of MTN, Airtel, Africel, Uganda Telecom (UTL) and the internet. A number of radio stations in the district allow for easy communication with the people at the grass roots.

2.4.9 Mineral Resources

Hoima is endowed with favorable geological conditions associated with a rich and diverse mineral resource base and substantial economic potential. Some of the known mineral resources have a mining history while others are yet to be exploited. Known deposits include: Gold, heamalite, salt, kaolin, clays, oil and gas and others (such as Ilmenite, Zircon, Monazite, Zonatime and Casserite).

## 3. ANTICIPATED ENVIRONMENTAL AND SOCIAL IMPACTS AND MITIGATIONS

The anticipated environmental and social impacts arising from geothermal development in Kibiro prospect are summarized in this section. The potential impacts have been modelled on similar projects that have been implemented in other parts of the world during geothermal development.

### 3.1 Geology and Land Use

The land in Kibiro is privately owned by the local community. The proposed project will involve construction of access roads to the drill site for moving equipment and accessories, and clearing of land for drill pads. Construction of roads and drill pads may change the geology and topography of the area. This may lead to soil erosion of cut slopes and fill slopes if the soil is not well compacted.

**Recommended Mitigation**

- Re-vegetation with grass and trees on the affected areas.

### 3.2 Fauna

Fauna is likely to be affected through the discharge of geothermal fluids to surface waters and streams. The hot water increases temperatures in the rivers and thus reduces the oxygen available to living organisms in the rivers and other water bodies downstream. Noise pollution during drilling and well testing could make animals move away from preferred habitats.

**Recommended Mitigation**

- Re-injection of fluid into the reservoir.

### 3.3 Flora

Original vegetation will be destroyed during road construction and drill pad preparation.

**Recommended Mitigation**

- Pad size reduction to guarantee minimum disturbance of natural vegetation.
- Re-vegetation with grass and trees on the affected areas.
- Re-injection of drilling effluents to minimize impacts on flora in the nearby environment.

### 3.4 Soil

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

**Recommended Mitigation**

- Re-vegetation with grass and trees on the affected areas.

### 3.5 Water Resources

Geothermal well drilling and construction of geothermal utilities requires large amounts of water for both domestic consumption and industrial uses. These activities are a source of wastewater, which is likely to affect the quality of surface and ground waters.

**Recommended Mitigation**

- Discharge of such fluid on the surface or into waterways must be avoided.
- Alternative sources of water for geothermal well drilling like drilling new boreholes.
- Adopt modern drilling techniques using minimal amounts of water during drilling and with recycling capability.

### 3.6 Air Quality

Most of the impacts arising during geothermal development will affect the air quality through the release of dust from site clearing, noise from the heavy machinery, emissions from the operation of drilling equipment, etc. This may create visual obstruction. The obstruction will be temporary during drilling and the natural beauty will be restored when the activity is completed.

**Recommended Mitigation**

- Reinjecting all the waste fluids.
- Employing active monitoring systems for quick detection of pollutants.

### 3.7 Population

Geothermal resource development attracts several people to the area in search of employment. This would lead to an increase in population thus affect the average age of the population since the workers will not be accompanied by their families.

### 3.8 Infrastructure

Geothermal development includes opening up of the area and improved road network through upgrading of existing roads.

### 3.9 Tourism

The Kibiro's beautiful scenery, hot springs and the salt industry attract a number of tourists. Therefore, the planned construction of geothermal utilities in the area is anticipated to attract both local and foreign people due to its unique feature. The area's potential to generate revenue from visitors will increase especially with revenue that will accrue from accommodation facilities that are in development.

### 3.10 Energy Consumption and Demand

The geothermal energy will not only produce electricity but also boost the existing hydropower supply. Being reliable and environmentally friendly, it will prevent further degradation of vegetation resources. It will also be used in industry and agriculture for drying and processing purposes.

## 4. CONCLUSION

The anticipated environmental impacts within the Kibiro geothermal prospects could be significant if not mitigated in time during civil works, drilling and testing of geothermal wells and power plant construction and operation. The social and economic impacts are both positive and negative. Through recommended mitigation measures, mainly re-vegetation and reinjection of fluids, the negative impacts can be of low significance.

## REFERENCES


Climate Data, C. J. U. w. e. c.-d. o. *Climate data*. (2015).

Goff, S., & Goff, F.: *Environmental impacts during geothermal development: some examples from Central America*. (1997)

Mawejje, P., Kato, V., Nnakirijja, J., Tunde, K., Birungi, U., Mulindwa, H., & M, T. M.: *The Geology and Potential of Kibiro Geothermal Field in Albertine Graben, Western Uganda*. (2014).

Torrance, M.: *IFC performance standards on environmental & social sustainability: A Guidebook*. LexisNexis. (2012)

Uganda Bureau of Statistics, U.: *National population and housing census 2014*. In: UBOS Kampala, Uganda. (2014).




ISSN 2703-4275