4. Environmental and Social Consideration Study

Rwanda has plans to develop power generation using hydro and thermal (diesel, methane, peat, etc.) sources, as well as to develop power systems. At the beginning of this study, geothermal development was considered the most promising generation method, and the viability of development plans for other options was uncertain. For these reasons, this study surveyed existing conditions for the four potential geothermal development areas, and evaluated the environmental impact in a strategic environmental assessment (SEA). This report presents a summary of the fundamental SEA results for the geothermal power plant sites, and the results of qualitative assessment of transmission lines to be connected to the geothermal power plants.

4.1. Environmental Baseline of the Study Area

4.1.1. Geothermal Project Location

Five geothermal project sites named Bugarama, Gisenyi, Karisimbi and Kinigi are located in the following administrative sectors (Fig. 4-1.1):

- Bugarama site is located in Nyakabuye Sector, Rusizi District, Western Province of Rwanda.

- Gisenyi site is located in Nyamyumba Sector, Rubavu District, Western Province of Rwanda.

- Karisimbi site is located in Kabatwa Sector, Nyabihu District, Western Province of Rwanda.

- Kinigi site is located in Kinigi sector, Musanze District, Northern Province of Rwanda.

Source: REMA

Fig. 4-1.1 Location of geothermal project

4.1.2. Bugarama

The Bugarama hot spring site is located in Nyakabuye Sector, Rusizi District in the Western Province of Rwanda. The Bugarama region is the warmest in Rwanda and also the site of the country's first cement and rice production.

(1) **Climate**

The Bugarama area has a tropical climate that is characterized by an average temperature of 24°C and a dry season from June to September. Total annual rainfall is about 1,050 mm. There are two rainy seasons: a short wet season from October to November and the main rainy season from mid-March to end May.

(2) **Biodiversity**

The study area around the site is has a rich and varied species composition including cultivated mixed crops widely distributed in the study area and some relic and several ruderal species. Several vulnerable and indigenous plant species of the area are gradually disappearing due to severe land use pressure and over-use by local people. Flora observed during site visits includes but is not limited to: Banana, Cassava, Coffee, Sorghum, Rice (Big space), Bamboo, Grevelia, Eucalyptus, Avocados, Flowers, some papaya, Ordinary beans, Climbing beans, Peas, Soybeans, Irish potatoes, Sweet potatoes, Taro, and Yam. Natural forest in the area consists of the Cyamudongo forest, which is a continuation of the Nyungwe Forest. This is located about 20 km from Bugarama Hot Spring Lake. Rice production dominates the Bugarama marshland and mixed agricultural characterizes the rest of land.

The planned site is bare ground on a plateau, and the surrounding area is also developed. Areas to the east, north, and west from the site are mountainous, and they can be categorized as residential areas with farmlands or grass/forest lands. To the south of the planned site is a large rice field. Overall, the Bugarama area ecosystem is linked closely with human settlements and human activities. The area has rivers whose sources are hot springs or water springs that run all the year. When the site was surveyed, water from the rivers was almost all being diverted to agricultural irrigation canals, and downstream from the canal dam the river was dry. However, as the downstream still maintains nature, once the water flow comes back a recovery of the river ecosystem can be expected.

During the site visit, amphibians and migrant bird species were observed. The population of mammals in the study area is very low, and in most cases the species that inhabited forest areas and wet marshlands in the past have become extinct locally due to loss of habitat and hunting pressure. During our field survey, a family of small monkeys was identified.

(3) **Water usage**

CIMERWA has installed a water treatment plant in the village of Nkangabashi that draws water from the Njambwe River. The water is treated and then supplied to the cement plant and nearby community. The water treatment plant treats 2,500 m^3 of water per day out of which 1,200 m^3/ day are supplied to the Plant. CIMERWA supplies the balance of the water to six villages

(Kabarore, Ramiro, Rubeho, Nyenyeri, Murabyo and Busasamana) and to a primary school. This meets the requirement of around 6,000 local villagers through Company-owned pipelines. Rivers from surrounding hills supply water to the Bugarama wetland, which is used for rice production. Downstream water from the hot springs is used by APC Mashyuza and COCOCHAUMA, two small factories producing lime in Bugarama. Water from natural sources is the primary source for all domestic activities.

Photo 4-1.1 Water Usage

(4) **Waste generation and Management**

In rural areas, waste is normally generated from food scraps and other household uses. No formal management system or technology is in places for managing waste in this study area. Every household has its own dumpsite for deposing collected waste, which later becomes compost to be used in agricultural land. Solid waste and other unused materials from the CIMERWA sewage treatment plant are transported to the Rusizi landfill. Waste from local markets is disposed in temporary dumpsites and then, after two weeks, collected and transported to Rusizi landfill.

(5) **Local natural resources**

Generally, the land within project area is used in agricultural activities. A large area of land is occupied by wetland of Bugarama, which produces rice. The rest of the land is used for subsistence agriculture. There are also three quarries in the vicinity.

(6) Population

The national census of 2012 shows that Rusizi is the most populated area in Western Province with 404,712 people (194,310 male and 201,402 female), while Nyabihu District is the least populated, with 295,580 inhabitants. The Rusizi District average annual growth rate is 2.0 and the District density of population is 422 people per square meter.

Table 4-1.1 The following table illustrates the distribution of population per sector

Sector	2002 Total Population	2012 Population			Sex Ratio	Population Change (2002-2012) (%)	Average Annual Growth Rate (2002-2012) (%)	Population Density (sq.km)
		Male	Female	Total				
Bugarama	20,271	14,632	15,449	30,081	95	48.4	4	1,266
Butare	16,932	9,416	10,585	20,001	89	18.1	1.7	97
Bweyeye	12,567	6,497	7,142	13,639	91	8.5	0.8	61
Gashonga	19,752	10,935	12,347	23,282	89	17.9	1.7	513
Giheke	18,827	8,864	10,631	19,495	83	3.5	0.3	545
Gihundwe	20,964	13,468	14,620	28,088	92	34	3	1,149
Gikundamvura	13,913	8,709	9,589	18,298	91	31.5	2.8	497
Gitambi	18,476	11,863	13,135	24,998	90	35.3	3.1	809
Kamembe	29,895	15,242	11,849	27,091	129	-9.4	-1	1,878
Muganza	16,781	13,461	14,311	27,772	94	65.5	5.2	1,482
Mururu	19,153	11,571	12,823	24,394	90	27.4	2.4	738
Nkanka	16,638	8,508	9,993	18,501	85	11.2	1.1	905
Nkombo	13,359	8,040	8,703	16,743	92	25.3	2.3	1,850
Nkungu	17,984	9,700	11,038	20,738	88	15.3	1.4	542
Nyakabuye	24,283	13,833	15,469	29,302	89	20.7	1.9	781
Nyakarenzo	13,224	7,273	8,282	15,555	88	17.6	1.6	495
Nzahaha	23,326	13,283	14,559	27,842	91	19.4	1.8	468
Rwimbogo	15,605	9,015	9,877	18,892	91	21.1	1.9	714
District	**331,950**	**194,310**	**210,402**	**404,712**	**92**	**21.9**	**2**	**422**

Source: NISR (National Census 2012)

The above table distributes all population of Rusizi District by Sector but our area of interest is Nyakabuye Sector which is populated by 29,302. Within this number, 13,833 (47%) are male and 15,469 (53%) are female.

(7) Local Economy such as Employment, Livelihood and Land use, etc.

1) Industry

Rusizi District hosts agro-processing industries for rice, tea, fruit, honey and cement production. The table below presents the production capacity of industries in Rusizi District and main challenges faced. These industries are not fully used because they operate at less than 25% of their production capacity. This is a great opportunity for rice cultivators and there is a strong need for encouraging all mechanisms which can help to increase the agro-production capacity.

Only COCOCHAUMA is located very close to the hot spring site (within 2 km). CIMERWA is about 7km far from the hot spring.

The major economic activities in the study area include those related to agriculture, apiculture, and handicrafts. The study area has 11 agricultural-based cooperatives of which 8 are involved in rice production in the Bugarama Marshland, 2 are involved in maize production and 1 in honey production. Some local people are employed by CIMERWA, the Health Centers, primary schools, financial institutions like COGEBANK and Micro financing organizations, NGOs (like PREPAF, CARITAS, and Global Fund), etc. Commercial activities such as kiosks and small scale trade center also characterize the study area.

Agriculture is the chief occupation in the area and is the main source of income. The dominant crops in the study area are rice, maize, cassava, beans, sorghum, banana, and mangoes. The dominant farming system is mixed crops .

A major part of the study area comprises of mixed agriculture and settlements. Another part is covered by artificial forest plantations and rice cultivation as a result of crop intensification programs. The Bugarama Marshland consists of monocrop agriculture (Rice) that is owned by cooperatives. Within our area of interest, we found 8 cooperatives involved in rice production.

The main livestock in the area include pigs, goats, sheep, cattle and hens. Geothermal initiatives would bring much-needed job creation opportunities and also support greater electrification in the zone.

Table 4-1.2 The table below indicates the distribution of industries in Rusizi District.

Name of industry	**Installed capacity**	**Capacity utilization (%)**	**Average Capacity Utilization (Rwanda)**	**Main challenges**
SODAR Rice mills	6720 (tons/year)	29.3	26.7%	Lack of sufficient raw material
MBIC Rice mills	13440(tons/year)	30.0		
ICM-BUGARAMA Rice mills	12096 (tons/year)	29.3		
DUKOREREHAMWE Rice mills	6720 (tons/year)	20.0		
COTICORI Rice mills	6720 (tons/year)	20.0		
SHAGASHA tea factory	3200 (MT of made tea/year)	65.0	74.8%	Lack of sufficient tea pluckers
Ingenzi beer Local wine producer	72575 (L/year)	22.0	53.5%	-Lack of packaging materials -Lack of modern equipment
Urwengero Dusabane Local wine producer	16800 (L/year)	60.0		

				-Lack of skilled personnel -Unfair competition due to existence of many informal wine producers
SONAFRUITS Mineral water processing plants	13,000,000 (L/year)	closed	Lack of working capital	SONAFRUITS Mineral water processing plants
ARDI Honey processing	1720 (kg/year)	25.0	50.3%	-Shortage of raw material -Lack of capacity building in bee keeping -Lack of appropriate machines
CIMERWA Cement production	100,000 (MT/year)	85.0	55%	-
COCOCHAUMA	364x103Tons/year	-	-	Renewable Energy to replace firewood.

Source: MINICOM, 2013

2) Labour Environment

Rusizi has an unemployment rate of 0.6%, which is close to the national average (0.9%), but a lower percentage of underemployment relative to the national average (21.6% versus 15.8%).

Table 4-1.3 Employment and inactivity rates

Indicator (%)	Rusizi	Rwanda
Employment	77.9	84.2
Unemployment	0.6	0.9
Inactivity	21.6	15.8

Source: EICV3. NISR 2011

The overall employment rate stands at 84% of the residential population aged 16 years old and equal in Rusizi District. The unemployment rate is 0.6% and the economic inactivity rate is 15.8%. Rusizi District is ranked the twenty ninety of thirty Districts by employment rate. The national average employment rate is 84%, the unemployment rate is 0.9% and the underemployment rate is 15.8%.

Within the project area (Bugarama), agriculture is the main activity, creating jobs with 70% of

the population aged 16 and above, followed by trade that employs 14% of Rusizi population aged 16 and over. Apart from substantial agriculture, rice cultivation in Bugarama wetland is the main deployment activity in Bugarama. Quarrying also creates job in this zone.

(8) **Socially vulnerable groups**

Within the study area, vulnerable groups include elderly, women heading households and some disabled people. No refugee camp are located in the Rusizi District.

(9) **HIV/AIDS**

HIV/AIDS and other communicable diseases are present, and are particularly prevalent in Bugarama. Awareness-raising efforts have been undertaken to stop the spread of disease by drivers who transport cement and rice. Awareness raising efforts are done in collaboration with local authorities, opinion leaders in health, youth clubs and the Bugarama community.

(10) **Scenic spots**

One thing attracting people to Bugarama is the hot spring, which, together with the surrounding land, is owned by CIMERWA. The garden space at the entrance to the hot spring has been developed by CIMERWA as a site for events such as weddings. Also, Rwandan's use the hot spring for therapeutic purposes. This is the reason why many elders wash their whole body in the hot spring lake.

The rice fields in Bugarama are large and provide attractive scenery at the flat bottom of the valley in which they are located.

Photo 4-1.2(1) Bugarama hot spring view

Photo 4-1.2(2) Bugarama Rice Field view

(11) **Soil erosion**

Soil erosion is not a big issue in Bugarama area because of a policy of planting trees as well as productive plantations and trenches. However, But during rainy periods, some sediments undamaging may damage the river. We recommend the continuing commitment of planting trees and good management of hill land. At a part of the plateau, we can construct facilities profitable to local communities.

4.1.3. Gisenyi

Gisenyi site is located in Nyamyumba sector, Rubavu District in Western Province of Rwanda. The District of Rubavu is composed by 12 administrative sectors, 80 Cells and 525 villages. Rubavu District results from the new administrative division of the country into five provinces and 30 districts. It is located in the Western Province at 152 km from Kigali. It is bordered on the east by the Nyabihu District, the West and North by DR Congo and south by the District Rutsiro. (Source: Rubavu District Development plan)

(1) **Climate**

The periphery of Rubavu District is dominated by the Volcanoes National Park in the north and Gishwati Forest in the south. Its altitude is 1,470 m and it. It has an equatorial climate. Average temperatures range from 20°C at the edge of Lake Kivu at 15°C on the vertices, where nighttime temperatures can drop to 6°C. There is abundant rainfall. Rainfall in Rubavu District varies between 1,200 mm and 1,500 mm per year.

(2) **Biodiversity**

Human settlements are found in the natural ecosystem that consists of hills, lakefront and lakeshore. We seldom see natural forests on the ground but natural sand beaches and reefs are well-kept at the lakeshore. Further, aquatic plants and a variety of bird species are found in inlets. Therefore, its the original biodiversity of the area is maintained to some extent.

The study area around the site is rich in species composition. Besides the extensive areas of cultivated mixed crops widely distributed in the study area, some relic and several ruderal species constitute the actual natural vegetation of the region. Several primitive and indigenous plant species of the area are gradually disappearing due to severe land use pressure and utilization by local people. Some of flora observed during our site visits but not limited to: Bamboo, Cassava, Coffee, Banana, Avocado (few), flowers, Grevelia, Eucalyptus, Papaya, Ordinary beans, Climbing beans, and Irish potatoes. Some artificial forests appear in the project zone but there is no natural forest within our area of interest except the continuity of Gishwati Natural forest appearing in 15 km from our area of interest.

Several parts of ecosystem are formed based on the coast in Kivu Lake. Many kinds of fishes, amphibians, birds live around coast area.

(3) **Water usage**

Most of people living in the vicinity of project use water from natural sources in their daily home activities except urban dwellers who use water from an EWSA connection. Industries in the region use water in cleaning such as Nyamyumba coffee washing station. Bralirwa uses water as a raw input into their process. Gisenyi hot spring is now a tourism site.

(4) **Waste generation and Management**

Normally in rural area, waste is generated by home activities such as food, animals and families members. Its management does not require high technology because all most of households depose waste in dumpsite and after a short period waste transformed in compost which is used in

agriculture fertilization. Bralirwa has its own sewage treatment plant and solid waste deposed in temporally dumpsite then after all solid waste transported to Rubavu Landfill. Waste from local markets collected and transported to Rubavu Landfill.

(5) **Population**

Rubavu District occupies a total area of 388.3 Km^2 and has 404,278 inhabitants. It has a population density of 1,041 persons per Km^2. This population is distributed as follows: male are 195,340 (48%) and female are 208,938 (52%). Nyamyumba sector were the hot spring located is populated of 37,917 distributed as follow: male 18,300 (48%) and female 19,617 (52%). The population density of Nyamyumba sector is 1,624 person per km^2. The reason of this high density is that this sector approaching Rubavu City. (Source: Rwanda national census 2012)

(6) **Local Economy such as Employment and Livelihood, etc.**

1) Labor Environment

Employment rate stands around 76.21% (EICV). In framework of farm and off-farm employment, the percentage of wage farmers 11.1% versus 23.9% of wage non-farmers, and then, the households with independent farmer are estimated to 37.8% against 23.8% for households with the independent no-farm. In public sector, 9.6% have the salaried work and 10.2% in private formal. In private informal, 76.2% of households represent the rate at district level according to EICV3/2011. Apart from Agriculture is the largest employer in the area, followed by aquaculture and Bralirwa. If geothermal drilling brings additional job opportunities, this will be better for the region.

2) Industry

Gisenyi hot spring is located in Nyamyumba sector. During our field data collection, we observe only three industries within 4 km vicinity of the project site named BRALIRWA and two coffee washing stations one located on X=0753565 , Y= 9806739 and other located on X=0755302, Y=9807535. Agricultural accounts for 45.5% of economic activity followed by trading with 22.7% and industry takes the third place with 13.4%(DDP).

We observed cage aquaculture in Kivu lake (in Kigufi side), and home livestock of goats, sheep, bees and, pigs. Fishing is also practiced especially for a small fish called isambaza.

Photo 4-1.3 Fish aquaculture in Kivu Lake (Kigufi side)

(7) **HIV/AIDS and other communicated diseases**

According to the EICV, people lives with HIV/AIDS are 3.3% of the population. The Rubavu health department is a concern about disease transmission, especially by youth who cross the DRC-Rwanda border to visit Lake Kivu beaches. To mitigate this issue, condoms are available at facilities such as health centers and youth clubs. The lack of access to clean water by 74% of the population leads to the high prevalence of diarrhoeas diseases and ophthalmic affections with respectively 17 and 13 % (DDP).

(8) **Scenic spots**

In the project zone, point located on X=0751934, Y=9809198 (Robono hill) is a scenic point from where it is easy to observe the whole Kivu Lake, Rubavu city and Goma City of DRC.

Photo 4-1.4(1) scenic point(Robono hill) view

Photo 4-1.4(2) scenic point(Robono hill) view

Photo 4-1.4(3) scenic point(Robono hill) view

Photo 4-1.4(4) scenic point(Robono hill) view

(9) **Soil Erosion**

Stakeholders in Nyamyumba sector (where the site is located) said that the problems related to flooding have been reported in the sectors of Nyundo and Nyamyumba, damaging an enormous households and crops around Sebeya River and Gitsimbe. Sometimes soil erosion and landslides affects the hilly zone of Nyamyumba. Terracing is one of solutions o avoid erosion. In Rubavu district, radical terracing comprises 91.2% of land area.

(10) **Socially vulnerable groups**

Within vulnerable group includes disabilities peoples, women heading households, extreme poverty, widows etc.., In Rubavu district, the extreme poverty rate is 19.2% with 35.8% under poverty line. The percentage of households with children under 7years of age is 71.8%, the households headed by women are 30.1%, the households headed by widows are 18.8%, and the rate of households headed by disability people is 7% (DDP).

(11) **Refugees**

Except Nkamira Refugee camp was existed recently but now closed. The Nkamira refugee camp is located nearby main road Musanze-Rubavu in Sector of Kanzenze (about 10 km from Rubavu to Musanze road). All refugees have been shifted in a new camp located in Gisagara District.

4.1.4. Karisimbi

The project area is located in Western Province, Nyabihu district, Kabatwa sector and Batikoti cell. Access to the site is by the Musanze-Rubavu national road, branching off at a small trading centre Seshwari by a newly rehabilitated earth feeder road to the site.

The northern of project site (about 400 m) is the buffer zone of Volcanoes National Park.

(1) **Climate**

The study area has a semi-arid climate which is dominated by a hot and dry season from June to August. The area experiences seasonal temperature variations with the highest temperatures occurring during the dry season and the coldest occur during the rainy season. The average maximum temperature ranges between 22-26°C while the average minimum temperature ranges between 10-15°C which is dispersed over four main seasons: a short dry season from January to March, a short rainy season from March to May, characterized by torrential rainfall, a long dry season from June to August and a long rainy season from September to December. The area experiences a typical tropical climate which is characterized by high annual rainfall of up to 1,500 mm per year for the north and northwest volcanic areas (REMA, 2009).

(2) **Biodiversity**

Biodiversity of the project zone is mainly based on National park species such as …. Apart from Volcano national park, the project zone produces Irish Potatoes and Pyrethrum. All species are annexed to the end of this report (Annex1: Biodiversity Field Survey Data).

(3) **Population and Demographic Movement**

According to the Executive Secretary of Kabatwa Sector, the population in this sector is coming

from different areas because the area was a part of Virunga National Park. The Sector has 17,766 habitants with 3,704 households. The Sector has 36 km^2, 24 km^2 populated and 12 km^2 for farming activities. The area is considered to be quite densely populated – 400 – 1,000 people per sq km). The young people and women are more represented than other category.

The major motive of population growth is the migration from other areas as a result potatoes farming, which is already the main income source of the Sector. In terms of population trends, there is out-migration because the population increases up but the land stays the same. People tend to move to Eastern Province

(4) **Local Economy such as Employment and Livelihood, etc**

Rwanda is a rural country with about 90% of the population engaged in (mainly subsistence) agriculture. It is the most densely populated country in Africa; is landlocked; and has few natural resources and minimal industry. By 1994, farm size, on average, was smaller than one hectare, while population density was more than 450 persons per Km^2 of arable land.

The district's economy is primarily based on agriculture. Agriculture is the chief occupation of the area and is the main source of income for all Sectors in Nyabihu District. The dominant crops in Kabatwa Sector are pyrethrum and Irish potatoes. The main livestock in the area include goats, sheep, cattle and hens. The area is among the first producers of potatoes in Rwanda which is the major source of income. Apart from farming activities, business is conducted in small trading centres alongside the road from the site to main road Musanze- Rubavu. This is one of the richest sectors in the district. Clearly, most people in the project zone are involved in potatoe agricultural as their primary job and source of income.

(5) **Land Use**

The project area was managed by the Virunga National Park. This area was changed from forest to villages in 1968. At that period, there were two main cash crops, tobacco and pyrethrum. The area was settled in a well-organized manner and the land was divided into plots. Residents were allowed to exploit the land, subject to some conditions:

- Rotating pyrethrum (40%) and potatoes (60%).
- People were obliged to live alongside on the road
- Avoiding polygamy

Recently, due to the land policy, the land ownership structure changed from a tenant-based system to one based on ownership. However, land ownership conditions stipulate that owbers must farm 40% pyrethrum and 60% of their own crops. Currently, the area is under intensive subsistence farming on individual plantations. Most common crops grown are Irish potatoes and pyrethrum. Other than agriculture, there are a few pockets of families with livestock. i.e. cattle and goats. Neither hunting activities nor collecting wood or fruits are allowed in the Virunga National park.

(6) **Water usage**

There is a shortage of water. During rain period, people dig a big ditch and cover it with sheeting to harvest rainwater. There is a local strategy to retain water in tanks which serves 2 purposes – water availability and prevention of erosion.

(7) **Deprivation and Vulnerable Groups**

According to the Executive Secretary of Kabatwa Sector, there is no historically marginalised group. Apart from this, there are vulnerable people such as widows and orphans and some people with disabilit. Special consideration in job recruitment should be given to them during implementation of this project.

(8) **Religion, Culture, Recreation**

More than half of Rwanda's population are Catholic (56.5%), 26% is Protestant, 11.1% is Adventist, 4.6% Muslim, 0.1% hold indigenous beliefs and 1.7% is of no religion. In Kabatwa Sector, the majority of the population are Adventists, Anglican and Baptists but there are also a few Catholics. Cultural practices are based on supporting each other in sad or happy events such as marriage ceremonies and burial ceremonies.

There are no visible archaeological remains of scientific, cultural, public, economic, ethnic or historical significance observed in the area. There are some caves in the Sector that can attract tourists specifically in Ngando and Gihorwe Cells, but these are not near the Project sites. No one was killed in the local project area during the genocide; hence there are no memorial sites.

(9) **Tourism**

Tourism is one of Rwanda's main sources of foreign exchange. The main attractions are gorilla trekking in Volcanoes National Park, Nyungwe Forest, which is home to chimpanzees, and Akagera Park, which is a national park bordering Tanzania. Volcanoes National Park was the first national park to be created in Africa and borders Virunga National Park in the Democratic Republic of Congo and Mgahinga Gorilla National Park in Uganda. Volcanoes National Park is best known for its population of mountain gorillas but it is also home to golden monkeys, both of which attract tourists. Other attractions in the Park include climbing Karisimbi and Bisoke Volcanoes, touring lakes and cases and visiting Dian Fossey's grave.

The headquarters of Volcanoes National Park is approximately 15 miles in a straight line from the Project area and the Project is situated within 300 meters of the border of the Park.

Rwanda Development Board (RDB) identified a place with a group of beautiful birds living in vicinity of Karago Lake.

Photo 4-1.5 Karago Birding site

4.1.5. Kinigi

Musanze District is divided into 15 sectors (imirenge) including where the Project site could be located (Kinigi sector). Musanze is Rwanda's most mountainous district, containing the largest part of the Volcanoes National Park and its head office at Kinigi.

Five of the eight volcanoes of the Virunga chain (Karisimbi, Bisoke, Sabyinyo, Gahinga and Muhabura) are within the District boundaries. It is also in this Musanze District that most of Rwanda's Mountain Gorillas are found, making it the most popular tourist destination in the country. The District capital serves as a hub for tourists.[1]

Kinigi Sector is subdivided into five cells and forty villages commonly called imidugudu. Its administrative office is located in the Nyagisenyi village in Nyonirima Cell.

Its boundaries are limited in the North by the Volcanoes National park, in the South and the East by Nyange Sector, and in the West by Shingiro Sector.

(1) **Climate**

The study area has a semi-arid climate which is dominated by a hot and dry season from June to August. The area experiences seasonal temperature variations with the highest temperatures occurring during the dry season and the coldest occur during the rainy season. The average maximum temperature ranges between 22-26°C while the average minimum temperature ranges between 10-15°C which is dispersed over four main seasons: a short dry season from January to March, a short rainy season from March to May, characterised by torrential rainfall, a long dry season from June to August and a long rainy season from September to December. The area experiences a typical tropical climate which is characterised by high annual rainfall of up to 1, 500 mm per year for the north and northwest volcanic areas (REMA, 2009).

(2) **Biodiversity**

As with the Karisimbi site, this section highlights the biodiversity of Volcanoes National Park and gives an overview of the main habitats encountered inside the park. Special attention will be given to plants, birds and mammals, especially the most vulnerable species, Gorilla beringei beringei, which is already at risk of extiction due to human activities and climate change. For plants, two aspects will be considered: the flora (species taken individually) and vegetation (referring to plants communities). More biodiversity are annexed to the report (Annex1: Biodiversity Field Survey Data).

(3) **Water usage**

The percentage of households in Musanze District with access to an improved drinking water source is 74%, which is below the EDPRS target of 85% (to be reached by 2012). The percentage of households having improved sanitation facilities in Musanze District is 51.7%, which is also lower than the national average (74.4%) and the EDPRS target on sanitation, which is to provide

[1] Musanze District retrieved from the website http://en.wikipedia.org/wiki/Musanze_District on 21st August 2014

65% of the total population with access to hygienic sanitation by 2012.

Water shortage also is the main problem of people living in the project vicinity. Most of sources are temporally and are available during rain period otherwise is not easy to find source of water in summer period.

(4) **Waste Management**

Waste management is the Kinigi sector is not well developed, but at the domestic level, the population does compost domestic wastes, which are applied in land as manure after their degradation. In Bunyenyeri village of Bisoke cell, biogas digestion systems are commonly used for houses having more than three cows. The resulting sludge is applied in farmland.

In the Kinigi sector, a waste storage facility is located in Kampanga cell, near the Kinigi commercial center, where all wastes from the market and houses in the vicinity of the center. At the Musanze district level the waste is collected by a private company to the district sanitary landfill located in Gakoro village, Rwambogo cell of Musanze sector (Cyuve landfill).

Photo 4-1.6 Kinigi waste storage site

(5) **Population**

The population of the Musanze District was 416,000[2] in 2010-2011. This represents 21% of the total population of the Northern Province and 3.9% of the total population of Rwanda. Females comprised 54.1% of the district population. The majority of the population is young with 84% of the population aged less than 40 years old[3].

[2] NISR, 2010/11 Integrated Household Living Conditions Survey (EICV3), District Profile, Musanze

[3] NISR, 2010/11 Integrated Household Living Conditions Survey (EICV3), District Profile,

The average household size is 4.8 people in the Musanze district, which is the same as the national average. Although Musanze is mainly urban district, where a lower average size of household is typical, it is in fact ranked above many rural districts on this indicator. The following table shows the population growth in Musanze District from 2002 to 2012.

Table 4-1.4 Population in Musanze District

District	2002 Total population	2012 population			Sex Ratio	Population Change 2002-2012 (%)	Average Annual growth rate 2002-2012 (%)	Population Density (Sq.km)
		Male	Female	Total				
Musanze	307,078	174,760	193,803	368,563	90	20.0	1.8	695

Source: NISR, 2012 Population and Housing census- Provisional results

According to current statistics, Kinigi Sector counts 25,542 inhabitants divided on a surface of 8,104 km^2, for an average density of 315 inhabitants per km^2. Kinigi Sector is notorious for having more than 99% of its population living in agglomerations[4]

Table 4-1.5 Population of Kinigi sector

Gender	Population	Percentage
Male	11.591	45,3%
Female	13.951	54,7%
Total	25.542	-

Source: Kinigi Sector Report, 2013

In Bisoke, the very high population density influences directly the availability of arable lands, their over exploitation, employment and family and individual incomes. There are 1,250 households in Kaguhu with 5,396 inhabitants, 1,055 households in Bisoke with 4,356 inhabitants, and 1,160 households in Kampanga with 4,780 inhabitants.

(6) **Local Economy such as Employment and Livelihood, etc**

In the Musanze District, the employment rate is in line with national averages at 84.7% of the resident population aged 16 years and above. The unemployment rate is 0.4% and the economic inactivity rate is 15%. Agriculture is the main industry for 67.1% of the population aged 16 and above, followed by trade (7.9%), other services (6.5%), and construction (6.2%)[5].

Musanze

[4] Report on Kinigi Sector, 2013

[5] idem

The economy of the Kinigi Sector is based primarily on agricultural activities, although tourism is also important. Agriculture and animal husbandry are the main sources of livelihood activities in Bisoke, Kampanga and Kaguhu cells. Young people from those three cells sometimes have the opportunities for paid labour when they accompany tourists in the Volcano National Park and carry their bags.

More than 90% of the inhabitants of the Musanze District are engaged in the agricultural industry. Agricultural products for this region include coffee, tea, pyrethrum, wheat, bananas, beans, sorghum, and potatoes. There are two large industries located within the District: a pyrethrum factory near the centre of town, and a wheat plant located on the outskirts near the road to Kigali. Other small-scale industrial activities involve cement-making, small-scale beverage production, chemical processing, and the production of soap, furniture, shoes, plastic goods, textiles, and cigarettes[6].

For regional agricultural activities, the Kinigi Sector chose pyrethrum and Irish potato crops, which are the principal sources of income in the sector. Other crops grown in the Kinigi Sector are corn, peas, beans, vegetables and fruits. Constraints on the agriculture sector include the scarcity of arable lands and demographic pressures.

(7) **Land Use and soil erosion**

In the Musanze District, the mean size of land cultivated per household is 0.45 ha, which is below the national average (0.59), the rural average (0.6) and the urban average (0.46). Indeed, it is among the lowest mean sizes in Rwanda. In the Musanze District, 87% of households cultivate under 0.9 ha of land. The percentage of land that has been reported as protected against soil erosion in Musanze district is 53.3%, compared to around 78% nationally[7].

In Bisoke, Kampanga and Kaguhu cells, the land was part of Volcanoes National Park until 1968, when it was re-designated for agriculture and settlements. At that time, 14,000 hectares of land was divided into two hectare plots and given by the Government of Rwanda to people willing to resettle and farm the land as part of a strategy to sell pyrethrum and tobacco into international and domestic markets.

At the same time system of new settlements called '*paysanat*' (meaning 'town in the countryside') was set up. The new settlements were carefully planned and houses were designated to be put by the roadside. A series of conditions were stipulated for land use, the main one being that people would agree to grow pyrethrum on 40% of their farm. Other conditions included the obligation for owners to respect and clean pathways; help prevent erosion; adopt a crop rotation system; and, not engage in polygamy so that the land does not become subdivided.

The farmers themselves own the plots of land and by law; the people have titles to their land. In principle, the law of succession does not apply to this land and when the farmer dies, his or her

[6] http://www.musanze.com/business/investing-in-musanze/ retrieved on 21st August 2014

[7] NISR, 2010/11 Integrated Household Living Conditions Survey (EICV3), District Profile, Musanze

land is returned to the Government at which time others apply for the plot and sign a new contract for land use. In practice, however, some people have inherited this land.

(8) **Archaeological and cultural heritage**

Archaeological and cultural heritage in the Kinigi geothermal prospect is dominantly presented by lava tunnels and caves, a genocide memorial site and a public burial.

1) Lava caves

The following are lava caves in Kinigi.

Table 4-1.6 GPS coordinates of Ndubi lava caves

Names of the cave	GPS coordinates	Remarks
Ndubi 1 lava cave	E029^0 31, 719' S01^{0}26,939' altitude: 2499m,	Length: 25 m Vertical range: +3m
Ndubi 2 lava cave	E029^0 31,719' S01^0 26,939' altitude: 2499m	Length 5 m, depth: 0m,
Ndubi 3 lava cave	E 029^0 31, 682' S 01^0 26,907' altitude: 2523m	Length 21 m and vertical range: +2m
Ndubi 4 lava cave	E 029^0 25', 634" S 01^0 26,892' altitude: 2543m	Length 10 m, vertical range: 0m

Photo 4-1.7 Ndubi lava cave

2) Genocide memorial site

There is a genocide memorial site located in the Butarwa 2 village of the Nyonirima cell of Kinigi sector near a bridge. The memorial is on the right side of Kinigi-Bisate road, before reaching the Mountain Gorilla lodge from the direction of Musanze The exact number of bodies of people buried in the memorial site has not been established as new bodies continue to be placed in public burial sites as they are discovered. The Kinigi genocide memorial site was constructed in 2000 by the Musanze district.

Photo 4-1.8 KINIGI Memorial Site

The Musanze district, through the Kinigi sector manages regular maintenance of memorial sites. The national institution in charge of genocide memorial sites is the National Commission for the Fight against Genocide (CNLG), based in Kigali.

3) Public burial

In the Kinigi sector, as in most rural areas of Rwanda, the population typically buries their dead on their own land, where they dig small holes for burial sites. However, the Kinigi sector has developed a public cemetery, located in Muhe village of Kampanga cell near the commercial center and market of Kinigi.

(9) **Socially Vulnerable Groups**

The Musanze District is ranked third lowest (20.1%) in terms of the percentage of poor and extremely poor population categories. Specifically, 79.9% of the District population is identified

as non-poor, 14.2% as poor and only 5.9% as extremely poor. Compared with other districts in Northern Province, Musanze District has the highest percentage of non-poor[8] populations.

In the Musanze District in general, and in Kinigi Sector specifically, there are orphans and widows who are genocide survivors as well as people with disabilities. According to the Executive Secretaries of cells, there are 625 widows in the Bisoke Cell; 543 widows in the Kaguhu Cell; and 327 widows in the Kampanga Cell. Vulnerable populations receive assistance especially in form of health insurance.

4.2. Policy, Legislative and National Environmental Management System

4.2.1. Rwandan National Policy on Environment

The National Policy on Environment (NPE) in Rwanda was established in November 2003 to develop a framework for sustainable environmental protection and management. The Policy establishes the basis for improving people's well-being, the prudent use of natural resources and the protection and rational management of ecosystems for sustainable development.

Following establishment of the environmental policy, Article 49 of the Constitution of the Republic of Rwanda of 4th June, 2003 (as amended), states that: "Every citizen is entitled to a healthy and satisfying environment. Every person has the duty to protect, safeguard and promote the environment. The State shall protect the environment. The law determines the modalities for protecting, safeguarding and promoting the environment."

4.2.2. Institutional Framework of Rwanda

The institutional framework for environmental management is set out in the Organic Law, which determines the modalities of protection, conservation and promotion of the environment in Rwanda. It is published in the Official Gazette RWA Nº 9 of the 1st May 2005, particularly in Chapter III which relates to the establishment of the institutions.

Article 65 of the Organic Law establishes the Rwanda Environment Management Authority (REMA) as being responsible for managing environmental issues in Rwanda with a duty to implement policies and laws related to the environment. REMA was established under the Organic Law (No. 04/2005 of 08/04/2005) and was given the responsibility of overseeing, co-ordinating and supervising the Environmental Impact Assessment (EIA) process, compliance and monitoring in Rwanda.

Recently, the responsibilities for EIA review and approval has been transferred from REMA to the Department of Environmental Compliance of the Rwanda Development Board (RDB).

According to the recent restructuring, governmental institutions involved directly or indirectly in environmental management include the following:

- Ministry of Natural Resources (MIINIRENA),

[8] NISR, *2010/11 Integrated Household Living Conditions Survey (EICV3), District Profile, Musanze*

- Ministry of Local Governance (MINALOC) through provinces and decentralised entities (districts, sectors),
- Ministry of Agriculture and Animal Husbandry (MINAGRI),
- Rwanda Environment Management Authority (REMA),
- Rwanda Natural Resources Authority (RNRA),
- Rwanda Bureau of Standards (RBS),
- Rwanda Utilities Regulatory Agency (RURA)

4.2.3. Environmental Law in Rwanda

The Constitution of the Republic of Rwanda, adopted in June 2003, ensures the protection and sustainable management of the environment and encourages the rational use of natural resources. Organic Law (No. 04/2005 of 08/04/2005) and various socio-economic development policies and strategies such as "Vision 2020" call for a well regulated environmental management system that takes into account principles of sustainable development while at the same time contributes to poverty reduction.

Following the establishment of the Constitution of the Republic of Rwanda and the National Environmental Policy in 2003, the legislative framework for environmental management was set up by the Government of Rwanda through Organic Law No 4/2005 of April 8, 2005, which established modes of protecting, safeguarding, and promoting the environment in Rwanda.

There are also a number of decrees, statutory instruments and ministerial orders which govern environmental protection in Rwanda.

Relevant national laws, ministerial orders and policies relating to this Project include:

- The Law on Land Use and Management (Organic Law N° 08/2005 of 14/07/2005)
- The Law on Forestry (No 47/1988 of 5 December 1988)
- The Water Law (Law N°62/2008 of 10/09/2008)
- The Land Title and Registration Law (Ministerial order N°002/2008 of 01/4/2008)
- Ministerial Order establishing the list of protected animal and plant species (Ministerial Order No 007/2008 of 15/08/2008)
- Ministerial Order relating to the requirements and procedure for environmental impact assessment (Ministerial Order n° 003/2008 of 15/08/2008)
- Ministerial Order determining modalities of establishing and functioning of occupational health and safety committees (Ministerial Order N°01 of 17/05/2012)
- National Strategy on Climate Change and Low Carbon Development for Rwanda,(DOI 10.4210/SSEE.PBS.2011.0002)
- The National Land Policy, 2004
- The Water and Sanitation Policy, 2004
- The Mines and Geology Policy, 2004
- National Forestry Policy, May 2010.

4.2.4. Social Law in Rwanda

The following laws and policies governing social protection are in place in Rwanda:

- Rwanda Environmental Policy, 2003
- Rwanda Health Sector Policy, 2005
- Rwanda Agricultural Policy, 2008
- Rwanda Land Policy, 2004
- Rwanda Water and Sanitation Policy, 2010,
- National Water Resources Management Policy, 2011
- National Poverty Reduction Strategy, 2008
- Rwanda Vision 2020 which aims to reduce poverty through a pro-poor national growth agenda
- Organic Law N° 04/2005 of 08/04/2005 determining legislation around environmental management and protection
- Rwanda Constitution of 2003
- Law N° 18/2008 of 23/07/2008 Relating to the Punishment of the Crime of Genocide Ideology
- N° 13/2009 of 27/05/2009 Law regulating labour in Rwanda (also covers health and safety)

The following national laws relate to land use and are applicable to land acquisition and resettlement.

- Land Act of 2004
- Organic Land Law No. 08/2005 of 14/07/2005 determining the use and management of land in Rwanda
- Land Valuation Law promulgated in 2007
- Land Expropriation Law promulgated No. 18/2007 of 19/04/2007
- Presidential Order No. 54/01 of 12/10/2006 determining the structure, the responsibilities, the functioning, and the composition of Land Commissions
- Ministerial Order No. 001/2006 of 26/09/2006 determining the structure of Land Registers, and the responsibilities and the functioning of the District Land Bureau.

4.2.5. National Permitting

National permits required for the construction and operation of this Project are listed in the table below.

Table 4-2.1 Rwandan national permit requirements

General Construction Permits Required	Issuing Authority	Comments
Approval on the terms of reference	RDB	Required under EIA general guideline (2006)
EIA implementation order	RDB	Required under EIA general guideline (2006)
EIA certificate of authorisation (EIACA)	RDB	Environmental organic law (2005) and EIA general guidelines (2006)
Liquid waste disposal and treatment	Rwanda Utilities Regulatory Agency (RURA)	Required under the law ° 39/2001 establishing RURA and the Directive on minimum requirements for liquid waste disposal and treatment (2009)
Management of waste disposal site	RURA	Standards on the management of waste disposal site (2009)
Construction permit	District level approval required.	Law governing urban planning and building in Rwanda (2012)
Water permit	Ministry of Natural Resources (MINIRENA)/Rwanda Natural Resources Authority (RNRA)	Law for the use, conservation, protection and management of water resources (2008)

Source: www.rdb.gov.rw

4.2.6. Requirements for Stakeholder Participation and Disclosure

Consultation with affected communities and individuals is regarded as an essential element of the ESIA process in Rwanda. Throughout the Rwandan ESIA process, stakeholder engagement in the form of consultation and involvement of the local communities and the affected persons is required. This occurs at three key stages:

1. During the screening stage to inform the terms of reference for the ESIA
2. On-going consultation during the ESIA study
3. During public hearings following submission of the ESIA

Following submission of the Project Brief (a summary of information about the Project and the

ESIA), RDB, who are responsible for the ESIA process, will publish the Project Brief and determine if a public hearing is necessary at this stage. This can include meeting with local communities and stakeholders to explain the ESIA process.

During the ESIA process, ESIA experts are required to seek the views of persons who may be affected by the Project. This will be performed particularly during the scoping phase of the Project in order to identify any significant issues, and at any other crucial stages considered necessary by the Permitting Authority (RDB).

Following submission of the ESIA to the authorities, the report is made available for public review before a public hearing is held. The purpose of a public hearing is to provide interested and affected parties and the public with an opportunity to comment on, or raise issues relevant to an application for environmental authorization. The range of individuals, agencies and organizations to be involved in public hearings should include as a minimum: government ministries likely to have their areas of responsibilities affected by the Project; the local government body with jurisdiction over the area where the Project is proposed; environmental committees; trade associations; local communities; non-governmental organizations; and the Developer. After the public hearing and following approval and issuance of the ESIA Clearance Certificate by the RDB, the Project Developer is required to make the ESIA non-technical summary (NTS) available to the public by announcing the project in local newspapers as well as the location at which the ESIA NTS can be found. The ESIA NTS must remain available at RDB for at least 120 days.

4.2.7. Environmental Standards and Other Related Standards in Rwanda

A list of standards is summarized below:

Table 4-2.2 Level of dust emission

Device	**Abbreviation**	**Emission(mg/Nm3)**
Multiclone	MLTC	2000
Fabric filter – sheet type/mech. Rapping	FF-sm	150
Electrostatic precipitator – lower efficiency	EP-le	500
Fabric filter – sleeve type/jet pulse cleaning	FF-jp	50
Electrostatic precipitator – high efficiency	Ep-he	50

Source: East African Community 2010

Table 4-2.3(1) Ambient air quality tolerance limits in East African Community

Pollutant	Time weighted Average				Test methods
		Industrial area	Residential, Rural & Other area	Controlled areas***	
Sulphur oxides (SO_X);	Annual Average*	80 µg/m³	60 µg/m³	15 µg/m³	IS0 4221-1980
	24 hours**	125 µg/m³	*80 µg/m³*	30 µg/m³	
	Annual Average		*0.019 ppm/50µg/m³*		
	Month Average				
	24 Hours		*0.048ppm /125µg/m³*		
	One Hour				
	Instant Peak		*500 µg/m³*		
	Instant Peak (10 min)		*0.191 ppm*		
Oxides of Nitrogen (NO_X);	Annual Average*	80 µg/m³	60 µg/m³	15 µg/m³	ISO7996: 1985
	24 hours**	150 µg/m³	80 µg/m³	30 µg/m³	
	8 hours				
	Annual Average		*0.2 ppm*		
	Month Average		*0.3 ppm*		
	24 Hours		*0.4 ppm*		
	One Hour		*0.8 ppm*		
	Instant Peak		*1.4 ppm*		
Nitrogen Dioxide	*Annual Average*	150 µg/m³	*0.05 ppm*		IS0 6768:1998
	Month Average		*0.08 ppm*		
	24 Hours	100 µg/m³	*0.1 ppm*		
	One Hour		*0.2 ppm*		
	Instant Peak		*0.5 ppm*		
Suspended particulate matter (SPM)	Annual Average*	360 µg/m³	140 µg/m³	70 µg/m³	ISO 9835:1993
	24 hours**	500 µg/m³	200 µg/m³	100 µg/m³	
		Industrial area	Residential, Rural & Other area	Controlled areas***	
	mg/Kg				
	Annual		100 µg/m³		

Source: East African Community 2010

Table 4-2.3(2) Ambient air quality tolerance limits in East African Community

Pollutant	Time weighted Average				Test methods
	Average****				
	24 hours***		180 µg/m³		
Respirable particulate matter (<10µm) (RPM)	Annual Average*	70 µg/m³	50 µg/m³	50 µg/m³	ISO 9835:1993
	24 hours**	150 µg/Nm³	100 µg/Nm³	75 µg/Nm³	
$PM_{2.5}$	Annual Average	35 µg/m³			ISO 9835:1993
	24 hours	75 µg/m³			
Lead (Pb)	Annual Average*	1.0 µg/Nm³	0.75 µg/Nm³	0.50 µg/m³	ISO 9855:1993
	24 hours**	1.5 µg/m³	1.00 µg/m³	0.75 µg/m³	
	Month Average		2.5		
Carbon monoxide (CO)/ carbon dioxide (CO_2)	*8 hours***	*5.0 mg/m³*	*2.0 mg/m³*	*1.0 mg/m³*	ISO 4224:2000
	1 hour	*10.0 mg/m³*	*4.0 mg/m³*	*2.0 mg/m³*	
	mg/Kg				
	*24 hours***				
Non-methane hydrocarbons					
	instant Peak	*700ppb*			
Total VOC	6 *mg/m³*				ISO16000-6:2004,
Ozone	1-Hour	200 µg/m³	0.12 ppm		ISO 13964:1998

Source: East African Community 2010

4.2.8. National Policy on EIA

The Constitution of the Republic of Rwanda, adopted in June 2003, ensures the protection and sustainable management of the environment and encourages the rational use of natural resources. Organic Law (No. 04/2005 of 08/04/2005) and various socio-economic development policies and strategies such as “Vision 2020” call for a well regulated environmental management system that takes into account principles of sustainable development while at the same time contributes to poverty reduction. The Organic Law (Article 67) requires that projects, programs and policies which may affect the environment shall be subjected to environmental impact assessment before obtaining authorization for implementation.

4.2.9. EIA Procedure in Rwanda

The EIA process in Rwanda provides a justification and a basis for future international cooperation and also aids in conflict resolution concerning environmental impacts at a regional level (REMA, 2006).

In Rwanda, an Organic Law n°004/2008 of 15/08/2008 establishes the list of works, activities and projects which are required to undertake an EIA (Table 4-2.4). They are classified into 4 categories: infrastructure, agriculture, works in a park and in its buffer zones, and mine

extraction (Republic of Rwanda, 2008). For example, the implementation of power generation projects fall in category I.

Table 4-2.4 List of projects, activities subject to EIA study in Rwanda

Infrastructure (I)	Agriculture (II)	Parks (III)	Mining (IV)
Construction and repair of international roads, national roads, district roads and repair of large bridges; Construction of industries, factories and activities carried out in those industries; Construction of hydro-dams, electrical lines and power generation facilities; Construction of public dams for water conservation, rain water harvesting for agricultural activities, and artificial lakes; Construction of oil pipelines and its products, gases and storage tanks; Construction of terminal ports, airports, railways, car parks; Construction of hotels, large public buildings which house more than a hundred people per day; water distribution networks and sanitation; Construction of public land fills; slaughter houses; hospitals; stadiums, and large markets; initial installation of communication infrastructure.	Agricultural and breeding activities which use chemical fertilizers and pesticides in wetlands and large scale monoculture agricultural practices such as tea, coffee, flowers and pyrethrum, etc… Works and activities that use bio-technology to modify seeds and animals	Works in parks and in its buffer zone	Work of extraction of mines

4.2.10. Environmental Impact Assessment System

REMA and RDB are in charge of EIA in Rwanda. The EIA for development projects is reviewed and approved by the REMA and RDB. The procedure of EIA is described in General Guidelines and Procedure for Environmental Impact Assessment (REMA, 2006). The functions of the REMA and RDB are defined as follows:

(1) **Rwanda Environment Management Authority (REMA)**

REMA was established to act as the implementation organ of environment‐related policies and laws. REMA is also tasked to coordinate different environmental protection activities undertaken by environmental promotion agencies; to promote the integration of environmental issues in development policies, projects, plans and programs (due the implication of EIA and SEA); to coordinate implementation of Government policies and decisions taken by the Board of Directors and ensure the integration of environmental issues in national planning among concerned departments and institutions within the Government; to advise the Government with regard to the

legislation and other measures relating to environmental management or implementation of conventions, treaties and international agreements relevant to the field of environment as and when necessary; to make proposals to the Government in the field of environmental policies and strategies.

(2) **Rwanda Development Board (RDB)**

The RDB was established so that all required procedures relating to the environment could be handled at one governmental office. This integrated office for one-stop application acceptance has made it more efficient to obtain approvals and has led to the facilitation of new investments (business projects).

With regard to EIA procedures, the RDB's responsibilities cover everything from receiving a Project Brief to granting EIA approval. All EIA-related documents are shared between the RDB and the Rwanda Environment Management Authority (REMA). The actual work involved in EIA processing, as well as the monitoring of projects during their implementation after EIA approval, is conducted by REMA.

1) Determination of whether a full EIA is required for development projects (implementation of on-site survey)
2) Review and approval of Terms of Reference (ToR) for full EIA
3) Review of EIA report (stakeholders hearings)
4) Approval of EIA and issuance of EIA certification of authorization

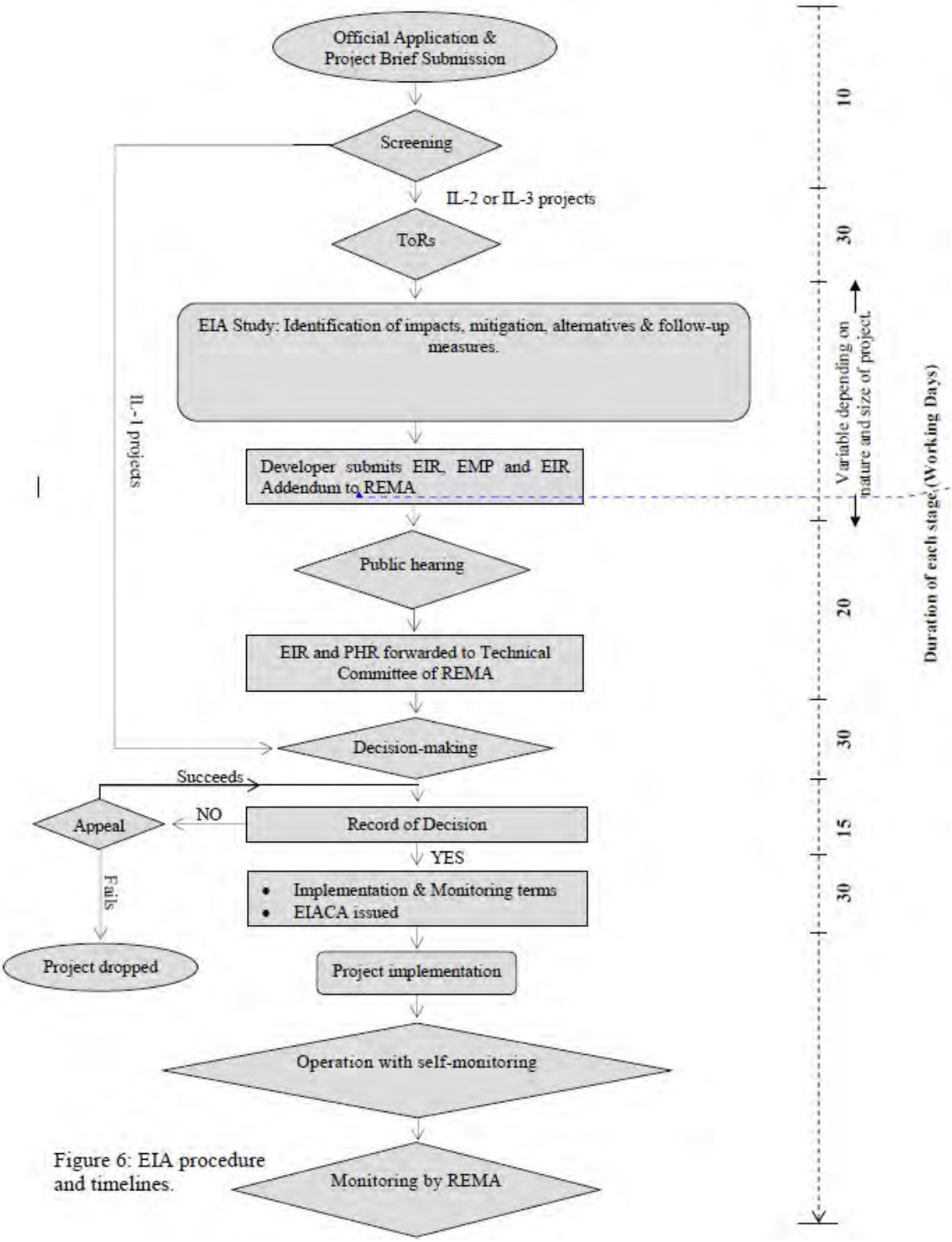


Figure 6: EIA procedure and timelines.

Source: General Guidelines and Procedure for Environmental Impact Assessment (REMA,2006)

Fig. 4-2.1 EIA procedure and timeline

Table 4-2.5 Chronological functions of various actors in the EIA process

Functions / EIA stages	Developers	REMA	Lead Agencies	Local Governments	Community
Application for EIA.	Submit application in form of Project Brief.	Receive and register EIA application (Project Brief) submitted by developer.			
Screening.		• Review Project Brief to determine project classification. • Identify relevant Lead Agency to participate in project screening.	• Participate in screening.		
Scoping & developing Terms of Reference.		• Transmit Project Brief to Lead Agency, Local Government. • Organize publication & consultation on the Project Brief. • Collect public comments. • Approve experts to conduct EIA study. • Write ToRs and send them to the Developer.	• Receive and review copy of Project Brief from Authority. • Send advice on Project Brief to REMA.	• Receive and review copy of Project Brief from REMA. • Send comment/ advice on Project Brief back to REMA.	• Receive and review copy of Project Brief from REMA. • Send comment/ advice on Project Brief back to REMA.
Assessment of impacts.		• Provide information when consulted by EIA experts during impact studies.	• Provide information to EIA Expert / and or Developer.	• Provide information to EIA Expert /and or Developer.	•Provide feedback during community consultations.
Submission of EIA documents to REMA.		• Receive prescribed number of copies of EIR, EMP and Addendum (if applicable) from developer. • Verify that submitted EIA documents are complete.			

Functions / EIA stages	Developers	REMA	Lead Agencies	Local Governments	Community
Public & stakeholder input.		• Transmit copy of EIR and EMP to Local Government(s), Lead Agencies and communities. • Organize public hearings. • Appoint Public Hearing presiding officer (Chairperson) from its staff. • Receive public comments.	• Receive and review copy of EIR and EMP from Authority (if not member of Technical Committee). • Serve on public hearing panel.	• Receive and review copy of EIR and EMP from Authority. • Assist REMA in organising public hearings. • Host public hearings. • Host individual consultations. • Collect written comments from general public. • Send collected public comments to REMA.	• Receive and review copy of EIR and EMP from Authority. • Send comments on project to Local Authority • Participate in public hearings.
Review process & decision-making.		• Appoint the Technical and Executive Committees to review EIA documents and make final decision, respectively. • Be member of the Technical Committee. • Transmit EIR, EMP & Public Hearing Report to Technical Committee. • Chair the Executive Committee. • Take decision and communicate to Developer.	• Serve on the Technical Committee. • Serve on the Executive Committee.		
Project implementation, monitoring & auditing.		• Inspect to ensure environmental compliance during project implementation. • Receive and review annual Monitoring Reports prepared by developers. • Cross-check monitoring results.	• Assist in inspecting and monitoring environmental compliance during project implementation.	• Environmental officers at Local Government level assist in inspecting and monitoring environmental compliance during project implementation.	

Functions / EIA stages	Developers	REMA	Lead Agencies	Local Governments	Community
		• Undertake routine inspection and auditing to enforce compliance. • Take action when project not in compliance.			

Source: General Guidelines and Procedure for Environmental Impact Assessment (REMA,2006)

4.2.11. Projects Requiring EIA

Projects with identified adverse impacts on environment call for a full EIA process for mitigation measures and thus the Ministerial Order N°004/2008 of 15/08/2008 establishing the list of works, activities and projects that have to undertake an environmental impact assessment highlights some projects as follows; construction and repair of international and national roads, large bridges, industries, factories, hydro-dams and electrical lines, public dams for water conservation, rain water harvesting for agricultural activities and artificial lakes, large hotels public building which accommodate more than one hundred daily, extraction of mines and public land fills among others.

4.2.12. Evaluation of EIA Level by Screening

Screening, carried out by the Authority is a process of determining impact level of a proposed project, which then determines extent of the EIA study. When the Authority receives the Project Brief, it reviews it seeking input from appropriate Lead Agencies and other relevant stakeholders. Based on information in the Project Brief and established project screening criteria as outlined in Fig. 4-2.1, REMA determines whether or/not an EIA is required and the developer is accordingly notified. Screening enables early identification of environmental issues of major concern and incorporation of appropriate mitigation measures. Screening also enables identification of potential impacts on natural resources (whether the project would result in direct or indirect negative or positive impacts to natural resources), excessive resource consumption and waste generation. Screening enables categorization of projects according to their Impact Level (IL) as follows:

(1) **IL 1: Projects not requiring further environmental analysis**

Projects in this category are believed to have minimal adverse impacts, which can easily be identified through a Project Brief. A Project Brief is a summary statement of the likely environmental effects of a proposed development and it includes description of the site and proposed development in sufficient detail to enable the Authority to determine whether an EIA is required or not. For potential impacts of these projects, mitigation measures can be integrated in the design of the project without necessarily requiring a detailed EIA. Hence, after a period of public input the project passes directly to decision-making level.

(2) **IL 2: Projects not requiring a full EIA but necessitate further level of assessment**

This category represents projects believed to have adverse, but not irreversible environmental impacts and mitigation and management measures can be readily designed and incorporated into the project. The EIA process for these projects is similar to that of IL3 projects.

(3) **IL 3: Projects requiring a full EIA**

This category involves projects for which it is evident that there will be significant and adverse environmental impacts whose mitigation measures cannot readily be prescribed, and thus, must undergo through a complete EIA process. The above definitions notwithstanding, categorization of project impact levels and extent of EIA studies (with respect to duration and detail of terms of reference) will be determined by REMA. If an EIA is not required, the project is exempted from further compliance with the EIA process in which case, REMA issues a certificate to that effect and advises the developer and relevant licensing authority of the exemption. Conversely, if an EIA is required, REMA informs the developer that a full impact study must be undertaken.

4.3. Brief Summary of Resettlement Policy Framework

4.3.1. Justification for and Scope of the Resettlement Policy Framework (RPF)

The Resettlement Policy Framework (RPF) provides guidelines for development of appropriate mitigation and compensation measures, for the impacts caused by future project activities whose exact locations are not known. This RPF is the instrument through which the project's environmental and social impacts are identified, assessed, evaluated and have appropriate mitigation, management and monitoring measures, designed and incorporated within the sub project itself.

4.3.2. Objectives and Principles of Resettlement Planning

This Resettlement Policy Framework (RPF) outlines the principles and procedures to ensure that if resettlement needs are identified, then the project follows the procedures for involuntary resettlement in compliance with the Government's own applicable laws and regulations along with the WB's policy OP 4.12 on Involuntary Resettlement. The RPF sets out the legal framework, eligibility criteria of displaced population, valuation methodology, compensation provision, entitlement matrix, implementation process, consultation procedures, grievance remedy mechanisms, entitlement payment procedures, and monitoring-evaluation procedures for land acquisition and resettlement under this project.

The basic objectives of the RPF are to:

1. Guide the in properly identifying, compensating, and restoring the livelihoods of Project Affected Persons (PAPs),
2. Serve as a binding document to ensure payment of compensation and assistance to PAPs, and
3. Provide direction in preparing, updating, implementing and monitoring project RAPs.

The RPF includes measures to ensure that PAPs are:

- Informed about their options and rights pertaining to resettlement;
- Consulted on, offered choices among, and provided with technically and economically feasible resettlement alternatives; and
- Provided prompt and effective compensation at full replacement cost for losses of assets attributable directly to the Project.

The RPF is based on the following principles:

- Involuntary resettlement is to be avoided or at least minimized;
- Compensation must ensure the maintenance of the PAPs' pre-project living standards;
- PAPs should be fully informed and consulted on compensation options;
- Particular attention should be paid to socially vulnerable groups, such as marginalized groups, female headed households, elderly households, etc...and appropriate assistance should be provided to help them improve their status;
- Land acquisition and resettlement should be conceived and executed as a part of the project, and the full costs of compensation should be included in project costs and benefits; and
- Compensation/rehabilitation assistance will be paid prior to ground levelling, demolition, and in any case, before an impact occurs.

4.3.3. Legal & Policy Framework

(1) **Overview**

This RPF has been prepared in accordance with laws, regulations and guidelines for land acquisition and resettlement of the Government of Rwanda (GoR) as well as WB OP4.12. Based on this legal and policy framework, eligibility and entitlements for assistance and compensation have been assessed and an entitlement matrix has been produced showing entitlements for each category of impact.

(2) **Legal and Policy Framework**

Rwanda has numerous legal and policy frameworks relating to land, expropriation and resettlement.

These include:

I. The Rwandan Constitution, promulgated in 2003;
II. Organic Land law No. 08/2005 of 14/07/2005 determining the use and management of land in Rwanda;
III. Organic law determining legislation around environmental management and protection;
IV. Land Valuation Law promulgated in 2007;
V. Land Expropriation Law promulgated No. 18/2007 of 19/04/2007;
VI. Presidential Order No. 54/01 of 12/10/2006 determining the structure, the responsibilities the functioning and the composition of Land Commissions; and

VII. Ministerial Order No. 001/2006 of 26/09/2006 determining the structure of Land Registers, the responsibilities and the functioning of the District Land Bureau.

This remainder of this section describes these legislations in more detail. After which a comparative analysis of Rwandan legislations with the World Bank provisions on resettlement are done on table No 20. The analysis identifies the gaps and provides the way forward to seal the gaps.

1) The Rwanda Constitution

The constitution is the supreme law of the land. Under Article 29 of the Rwanda constitution every citizen has a right to private property, whether personal or owned in association with others. Further it states private property, whether individually or collectively owned, is inviolable. However this right can be interfered with in case of public interest, in circumstances and procedures determined by law and subject to fair and prior compensation.

Article 30 stipulates that private ownership of land and other rights related to land are granted by the State. The constitution provides that a law should be in place to specify modalities of acquisition, transfer and use of land.

2) Law No. 18/2007 of 19/04/2007 relating to Expropriation in the Public interest, O.G. Special No. of 21/5/2007

This law determines the procedures relating to expropriation of land in the interest of the public. Article 3 of the law stipulates that it is only the government that has authority to carryout expropriation. Any project which intends to carry out acts of expropriation in public interest, shall provide funds for inventory of assets of the person to be expropriated and for just compensation for losses.

According to the organic law, no person shall hinder the implementation of the program of expropriation on pretext of self-centered justifications and no land owner shall oppose any underground or surface activity carried out on his or her land with an aim of public interest. In case it causes any loss to him or her, he or she shall receive just compensation for it.

Chapter IV deals with valuation of land earmarked for expropriation. The law identifies property to be valued for just compensation such as land and activities that were carried out on the land including different crops, forests, any buildings or any other activity aimed at efficient use of land or its productivity.

3) Organic Law No. 08/2005 Determining the use and management of Land in Rwanda of 2005

This is the law that determines the use and management of land in Rwanda. It also institutes the principles that are to be respected on land legal rights accepted on any land in the country as well as all other appendages whether natural or artificial.

According to the Organic Law, land in Rwanda is categorized into two: Private land and Public land. The latter is subdivided into two categories: state land in public domain and state land in

private domain. State land in public domain includes national land reserves for environmental conservation; land over which administrative buildings are erected, state roads, land containing lakes, rivers, stream and springs. State land in private domain include swamps that may be productive in terms of agriculture, vacant land with no owner, land purchased by the State, donation, land acquired through expropriation and land occupied by state owned forests. Land in Rwanda is predominantly private land.

The law gives the owner of land full rights to exploit his or her land in accordance with the existing laws and regulations. The law also provides for expropriation through article 56 which stipulates that land expropriation can be undertaken if it's for public interest.

4) Land Tenure System and provisions in Rwanda

The Organic Land Law provides two types of formal land tenure: full ownership/ freehold and long term leasehold.

As a result of the recent privatization of State owned lands, many land users don't hold either type of land tenure. As a result of this, the Organic Land Law recognizes existing rights, whether written or unwritten, under both civil law and customary practices through new national land tenure arrangements.

Article 7 of the law formalizes land ownership, especially those acquired through customary means. In such cases, populations with customary/indigenous land rights are being encouraged to register their land through decentralized the District Land Bureau, Sector Land Committees and Cell Land Committees. However in doing so all types of land tenure must be in compliance with the designated land use and environmental protection measures as outlined in the Land Use Master Plan (Organic Land law N0 08/2005 of 14/07/2005, article6).

5) Law No.17/2010 of 2010 Establishing and Organizing the Real Property Valuation Profession in Rwanda

This law provides for the registration of land valuers in Rwanda and conditions for registration. The law also allows the Government to conduct valuation when mandated by their government institutions. Articles 27, 29, 30 and 31 of the law deals with valuation methods; these articles stipulate that price for the real property shall be close or equal to the market value. The valuation could also compare land values country wide. Where sufficient comparable prices are not available to determine the value of improved land, the replacement cost approach shall be used to determine the value of improvements to land by taking real property as a reference. The law also allows the use of international methods not covered in the law after approval from the Institute of Valuers council.

6) Presidential Order No. 54/01 of 2006

This presidential order determines the structure, the responsibilities, the functioning and the composition of Land bureau. Article 9 of the order gives the office of the land commission independence in the discharge of its daily technical duties. Therefore, it receives no instructions from any other organ.

7) Ministerial Order No. 001/2006 of 2006 Determining the Structure of Lands Registers, the Responsibilities and Functioning of the District Land Bureau

This ministerial order determines the structure of Land Registers, the responsibilities and the functioning of the District Land Bureau.

The responsibilities of the land bureau include among others to implement land registration and manage land and update, safely keep records of land registers and monitor and approve activities pertaining to valuation of land, other immovable property and demarcate and approve land cadastral maps.

8) Ministerial Order No.002/16.01 of 2010 on Determining the Reference Land Price Outside Kigali City

The purpose of this order is to provide reference land prices to be used in areas outside Kigali City. This order was aimed at protecting land owners from exploitation and to prevent land speculation when the market is not developed. However with the propagation of land valuation law, the order seems to have been overtaken by events and practicability. This is due to the fact that valuation law provides for independent market rates to apply in land valuation.

9) Ministerial Order No. 002/2008 of 2008 Determining Modalities of Land Registration

Annex 3 of the ministerial order provides for dispute resolutions procedures and some provisions related to the cell adjudication committee ("CAC"). Articles 17, 20, 22, and 23 provide the process for resolving disputes. Article 17 grants parties to a dispute the right to take that dispute to the mediation committee. That article also provides that where a dispute arose during demarcation and adjudication but, with the assistance of the CAC, the parties were able to resolve the dispute, the parties are bound by that agreement, and may not later attempt to raise the issue.

Article 20 provides procedures for the CAC when hearing disputes, including that the hearing is open to the public and announced eight days in advance, among other requirements.

Articles 22 and 23 govern the lodging and processing of objections and corrections during a 60-dayperiod.The CAC is comprised of all five members of the cell land committee and five members of the particular village (umudugudu) where demarcation and adjudication is taking place. The cell executive secretary acts as the CAC secretary, although he or she has no voting rights. This order can be used to resolve resettlement conflict in the project area.

10) Criteria for Expropriation and Compensation

(a) Eligibility

Eligibility for compensation as a result of expropriation is enshrined in the constitution under article 29 of Rwanda Constitution and the Expropriation Law. The two laws regulate and give entitlement to those affected, whether or not they have written customary or formal tenure rights. The person to be affected by expropriation is defined under article 2(7) of the Expropriation Law to mean any person or legal entity who is to have his or her private property transferred due to public interest, in which case they shall be legally entitled to payment of compensation.

(b) Compensation Entitlement

In event of loss occurring to an individual, Article 3 of the Expropriation Law stipulates that he or she should receive just compensation for it. This entitlement is based on the figure arrived at by the independent valuer. Article 4 of this law also stipulates that any project which results in the need for expropriation for public interest shall provide for all just compensation in its budget. Through mutual arrangement, both parties can determine the mode of payment.

Article 22 (2) of the Expropriation Law provides that through an agreement between the person to expropriate and the one to be expropriated, just compensation may either be monetary, alternative land or a building equivalent as long as either option equates to fair and just monetary compensation. In case the determination of 'just' compensation exceeds in value the alternative land given to the person affected by expropriation, the difference will be paid to the affected person.

(c) Land Expropriation and Valuation in Rwanda

A landowner whose land is to be expropriated shall be entitled to payment of compensation for land and other assets, plus compensation relating to all activities resulting in any improvement to the land.

Land and other assets are classified into two categories: movable and immovable assets, both of which are eligible for compensation. For movable assets, compensation relates to inconveniences and other transition costs caused in the process of relocation. Immovable assets include: crops, forests, any building or other activity aimed at efficient use of the land, the value of land, and the activities thereon that belong to the person expropriated.

Valuation of land and property on it is done by the government or valuers registered by

Institute of Real Property Valuers based on land size, nature and location of land as well as the prevailing market price or any other international methods. The amount of compensation for property is determined on the basis of the replacement cost of the property.

The law provides that the valuation for expropriated lands be based on its type, use, location and availability, building on this guidance provided by MINIRENA. At the moment market prices for land and property on it are negotiated openly and freely by the buyer and the seller based on mutual agreement (willing seller willing buyer basis).

(d) Procedures for Expropriation

Organic law on expropriation stipulates and provides for public sensitization on the importance of the project to be established and the need for expropriation. In addition to sensitization, the Expropriation Law requires prior consultative meetings and examination of the project proposal involving expropriation, with a view to avoid eventual prejudice on the person or entity subject to expropriation. Normally, a consultative meeting is held within 30 days after receipt of the application for expropriation. Based on these consultations, the relevant Land Commission or Committee (Cell level, sector, district or National level) takes a decision to approve the project

within a period of 15 days.

The application for expropriation should have relevant information about the project, including description, the justification that the project is aimed at the public interest, the Land Use Master Plan for the land area on which the project shall be implemented, documentation indicating that the project does not have negative impacts on environment (or that the impact is mitigated by the project) as well as proof confirming the availability of funds to fully cover compensation costs. The Land Use Master Plan should be referred and a survey conducted in order to get a comprehensive description of the activities/ items on that land as well as the list of beneficiaries of activities on that land.

After the survey process is completed and approved by the expropriating agency, parties must sign a contract detailing the objective of expropriation, the value of compensation and the payment method and schedule. The contract serves as a documentary evidence of the full consent of all parties to the rights and obligations as well as procedures enshrined therein. They bind the parties to it and the contractual provisions become the law between the parties.

The final decision is normally communicated publicly to the population by the relevant Land Bureau. The decision is also normally posted in the public offices where the land at issue is located as well as on radio Rwanda and in State newspapers. As such, this is intended to inform the concerned parties and it is normally done within 30 days after the decision has been made (Article 13 of the Expropriation Law).

(e) Complaints Procedures and Redress

Article 26 of the Expropriation Law N0 18/2007 of 19/04/2007 provides complaints procedures for individuals dissatisfied with the value of their compensation. Article 19 of the expropriation law stipulates that dissatisfied persons have a grace period of 30 days after the project approval decision has been taken to appeal.

The first step of redress is to inform those to be expropriated of their rights during the expropriation process. Articles 17-20 of the Expropriation Law obliges the representative government authority (that which is implementing the project requiring expropriation) to inform affected people of their rights at each stage of the process.

4.3.4. Eligibility Criteria and Procedures for Various Categories of Affected People

This section sets out eligibility criteria, which are necessary to determine who will be eligible for resettlement and benefits, and to discourage inflow of ineligible people.

(1) **Principles**

The involuntary taking of land results in relocation or loss of shelter; and loss of assets or access to assets or loss of income sources or means of livelihood, whether or not the PAPs must move to another location or not. Meaningful consultations with the affected persons, local authorities and community leaders will therefore allow for establishment of criteria by which displaced persons will be deemed eligible for compensation and other resettlement assistance.

OP 4.12 suggests the following three criteria for eligibility:

1) Those that have formal rights to land including customary/communal land, traditional and religious rights recognized under Rwandan Law.
2) Those who do not have formal legal rights to land at the time the project or census commences but have a claim to such land or assets provided that such claims are recognized under the laws of Rwandan or become recognized through a process identified in the RPF / RAP.
3) Those that have no recognizable legal right or claim to the land they are occupying, using or getting their livelihood from before the cut-off date, but are recognized under World Bank OP 4.12.

Those covered under (a) and (b) above are to be provided compensation for the land they lose, and other assistance in accordance with this RPF.

Persons covered under (c) above are to be provided with resettlement assistance in lieu of compensation for the land they occupy, and other assistance, as necessary, to achieve the objectives set out in this RPF, if they occupy the project area prior to a cut-off date established by the project authorities in close consultation with the potential PAPs, local community leaders and the respective local authorities and acceptable to the World Bank.

Persons who encroach on the area after the cut-off date are not entitled to compensation or any other form of resettlement assistance. All persons included in (a), (b) or (c) above are to be provided with compensation for loss of assets other than land. It is therefore clear that all project affected persons irrespective of their status or whether they have formal titles, legal rights or not, squatters or otherwise encroaching illegally on land, are eligible for some kind of assistance if they occupied the land or had use of it, before the entitlement cut-off date.

(2) **Eligibility Criteria and Entitlements**

Defining eligibility criteria is essential for the resettlement/ rehabilitation process and compensation payments. The census and property inventories provide the basis of the identification of PAPs and assets. This table outlines the categories of Project affected peoples who are recognized as potentially affected by project activities and describes the categories of entitlements:

Table 4-3.1 Entitlements Matrix to be used for geothermal potential sites

Type of Loss	Application	Definition of PAP Entitled	Compensation Entitlement	Implementation Issues / Challenges
1.Permanent loss of agricultural land	Removal of project affected peoples (PAPs) from agricultural land located access road and water pumping station	Owner (person with legal title/registration of land ownership)	Cash compensation at market rates (free of taxes, registration and transfer costs). Cash compensation to be paid for transaction costs, taxes and titling. Priority for employment on the project for at least one member of affected household[9].	The valuation calculation methodology and the unit value rates used needs to be transparently disclosed and explained to PAPs.
		All persons using or cultivating land (including tenants, share-croppers, and those without legal title.)	Cash compensation at equivalent to market value of gross harvest of the affected land for one year. Priority for employment on the project for at least one member of affected household (AH)	Identification of informal users without legal entitlements can be challenging. Approach will be to consult with community leaders, undertake participatory land use mapping and seek verification of entitlement claims.
2. Temporary loss of agricultural land	Temporary loss of land at the campsite and construction depot and all drilling sites.	Owner (person with legal title/registration of land ownership)	Cash compensation at market rates (free of taxes, registration and transfer costs) If the geothermal resource is not proven, the land will be restored to its original condition and given back. The lease will be extended until such time that the PAP and Executive Secretary of the Cell and Sector agree that it is in a useable condition. If land is not restored and returned to PAPs, the land will be purchased outright in full at the market rate at the time of purchase, as per loss category 1.	Restoration of returned land may be challenging if contaminated by drilling muds or other activities which may lower soil fertility.
		All persons using or cultivating land (including tenants, share-croppers, and those without legal title.)	Cash compensation at equivalent to market value of gross harvest of the affected land for term of lease, and up until the first harvest after the land is returned. If land is not returned, further compensation as per permanent land loss detailed in loss category 1.	
3. Loss of crops	Removal of crops from project area, whether permanent or temporary land loss	Owner of crop	Monetary compensation to farmers based on area of crops lost and market rates based on District Land Bureau estimates. Plus cost of replacement of seed based on District Land Bureau estimate. Plus advance notice to harvest last crop prior to displacement.	
4. Loss of productive and decorative trees	Removal of trees within project area, whether permanent or temporary land loss	Owner of trees	Cash compensation to equal amount of market value of tree lost plus cost of replacement of seed based on District Land Bureau estimate taking into account type, age and productive value. Plus advance notice to harvest tree	Determination of tree maturity and productivity.

[9] Household is defined as including all those who are economically dependent on the household head.

Type of Loss	Application	Definition of PAP Entitled	Compensation Entitlement	Implementation Issues / Challenges
			products prior to displacement.	
5. Loss of fixed assets (walls, fences, wells, sheds)	Clearance of land of all structures	Owner of fixed asset.	Compensation at full replacement cost (free of taxes, registration and transfer costs).	
6. Vulnerable people's assistance	Impacts on vulnerable people	AHs below poverty line[10],, elderly, people not protected by national land law, large (>8) households, historically marginalised people,	Employment priorities are given to *all* members of vulnerable AH that are of working age Vulnerable people to be paid any cash compensation at 25% greater than standard rate.	Special efforts to engage with vulnerable PAPs through consultation and to monitor impacts post land acquisition. If vulnerable households found to need further assistance, additional support to be provided.
7. Severe impacts allowance	When more than 25% of productive land (or resources) are taken, physical relocation occurs from one's residence or place of business, or people suffer significant loss of livelihood and income.	Affected person.	Employment priorities are given to *all* members of severely AH that are of working age Severely affected people to be paid any cash compensation at 25% greater than standard rate.	
8.	Damaged crops (through soil dumping, discharged waste water, drilling impacts, or other)	Owner of crop	Monetary compensation to farmers based on area of crops lost and market rates based on District Land Bureau estimates. Plus cost of replacement of seed based on District Land Bureau estimate.	
9. Permanent acquisition of structure.	Any structure including house, fence, sanitation structure etc.	Owner of structure	Replacement structure or Cash compensation at replacement value of a new structure plus full compensation for all fees needed to make replacement new structure.	

[10]Living on < $0.90 USD per person per day

(3) Vulnerable Sub-Groups

Particular attention will be given to identify PAPs falling into vulnerable groups such as the landless, women-headed households, households with orphans, elderly living alone, sick head of household to ensure that their needs are identified and that they are provided adequate support. Vulnerability will be defined at the household level and could be based on economic vulnerability, social vulnerability or a combination of these. The socio-economic survey for the project RAP will clearly identify the households that are deemed vulnerable in terms of project impact, provide a detailed justification describing the project impact and rationale for vulnerability.

The RAP will clearly describe the nature of the impact, the vulnerability and the detailed provisions offered to the household by the project that are specific to its particular needs and cater to its limitations. All vulnerable households will be included in the monitoring samples and follow up visits will be done for at least 1 year after completion of resettlement. Similarly, any grievance complaints made by vulnerable households will be given preference and they will be provided assistance to submit such complaints.

(4) Methods to Determine Cut-Off Dates

Once the design of the project has been finalized and legal procedures completed, a RAP will be prepared for this project. As part of the RAP, a census will be undertaken to identify all the PAPs and the related levels of impact. The date that the census begins is the cut-off date for eligibility for resettlement and compensation. It is key, therefore, that this date is fully communicated to all potential PAPs in the project affected area with sufficient time for these people to ensure their availability for the census.

This communication will be done through the Resettlement and Compensation Committees and in line with the consultation procedures outlined in this document. The potential PAPs will be informed through both formal notification in writing and by verbal notification delivered in the presence of the local leaders or their representatives.

Once the census had been undertaken, the lists will be verified and validated by the relevant authorities such as the Vice Mayor of Social Affairs, local authorities, etc.). Once these lists have been approved, thereafter, no new cases of affected people will be considered. Once land users have been identified, their details and eligibility will be submitted to the Resettlement and Compensation Committee and these new PAPs will be considered eligible for compensation.

The establishment of a cut-off date is required to prevent opportunistic invasions/rush migration into the chosen land areas thereby posing a risk to the project. Therefore, establishment of a cut-off date is of critical importance. The Resettlement and Compensation Committees will play a crucial role in identifying users of land.

Because the time period between the cut-off date and the time actual of the project activities (civil works, etc.) would start, bearing also in mind that only after PAPs have been compensated

and any replacement structures built according to the requirements of this RPF, is likely to be anytime period from six months on, special attention needs to be taken to secure the sites from rush and opportunistic invasion. These measures should include close consultation with the recognized PAP's, signs that inform general public of intended use of site, security patrols to identify opportunistic invaders etc...

4.4. Conformity with the JICA's Environmental Guidelines

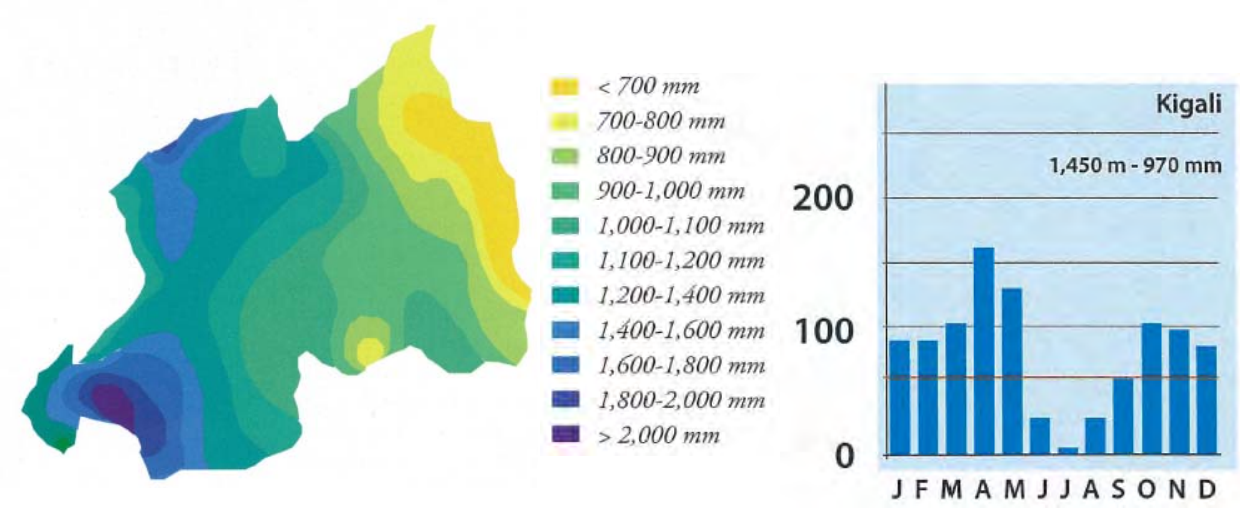
In Rwanda, general EIA guidelines for development projects have been established, and related systems, including EIA procedures, approval systems and support for stakeholders, have been well developed. These Rwandan guidelines and related systems cover, in terms of items, basic matters addressed in JICA Guidelines for Environmental and Social Considerations, and include the spirit conveyed in the latter's principle, basic policy, objectives and definitions. Therefore, the system in Rwanda related to environmental and social considerations can be evaluated as having no significant discrepancies from JICA Guidelines for Environmental and Social Considerations. However, the EIA guidelines for geothermal development are still being formulated. With regard to natural environment items, as is typically noted for mountain gorillas, available data on environmental impact brought about by development projects is insufficient and evaluation methods have not been fully established yet. It will be necessary to take an adaptive approach to the assessment of natural environmental impact by evaluating impact based on the latest information, and by thoroughly reviewing environmental management programs and monitoring plans.

4.5. Natural Environment and Protected Areas in Rwanda

4.5.1. Climate of Rwanda

(1) **Rainfall**

Schematically, rainfall increases from east to west. The wettest areas, which a mean annual rainfall of more than 2,000 mm are centered on the Congo-Nile divide, especially the western part of Nyungwe National Park, and the western volcanoes (Karisimbi). In most years November and April are the wettest months. January and February (the "short dry season") are less humid, while June, July and August (the "long dry season") are really dry (Fig. 4-5.1).



source: Birds in Rwanda (RDB,2010)

Fig. 4-5.1 Mean annual rainfall distribution in Rwanda and Mean monthly rainfall in Kigali

(2) **Temperature**

On the central plateau mean temperature is between 18°C and 20°C. The eastern low-lying basins are somewhat hotter, with mean temperature of 20°C to 22°C. Monthly variations do not exceed 1°C to 2°C. The coolest period is usually between April and August, July being often the coolest month.

4.5.2. Forestry Resources in Rwanda

Rwanda forests and woodlands can be classified into four categories: the natural forests of the Congo Nile Ridge comprised with Nyungwe National Park Gishwati, and Mukura; the natural forests of the Volcanoes National Park; the natural forests in the savannah and gallery-forest of the Akagera National Park and remnants of gallery-forests and savannahs of Bugesera, Gisaka and Umutara; and forest plantations dominated by exotic species and trees scattered on farmlands (agroforestry) and along ditches.

4.5.3. Water and Wetlands Resources

Rwanda is divided into two major drainage basins (Congo and Nile Basin). The country's hydrological network includes numerous lakes and rivers and its associated wetlands. A recent inventory of marshlands in Rwanda conducted in 2008 identified shows 860 marshlands, covering a total surface of 278,536 ha, which corresponds to 10.6 per cent of the country surface, 101 lakes covering 149,487 ha, and 861 rivers totaling 6,462 km in length.

4.5.4. Protected Areas

This rich biodiversity is mainly conserved in protected areas (three national parks, natural forests, wetlands). These cover almost 10 per cent of the national territory while the rest of the country is densely populated.

(1) **Volcanoes National Park**

The Volcanoes National Park (Fig. 4-5.2) is home to about 30 per cent of the global population of Mountain Gorilla (*Gorilla gorilla beringei*). It has other 115 mammals' species, including the golden monkey (*Cercopithecus mitis kandti*), elephants, buffaloes, 187 bird species, 27 species of reptiles and amphibians and 33 arthropod species. CITES consider *Rana anolensis*, *Chameleo rudi* and *Leptosiaphos grauer* endangered.

(2) **Nyungwe National Park**

Nyungwe National Park (Fig. 4-5.2) has 75 species of mammals, including 13 species of primates with some on the IUCN Red list such as the Eastern Chimpanzee (*Pan troglodytes schweinfurthii*), owl-faced guenons (*Cercopithecus hamlyni*) and the Angolan Colobus monkey (*Colobus angolensis ruwenzorii*). The national park is also considered an African Important Bird Area (IBA) with 285 bird species comprising 25 endemic to the Albertine Rift.

(3) **Akagera National Park**

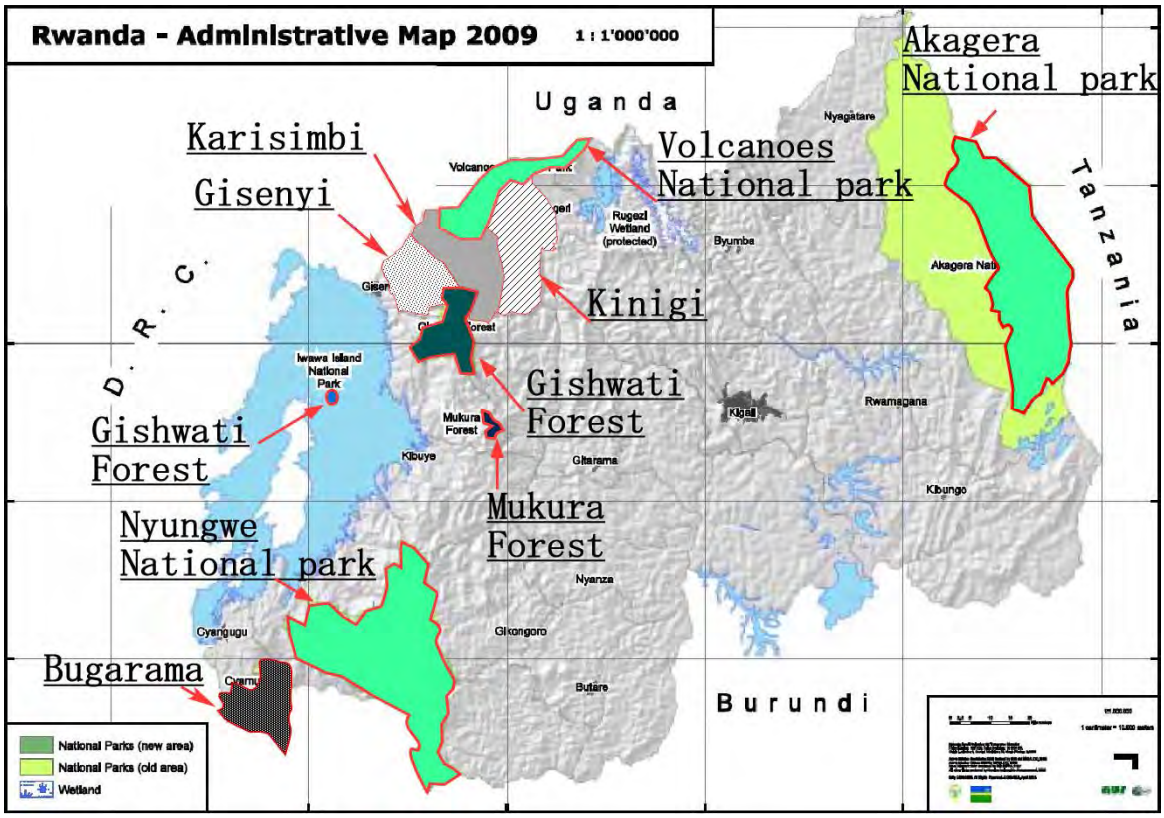
The wildlife in the Akagera National Park (Fig. 4-5.2) comprises 90 species of mammals, 530 bird species and 35 fish species. The most threatened species are rhinoceros, large carnivores, particularly lions. Many species in the Akagera National Park are protected by the CITES convention such as *Loxodonta africana* (African elephant), *Sincerus caffer* (buffalo), *Panthera leo* (leopard) and *Tragelaphus spekii* (sitatunga). The flora of the Akagera National Park is diverse and 6 species of orchids are recorded. The grass savanna is dominated by *Themeda triandra* and *Hyparrhenia* sp. accompanied with normal species like *Sporobolus pyramidalis* and *Botriochloa insculpta*.

(4) **Natural Forests**

Natural forests are rich in fauna species. Gishwati forest (Fig. 4-5.2) includes species such as *Pantroglodytes schewinfurthii, Colobus angolensis ruwenzorii, Potamochoerus porcus, Cephalophus nigrifons, Dendrohyrax arboreus, Felis serva*l and *Felis aurata* .

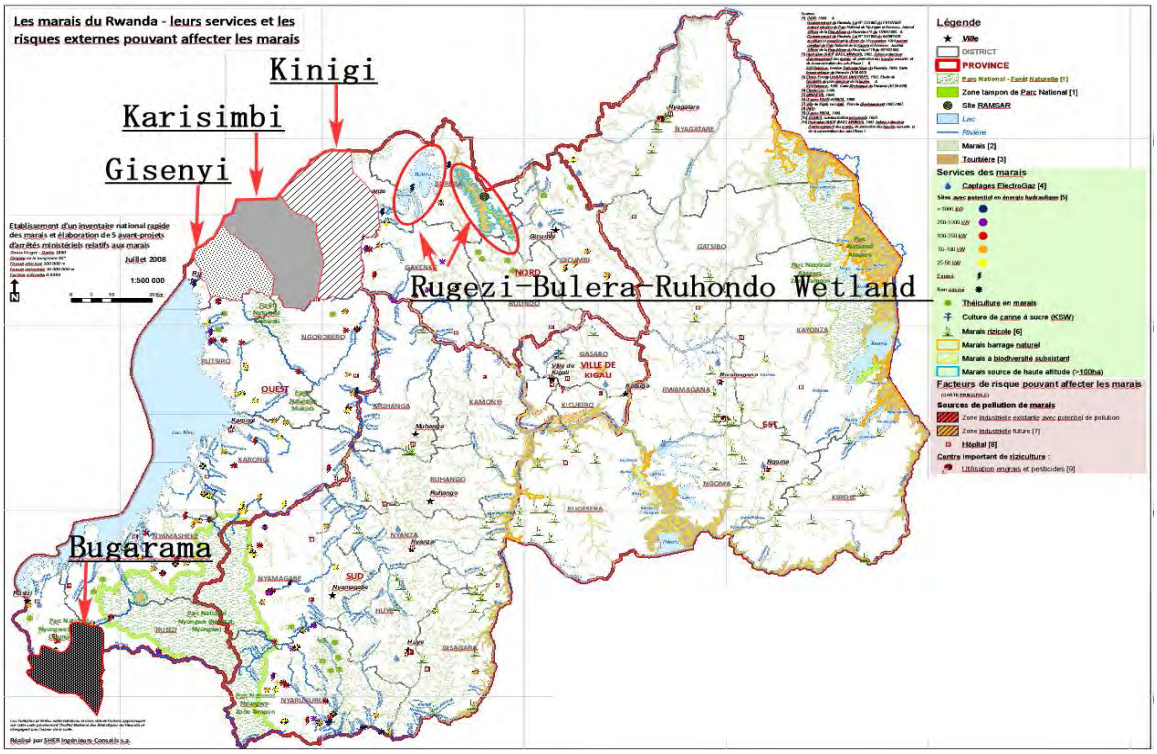
(5) **Natural Wetland**

Rugezi wetland (Fig. 4-5.3) is habitat to an endangered bird and hosts 60 per cent of the global population of Grauer's swap-warbler (*Bradypterus graueri*). It is also habitat to 19 bird species, including two species of Threskiornithidae, protected by CITES.



source: REMA MAP

Fig. 4-5.2 National park and Forest in Rwanda



source: REMA MAP

Fig. 4-5.3 Wetland in Rwanda

(6) **Major precious species in Rwanda**

Major precious species in Rwanda are summarised in the Table 4-5.1.

Some of them were identified during our field study.

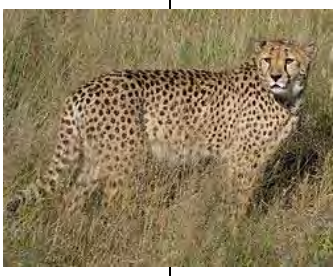
Table 4-5.1 List of major precious species in Rwanda

Species		VALCANOES	NYUNGWE	Outline
Gorilla	*Gorilla gorilla beringei* 	○	×	The mountain gorilla (Gorilla beringei beringei) is one of the two subspecies of the eastern gorilla. As of November 2012, the estimated total number of mountain gorillas is around 880. The fur of the mountain gorilla, often thicker and longer than that of other gorilla species, enables them to live in colder temperatures. Males, at a mean weight of 195 kg and upright standing height of 150 cm usually weigh twice as much as the females, at a mean of 100 kg and a height of 130 cm. Adult males are called silverbacks because a saddle of gray or silver-colored hair develops on their backs with age. The mountain gorilla inhabits the Albertine Rift montane cloud forests and of the Virunga Volcanoes, ranging in altitude from 2,200–4,300 metres. The mountain gorilla is diurnal.Each gorilla builds a nest from surrounding vegetation to sleep in, constructing a new one every evening. The mountain gorilla is primarily a herbivore; the majority of its diet is composed of the leaves, shoots and stems (85.8%) of 142 plant species. It also feeds on bark (6.9%), roots (3.3%), flowers (2.3%), and fruit (1.7%), as well as small invertebrates. (0.1%). The mountain gorilla is highly social, and lives in relatively stable, cohesive groups held together by long-term bonds between adult males and females. Group sizes vary from five to thirty, with an average of ten individuals. Source:http://en.wikipedia.org/wiki/Gorilla_gorilla_beringei
Chimpanzee	*Pan troglodydes* 	×	○	Chimpanzees, sometimes colloquially chimps, are two extant hominid species of apes in the genus Pan. Source:http://en.wikipedia.org/wiki/Chimpanzee#Intelligence

Species		VALCANOES	NYUNGWE	Outline
Black rhinoceros	*Diceros bicornis* 	×	×	The hook-lipped rhinoceros (Diceros bicornis) is a species of rhinoceros, native to eastern and central Africa including Kenya, Tanzania, Cameroon, South Africa, Namibia, Zimbabwe, and Angola. Although the rhinoceros is referred to as black, its colors vary from brown to grey. The optimum habitat seems to be one consisting of thick scrub and bushland, often with some woodland, which supports the highest densities. An adult black rhinoceros stands 140–180 cm high at the shoulder and is 3–3.75 m in length.An adult typically weighs from 800 to 1,400 kg , however unusually large male specimens have been reported at up to 2,199–2,896 kg . The females are smaller than the males. Two horns on the skull are made of keratin with the larger front horn typically 50 cm long, exceptionally up to 140 cm . Black rhinoceros are generally thought to be solitary, with the only strong bond between a mother and her calf.They are not very territorial and often intersect other rhino territories. Home ranges vary depending on season and the availability of food and water. Generally they have smaller home ranges and larger density in habitats that have plenty of food and water available, and vice versa if resources are not readily available. In the Serengeti home ranges are around 70 to 100 km2 (27 to 39 sq mi), while in the Ngorongoro it is between 2.6 to 58.0 km2 (1.0 to 22.4 sq mi). The black rhinoceros is a herbivorous browser that eats leafy plants, branches, shoots, thorny wood bushes, and fruit. Mating does not have a seasonal pattern but births tend to be towards the end of the rainy season in more arid environments.The gestation period is 15 to 16 months.The mother and calf stay together for 2–3 years until the next calf is born.The young are occasionally taken by hyenas and lions.Sexual maturity is reached from 5 to 7 years old for females, and 7 to 8 years for males. The life expectancy in natural conditions (without poaching pressure) is from 35 to 50 years. Source:http://en.wikipedia.org/wiki/Black_rhinoceros
African bush elephant	*Loxodonta Africana* 	○	×	The African bush elephant (Loxodonta africana) is the larger of the two species of African elephant. They distributed in Western and Central and East and South Africa. African bush elephants are the largest living terrestrial animals, being up to 3.96 m tall at the shoulders. On average, males are 3.3 metres tall at the shoulders and 5.5 tonnes in weight, while females are much smaller at 2.8 metres tall and 3.7 tonnes in weight. Adult males usually live alone. Herds are made up of related females and their young, directed by the eldest female, called the matriarch. Infrequently, an adult male goes with them, but those usually leave the herd when reaching adolescence to form bachelor herds with other elephants of the same age. Later, they lead a solitary life, approaching the female herds only during the mating season. The African bush elephant is herbivorous. Its diet varies according to its habitat; elephants living in forests, partial deserts, and grasslands all eat different proportions of herbs and tree or shrubbery leaves. Source:http://en.wikipedia.org/wiki/Loxodonta_Africana

Species		VALCANOES	NYUNGWE	Outline
Roan antelope	*Hippotagus equinus* 	×	×	Roan antelope are one of the largest species of antelope. They distributed in Africa. They measure 190–240 cm from the head to the base of tail and the tail measures 37–48 cm. The body mass of males is 242–300 kg and of females is 223–280 kg. The shoulder of this species is typically around 130–140 cm.The horns are ringed and can reach a metre long in males, slightly shorter in females. Roan antelope are found in woodland and grassland savanna, mainly in the tropical and subtropical grasslands, savannas, and shrublands biome, which range in tree density from forest with a grassy understorey (such as central Zambezian Miombo woodlands) to grasslands dotted with few trees, where they eat midlength grasses. They form harem groups of five to 15 animals with a dominant male. Source:http://en.wikipedia.org/wiki/Roan_antelope
Sitatunga	*Tragelaphus spekeii* 	×	×	The sitatunga or marshbuck (Tragelaphus spekii) is a swamp-dwelling antelope found throughout Central Africa, centering on the Democratic Republic of the Congo, Cameroon, parts of Southern Sudan, Ghana, Botswana, Zambia, Gabon, Tanzania, Uganda and Kenya.The head-and-body length is typically between 115–170 cm.Males reach approximately 88–125 cm at the shoulder, while females reach 75–90 cm.Males typically weigh 70–125 kg and females 50–57 kg.The tail is 30–35 cm long.The coat colour varies geographically, but, in general, is a rufous red in juveniles and chestnut in females.The coats of males darken with age, becoming gray to dark brown.As a prominent sign of sexual dimorphism, only the males possess horns. The spiral horns shown one or two twists, and are 45–90 cm long. Both horns are tipped with ivory. Source:http://en.wikipedia.org/wiki/Sitatunga
Lions	*Panthera Leo* 	×	×	The lion (Panthera leo), also known as the African lion, is one of the five big cats in the genus Panthera and a member of the family Felidae. With some males exceeding 250 kg in weight,it is the second-largest living cat after the tiger. Wild lions currently exist in sub-Saharan Africa and in Asia. Lions spend much of their time resting and are inactive for about 20 hours per day. Although lions can be active at any time, their activity generally peaks after dusk with a period of socializing, grooming, and defecating. Intermittent bursts of activity follow through the night hours until dawn, when hunting most often takes place. A pride of lions consists of related females and offspring and a small number of adult males. The prey consists mainly of medium-sized mammals, with a preference for wildebeest, zebras, buffalo, and warthogs in Africa and nilgai, wild boar, and several deer species in India. Many other species are hunted, based on availability. Mainly this will include ungulates weighing between 50 and 300 kg such as kudu, hartebeest, gemsbok, and eland. Source:http://en.wikipedia.org/wiki/Lion

Species		VALCANOES	NYUNGWE	Outline
Leopard	*Panthera pardus* 	×	○	The leopard is one of the five "big cats" in the genus Panthera. It is a member of the Felidae family with a wide range in some parts of sub-Saharan Africa, West Asia, the Middle East, South and Southeast Asia to Siberia. Head and body length is usually between 90 and 165 cm . The tail reaches 60 to 110 cm long, around the same length as the tiger's tail and proportionately long for the genus. Shoulder height is from 45 to 80 cm. Leopards show a great diversity in coat color and rosettes patterns. In general, the coat color varies from pale yellow to deep gold or tawny, and is patterned with black rosettes. The head, lower limbs and belly are spotted with solid black. Coat color and patterning are broadly associated with habitat type. Leopards are exceptionally adaptable, although associated primarily with savanna and rainforest. Populations thrive anywhere in the species range where grasslands, woodlands, and riverine forests remain largely undisturbed. Leopards are elusive, solitary and largely nocturnal.Leopards are versatile, opportunistic hunters, and have a very broad diet. They feed on a greater diversity of prey than other members of the Panthera genus, and are reported to eat anything from dung beetles to common elands, though medium-sized prey species in the 20–80 kg range are usually taken. Source:http://en.wikipedia.org/wiki/Leopard
Klipspringer	*Oreotragus oretragus* 	?	?	The klipspringer (Oreotragus oreotragus) is a small species of African antelope. They distributed in Central and East and South Africa. Reaching approximately 58 cm at the shoulder, klipspringers are smaller than most other antelopes. They stand on the tips of their hooves and can fit all four hooves on a piece of cliff the size of a Canadian dollar coin (Loonie), roughly 30 mm in diameter. Male klipspringer horns are usually about 10–15 cm long.With a thick and dense, speckled "salt and pepper" patterned coat of an almost olive shade, klipspringers blend in well with the koppies (rock outcrops) on which they can usually be found. Klipspringers form breeding pairs rather than herds. The pairs mate for life and will spend most of their lives in close proximity to each other. When one klipspringer is eating, the other will assume lookout duty, helping to keep the pair aware of any predators. The mating season for klipspringers is from September through January. The gestation period is about 214 days Klipspringers are herbivores, eating plants growing in mountainous habitats and rocky terrain. They never need to drink, since the succulents they consume provide them with enough water to survive. Source:http://en.wikipedia.org/wiki/Klipspringer
African buffalo	*Syncerus caffer (Sparrman)*	○	×	The African buffalo or Cape buffalo (Syncerus caffer), is a large African bovine. They distributed in Western and Central and East and South Africa. Its shoulder height can range from 1 to 1.7 m and its head-and-body length can range from 1.7 to 3.4 m . Compared with other large bovids, it has a long but stocky body (the body length can exceed the wild water buffalo, which is rather heavier and taller) and short but thickset legs,

Species		VALCANOES	NYUNGWE	Outline
				resulting in a relatively short standing height. The tail can range from 70 to 110 cm long. Savannah-type buffaloes have black or dark brown coats with age. Old bulls have whitish circles around their eyes. Females tend to have more-reddish coats. Forest-type buffaloes are reddish brown in colour with horns that curve back and slightly up. Calves of both types have red coats. From the base, the horns diverge, then bend down, and then smoothly curve upwards and outwards. The African buffalo is one of the most successful grazers in Africa. It lives in swamps and floodplains, as well as mopane grasslands and forests of the major mountains of Africa. Herd size is highly variable. The core of the herds is made up of related females, and their offspring, in an almost linear dominance hierarchy. Source:http://en.wikipedia.org/wiki/Syncerus_caffer
Cheetah	*Acinonyx jubatus (Schreber)*	×	×	The cheetah (Acinonyx jubatus) is a large feline (family Felidae, subfamily Felinae) inhabiting most of Africa and parts of Iran. It is the only extant member of the genus Acinonyx. The adult cheetah weighs from 21 to 72 kg . Its total head-and-body length is from 110 to 150 cm , while the tail can measure 60 to 84 cm in length.Cheetahs are 66 to 94 cm tall at the shoulder.Males tend to be slightly larger than females and have slightly bigger heads, but there is not a great variation in cheetah sizes and it is difficult to tell males and females apart by appearance alone. Compared to a similarly sized leopard, the cheetah is generally shorter-bodied, but is longer tailed and taller (it averages about 90 cm tall) and so it appears more streamlined.The cheetah thrives in areas with vast expanses of land where prey is abundant. The cheetah likes to live in an open biotope, such as semidesert, prairie, and thick brush, though it can be found in a variety of habitats. In Namibia, for example, it lives in grasslands, savannahs, areas of dense vegetation, and mountainous terrain.Females live alone, except when they are raising cubs and they raise their cubs on their own. The cheetah is a carnivore, eating mostly mammalian herbivores under 40 kg and that which specialise in eating C3 plants, including the Thomson's gazelle, the Grant's gazelle, the springbok, impala and blesbok. Females give birth to up to nine cubs after a gestation period of ninety to ninety-eight days, although the average litter size is four. Source:http://en.wikipedia.org/wiki/Cheetah
				
Cephalophus	*Cephalophus nigrifrons (Grays)*	○	○	The black-fronted duiker is a small antelope found in central and west-central Africa. It averages 10 kg and a shoulder height of 43 cm . It has been found as far south as northern Angola. Source:http://en.wikipedia.org/wiki/Cephalophus_nigrifrons
				

Species		VALCANOES	NYUNGWE	Outline
Wild dog	*Lycaon pictus (Temminck)* 	○	○	Lycaon pictus is a canid native to Sub-Saharan Africa. It is the largest of its family in Africa, and the only member of the genus Lycaon, which is distinguished from Canis by its fewer toes and dentition, which is highly specialised for a hypercarnivorous diet. L. pictus is the bulkiest and most solidly built of African canids.The species stands 60–75 cm in shoulder height, and weighs 20–25 kg in East Africa and up to 30 kg in southern Africa. Females are generally 3-7% smaller than males. The fur of L. pictus differs significantly from that of other canids, consisting entirely of stiff bristle-hairs with no underfur.Much of the species' coat patterning occurs on the trunk and legs. There is little variation in facial markings, with the muzzle being black, gradually shading into brown on the cheeks and forehead.A black line extends up the forehead, turning blackish-brown on the back of the ears. A few specimens sport a brown teardrop shaped mark below the eyes. The back of the head and neck are either brown or yellow. L. pictus is mostly found in savanna and arid zones, avoiding forested areas. L. pictus is a specialised pack hunter of common medium-sized antelopes. The gestation period lasts 69-73 days, with the interval between each pregnancy being 12-14 months on average. L. pictus produces more pups than any other canid, with litters containing around 6-16 pups, with an average of 10, thus indicating that a single female can produce enough young to form a new pack every year. Source:http://en.wikipedia.org/wiki/Lycaon_pictus
Bushbuck	*Tragelaphus (Pallas)* 	○	×	The genus Tragelaphus contains several species of bovine, all of which are relatively antelope-like. Species in this genus tend to be large sized, lightly built, have long necks and considerable sexual dimorphism. Source:http://en.wikipedia.org/wiki/Tragelaphus

Species		VALCANOES	NYUNGWE	Outline
Hippopotamus	*Hippopotamus amphibius* 	×	×	The hippopotamus (Hippopotamus amphibius) is a large, mostly herbivorous mammal in sub-Saharan Africa, and one of only two extant species in the family Hippopotamidae. Hippopotamuses are among the largest living land mammals; only elephants and some rhinoceroses are heavier. The average weights for adult males between 1,500 and 1,800 kg. Females are smaller than their male counterparts, with average weights between 1,300 and 1,500 kg. The hippo's jaw is powered by a large masseter and a well-developed digastric; the latter loops up behind the former to the hyoid. The jaw hinge is located far back enough to allow the animal to open its mouth at almost 180°. Hippopotamus teeth sharpen themselves as they grind together. The lower canines and lower incisors are enlarged, especially in males, and grow continuously. The incisors can reach 40 cm , while the canines reach up to 50 cm . The common hippopotamus is semiaquatic, inhabiting rivers, lakes and mangrove swamps, where territorial bulls preside over a stretch of river and groups of five to 30 females and young. During the day, they remain cool by staying in the water or mud; reproduction and childbirth both occur in water. They emerge at dusk to graze on grasses. While hippopotamuses rest near each other in the water, grazing is a solitary activity and hippos are not territorial on land. Female hippos reach sexual maturity at five to six years of age and have a gestation period of eight months. Source:http://en.wikipedia.org/wiki/Hippopotamus
Burchell’s zebra	*Equus quagga burchellii* 	×	×	Burchell's zebra (Equus quagga burchellii) is a southern subspecies of the plains zebra. Like most plains zebras, females and males are relatively the same size. Source:http://en.wikipedia.org/wiki/Burchell%E2%80%99s_zebra

Species		VALCANOES	NYUNGWE	Outline
Black-headed Heron	*Ardea melanocephala* 	×	○	The black-headed heron (Ardea melanocephala) is a wading bird of the heron family Ardeidae, common throughout much of sub-Saharan Africa and Madagascar. It is mainly resident, but some west African birds move further north in the rainy season. This species usually breeds in the wet season in colonies in trees, reedbeds or cliffs. It builds a bulky stick nest, and lays 2–4 eggs. The black-headed heron is a large bird, standing 85 cm tall, and it has a 150 cm wingspan. It is nearly as large as the grey heron, which it resembles in appearance, although it is generally darker. Its plumage is largely grey above, and paler grey below. It has a powerful dusky bill. Source: http://en.wikipedia.org/wiki/Black-headed_Heron
Cattle Egret	*Bubulcus ibis* 		○	The cattle egret (Bubulcus ibis) is a cosmopolitan species of heron (family Ardeidae) found in the tropics, subtropics and warm temperate zones. Originally native to parts of Asia, Africa and Europe, it has undergone a rapid expansion in its distribution and successfully colonised much of the rest of the world in the last century. It is a white bird adorned with buff plumes in the breeding season. It nests in colonies, usually near bodies of water and often with other wading birds. The nest is a platform of sticks in trees or shrubs. Cattle egrets exploit drier and open habitats more than other heron species. Source: http://en.wikipedia.org/wiki/Bubulcus_ibis
Grauer's Swamp Warbler	*Bradypterus graueri* 	○	○	The Grauer's swamp warbler (Bradypterus graueri) is a species of Old World warbler in the Locustellidae family. It is found in Burundi, Democratic Republic of the Congo, Rwanda, and Uganda. Its natural habitats are freshwater lakes and freshwater marshes. Source: http://en.wikipedia.org/wiki/Bradypterus_graueri http://avibase.bsc-eoc.org/species.jsp?avibaseid=1DC480582B145B23

Species		VALCANOES	NYUNGWE	Outline
Owls	*Strigidae* 		○	The true owls or typical owls (family Strigidae) are one of the two generally accepted families of owls, the other being the barn owls (Tytonidae). The typical owls have a cosmopolitan distribution and are found on every continent except Antarctica. The feathers are soft and the base of each is downy, allowing for silent flight. They tend to have large heads, short tails, cryptic plumage and round facial discs around the eyes. The wings are large, broad, rounded and long. The feathers of the facial disc are arranged in order to increase sound delivered to the ears. Hearing in owls is highly sensitive and the ears are asymmetrical allowing the owl to localise a sound. Source: http://en.wikipedia.org/wiki/Strigidae
Grey Crowned-Crane	*Balearica regulorum* 	×	○	The grey crowned crane (Balearica regulorum) is a bird in the crane family Gruidae. It occurs in dry savannah in Africa south of the Sahara, although it nests in somewhat wetter habitats.The grey crowned crane is about 1 m (3.3 ft) tall and weighs 3.5 kg (7.7 lbs)and a wingspan of 2 m . Its body plumage is mainly grey. The wings are also predominantly white, but contain feathers with a range of colours. The head has a crown of stiff golden feathers. The sides of the face are white, and there is a bright red inflatable throat pouch. They can also be found in marshes, cultivated lands and grassy flatlands near rivers and lakes in eastern from the Uganda and Kenya, south to South Africa. Source: http://en.wikipedia.org/wiki/Balearica_regulorum

Species		VALCANOES	NYUNGWE	Outline
Swallow 	*Hirundinidae*	?	?	The swallows and martins are a group of passerine birds in the family Hirundinidae which are characterised by their adaptation to aerial feeding. The swallows have a cosmopolitan distribution across the world and breed on all the continents except Antarctica. The wings are long, pointed, and have nine primary feathers. The tail has 12 feathers and may be deeply forked, somewhat indented, or square-ended. Swallows have adapted to hunting insects on the wing by developing a slender, streamlined body and long pointed wings, which allow great maneuverability and endurance, as well as frequent periods of gliding. The more primitive species nest in existing cavities, for example in an old woodpecker nest, while other species excavate burrows in soft substrate such as sand banks. Swallows in the genera Hirundo, Ptyonoproggne, Cecropis, Petrochelidon and Delichon build mud nests close to overhead shelter in locations that are protected from both the weather and predators. Source: http://en.wikipedia.org/wiki/Swallow
Arrow-marked Babbler 	*Turdoides jardineii*	?	?	The arrow-marked babbler (Turdoides jardineii) is a species of bird in the Leiothrichidae family. It is found in Angola, Botswana, Burundi, Republic of the Congo, Democratic Republic of the Congo, Gabon, Kenya, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe. Its natural habitats are subtropical or tropical dry forests, dry savanna, and subtropical or tropical moist shrubland. The arrow-marked babbler is a medium sized babbler, 22–25 cm in length and weighing 56–85 g . The common name for the species is derived from its plumage, which is brownish-grey above and lighter below, with white tips to the feathers on the throat, neck and head. The iris is bright red and the inner ring of the eye bright yellow or orange. The males and females are identical in appearance. The arrow-marked babbler lives in social groups of between 3 to 15 birds (six being the average) that defend large territories, with the size of the territory being dependent upon the number of individuals in the group. Source: http://en.wikipedia.org/wiki/Arrow-marked_Babbler

Species		VALCANOES	NYUNGWE	Outline
Cape Robin-Chat	*Cossypha caffra* 	○	○	The Cape robin-chat (Cossypha caffra) is a small passerine bird of the Old World flycatcher family Muscicapidae.It is a mainly resident breeder in southern and eastern Africa from Kenya south to Namibia, Zambia, Zimbabwe, South Africa, Lesotho and Swaziland. It is a common species at forest edges and in scrub, fynbos, karoo, plantations, gardens and parks. The Cape robin-chat is 16–17 cm long. The adult's upper-parts are grey, and the face sides in front of and behind the eye are blackish, separated from the crown by a white supercilium. The chin, throat, central breast, rump, under-tail coverts and outer tail feathers are orange, and the central tail feathers are greyish-brown. The belly is pale grey.The black bill is short and straight, with a slightly down-curved upper mandible. The Cape robin-chat builds a cup-shaped nest of coarse vegetation, lined with animal hair, rootlets and other fine material. Source: http://en.wikipedia.org/wiki/Cossypha_caffra
Vulture	*Aegypiidae* 	○	○	Vulture is the name given to two groups of convergently evolved, usually scavenging birds of prey. A particular characteristic of many vultures is a bald head, devoid of normal feathers. Vultures rarely attack healthy animals, but may kill the wounded or sick. When a carcass has too thick a hide for its beak to open, it waits for a larger scavenger to eat first. Source: http://en.wikipedia.org/wiki/Vulture
Bee-eater	*Meropidae* 	○	○	The bee-eaters are a group of near-passerine birds in the family Meropidae. Most species are found in Africa and Asia but others occur in southern Europe, Australia, and New Guinea. They are characterised by richly coloured plumage, slender bodies, and usually elongated central tail feathers. The bee-eaters are almost exclusively aerial hunters of insect prey. Prey is caught either while in continuous flight or more commonly from an exposed perch where the bee-eater watches for prey. Smaller, rounder-winged bee-eaters typically hunt from branches and twigs closer to the ground, whereas the larger species hunt from tree tops or telegraph wires. One unusual technique often used by carmine bee-eaters is to ride the back of bustards. In the case of the bee-eaters the nests are burrows dug into the ground, either into the sides of earth cliffs or directly into level ground. Source: http://en.wikipedia.org/wiki/Bee-eater

Species		VALCANOES	NYUNGWE	Outline
Hamerkop	*Scopus umbretta* 	○	○	It constitutes a family (Scopidae) and genus (Scopus) all on its own because of its unique characteristics. It ranges from Africa, Madagascar to Arabia, in wetlands of a wide variety, including estuaries, lakesides, fish ponds, riverbanks and rocky coasts in Tanzania. The hamerkop is a medium-sized wading bird 56 centimetres (22 in) in length with a weight of 470 grams (17 oz). The shape of its head with a long bill and crest at the back is reminiscent of a hammer, hence its name. Its plumage is a drab brown with purple iridescence on the back.The bill is long, flat, and slightly hooked.The neck and legs are shorter than those of most of the Ciconiiformes. The hamerkop has, for unknown reasons, partially webbed feet. The strangest aspect of hamerkop behaviour is the huge nest, sometimes more than 1.5 metres across, comprising perhaps 10,000 sticks and strong enough to support a man's weight. These birds are compulsive nest builders, constructing three to five nests per year whether they are breeding or not. Both sexes incubate for 28 to 30 days. Source: http://en.wikipedia.org/wiki/Hamerkop
Sunbirds	*Nectarinidae* 		○	The sunbirds and spiderhunters make up a family, Nectariniidae, of very small passerine birds. The family is distributed throughout Africa, the Indian subcontinent, Southeast Asia and just reaches northern Australia. Most sunbirds feed largely on nectar, but also take insects and spiders, especially when feeding young. Sunbirds have long thin down-curved bills and brush-tipped tubular tongues, both adaptations to their nectar feeding. Source: http://en.wikipedia.org/wiki/Nectariniidae
Calanthe sylvatica	*Calanthe sylvatica* 			Calanthe sylvatica is a species of orchid. It is native to tropical and southern Africa from Sierra Leone to Tanzania to South Africa, as well as Madagascar, Comoros, Mauritius and Réunion. Source: http://en.wikipedia.org/wiki/Calanthe_sylvatica

(7) **Moutain Gorillas**

Gorillas inhabit areas in Angola, Uganda, Gabon, Cameroon, The Republic of the Congo, The Democratic Republic of the Congo (DRC), Equatorial Guinea, The Central African Republic, Nigeria and Rwanda. They belong to the Mammalia Class, Primate Order, Hominid Family, and Gorilla Genus. There are two species: Gorilla gorilla and Gorilla beringei. Mountain gorillas are a subspecies of Gorilla beringei. Only about 800 mountain gorillas inhabit the planet and they are designated as an Endangered Species (EN) by IUCN (International Union for Conservation of Nature) Red List of Threatened Species.

Gorillas are polyphagia and prefer plant-eating. Their principal foods are plant leaves, fruits, and insects. During dry seasons of low availability of foods, mountain gorillas also eat plant shoots, barks, roots, etc. The lifespan is around 40 to 50 years and they are diurnal. They prepare different nests to sleep every night. They home range is about 10 to 50 square km and they move around 0.5 to 2km every day (Obara, et.al., 2000). They have childbirth every 4 to 5 years and their pregnancy period is 258 days. Females show reproductive behaviour only for about two days during their menstrual cycle of about one month. Around 1 to 2 baby gorillas can become fertile per female gorilla, and it takes long time to recover the population once it decreases (Yamagiwa, 2005). This low breeding coefficient is the primary reason of importance of their protection.

The protection of mountain gorillas is led by NGOs such as the Dian Fossey Gorilla Fund International (established by late Dr. Dian Fossey), by eliciting worldwide support and by maintaining strong ties with the governments of Rwanda, Uganda and the DRC. Protection activities not only include monitoring of movements of mountain gorillas, but also medical examinations of the gorillas when needed.

Kayijamahe (2008) investigates relationships between mountain gorilla habitat and human impacts in the national park and analyses suitable habitat of the gorillas by establishing a suitable habitat model based on data about vegetation, altitudes, slopes, temperatures, amounts of solar radiation, and other elements in the Volcano National Park (Figures 4-5.4, 4-5.5 and 4-5.6).

The distribution of gorilla groups over several years is illustrated in Figure 4-5.7. We only see one group in the Karisimbi area, but about 10 groups have been identified in the Kinigi area. Though a buffer zone of 800 meters should be installed at the border of the national park, farmlands actually encroach right up to the border. In the Kinigi area, where many gorilla groups have been identified near the border, geothermal development will be placed away from the border by at least 1 km, in consideration of the buffer zone. The buffer zone was originally established by the former national tourism board (which has since been integrated into the RDB) after a study in the national park investigated the movements of mountain gorillas.

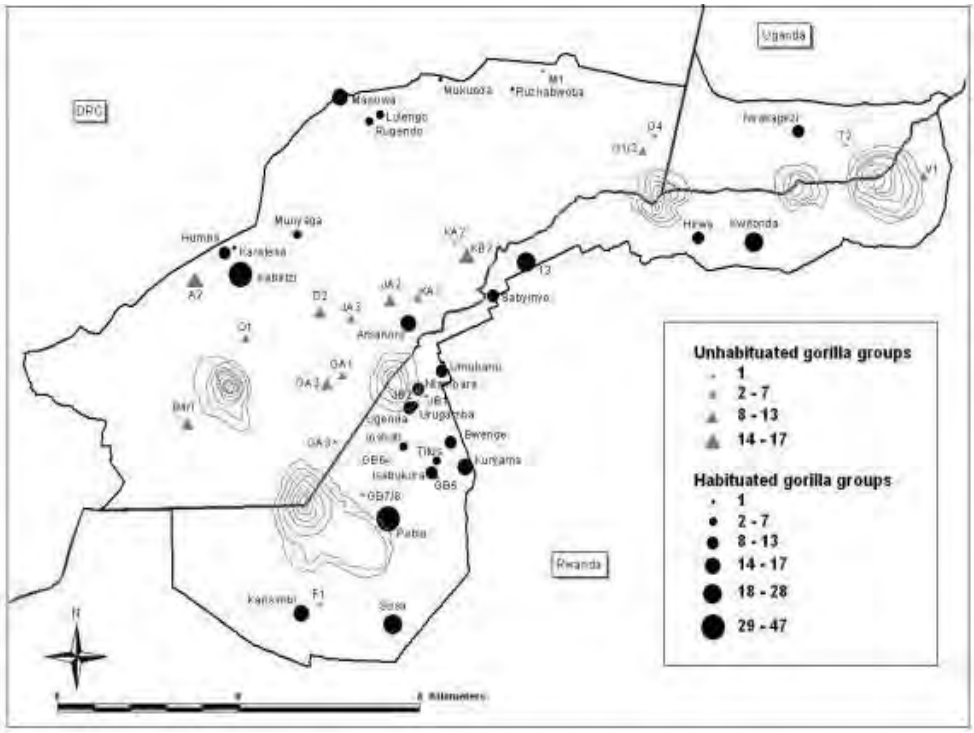
Currently, some investigations are being conducted on relationships between gorilla habitats and human activities in the park, but there is no quantitative data on the impact of development activitiesAt present, some investigations are done on relationships between gorilla habitat and

human activities in the park, but there is no quantitative data about impacts of development activities by humans to mountain gorillas.

With regard to the impact assessment during test drilling in Karisimbi, no significant changes in mountain gorilla activities were found during that period. Thus, the test drilling impact was recognised as minor (ex-EWSA).

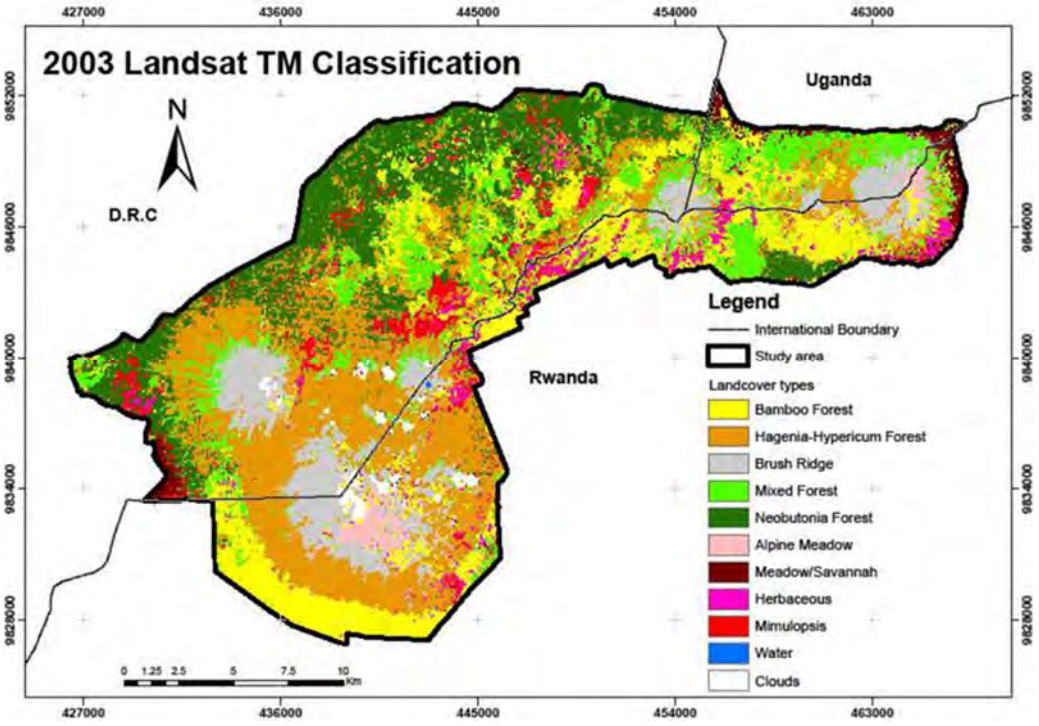
However, this assessment was not conducted by visiting the project site intensively and frequently, or by considering the impact of field work such as land development and drilling. Further, the assessment does not include an investigation of data on gorilla movements during the drilling period gathered by NGOs (who best understand the situation) dealing with mountain gorilla conservation.

Sufficient monitoring and assessments based on these results, in addition to the introduction of impact mitigation measures when necessary, would be essential for future geothermal project implementation near any mountain gorilla habitat. Moreover, monitoring, impact assessments and the introduction of needed measures should be realised with frequent communication and the involvement of NGOs and other stakeholders. We should also consider the impact not only directly on mountain gorillas, but on other fauna and flora that are part of the mountain gorilla habitat.



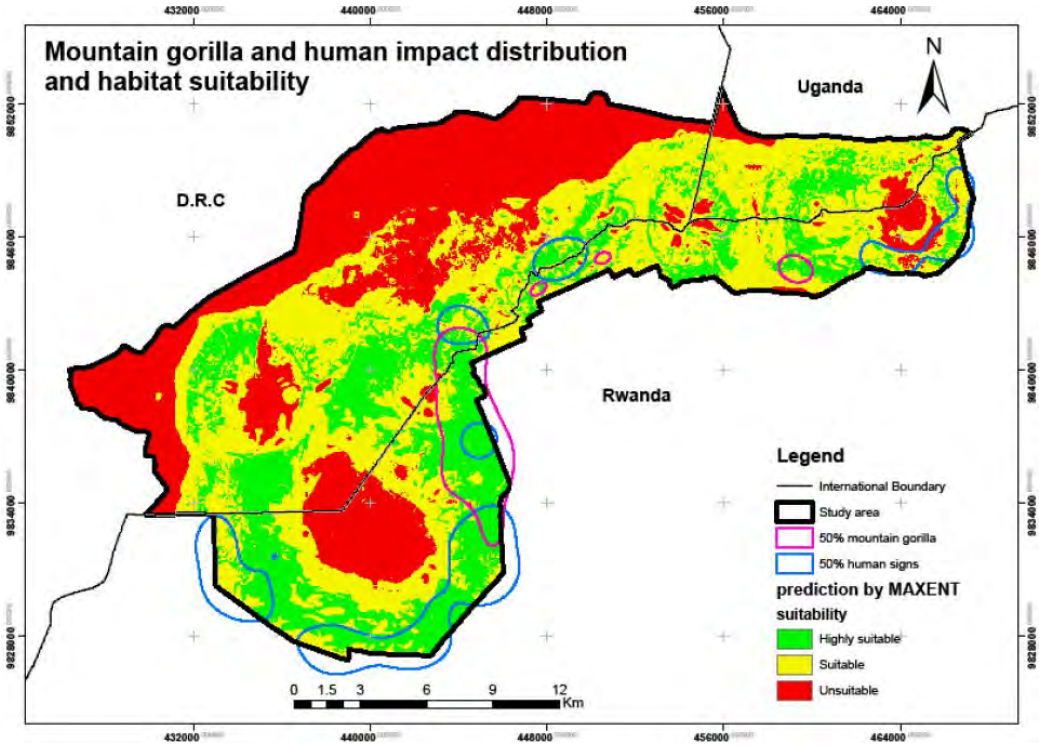
Source: Geoscientific Surveys of the Rwandan Karisimbi, Gisenyi and Kinigi Geothermal Prospects, 2012

Fig. 4-5.4 Identified habitat of mountain gorilla groups in the Volcano National Park



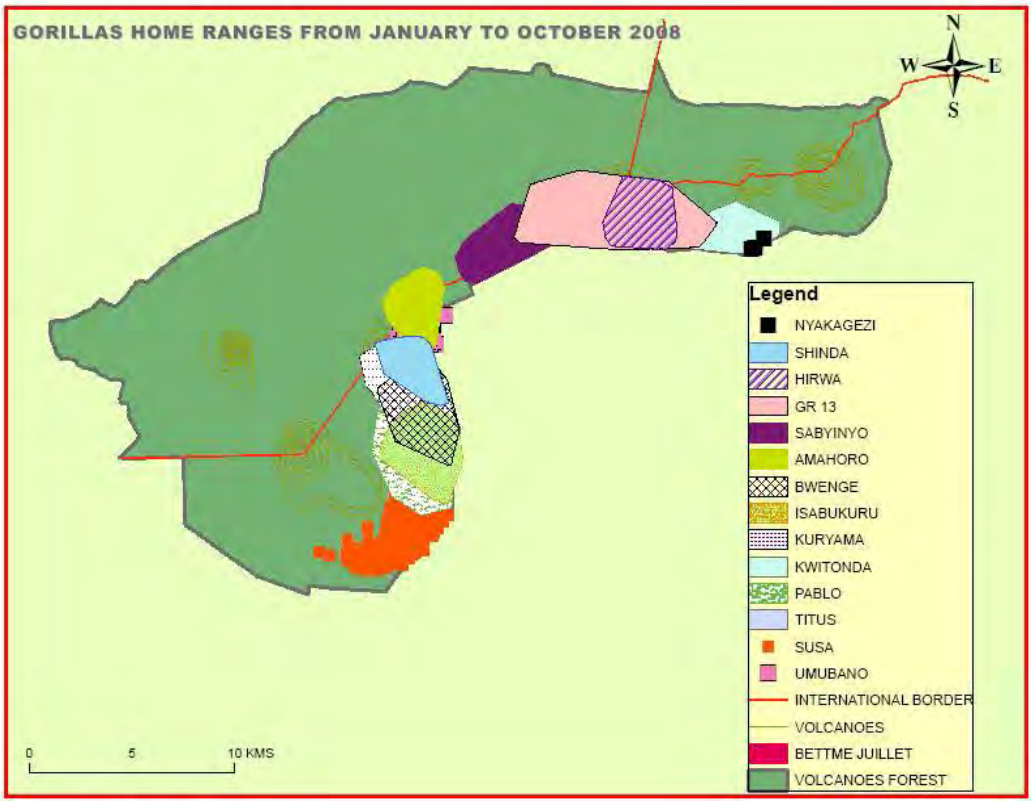
Source: information about planned development area is added to Kayijamahe,2008

Fig. 4-5.5 Vegetation in the Volcano National Park



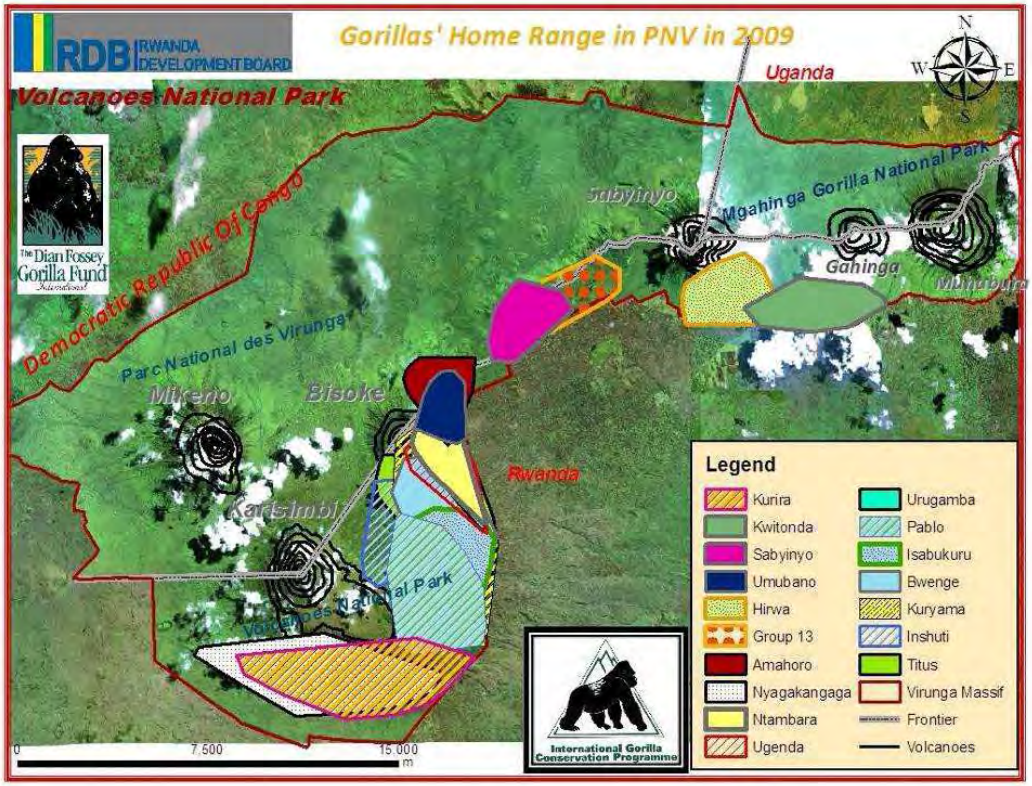
Source: information about planned development area is added to Kayijamahe, 2008

Fig. 4-5.6 Distribution of suitable habitat of mountain gorillas, actual habitat of the gorillas, and human activities



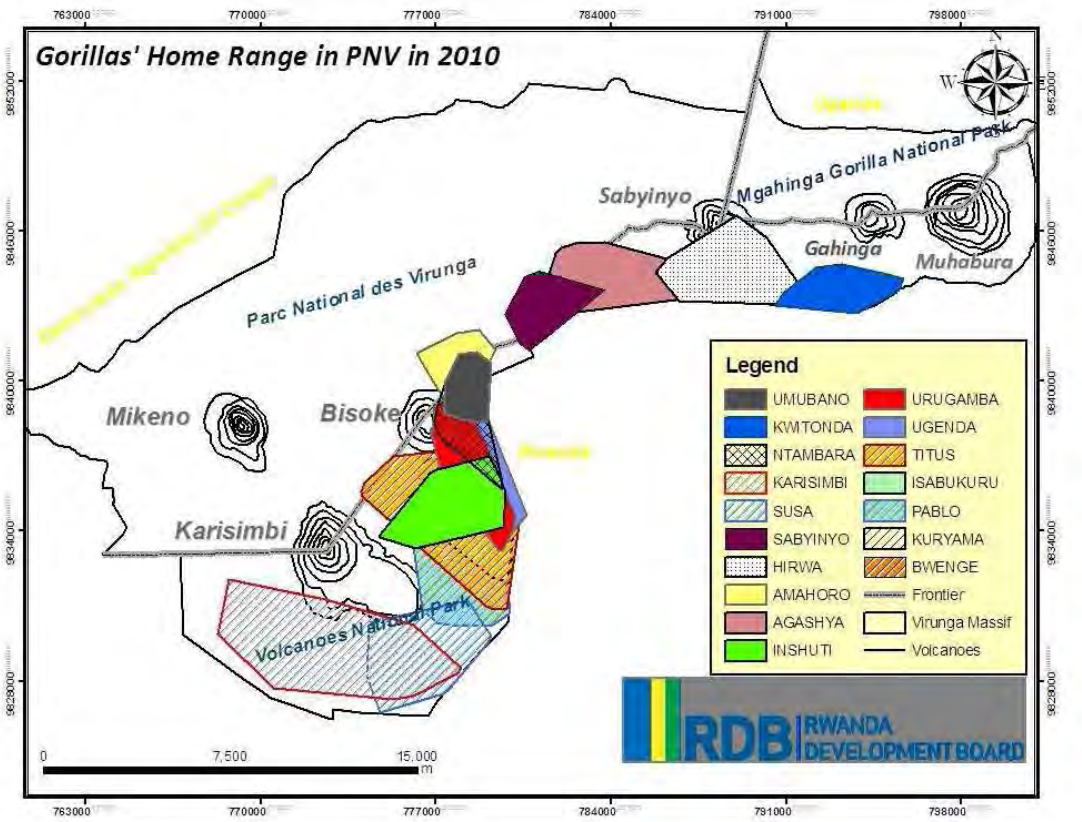
Source: RBD

Fig. 4-5.7(1) Annual changes of mountain gorilla habitat 2008



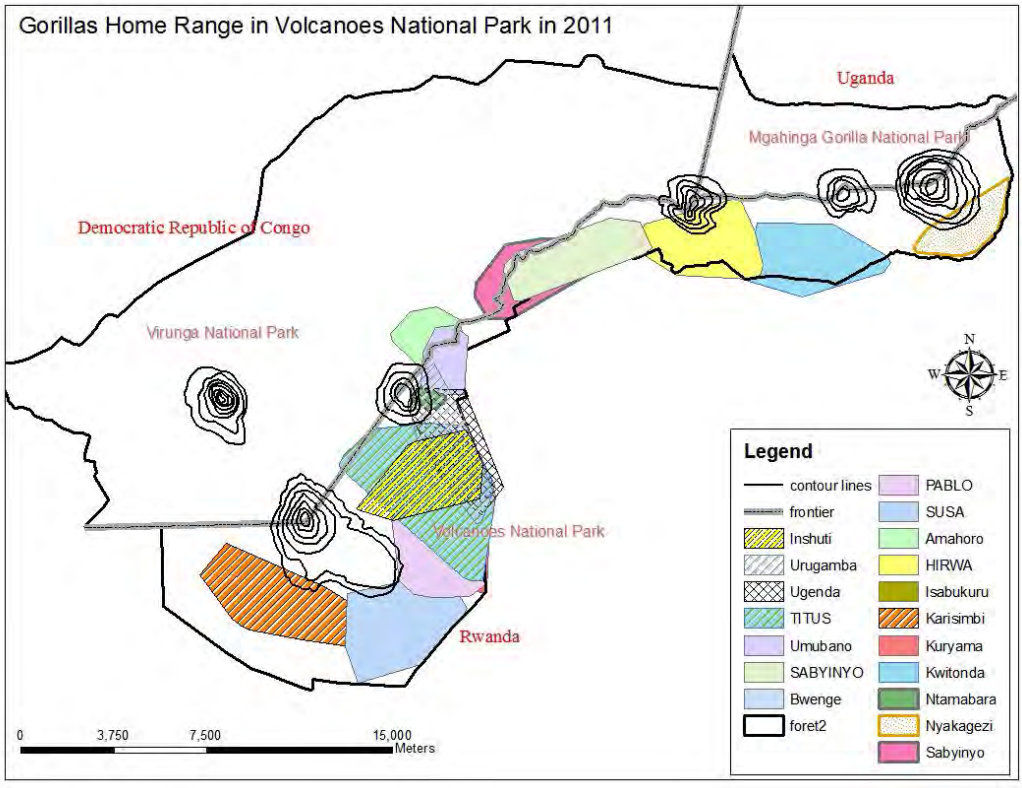
Source: RBD

Fig. 4-5.7(2) Annual changes of mountain gorilla habitat 2009



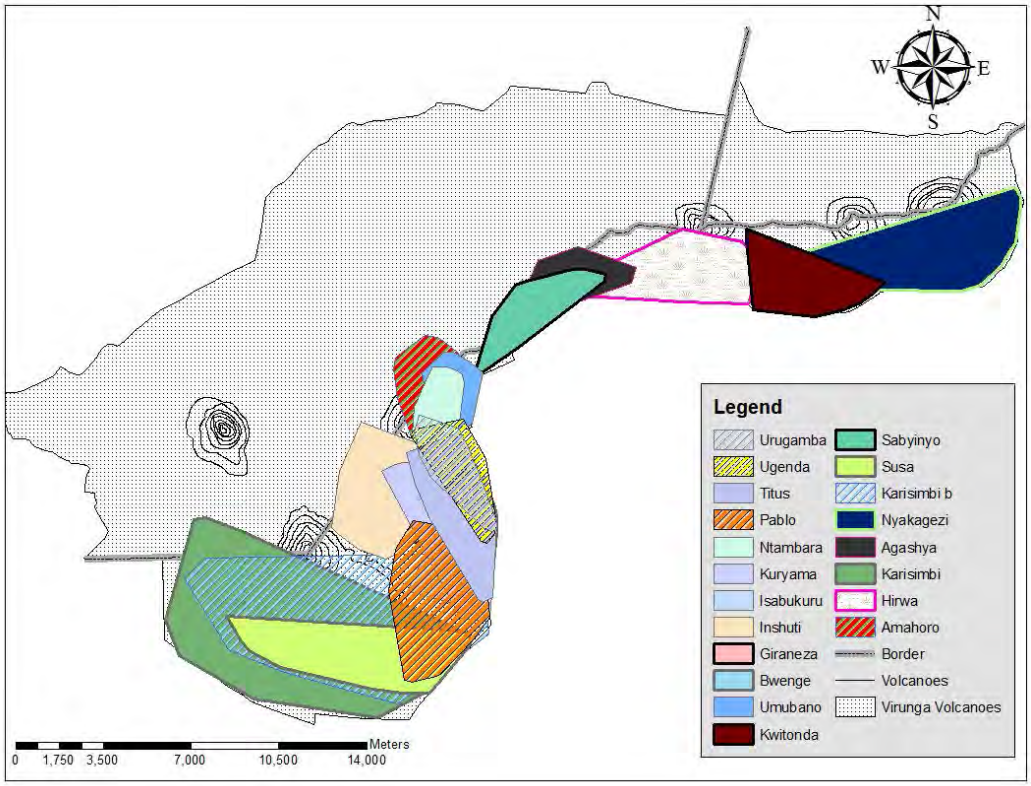
Source: RBD

Fig. 4-5.7(3) Annual changes of mountain gorilla habitat 2010



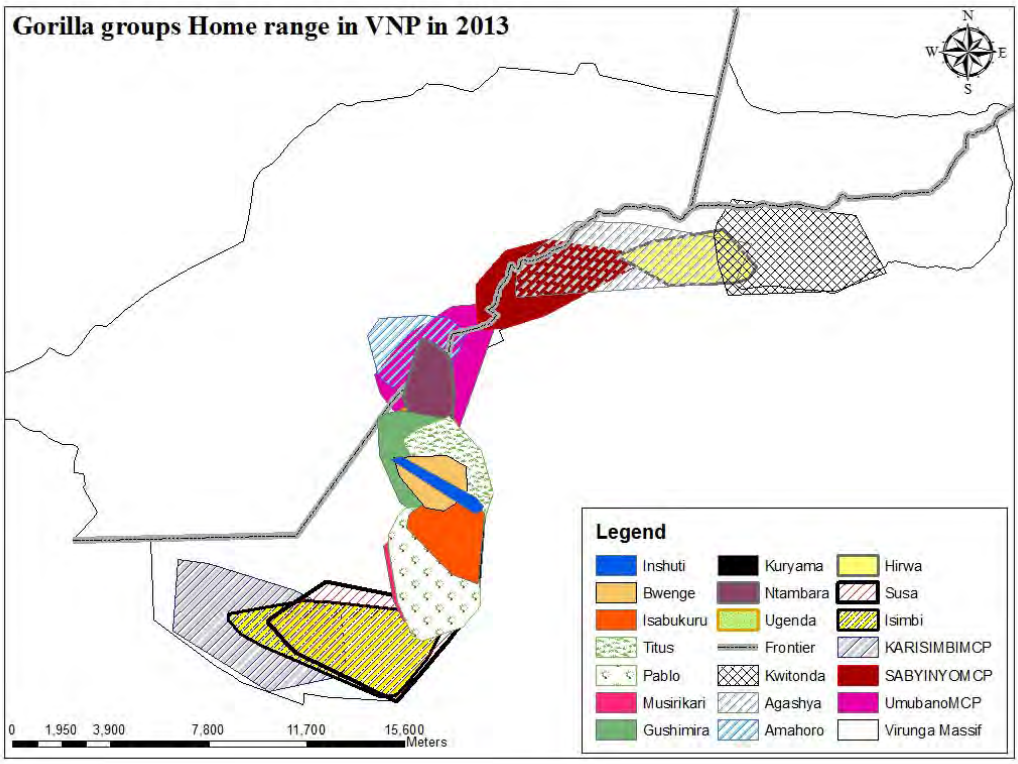
Source: RBD

Fig. 4-5.7(4) Annual changes of mountain gorilla habitat 2011



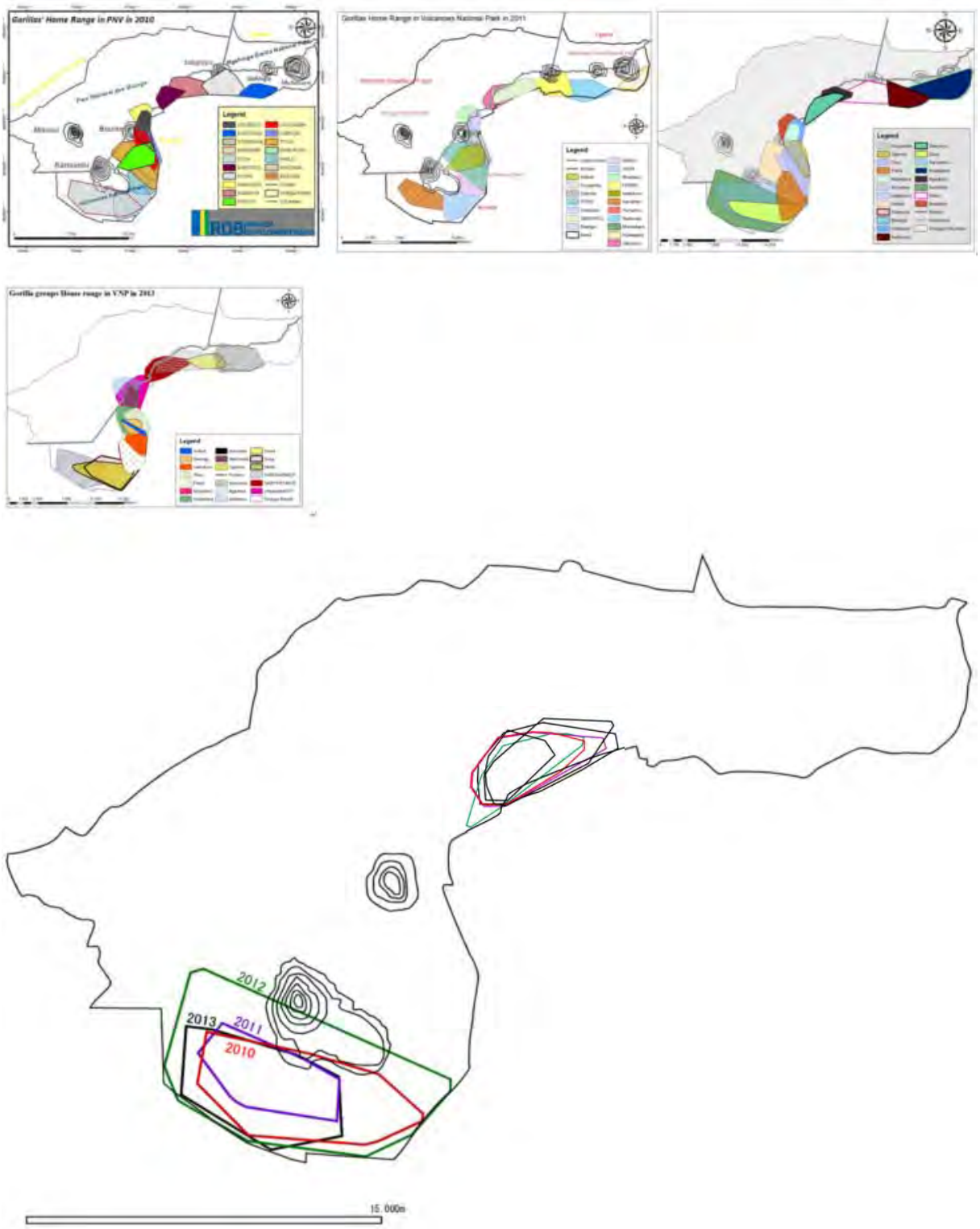
Source: RBD

Fig. 4-5.7(5) Annual changes of mountain gorilla habitat 2012



Source: RBD

Fig. 4-5.7(6) Annual changes of mountain gorilla habitat 2013



Source:JICA STUDY TEAM

Fig. 4-5.7(7) Annual changes of mountain gorilla habitat (Karisimbi and Kinigi-Sabyinyo Group)

4.5.5. Water Quality Information Relating to Potential Geothermal Activity Area

In regards to the process of identifying possible water quality impacts associated with geothermal development, this study should identify the possible water contaminants that exist in regional geothermal waters and document the baseline chemical composition of the waters of the area's springs, rivers and lakes.

The purpose of this reporting effort is to assess the current water quality status concerning the sites identified as having the potential for development of geothermal energy as a resource. A systematic investigation of water quality information relating to potential geothermal activity has been completed. This report represents the results of a baseline water quality assessment at the site of the geothermal prospects.

The assessment was comprised of water quality sampling and testing to establish the pre-development baseline data. The sampling and laboratory analysis were performed in July-August 2014.

This study identified five different sites of different important water resources (rivers, lakes, springs, etc.) in the area of potential geothermal prospects. Water samples were collected from various areas in the country, including BUGARAMA, GISENYI, KALISIMBI, KINIGI and KARAGO. During the field campaign, 9 water samples were taken and then were examined for different parameters (physical, chemical and bacterial). Results and methods are annexed to the end of this report (Annex2: Results from water analysis, Annex3: Methods of water sampling and water analysis).

(1) **Study areas description**

1) Bugarama

Bugarama hot stream is located in Western province, in Rusizi district. There are several activities which take place around the stream. For example, people use the upstream area for swimming because they believe that this water can cure diverse diseases, including stress; this could have a significant impact on the quality of this water as the people may urinate into the water. People also wash their clothes in the stream and these activities may increase the nutrient content.

In the downstream area, agricultural activities around the stream are the most common. This can change the different physico-chemical and even bacteriological parameters of this water.

Photo 4-5.1 Bugarama hot stream area. (left) Bugarama upstream, (right) Bugarama downstream

2) Gisenyi

Two sites have been identified in Kivu Lake (Kivu Lake 1 and Kivu Lake 2). They are both located in Rubavu district, in Western province of Rwanda. The quality of this water is vulnerable to different activities carried out in this lake. The life of the people in the area depends mainly on activities in and around the lake, and this likely affects the quality of the water.

The main activities in the lake include fishing and transportation, however swimming and nearby agricultural activities are also frequently observed.

Photo 4-5.2 Gisenyi area. (left) near Kivu 1, (right) near Kivu 2

3) Karago

Two sites; Karago Lake and Nyamukongo River have been selected in this area. They are located in a mountainous and volcanic region and are surrounded by short hills, holding different agricultural activities. In general, water bodies in the area are mainly affected by erosion from the surrounding hills. Human activities including cutting down trees, settlement and infrastructural development around Lake Karago (including the construction of a military camp in Mukamira in the 1980s), are some of the factors that have led to the deterioration of the lake. Karago Lake was a major source for fish and a clean water reservoir, but all the human activities mentioned led to direct erosion and drained it up. Currently, the lake water is used for different purposes like domestic activities and swimming.

Other side of the lake, the Nyamukongo River is flowing into the lake and may carry different physical materials that can change the lake's water quality.

Photo 4-5.3 Karago area. (left) Karago Lake, (right) Nyamukongo

4) Kinigi

The Mpenge river, located in Northern Province, in Musanze district, is one of the study sites in the Kinigi area. The Mpenge river is a well-known river due to its usage for baptismal ceremonies. The river is vulnerable to agricultural activities and commercial activities because its flow passes between residential homes. People in the area use this water for washing their bodies and their clothes, and many other different activities which can affect the quality of the river as shown by the photograph below.

Photo 4-5.4 Kinigi area: Mpenge River and its surround

In the Kinigi area, the Susa River was also chosen for water quality assessment. Unfortunately, during the time allotted to collect the sample, it had no water due to the dry season. This is illustrated by the photograph below.

Photo 4-5.5 Susa with no water due to dry season

Cyabirumba Water Source was then chosen to replace the Susa River because it is located nearby. It is also located in Northern Province, in Musanze District, near the Sabyinyo Volcano. This spring is used as a water supply by the local people. The quality of this water is affected by the different activities occurring around it because it is not well managed. In the area around the spring, agricultural activities could be found, including the presence of cows near the spring, which may affect the water. This is a big issue because the Cyabirumba Water Source is the only source of clean water for the surrounding population.

Photo 4-5.6 Kinigi area (Cyabirumba Water Source)

Rubindi Cold Spring is located in Gataraga village of Musanze District in Northern Province about 8 km Northwest of Musanze town. The spring is located at the footstep of Karisimbi volcano in Virunga Volcanic Range 600 meters below the park boundary.

Rubindi spring is the collection of three small springs which take their sources from Karisimbi volcano and meet to form a large spring. Together with Mutobo and Mpenge; those springs have the potential to supply water to large number of people due to their quantity and flow rate. However the water quality of Rubindi spring depends on the surrounding environment and human activities around the spring. The spring is surrounded by cultivated land and it flows between residences of people around there. Discharge from agricultural and residential areas may change the natural quality of the spring. Looking at surrounding environment, the spring is flowing above the molten rock from volcanoes and is passing by a small ironized wetland as shown by the photograph below. Around the spring also you can find people using this water for different activities such washing clothes, washing their body by immersing sack full of sorghum.

Photo 4-5.7 Kinigi area (Rubindi Spring)

Cyabararika Cold Spring is a small spring located in Musanze district, in Northern Province alongside the Mpenge River. It is usually called Amakera by local people due to the taste of its water. This spring takes its source from underground aquifers and was constructed many years ago to maintain its special quality, different from other surrounding water. This spring does not flow but instead it is bubbling up from between two old constructed walls due to gases from underground. The spring is surrounded by a small wetland alongside the Mpenge River and it is used for different human activities. Even though this spring takes its source from underground, it is mixed with water discharge from local residences and with rain water because the protecting walls are old.

Cyabararika cold spring's water is used by a number of people in the area. At the spring, a large number of men and women were found, coming to fetch the water for drinking purposes. Many people like the taste of this water which is like "carbonated water". This usage, together with different activities around the spring, may deteriorate its natural quality. Looking at the color of this water, as illustrated by the photograph below, it can be seen that it is reddish, which may due to the large content of iron in the soil and mainly to iron content of underwater mixed with air (oxygen) and then form iron oxide.

Photo 4-5.8 Kinigi area (Cyabararika Spring)

5) Karisimbi

For this area, a water sample was taken from Cyamabuye spring. Cyamabuye is a spring located in Western province, in Nyabihu district. It is a well-managed spring pumped from groundwater and used as a potable water supply for people in the area. It is located near the main road, Kigali-Rubavu, and is surrounded by a Eucalyptus plantation.

Photo 4-5.9 Karisimbi area: Cyamabuye Water Source

(2) **Findings**

In this section the results from the experimental studies are provided, with the aim of assessing water quality status at different areas with potential geothermal resources in Rwanda.

Baseline water quality information sources for RBS are presented in the next paragraphs.

1) Temperature

Water temperature for all nine sites surveyed ranged from 16.1˚C to 40.6˚C among the proposed sites (Fig. 4-5.8). The lowest temperature was recorded at the Jordan Spring and the highest temperature was recorded at Bugarama River (upstream station). Temperature is affected by many factors including both natural and anthropogenic processes, including but not limited to season, time of day, altitude and cloud cover. The high values recorded at Bugarama Stream were due to natural factors, and this is a great sign of potential geothermal resources in the area.

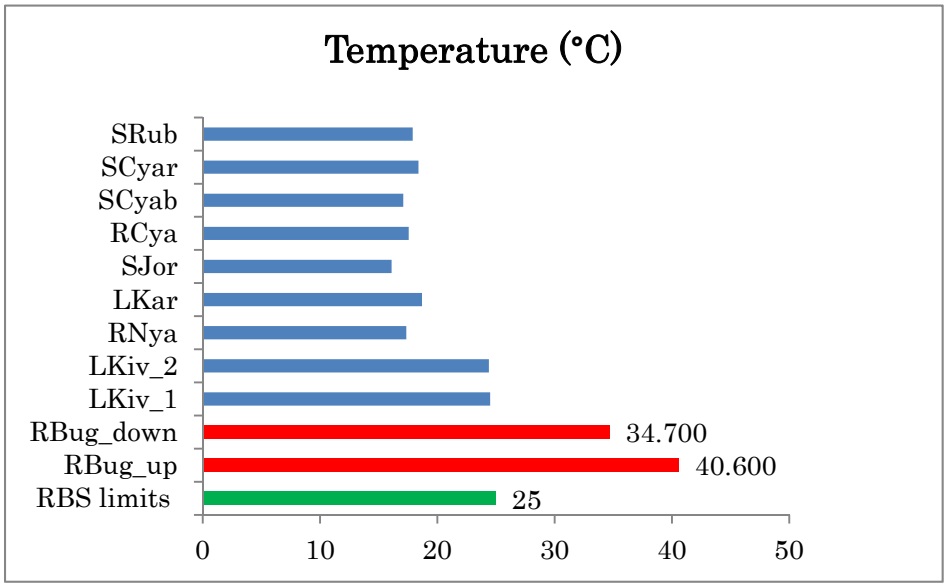


Fig. 4-5.8 Variation of temperature (˚C) for all sites.

Green color indicates RBS limits, red color indicates the values above RBS limits and the blue one indicates values within RBS limits.

One important aspect of water temperature is its effect on the solubility of gases, such as oxygen.

More gas can be dissolved in cold water than in warm water. Animals, such as salmon, that require a high level of dissolved oxygen will only thrive in cold water. Temperature impacts the rates of metabolism and growth of aquatic organisms, rate of plants' photosynthesis, solubility of oxygen in river water, and organisms' sensitivity to disease, parasites, and toxic materials. At a higher temperature, plants grow and die faster, leaving behind matter that requires oxygen for decomposition. A change in water temperature can also affect the general health of the aquatic organisms, thus changing the quality of the water.

When the water temperature becomes too hot or too cold, organisms become stressed, lowering their resistance to pollutants, diseases, and parasites. Temperature could also affect physical, chemical and biological processes in water bodies and, therefore, the concentration of many variables. As water temperature increases, the rate of chemical reactions generally increases together with the evaporation and volatilization of substances from the water (Sekomo et al. 2011).

2) pH

pH is a term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0. The pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body. During this assessment, pH ranged from 6 at Cyabirumba Water Source to 8.7 at Lake Kivu 2, respectively. All sited visited were within RBS's water quality standards for livestock feeding, as it is shown in the figure below.

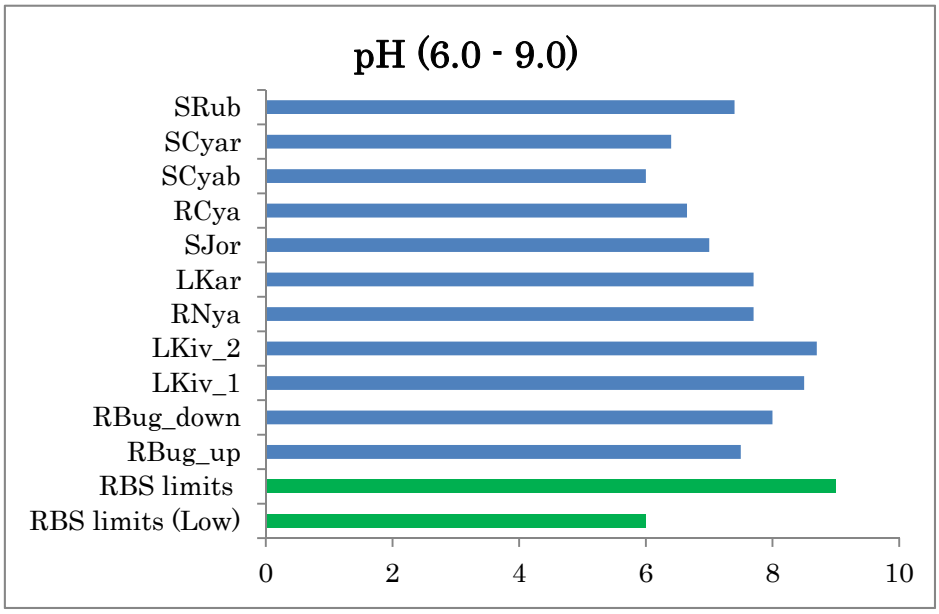


Fig. 4-5.9 Variation of pH for all sites.

Green color indicates RBS limits and the blue one indicates values within RBS limits.

3) Electrical Conductivity

Electrical Conductivity (EC) is a measure of the mineral content of natural waters. Increases in EC values may be related to mineral inputs as well as evaporation from the river channel. EC ranged from 120.1 µS/cm at Cyabirumba Water Source to 2110.3 µS/cm at Upstream Bugarama River (Fig. 4-5.10).

According to the results from this assessment, water samples from all the sites can be consumed by humans, although most would prefer water in the lower half of this range (e.g. Bugarama River and Lake Kivu sites). When used for irrigation, special management including suitable soil management, good drainage and consideration of the salt tolerance of plants will be required.

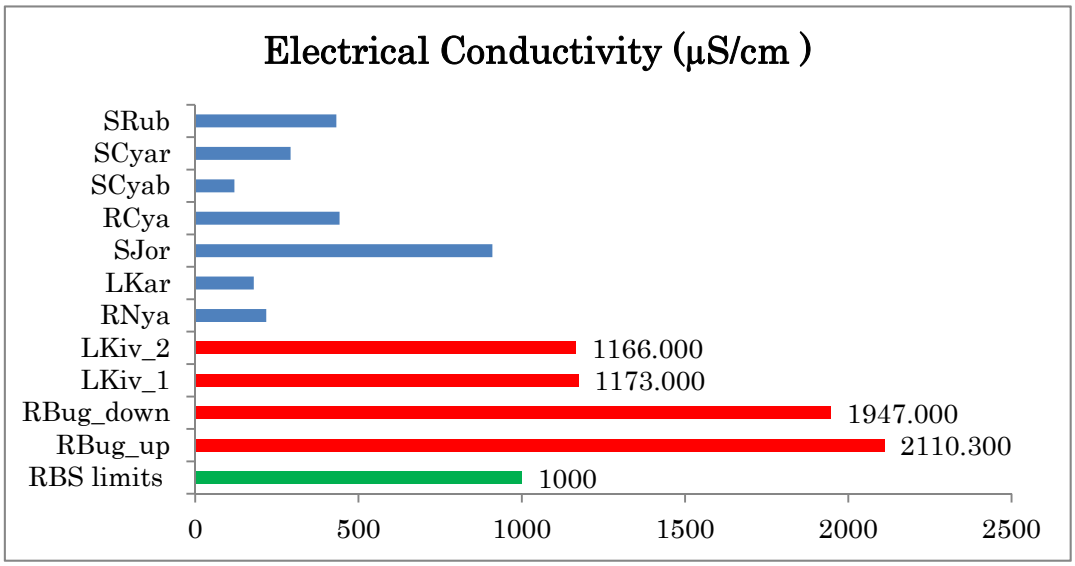


Fig. 4-5.10 Variation of electrical conductivity (µS/cm) for all sites.

Green color indicates RBS limits, red color indicates the values above RBS limits and the blue one indicates values within RBS limits.

4) Turbidity and Secchi disk measurement

Turbidity and Secchi disk measures are measurements of the level of suspended solids in water, which may be mineral or organic material. A high level of turbidity reduces light penetration in the water column, which may then reduce photosynthesis by submerged aquatic plants.

Results from this study showed that turbidity ranged from 0.4 NTU at Cyabirumba Water Source to 71.2 NTU at Nyamukongo River. Fig. 4-5.11 illustrates that most of the sites assessed are out of the range (RBS limits) except the Lake Kivu sites, Cyamabuye Spring and Cyabirumba Water Source. This could be attributed to the geographic features of the study areas which are affected by erosion from the surrounding hills, including the Nyamukongo River, as mentioned previously.

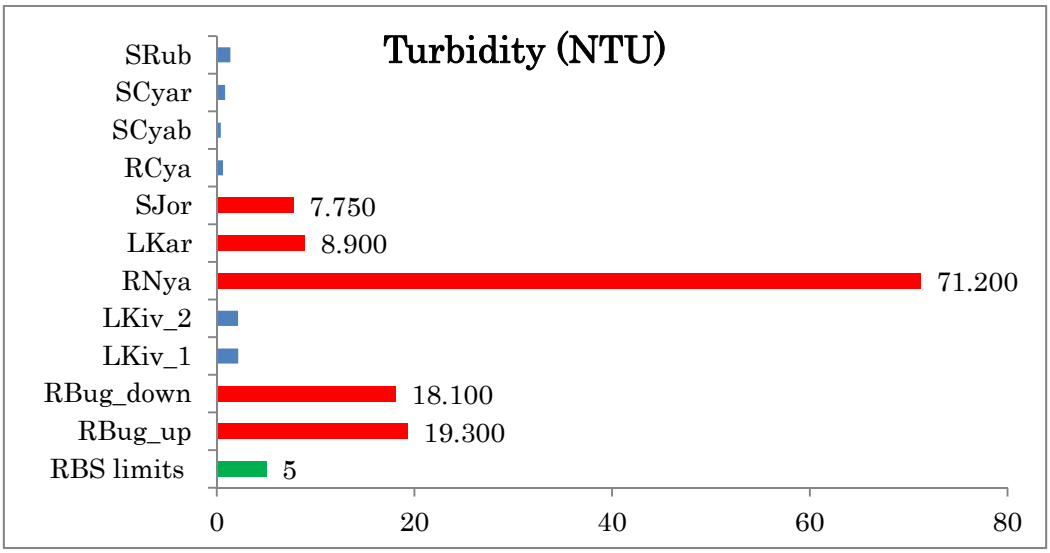


Fig. 4-5.11 Variation of turbidity (NTU) for all sites.

Green color indicates RBS limits, red color indicates the values above RBS limits and the blue one indicates values within RBS limits.

On the other hand, secchi disk measurement results varied from 99.0 cm at Karago Lake to 185.0 cm and at the Lake Kivu sites. If we convert 1.85 m into feet, it results in 6.07 feet which, from the table below, corresponds to a good status for water.

In general, pollution tends to reduce water clarity. Watershed development and poor land use practices cause increases in erosion, organic matter, and nutrients, all of which cause increases in suspended particulates and algae growth. Therefore, all watershed development should take pollution control measures into consideration in order to maintain the quality of water.

Table 4-5.2 Secchi disk measurement indication

PARAMETER: SECCHI DISK TRANSPARENCY

Unit of Measurement: feet
Description: A naked-eye measure of water clarity generally correlated with the amount of planktonic algae in the river, but can also relate to the turbidity from suspended soil particles.
Visual observation: Clear, green, brown
Class A NH surface water quality standard: No numeric standard
Class B NH surface water quality standard: No numeric standard

Categories	
< 4	Poor
4 - 15	Good
> 15	Excellent

5) Hardness

Hardness is another parameter reflecting the mineral content of natural water. Calcium and magnesium indicate the level of water hardness, thus they both were analyzed in that regard. They are naturally present in water and they may dissolve into the water from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite.

Calcium is largely responsible for water hardness, and may negatively influence toxicity of other compounds. In limed soils, calcium may immobilize iron. This may cause iron shortages, even when plenty of iron is present in the soil. Calcium also competes with other ions for binding spots in the gills. Consequently, hard water better protects fish from direct metal uptake.

Magnesium is a central atom of the chlorophyll molecule, and is therefore a requirement for plant photosynthesis. Magnesium is not only found in seawater, but also in rivers and rain water, causing it to naturally spread throughout the environment.

Results from this water quality assessment showed that calcium content varied from between 3.0 and 10 mg/L, while magnesium content was between 2.0 and 18 mg/L. As illustrated by the figure below, all identified sites of this study were within RBS limits for calcium and magnesium content.

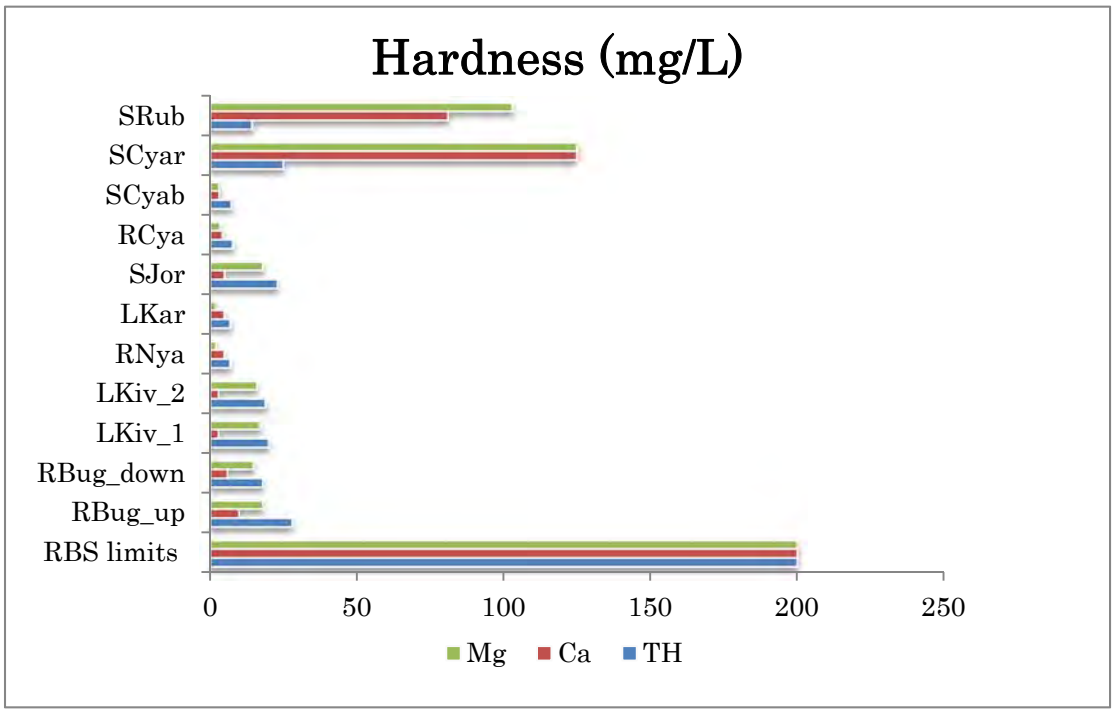


Fig. 4-5.12 Variation of hardness (mg/L) for all sites expressed by Mg^{2+}, Ca^{2+} and TH

6) Dissolved Oxygen, COD and BOD

Dissolved oxygen (DO) is among the most important water quality parameters for its strong influences on aquatic organisms. DO levels below 5 mg/L are generally an indication of high levels of dissolved organic matter, which may derive from natural or anthropogenic sources. Anthropogenic sources of organic material include domestic sewage and agricultural wastes.

Patterns in DO concentrations ranged from a low of 4.9 mg/L at both Bugarama streams (up and downstream) to 6.6 mg/L at the Lake Kivu sites (Fig. 4-5.13). With the exception of the Bugarama sites, DO levels at all the other sites were within standards for receiving waters suitable for fisheries and domestic livestock. The low DO levels found at Bugarama stream are likely attributable to a high level of organic matter. This could be caused by the agricultural activities in the area which is accompanied by an increase in fertilizer use and runoff. Whatever the source, the low DO levels at this station is known to be harmful to many fish species (Chapman, 1996).

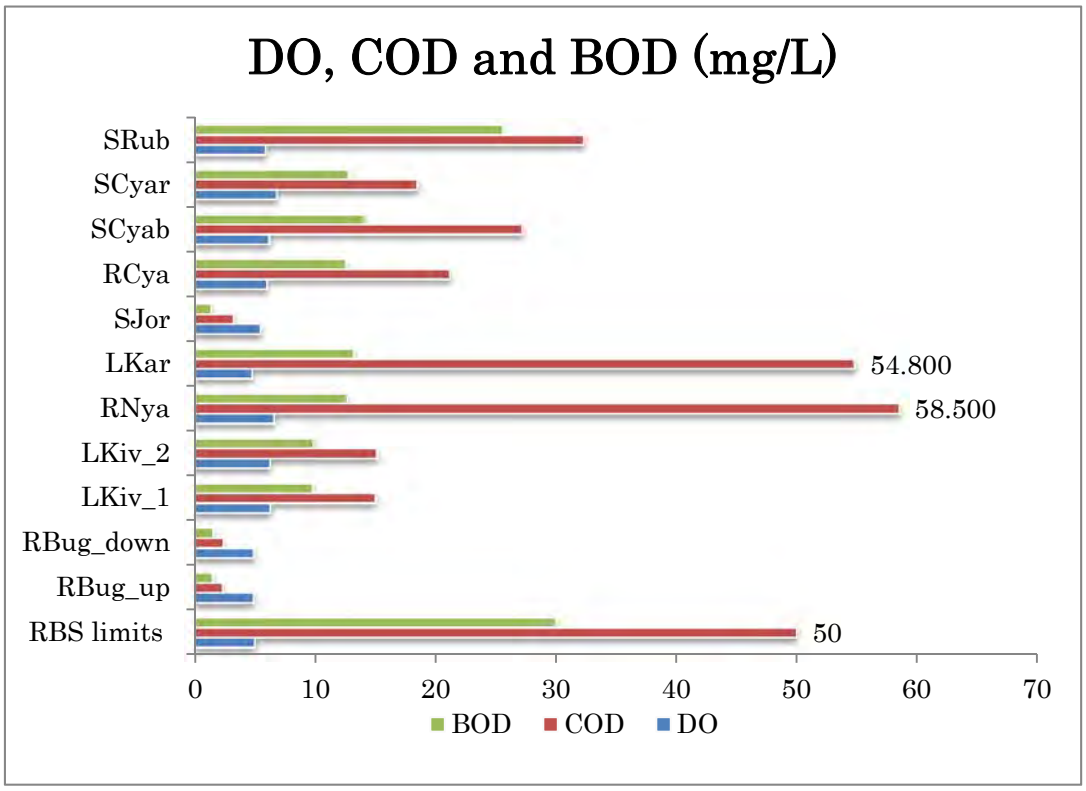


Fig. 4.5-13 Variation of DO, COD and BOD (mg/L) for all study sites

The Chemical Oxygen Demand (COD) is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in water bodies and in the effluents from sewage and industrial plants. The COD was high when compared to the standard for surface water at Lake Karago and Nyamukongo River as illustrated in Fig. 4-5.13.

These high values of COD are an indication of water pollution, mainly due to the surrounding human activity occurring near the sites. This may be due to the dumping of wastewater, a result of soil erosion, or agricultural activity in the surrounding area.

In addition to the COD, the Biochemical Oxygen Demand (BOD) is a common measure of water quality that reflects the degree of organic matter pollution of a water body. BOD is a measure of the amount of oxygen removed from aquatic environments by aerobic micro-organisms as a result of their metabolic requirements during the breakdown of organic matter. Systems with high BOD tend to have low dissolved oxygen concentrations. Increased BOD can result in the death of fish and other animals (UNEP, 2006). During this assessment, all monitored sites were in good condition in terms of BOD concentration.

7) Nutrients

Waters containing an excess of nutrients are said to be eutrophic. The dominant nutrients in aquatic systems are nitrogen (N) and phosphorus (P), and both occur in organic and inorganic forms.

Nitrate is present in both ground and surface waters as the end product of the aerobic decomposition of organic nitrogenous matter. Anthropogenic inputs of nitrate include fertilizers and domestic and industrial wastewaters. Nitrite is another, more toxic, form of inorganic N that is rarely present in significant concentrations because it is rapidly oxidized to nitrate. Ammonia is a common form of inorganic N present in both ground and surface waters and is the dominant form of inorganic N under low-oxygen conditions. Plants and microbes utilize all these N forms as a nutrient source. Nutrients could be also expressed by total nitrogen (TN) content.

Normally, high concentration of all these Nitrogen forms come from the decomposition of livestock waste, human waste, plant matter, runoff of fertilizer used in agricultural lands, and the discharge of municipal waste into rivers and lakes, causing eutrophication of waters.

Fig.4-5.14 shows high concentrations of TN (4.4 and 13.8 mg/L) and NO3- (12.6mg/L) at Kivu Lake, Nyamukongo River stations and Cyabirumba Water Source respectively. This high TN content could be attributed to the agricultural activities around all three of the above mentioned sites and swimming in the Kivu Lake, in which human wastes easily enter the water (Photo 4-5.2).

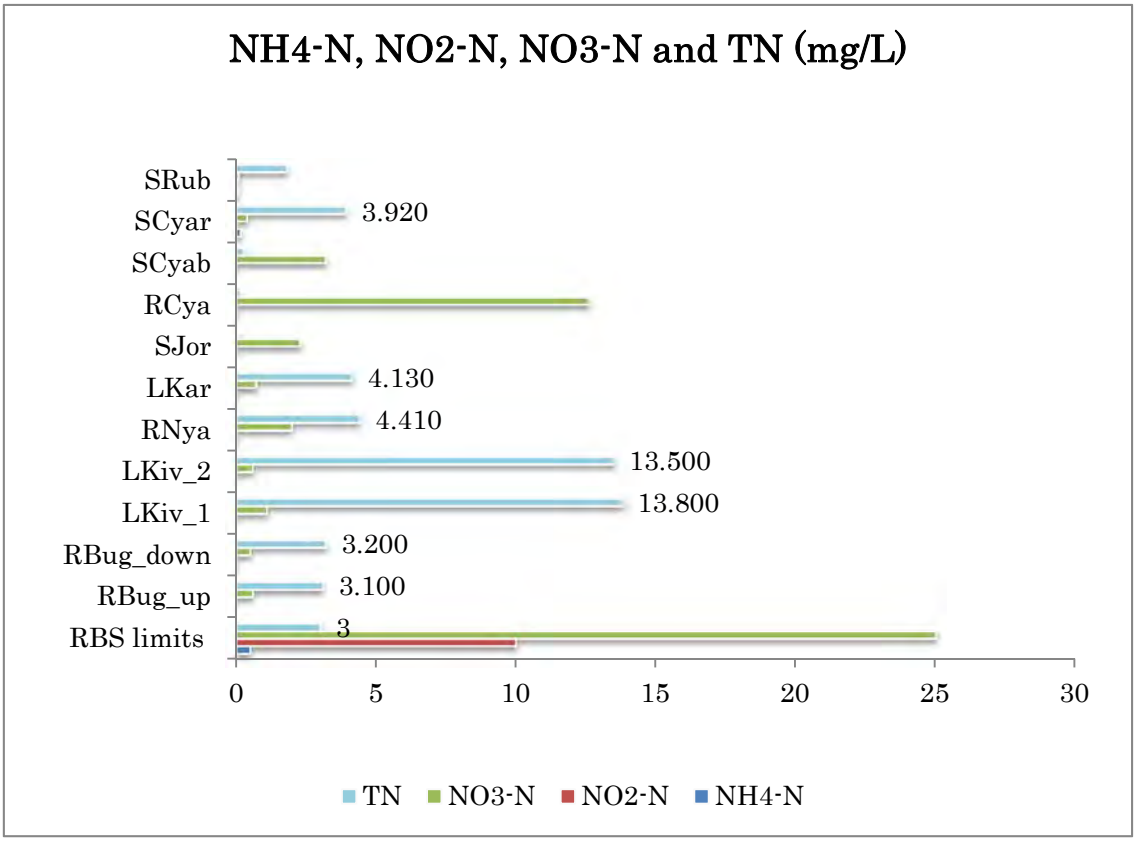


Fig. 4-5.14 Variation of TN, NO_3^-, NO_2^- and NH_4^+ (mg/L) for all study sites

On the other hand, Phosphorous (P) is often the limiting nutrient in freshwater systems, which means that aquatic primary production changes in direct proportion to concentrations of P until another factor becomes the limiting factor. Natural inputs of phosphorous include decay of

organic matter, excretion by organisms and weathering of P-containing rocks and sediments. Excessive inputs of phosphorous (as found in fertilizers, detergents and mining processes) lead to eutrophication. Figure 4-5.15 shows that the high PO43- content has been observed at Cyamabuye Spring (1.2 mg/L), Jordan Stream (9.6 mg/L) and Cyabirumba Water Source (6.2 mg/L).

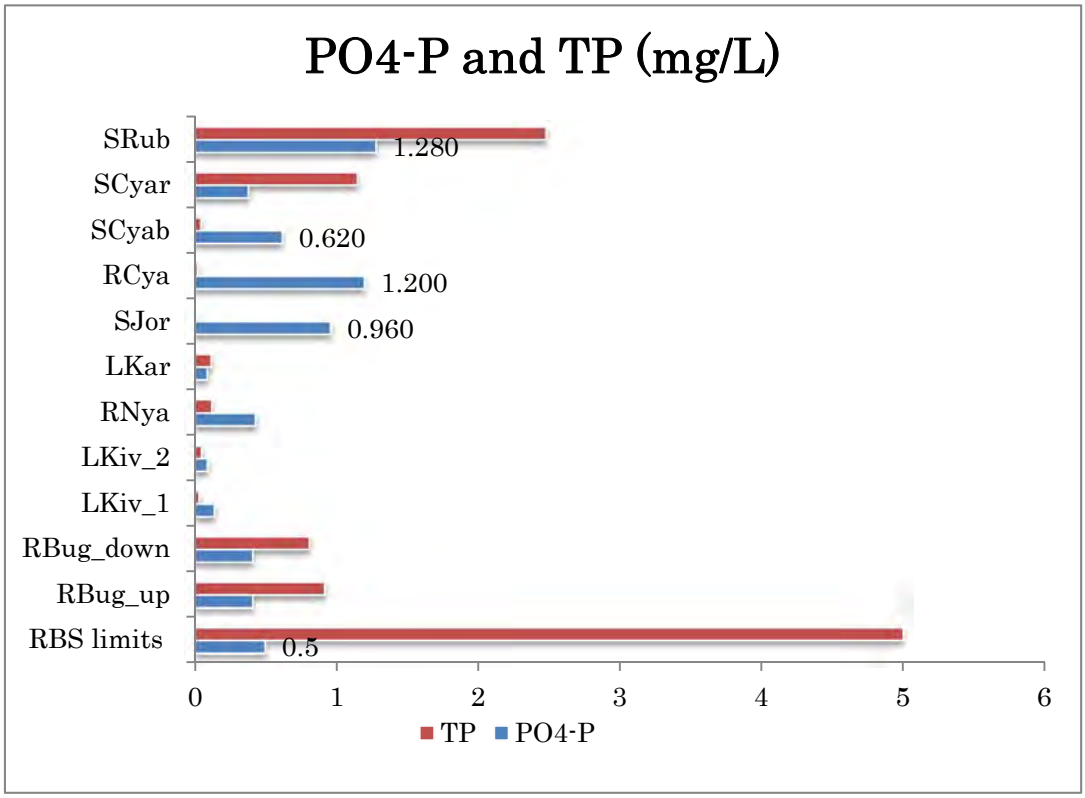


Fig. 4-5.15 Variation of TP and PO_4^{3-} (mg/L) for all study sites

8) Sodium, potassium, arsenic and boron

These four elements are very frequently found in areas with potential geothermal resources. In that context, they were documented and analyzed with the purpose of assessing their status in this study.

Over many years sodium is washed out from rocks and soils, ending up in oceans. Seawater contains approximately 11,000 ppm sodium while rivers contain only about 9 ppm. The sodium tends to settle, and consequently it primarily ends up in sediment. Rivers generally contain about 2-3 ppm potassium. Potassium salts, like sodium salts contribute to the total dissolved solids in water environments. If the levels are too high, the aquatic animals can be impacted, or even killed. This is rare since the level has to be very high and normally the level of potassium never approaches these levels. Increased sodium levels caused by sodium salts are more common, and therefore are more of a concern when released into the environment (http://www.lenntech.com/periodic/water/).

Arsenic compounds are abundant in the earth's crust. Particles are released during mining, and spread throughout the environment. Arsenic from weathered rocks and soils dissolves in groundwater. Arsenic concentrations in groundwater are particularly high in areas with geothermal activity.

In aquatic ecosystems, inorganic arsenic derived from rocks such as arsenic trioxide (As2O3), orpiment (As2S3), arsenopyrite (AsFeS) en realgar (As4S4) is most prevalent. Arsenic related illness is usually caused by consumption of contaminated drinking water. In years past it was used as a poison, because the symptoms of arsenic poisoning resemble cholera symptoms, and therefore the true cause of death could be hidden. (http://www.lenntech.com/periodic/water/).

Boron, unlike sodium, is an essential element for plant growth. Boron is needed in relatively small amounts, however, and if present in amounts appreciably greater than needed, it becomes toxic. For some crops, if 0.2 mg/l boron in water is essential, 1 to 2 mg/l may be toxic. Surface water rarely contains enough boron to be toxic, but well water or springs occasionally contain toxic amounts, especially near geothermal areas and earthquake faults. Boron problems originating from water are probably more frequent than those originating in the soil. Boron toxicity can affect nearly all crops but, like salinity, there is a wide range of tolerance among crops (http://www.fao.org/docrep/003/t0234e/t0234e05.htm).

Results from this study show the sodium concentration varying from between 69.73 at Lake Kivu to 366.51 mg/L at the Bugarama streams.. Boron content, on the other hand, varied from 0.017 at Jordan Stream to 74.85 mg/L at Bugarama Stream.

When compared with RBS limits in terms of sodium concentration, Bugarama streams presented highest level of deviation, followed by Cyamabuye Water Source, Jordan Stream and then Cyabirumba Spring as shown in the figure below (Fig. 4-5.16). Only the Lake Kivu and Karago areas were found to be in the range of RBS limits. However, they were the ones to have high levels of potassium (~42 and 33 mg/L of K respectively). These high concentrations are attributed to the potential geothermal resources in all areas, which are released into the environment at different proportions throughout the area. Arsenic content was not detected at any of the sites, which is a good sign for toxicity level.

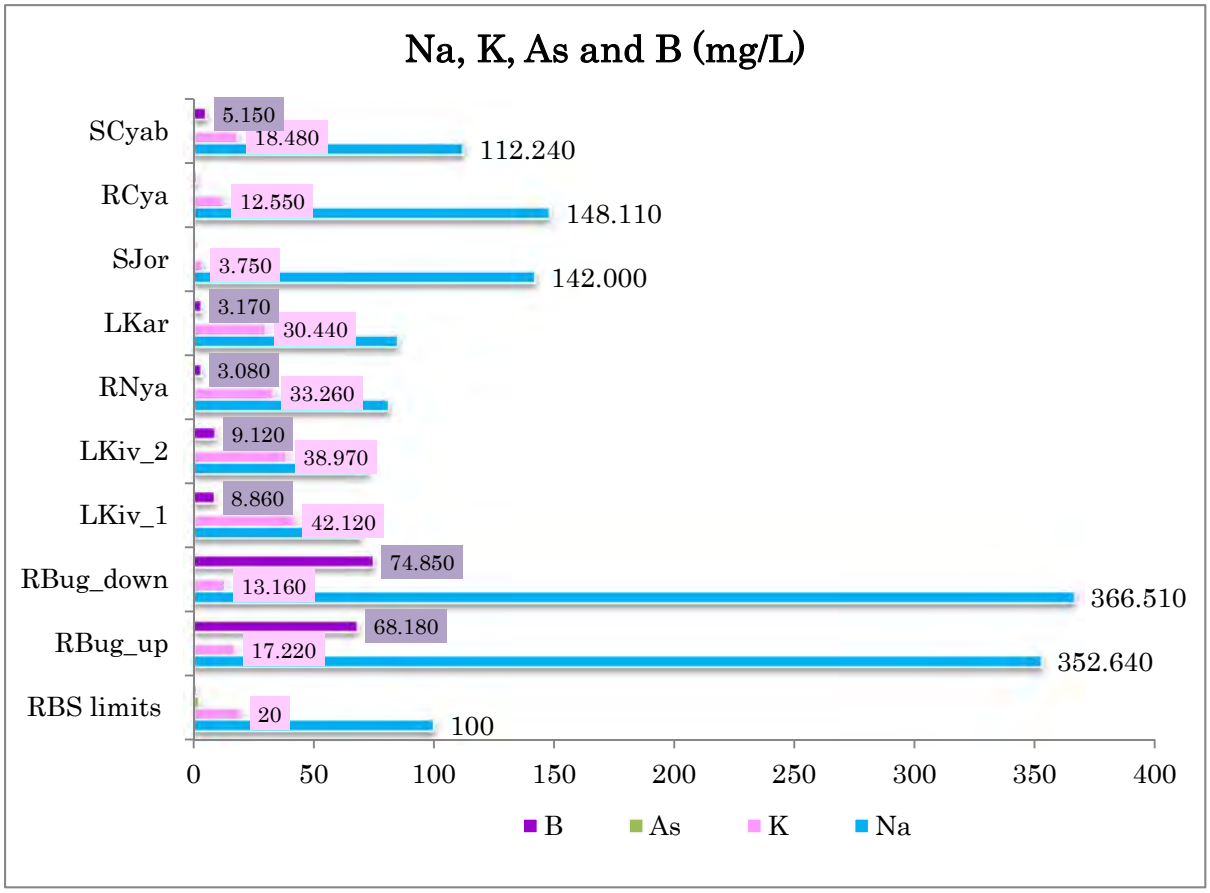


Fig. 4-5.16 Variation of B, As, K and Na (mg/L) for all study sites

P.S: Those parameters were not analyzed for Cyabararika and Rubindi springs.

9) Sulfate and chloride ions

Almost all natural waters contain chloride and sulfate ions. Their concentrations vary considerably according to the mineral content of the earth in any given area. In small amounts they are not significant. In large concentrations they present problems. Usually chloride concentrations are low. Sulfates can be more troublesome because they generally occur in greater concentrations. Low to moderate concentrations of both chloride and sulfate ions add palatability to water. In fact, they are desirable for this reason. Excessive concentrations of either, of course, can make water unpleasant to drink.

The figure below (Fig. 4-5.17) shows that both chloride and sulfate ions were within national standards. The variation was from 5.1 to 110 mg/L of chloride, and from 2.2 to 44 mg/L of sulfate ions.

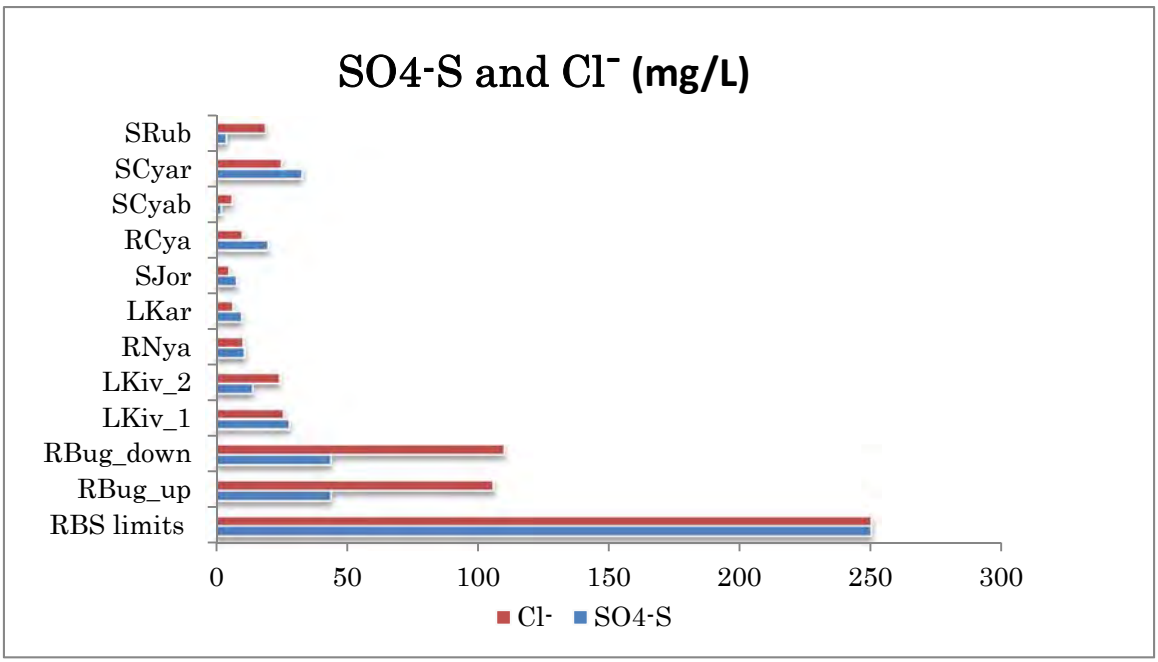


Fig. 4-5.17 Variation Cl^- and SO_4^{2-} ions (mg/L) for all study sites

10) Iron and fluoride ions

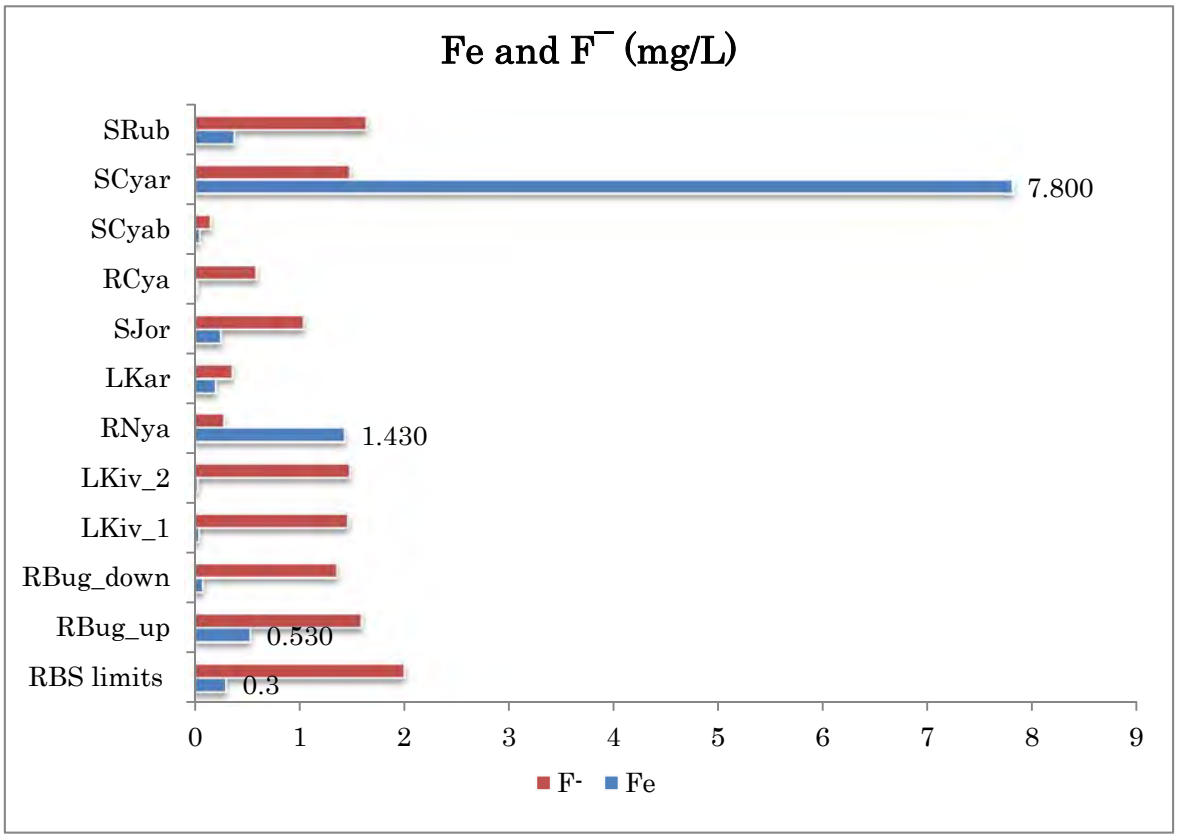


Fig. 4-5.18 Variation of F^- and Fe (mg/L) for all study sites

Iron and fluoride ions were also measured for all study sites. Results are shown in the figure

above. Fluoride ion concentrations were within RBS limits for all sites, while iron ion content in the Cyabararika Spring and Nyamakongo River samples were found to be out of the acceptable range with a result of 7.8 and 1.43 mg/L respectively (Fig. 4-5.18).

The occurrence of iron in aqueous solution is dependent on environmental conditions, especially oxidation and reduction. Flowing surface water, fully aerated, should not contain more than a few micrograms per liter of uncomplexed dissolved iron at equilibrium in the pH range 6.6 to 8.5. Iron is generally present in surface waters as salts containing Fe (III) when the pH is above 7. Most of those salts are insoluble and settle out or are absorbed onto surfaces; therefore the concentration of iron in well-aerated waters is seldom high. Under reducing conditions, which may exist in some groundwater, lakes or reservoirs, and in the absence of sulphide and carbonate, high concentrations of soluble Fe(II) may be found.

The presence of iron in above sites could be attributed to the weathering of rocks and minerals and acidic mine water drainage in the area.

11) Mercury and grease & oil

Mercury has been well known as an environmental pollutant for several decades. As early as the 1950's it was established that emissions of mercury to the environment could have serious effects on human health. These early studies demonstrated that fish and other wildlife from various ecosystems commonly attain mercury levels of toxicological concern when directly affected by mercury-containing emissions from human-related activities. Human health concerns arise when fish and wildlife from these ecosystems are consumed by humans. This study did not detect mercury at any of the identified sites.

The Oil and Grease (O&G) parameter provides a measure of hexane extractable non-volatile oils and greases which may be of either petrogenic or natural origin. Mineral Oil and Grease parameter determines only non-volatile, non-polar oils and greases. Most natural oils and greases (e.g. vegetable oils, animal fats) are polar, and are excluded from the Mineral Oil and Grease parameter. Singapore’s effluent discharge standards for oil and grease range from 5 to 30 mg/L depending on the water use. Thailand’s effluent discharge standard for oil and grease is 5.0 mg/L. Vietnam’s standards for industrial wastewater range from non-detectable to 5 mg/L for mineral oil and fat, and from 5 to 30 mg/L. At most of the sites assessed, oil and grease was not detected. Only Bugarama stream (both up and downstream) contained detectable O&G of 0.24 and 0.19 mg/L respectively. According to the above effluent discharge standards, Bugarama site was within the normal range.

12) Fecal coliforms and Chl-a

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water may have also been contaminated by pathogens or disease producing bacteria or viruses which can exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A

(http://bcn.boulder.co.us/basin/data/FECAL/info/FColi.html). The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste (UNEP, 2006).

Results from this study showed fecal coliform concentrations varying from between 9 cfu/100mL at Cyamabuye Water Source to 691 cfu/100ml at Bugarama downstream. The two Bugarama sites were the only sites out of the 9 sites which had higher fecal coliform concentrations than the required standard limit (Fig. 4-5.19).

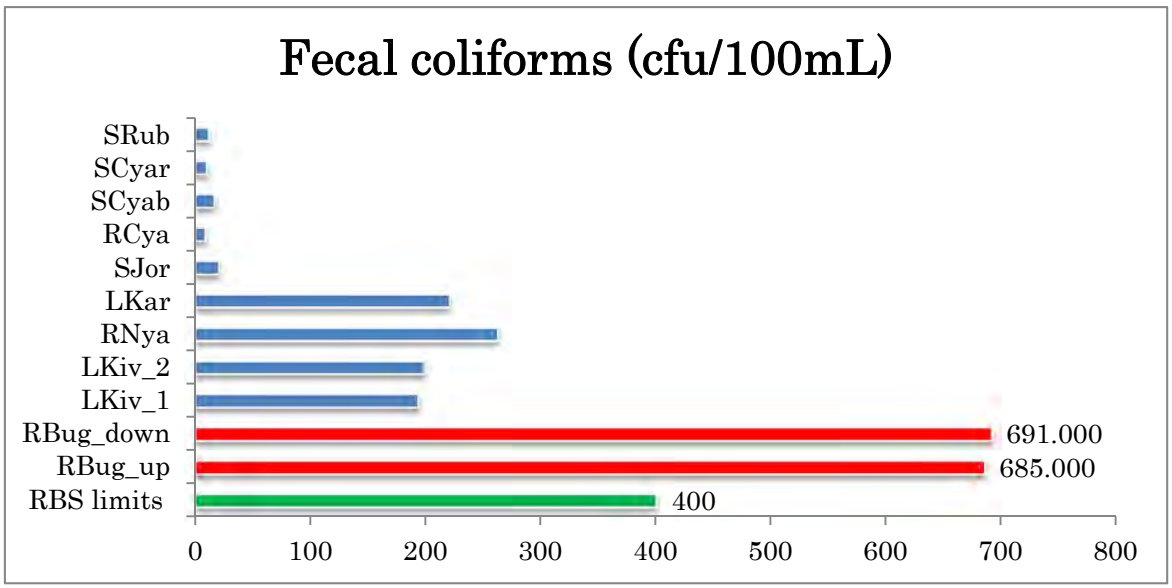


Fig. 4-5.19 Variation of fecal coliforms (cfu/100mL) for all sites.

Green color indicates RBS limits, red color indicates the values above RBS limits and the blue one indicates values within RBS limits.

On the other hand, chlorophyll-a is often used as a means to measure the productivity of plants and algae in a waterbody. The direct causes of algal blooms are often associated with increased total phosphorous (TP) and/or total nitrogen (TN) levels in a waterbody. TP and TN are referred as the causal or contributing variables of nutrient enrichment by EPA. While TN and TP concentrations can vary widely in order to produce an algal response of 10 µg/L chlorophyll-a, taste and odor problems begin occurring once chlorophyll-a values reach 10 µg/L.

Table 4-5.3 Chlorophyll-a measurement indication

PARAMETER: CHLOROPHYLL *a* (abbreviated as Chlor *a*)

Unit of Measurement: micrograms/liter (abbreviated as µg/l)
Description: An estimate of the biomass of planktonic algae in the river. The technical term "biomass" is used to represent "amount by weight". Chlorophyll *a* can be strongly influenced by phosphorus, which is derived by natural and human activities.
Visual observation: Green, suspended particles
Class A NH surface water quality standard: No numeric standard
Class B NH surface water quality standard: No numeric standard

Categories	
< 3	Excellent
3 - 7	Good
7 - 15	Less than desirable
> 15	Nuisance

For this study, Chl-a concentration ranged from 0.02 at Cyamabuye Water Source to 2.49µg/L at Lake Karago. Chl-a was not detected at most of the study sites. The table above shows that all sites are in excellent condition in terms of Chl-a concentration.

13) SUMMARY AND CONCLUSIONS

Based on the current water quality survey results, water quality features in Rwanda can be summarized from the point of view of an EIA for geothermal development as follows:

The rainy seasons and the dry seasons significantly influence the annual environment, such as the river system, in Rwanda. Water drainage planning must consider the river system's hydrological features and water quality fluctuation caused by the seasonal changes, both during geothermal development and operation. The mountainous region in Kinigi area, in Northern Province seldom has surface water flowing during the dry seasons and only underflows are identified. Thus, there is a risk that geothermal project drainage could be directly connected to the underflows and join the river system. We should pay attention to this point and consider potential impacts to water quality and the ecosystem in the area around the water system.

Groundwater obtained through water springs is commonly used as domestic water in many locations in Rwanda. At the same time, the agricultural practice of applying fertilizers to farmland, such as tea plantations is quite common. One typical environmental issue caused by agriculture to groundwater is nitric acid pollution. Drinking water polluted by nitric acid could cause issues regarding blood circulation, especially in babies and infants. Nitric acid pollution of groundwater is a feature which is revealed after an incubation period of tens of years. In the case of Japan, the introduction of measures to deal with the pollution was delayed and as a result we still see many groundwater sources that are difficult to recover. It is important in Rwanda to introduce prevention measures with a long-term vision, to avoid such pollution. During geothermal development, we should take sufficient preventative measures not to drain and/or permeate polluted elements such as organic liquid waste and heavy metals into the surface water or groundwater systems.

The water quality of Lake Kivu is currently fine and this enhances the value of the lake as a tourist resource. However, because of economic development in Rwanda, the lake is more often receiving drainage containing high levels of nutrients, organic matter, pesticides and other elements that increase the environmental burden and pollute the lake. In the case of Lake Karago, the depth of the lake is shallow. If inputs of pollutants such as nutrients continue to increase, there is a risk of observing water blooms such as those caused by the Cyanobacteria Microcystis, which generates toxic substances. Water blooms decrease biodiversity, make domestic and industrial usage of water difficult, and prevent economic development.

During geothermal development, it is ideal to prepare necessary measures such as impact assessments and pollution prevention activities by considering the entire water system. This requires monitoring the water quality of the whole system, including the river and the lakes/marshes into which the water flows. Additionally, all collected data through this exercise should be open to the public so that people can use it for proper management of the hydrological environment, the biological environment, and the living environment. This will help with the realization of sustainable national development. From the standpoint of avoiding emission of toxic methane gas in Lake Kivu, we need to reduce lake inputs of organic pollutants, phosphorus that nurtures phytoplankton and organic matter, and nitrogen. The long-term measures implemented must also consider any potential future impacts on the countries further down the water system.

The water sources of rivers in Bugarama are located at the hot spring area. Thus, a high content of elements linked to the hot spring are identified. When we design measures to study, evaluate, and protect water quality and to use water during geothermal development, it is critical to keep in mind features of the water quality of the targeted river. Additionally, as the region downstream from the geothermal development area is used for irrigation, we need to assess impacts of the development on that region.

4.5.6. Noise

(1) Introduction

Sound is the result of fluctuations or oscillations in atmospheric pressure. These excite the ear mechanism and evoke the sensation of hearing. Noise is generally defined as any “unwanted sound”. Environmental (formerly community) noise control has two basic objectives 1) to protect people in the present against noise intrusions which annoy people and disrupt daily activities and 2) to protect people in the future against increasing noise levels that would further reduce the quality of their environment.

The basic unit of measurement for environmental noise is the dB, but other measuring concepts, based on dB(A), are used to provide single-number criteria for describing fluctuating noise and to predict human reaction to the temporal qualities of noise. Normally during the measurement of noise, dB(A) has been used for this study.

Table 4-5.4 Example Noise Levels

Sound Pressure Level (dBA)	Typical examples of noise source	Subjective Evaluation
140	Long range gun, gunners ear	Extremely noisy to intolerable
130	Threshold of pain	
120	Jet take-off at 100m	
110	Night club dance floor	
100	Loud car horn at 3 meters	Very noisy
90	Heavy truck at 10m	
80	Curbside of busy street	Loud
70	Car interior	
60	Normal conversation at 1m	Moderate to quiet
50	Office noise	
40	Living room in quiet area	Quiet to very quiet
30	Inside bedroom at night	
20	Unoccupied recording studio	Almost silent

(2) **Methodology**

The implementation of geothermal projects may generate noise throughout each of the phases (construction, operation and decommissioning). During the construction phase, noise may be caused by: Site clearance; Construction of a temporary water pipeline and water storage tanks; Construction of workers' accommodations; Road traffic on local roads associated with construction (movement of materials and equipment etc.); and, Upgrade of the carriageway surface to access the well pad site. The operation phase may also generate noise through: Drilling activities and fixed plant operating at the well pad site (generators, compressors, pumps etc.). The decommissioning phase may cause noise from activities regarding the removal of the rig and other materials which were used during drilling.

Due to the above factors, we measured baseline noise status for five sites (Bugarama, Gisenyi, Karisimbi, Karago and Kinigi prospects) in order to obtain baseline data for noise before implementation of this project.

General assessment approach included:

・ Site visits in July and August 2014 with daytime noise measurements conducted in the areas near the proposed sites;
・ Review of case studies regarding guidance, best practice and the consideration of noise for geothermal exploration activities;
・ The use of a sound level meter to measure noise;
・ Identification of noise sources, activities and fluctuations;
・ To mention the maximum noise if there is any special noise source;

- Consideration of measures to mitigate noise and residual effects where appropriate.
- Providing maps and pictures related to the area where noise measurement has been taken;
- Using a stopwatch to ensure that each measurement is taken for 10 minutes;
- Consideration of weather conditions during the measurements.

(3) **Findings**

The survey results are as shown starting on the next page. The summary is as follows:

For this study, we measured noise levels, primarily along roads, for 10 minutes during the daytime as a reference. The levels were: 43.0 to 71.0 dB (Leq) in Bugarama, 59.8 to 70.6 dB (Leq) in Gisenyi, 48.4 to 73.0 dB (Leq) in Karago, and 46.3 to 71.0 db (Leq) in Kinigi. The maximum noise levels of all the sites were mainly caused by traffic and they reached around 70 dB (Leq). The minimum noise level in Gisenyi was relatively high because it was influenced by wave sound from the Lake Kivu, voices of hot spring visitors, etc.

BUGARAMA

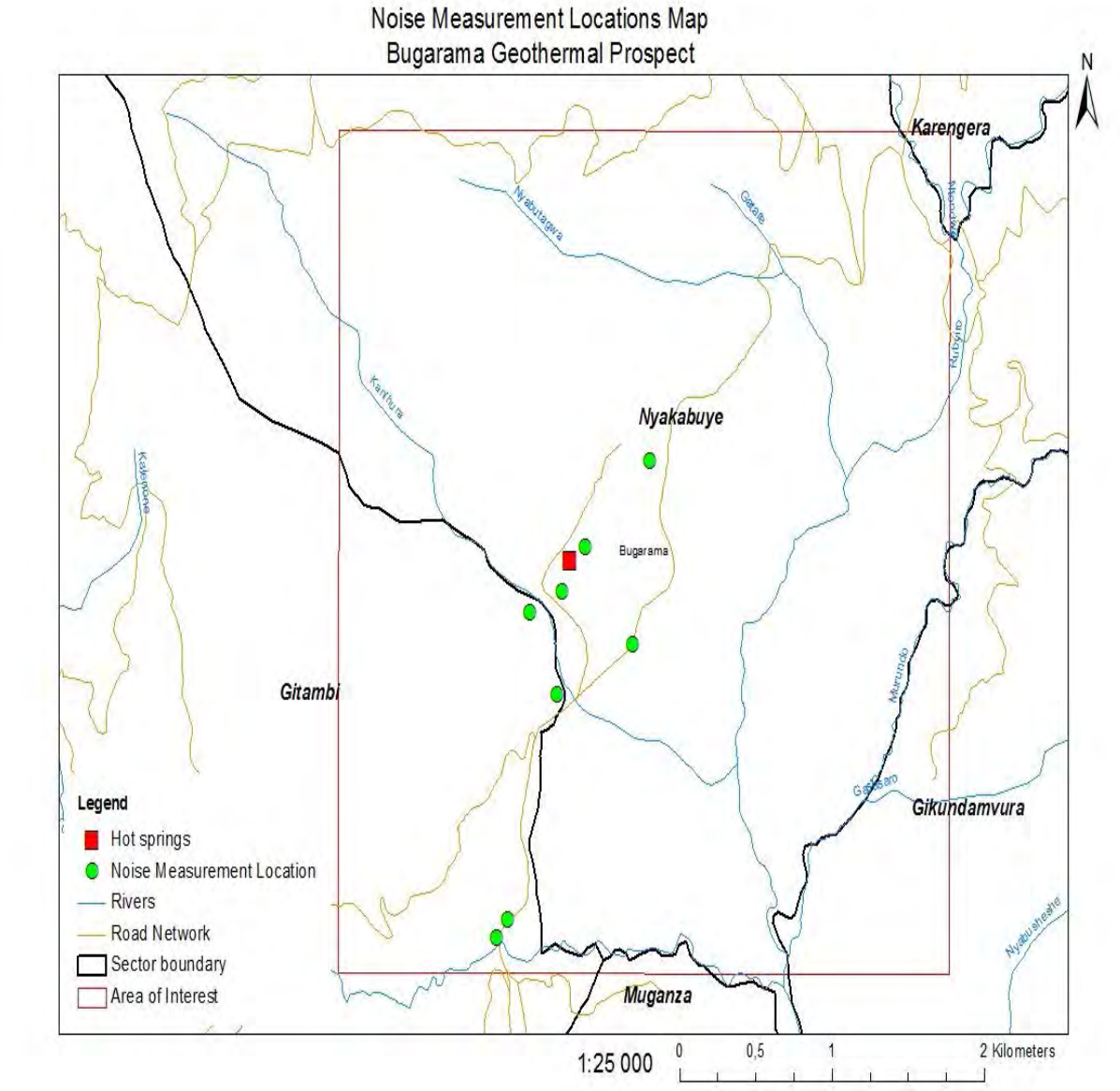


Fig. 4-5.20 Noise measurement location map for Bugarama area

Date: 27 /07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0724010, Y=9713678					
Start time:11:58 am		**End time:12:09 pm**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No Traffic)**	**Fluctuation source**		
L max	72.2	Car: 1 Track: 1 Bus: Machine: Bike: Bicycle:	**Sound source**	**Frequency Level**	**Max dB**
L 5	63.0				
L 50	50.0		wind	M	60.0
L 95	43.5		Track (But very far)	L	67.6
L eq	56.0		Car (Far)	L	60.2
L 10	59.5		Chicken	M	53.3
L 90	44.7				
LE	83.8				

Related pictures

Date: 23/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0723634, Y=9712478					
Start time: 1:00 pm	**End time: 1:10 pm**		**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	77.6	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	63.6	Track:	Bike	L	72.3
L 50	56.3	Bus:	Radio	H	61.1
L 95	51.2	Machine:	Passenger talking on phone	L	56.6
L eq	59.1	Bike: 1	Conversation of two women	M	65.8
L 10	61.7	Bicycle:	A group of girls passing	L	64.0
L 90	52.2				
LE	86.9				

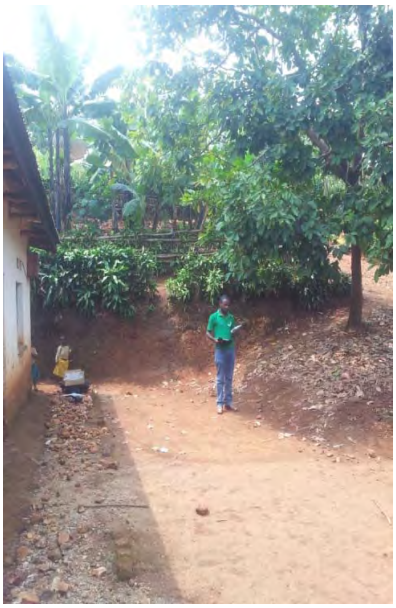
Related pictures



Date: 22/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0724619, Y=9714787					
Start time: 1:23 pm		**End time: 1:34 pm**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	72.2	Car: 1	**Sound source**	**Frequency Level**	**Max dB**
L 5	58.1	Track:			
L 50	47.5	Bus:	Wind	M	55.0
L 95	43.2	Machine:	Car	L	61.3
L eq	52.5	Bike:	Group of children	L	60.0
L 10	55.3	Bicycle:	A man greet an other	L	67.4
L 90	43.9				
LE	80.3				

Related pictures





Date: 22/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0723829, Y= 9714067					
Start time: 1:50 pm		**End time: 2:02 pm**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	71.8	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	54.3	Track:			
L 50	46.2	Bus:	Children	L	50.7
L 95	41.2	Machine:	HH member smile	L	58.0
L eq	49.6	Bike:	Wind	M	61.2
L 10	51.4	Bicycle:			
L 90	42.1				
LE	77.4				

Related pictures



Date: 23/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0724058, Y= 9713914					
Start time: 7:39 am		**End time: 7:49 am**	**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	85.2	Car: 1	**Sound source**	**Frequency Level**	**Max dB**
L 5	70.9	Track: 2			
L 50	51.2	Bus:	Track	L	81.1
L 95	44.1	Machine:	Bike	M	67.9
L eq	65.9	Bike: 4	Car	L	75.3
L 10	67.9	Bicycle:	Children	M	47.3
L 90	45.3		Radio	L	65.3
LE	93.7				

Related pictures



Date: 23/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X= 0724058, Y=9714129 **Entrance of Hot spring**					
Start time: 8:50 am		**End time: 9:01 am**	**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	63.3	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	51.1	Track:			
L 50	44.1	Bus:	Bird	L	45.6
L 95	40.6	Machine:	Conversation of two men	M	51.5
L eq	46.5	Bike:	Child	L	57.2
L 10	49.6	Bicycle:			
L 90	41.2				
LE	74.2				

Related pictures



Date:			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X= 0724194, Y= 9714376 **Next right to the hot spring**					
Start time: 9:10 am		**End time: 9:20 am**	**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	58.3	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	46.0	Track:			
L 50	42.1	Bus:	Greetings between two men	L	47.1
		Machine:			
L 95	39.5	Bike:			
L eq	43.0	Bicycle:			
L 10	45.0				
L 90	40.0				
LE	70.8				

Related pictures



Date: 22/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0723786, Y=9712663					
Start time: 10:21 am		**End time: 10:31 am**	**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	90.8	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	74.1	Track: 4			
L 50	57.1	Bus:	Track	M	90.4
L 95	49.1	Machine: 1	Human noise	H	65.7
L eq	71.0	Bike: 2	Bike	M	79.6
L 10	67.7	Bicycle:	Machine	L	62.4
L 90	50.0				
LE	98.8				

Related pictures



GISENYI

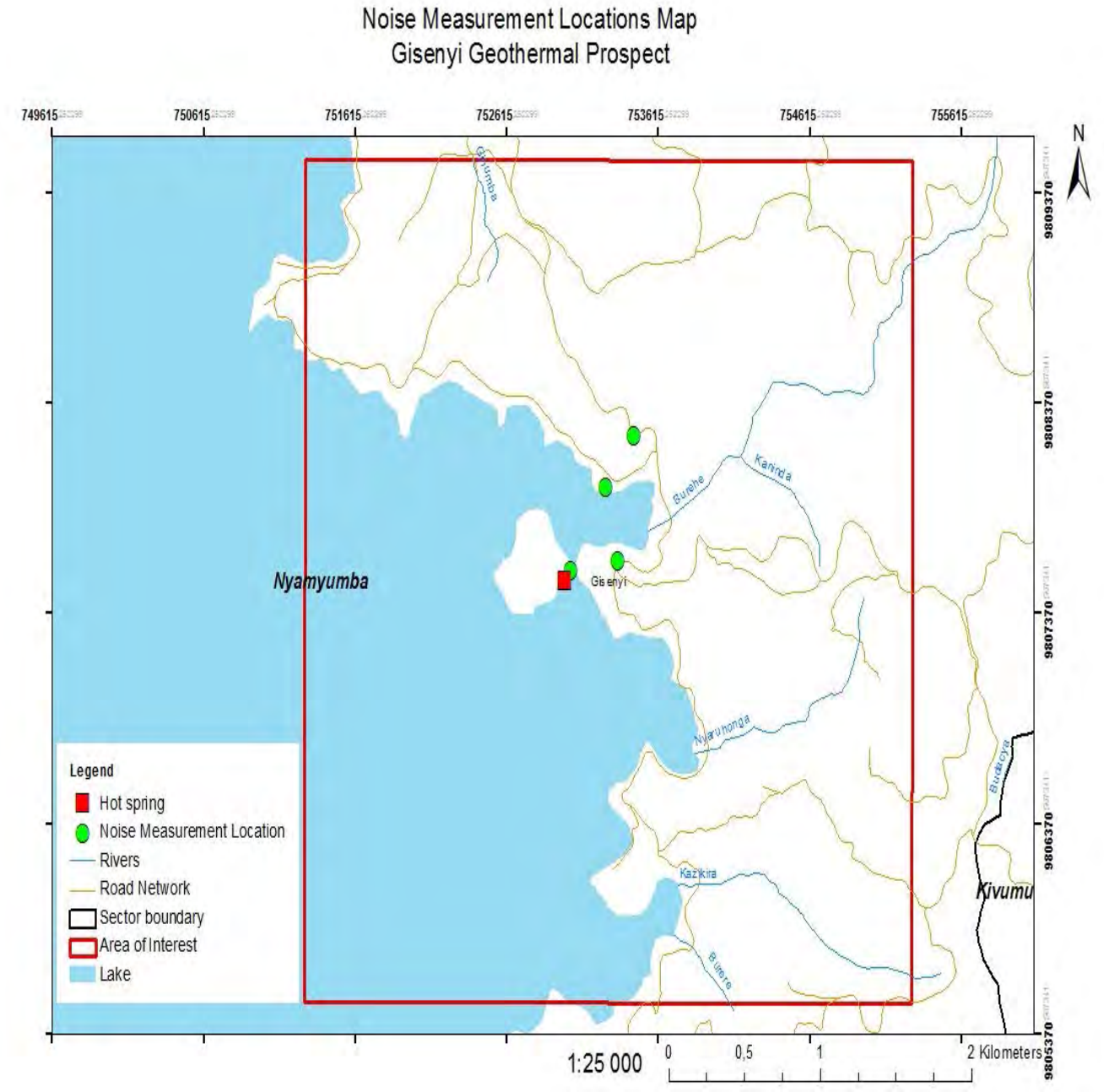


Fig. 4-5.21 Noise measurement location map for Gisenyi area

Date: 30/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0753038, Y=9807573 **At hot spring**					
Start time: 11:05 am	**End time: 11:15 am**		**Steady source wave wind**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	76.1	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	63.6	Track:			
L 50	58.5	Bus:	Water flow	H	67.5
L 95	54.5	Machine:	Bird	L	63.6
L eq	59.8	Bike: Bicycle:	Tourists coming to visit hot spring	M	65.5
L 10	62.4				
L 90	55.3				
LE	87.5				

Related pictures

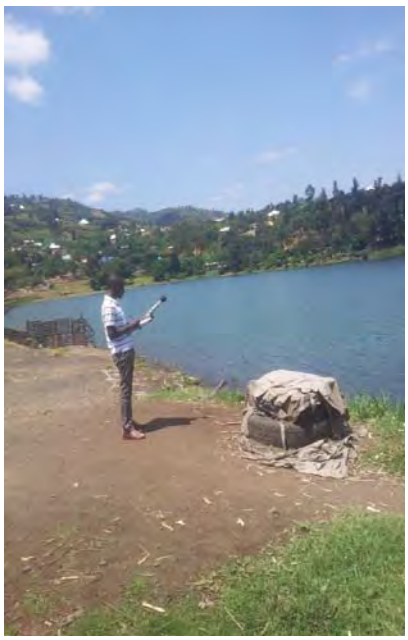


Date: 30/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0753348, Y= 9807619 **Road to hot spring**					
Start time:11:23 am		**End time:11:33 am**	**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	86.5	Car: 2	**Sound source**	**Frequency Level**	**Max dB**
L 5	70.2	Track:	car	L	86.0
L 50	56.8	Bus:	Bike	H	67.4
L 95	53.2	Machine:	Tourists	L	77.0
L eq	65.2	Bike: 7	Airplane	M	72.4
L 10	67.2	Bicycle:			
L 90	53.8				
LE	92.9				

Related pictures

Date: 30/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0753269, Y= 9807966 **Fishing area (Near big ship)**					
Start time: 11:42		**End time: 11:52**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	85.8	Car:1	**Sound source**	**Frequency Level**	**Max dB**
L 5	76.1	Track:			
L 50	66.9	Bus:	Bird	L	78.5
L 95	59.5	Machine:	Noise from a Man	M	62.6
L eq	70.6	Bike:	Wind	M	80.7
L 10	74.5	Bicycle:	Car	L	74.3
L 90	60.9		Ship construction (Soldering)	M	77.6
LE	88.3				

Related pictures


Date: 30/07/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X= 0753457, Y= 9808211 **Traffic (Bralirwa road)**					
Start time: 12:45 pm		**End time: 12:55 pm**	**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	86.4	Car: 7 Track: 1 Bus: 3 Machine: Bike: 11 Bicycle:	**Sound source**	**Frequency Level**	**Max dB**
L 5	73.5				
L 50	59.0		Track	L	85.9
L 95	53.3		Car	M	77.5
L eq	67.0		Group of girls	L	71.5
L 10	70.3		Bike	H	77.8
L 90	53.8		Bus	L	81.7
LE	94.9				

Related pictures

KARISIMBI-KARAGO

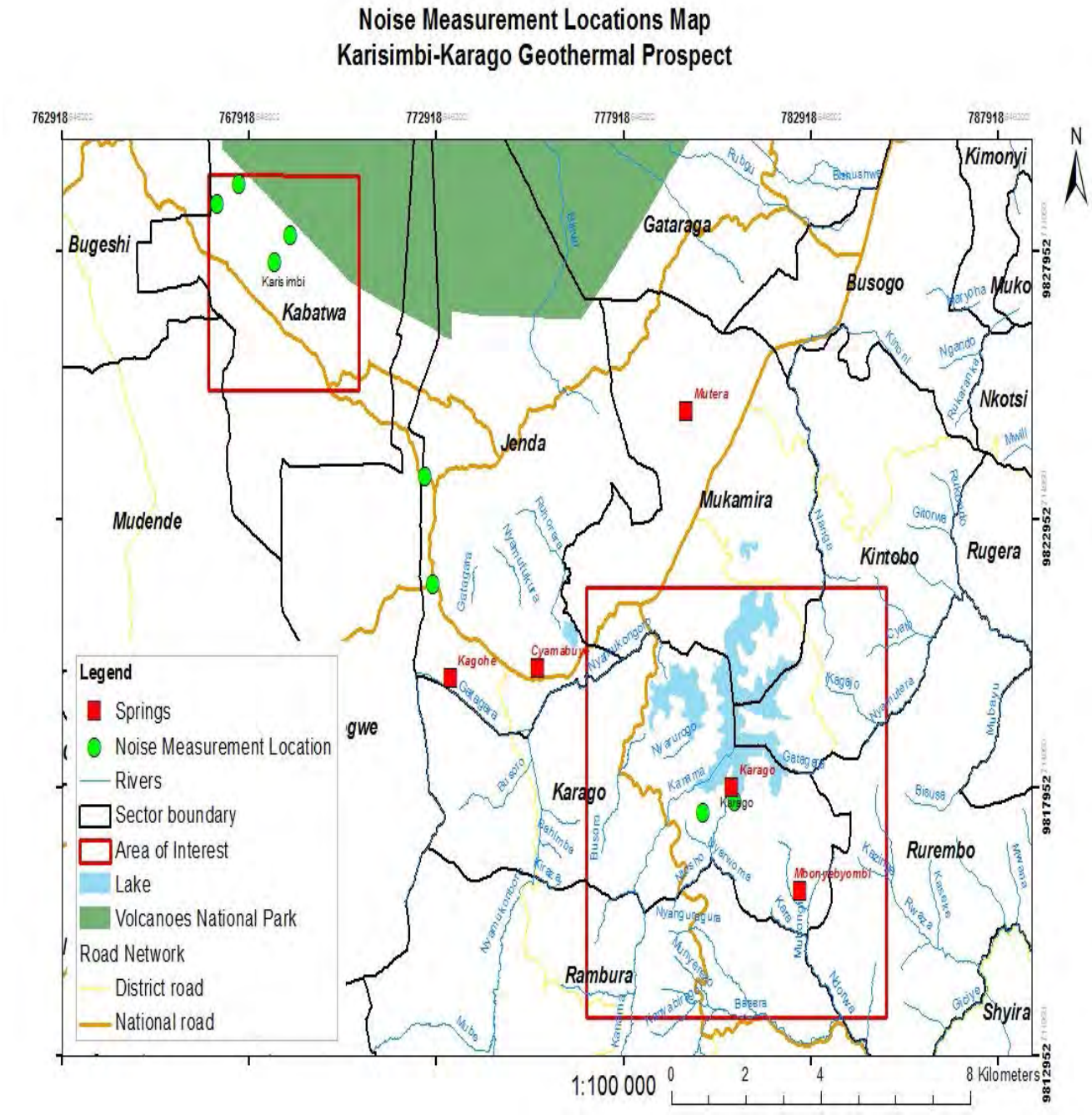


Fig. 4-5.22 Noise measurement location map for Karisimbi and Karago areas

Date:01/08/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0780051, Y= 9817460 **Road to Karago hot spring**					
Start time: 9:10 am		**End time: 9:20 am**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	77.1	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	63.1	Track:			
L 50	52.2	Bus:	Wind	M	70.5
L 95	44.4	Machine:	Group of children	M	62.8
L eq	57.3	Bike:	Man passed with radio	L	64.2
L 10	60.6	Bicycle:	Woman greet other	L	68.9
L 90	45.7				
LE	85.1				

Related pictures

Date: 01/08/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X= 0780889, Y= 9817675 **At Karago hot spring**					
Start time: 9:46 am		**End time: 9:56 am**	**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	72.3	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	52.5	Track:			
L 50	42.2	Bus:	Noise from cow boy	M	52.2
L 95	37.7	Machine:	Cattle	L	56.0
L eq	48.4	Bike:			
L 10	49.6	Bicycle:			
L 90	38.4				
LE	76.2				

Related pictures



Date: 02/08/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0772623, Y= 9823744 **Traffic**					
Start time: 9:55 am		**End time: 10:05 am**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	85.1	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	73.3	Track:			
L 50	60.3	Bus:	Bike	M	84.9
L 95	52.6	Machine:	Wind	M	71.3
L eq	67.4	Bike: 6			
L 10	70.6	Bicycle:			
L 90	53.8				
LE	95.2				

Related pictures



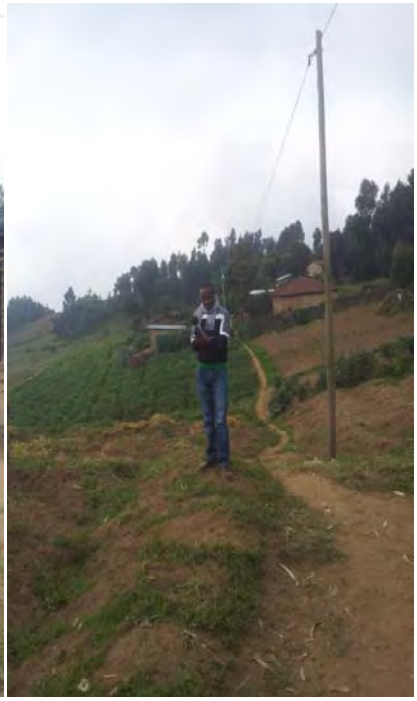
Date: 02/08/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0772844, Y= 9821719 **Traffic at Sashwara (Main road Gisenyi-Musanze)**					
Start time: 10:35		**End time:10:45**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	87.1	Car: 9 Track: Bus: 7 Machine: Bike: 5 Bicycle:	**Sound source**	**Frequency Level**	**Max dB**
L 5	77.5				
L 50	70.5		Car	H	77.9
L 95	64.9		Bus	M	86.4
L eq	73.0		Wind	M	77.1
L 10	75.9		Bike	L	78.4
L 90	66.0		Population motion	H	71.7
LE	100.8				

Related pictures

Date: 06/08/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0768591, Y= 9827739 **South of site 1**					
Start time: 10:01 am		**End time: 10:11 am**	**Steady source**		
Weather: Normal atmosphere			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	77.1	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	63.5	Track:			
L 50	56.1	Bus:	Children	L	60.8
L 95	45.7	Machine:	Sheep	L	71.9
L eq	59.0	Bike:			
L 10	62.0	Bicycle:			
L 90	47.0				
LE	86.7				

Related pictures





Date: 06/08/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0769031, Y= 9828223 **North of site 1**					
Start time: 10:41 am		**End time: 10:51 am**	**Steady source**		
Weather: High wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	75.4	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	64.6	Track:			
L 50	54.5	Bus:	Wind	H	72.8
L 95	51.0	Machine:			
L eq	58.7	Bike:			
L 10	61.7	Bicycle:			
L 90	51.5				
LE	86.5				

Related pictures



Date: 06/08/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X= 0767080, Y= 9828819 **South of Site 2**					
Start time: 11:23 am		**End time: 11:33**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	79.4	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	65.3	Track:			
L 50	51.4	Bus:	Wind	M	65.1
L 95	42.7	Machine:	Woman greet other	L	73.3
L eq	59.4	Bike:	Children	M	64.4
L 10	62.2	Bicycle:	Bird	L	74.1
L 90	44.1				
LE	87.2				

Related pictures



Date: 06/08/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0767661, Y= 9829189 **North of site 2**					
Start time: 11:58 am		**End time: 12:08 pm**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	78.2	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	64.3	Track:			
L 50	49.1	Bus:	Wind	M	68.7
L 95	40.4	Machine:	Bird	L	64.4
L eq	58.1	Bike:	Children	L	67.2
L 10	61.2	Bicycle:			
L 90	41.8				
LE	85.9				

Related pictures

KINIGI

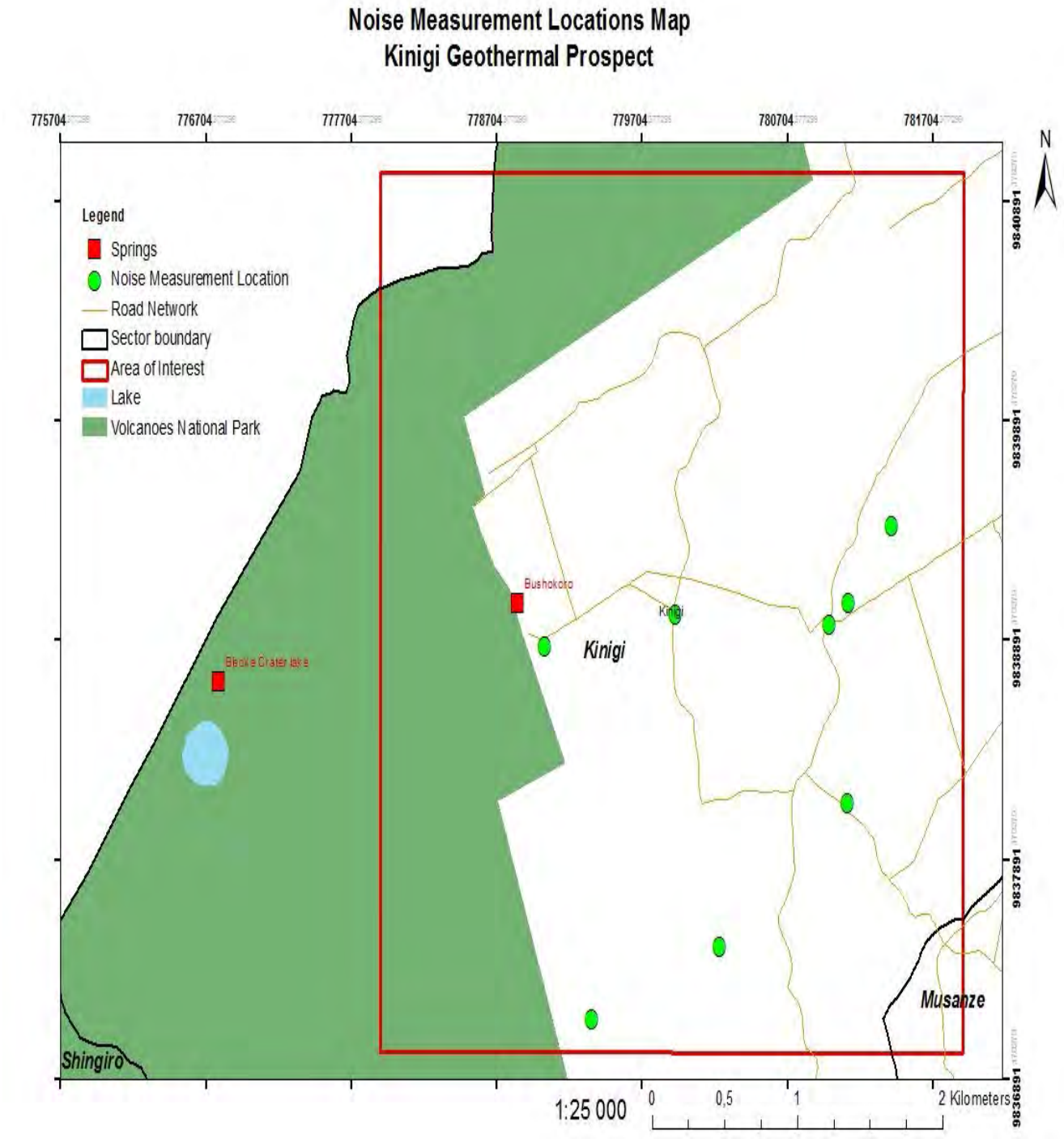


Fig. 4-5.23 Noise measurement location map for Kinigi area

Date: 05/06/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0779034, Y= 9838863 **North of site 1 (Buffer zone)**					
Start time: 9:05 am		**End time: 9:15 am**	**Steady source**		
Weather: High wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	80.5	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	72.8	Track: Bus:			
L 50	63.2	Machine:	Child crying	M	65.7
L 95	49.9	Bike:	Wind	H	78.3
L eq	67.0	Bicycle:	Tourists motion and conversation	M	74.0
L 10	70.9				
L 90	53.0				
LE	94.8				

Related pictures

Date: 05/06/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0779933, Y= 9839008 **At site 1**					
Start time: 9:42 am		**End time: 9:53 am**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	74.1	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	60.8	Track:			
L 50	47.0	Bus:	Wind	M	67.6
L 95	41.1	Machine:	Woman	L	58.4
L eq	54.2	Bike:			
L 10	57.6	Bicycle:			
L 90	42.1				
LE	82.0				

Related pictures



Date: 05/06/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0779359, Y= 9837160 **North of site 2 (Buffer zone)**					
Start time:10:53 am		**End time: 11:03 am**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	69.8	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	52.4	Track:			
L 50	43.4	Bus:	Wind	M	56.2
L 95	40.5	Machine:	Cattle	L	51.1
L eq	48.2	Bike:			
L 10	49.5	Bicycle:			
L 90	41.0				
LE	76.0				

Related pictures

Date: 05/06/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0780236, Y= 9837492 **At site 2**					
Start time: 11:42 am		**End time: 11:52 am**	**Steady source**		
Weather: Low wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	70.7	Car:	**Sound source**	**Frequency Level**	**Max dB**
L 5	50.2	Track:			
L 50	41.7	Bus:	Wind	L	61.5
L 95	37.3	Machine:			
L eq	46.3	Bike:			
L 10	47.8	Bicycle:			
L 90	38.2				
LE	74.1				

Related pictures



Date: 05/06/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0781115, Y= 9838149 **At site 4**					
Start time: 1:25 pm		**End time: 1:35 pm**	**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	76.6	Car:	**Sound source**	**Frequency Level**	**Max dB**
		Track:			
L 5	59.3	Bus:			
L 50	44.2	Machine:	Two women converse	L	51.6
L 95	35.0	Bike:	Sheep	L	46.7
L eq	54.4	Bicycle:	Wind	M	68.8
L 10	56.0				
L 90	35.8				
LE	82.2				

Related pictures

<table>
<tr><td colspan="3">Date: 05/06/2014</td><td colspan="3">Researcher: Emmanuel MANIRAFASHA</td></tr>
<tr><td colspan="3">Measurement location: X=0781121, Y= 9839061
Bisate school</td><td colspan="3"></td></tr>
<tr><td colspan="2">Start time: 2:06 pm</td><td>End time: 2:16 pm</td><td colspan="3">Steady source</td></tr>
<tr><td colspan="3">Weather: Normal atmosphere</td><td colspan="2">Sound source</td><td>dB</td></tr>
<tr><td colspan="2">dB</td><td>Special report (No of Traffic)</td><td colspan="2">Fluctuation source</td><td></td></tr>
<tr><td>L max</td><td>84.4</td><td rowspan="9">Car:
Track:
Bus:
Machine:
Bike:
Bicycle:</td><td>Sound source</td><td>Frequency Level</td><td>Max dB</td></tr>
<tr><td>L 5</td><td>66.8</td><td></td><td></td><td></td></tr>
<tr><td>L 50</td><td>56.8</td><td>Children playing football</td><td>H</td><td>68.5</td></tr>
<tr><td>L 95</td><td>51.2</td><td></td><td></td><td></td></tr>
<tr><td>L eq</td><td>61.4</td><td></td><td></td><td></td></tr>
<tr><td>L 10</td><td>64.7</td><td></td><td></td><td></td></tr>
<tr><td>L 90</td><td>51.9</td><td></td><td></td><td></td></tr>
<tr><td>LE</td><td>89.2</td><td></td><td></td><td></td></tr>
<tr><td colspan="3"></td><td></td><td></td><td></td></tr>
</table>

Related pictures



Date: 05/06/2014			**Researcher: Emmanuel MANIRAFASHA**		
Measurement location: X=0781422, Y= 9839407 ADEPR Bisate church					
Start time: 2:52 pm	**End time: 3:02 pm**		**Steady source**		
Weather: Medium wind			**Sound source**		**dB**
dB		**Special report (No of Traffic)**	**Fluctuation source**		
L max	80.1	Car: 1	**Sound source**	**Frequency Level**	**Max dB**
L 5	71.7	Track:			
L 50	51.3	Bus:	Wind	M	68.6
L 95	44.2	Machine:	Children playing nearby the church	H	67.6
L eq	64.0	Bike:	Airplane	L	71.5
L 10	68.6	Bicycle:	Car (But far from the church)	L	52.2
L 90	45.3		`		
LE	91.7				

Related pictures



<table>
<tr><td colspan="3">Date: 05/06/2014</td><td colspan="3">Researcher: Emmanuel MANIRAFASHA</td></tr>
<tr><td colspan="3">Measurement location: X=0780989, Y= 9838959
Traffic (Bisate centre)</td><td colspan="3"></td></tr>
<tr><td colspan="2">Start time:3:36 pm</td><td>End time: 3:46pm</td><td colspan="3">Steady source</td></tr>
<tr><td colspan="3">Weather: Normal atmosphere</td><td colspan="2">Sound source</td><td>dB</td></tr>
<tr><td colspan="2">dB</td><td>Special report (No of Traffic)</td><td colspan="2">Fluctuation source</td><td></td></tr>
<tr><td>L max</td><td>89.9</td><td rowspan="8">Car:
Track: 1
Bus: 1
Machine:
Bike: 1
Bicycle:</td><td>Sound source</td><td>Frequency Level</td><td>Max dB</td></tr>
<tr><td>L 5</td><td>74.6</td><td></td><td></td><td></td></tr>
<tr><td>L 50</td><td>64.5</td><td>Track</td><td>L</td><td>89.6</td></tr>
<tr><td>L 95</td><td>58.8</td><td>Radio</td><td>L</td><td>81.4</td></tr>
<tr><td>L eq</td><td>70.1</td><td>Caw</td><td>L</td><td>70.7</td></tr>
<tr><td>L 10</td><td>72.1</td><td>Bike</td><td>L</td><td>77.6</td></tr>
<tr><td>L 90</td><td>59.7</td><td>Bus</td><td>L</td><td>88.7</td></tr>
<tr><td>LE</td><td>97.9</td><td>Population motion</td><td>M</td><td>63.0</td></tr>
<tr><td colspan="3"></td><td></td><td></td><td></td></tr>
</table>

4.5.7. H2S from Spring

There are no significant sources of H2S gas emissions (such as active volcanoes and fumaroles) or terrestrial heat in Rwanda

We measured H2S volumes at the hot springs in Gisenyi and Bugarama, and gushing water in Kinigi (Rubindi Spring, Cyabararika Spring) by using a portable H2S measurement machine (Picture 4.5-10).

Photo 4-5.10 Gastec (GV-100S)

The results were all ND (non-detected: <0.01ppm).

The following pictures illustrate haw measurements have were taken. We took each measurement two or three suction times. Each measurement took about 1.5-2 minutes.

Photo 4-5.11 Bugarama hot spring

Photo 4-5.12 Gisenyi hot spring

Rubindi spring Cyabararika spring

Photo 4-5.13 Kinigi springs

4.6. Basic Scoping

4.6.1. Geothermal Energy and Related Environmental Problems

Geothermal energy is a renewable and indigenous resource that functions independently of weather and climate change, effective for on and off grid developments and for the provision of base-load power. Compared to fossil fuels, it is environmentally friendly and is not affected by oil price fluctuations. However, geothermal utilization is not completely without some environmentally adverse impact.

Some environmental problems arise during plant construction and operation. Geothermal fluids (steam or hot water) usually contain gases such as carbon dioxide (CO2), hydrogen sulfide (H2S), ammonia (NH3), methane (CH4), and trace amounts of other gases, as well as dissolved

chemicals whose concentrations usually increase with temperature. For example, sodium chloride (NaCl), boron (B), arsenic (As) and mercury (Hg) are a source of pollution if discharged into the environment. The wastewater from geothermal plants also has a higher temperature than the environment and therefore constitutes a potential thermal pollutant.

4.6.2. Basic Scoping for the Project Areas

To consider the items to be addressed in the initial environmental studies, basic scoping was carried out for project areas where development plans and land requirements have been made clear to some extent. The basic scoping was based on the assumption that the projects would involve the construction geothermal power plants and the installation of transmission lines to accompany the plants, and rather extended ranges were defined as potentially affected areas. The results are shown in Table 4-6.1 to Table 4-6.4.

Table 4-6.1(1) Basic scoping for Bugarama areas

Item			Evaluation: construction	Evaluation: operation	Reason
Pollution Control	Air Quality	H2S	B-	A-	**During construction:** Production test conducted for reservoir evaluation may invoke no condensable gas emission containing H2S, which will temporarily affect the surrounding areas. This case is the same as other geothermal sites. **During plant operation:** Since steam from the geothermal fluid origin which contains H2S will be used to generate electricity, H2S will be emitted with the steam through the cooling tower to the atmosphere, which will affect the living and natural environment. Monitoring will be required in order to know the quantity which will be generated by the plant.
		Dust	B-	D	**During construction:** Vehicles transporting equipment and materials during construction will cause dirt and dust clouds. Site clearing, road rehabilitation and rig installation might also cause dust emission. But the affected area will be limited. **During plant operation:** Because of little traffic activity during this phase, it is not expected to cause any affects. However, if there is a plan to make unpaved road to be paved, it is rated to"B +" as effect of dust is reduced.
	Water Quality		A-	A-	**During construction:** Muddy water, generated from the drilling activity, will affect the surrounding water environment even the hot spring lake. The surface soil runoff from bare field due to rainfall, will affect the generation of turbid water such as the river. The effluent from the project facilities such as camp site may adversely affect the surrounding water environment. **During plant operation:** As geothermal fluid will be extracted from deep underground and separated thermal brine will be re-injected back to the deep underground, the impact is not expected. The effluent from the power plant may adversely affect the downstream water environment. The estimated result will be "B-" or "A-" based on relative position between the affected object and the power plant (To be determined rater)
	Wastes		A-	A-	**During construction:** Some impact may occur during well drilling. Waste steams produced during construction will primarily be of non-hazardous forms. **During plan operation:** The effluent from the power plant may adversely affect the surrounding environment. Potential hazardous waste materials produced across the project may include oils and solvents, chemicals used during drilling, contaminated ground, used batteries etc.
	Soil Contamination		D	D	It does not use materials which may cause the soil pollution, the impact is not expected. As geothermal fluid extracted from deep underground and hot water will be returned to the deep underground, the impact is not expected.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.1(2) Basic scoping for Bugarama areas

Item		Evaluation		Reason
		construction	operation	
Pollution Control	Noise and Vibration	A-	A-	**During construction:** It is expected that Potential noise impacts associated with a range of construction activities, particularly during and as a result of piling, drilling, excavation works and site vehicle movements. During the construction of the Project sites, large plant items will need to be transported via road networks (Bugarama road). However, such noise and vibration is only temporary, and thus deems to have only a minor impact on the environment. **During plant operation:** Noise and vibration will be generated from the cooling towers, steam turbines, generators and other such equipment, which will affect the private residence and the environment near the power plant. Noise and vibration impacts during the operational phase will arise due to continuous drilling activities, which will be followed by well testing. Transport impacts during operation are likely to be limited to movements of worker movements.
	Ground Subsidence	C	C	**During construction:** Since production of the geothermal fluid from deep underground is limited to a short term, the impact is not expected. Thus rated as (D). If the plan is to use underground water as drilling fluid, it could cause field subsidence surrounding production zone. However the consequence is hardly predictable, thus the degree of impact by project implementation is identified as ”C” **During plant operation:** Since geothermal fluid will be produced for long term, ground subsidence is forecasted in the neighborhood of the power plant. The degree of impact by project implementation is unidentified. Though in case underground water to be used for the power plant operation, ground subsidence may occur in vicinity of the water pumping region. But the degree of impact by project implementation is unidentified.
	Odor	B-	B-	**During construction:** It is assumed a possibility of unpleasant or foul odors of H2S generation during the well-production tests which may temporarily affect the surrounding areas. Also, emissions associated with construction site plant and equipment as these often use diesel which leads to the emission of particulate matter (PM10) and oxides of nitrogen (NOx). **During plant operation:** Emissions from drilling and well testing will include hydrogen sulfide. Emissions to air have the potential to cause human health and ecological impacts.
	Sediment	D	D	The work which affects the sediment is not expected.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.1(3) Basic scoping for Bugarama areas

Item		Evaluation: construction	Evaluation: operation	Reason
Natural Environment	Protected areas Ecosystem Biodiversity	B-	B-	**During construction:** Potential adverse impacts on terrestrial ecology and biodiversity of the project footprint through habitat loss and disturbance during construction phase. It is also expected to cause temporary impacts on the biodiversity due to noise, vibration and dust caused by work, air pollution and emission of odor material (H2S) during production test, and polluted water disposal from drilling activity and altered bare land. **During plant operation:** In power plant operation, noise and vibration, air pollution, offensive odor H2S) and drainage will affect on the natural environment. The existence of transmission line facilities may have some impact on birds, and may cause disruption of the ecosystem. Water abstraction and materials transport to and from the Project may also cause Potential adverse impacts on local ecology and biodiversity.
	Groundwater	C	C	The degree of impact by project implementation is unidentified. When the groundwater is not pumped up, the impact is not expected. The impact on groundwater is identified "D".
	Lakes and rivers	B-	B-	**During construction:** In Bugarama area, only hot spring lake and Rubyiro River are only two water source appear in the area. When there is no significant earth work which change in the structure and Hydrology of lake and river, the impact is not expected. The impact on lakes and rivers is identified "D". **During plant operation:** Impact will depend on location of power plant and method of water supplies. If it will approach the spring and the river, the impact will be “B-“ otherwise it will be “D”.
	Topography and Geographical Features	B-	D	**During construction:** It is anticipated that drilling activity, power plant and transmission line tower construction work may cause some topographical impacts on land. This is the same case as on other sites. **During plant operation:** It is expected to cause no change in topography and geographical features, thus to cause no impact.
	Soil Erosion	B-	D	**During construction:** The bare field and its surrounds formed during drilling activity, power plant and transmission line tower site development or access road construction & rehabilitation and all project facilities may cause soil erosion due to rainfall. **During plant operation:** There is no significant earth work, thus the impact on the soil erosion is not expected.
	Landscape	B-	B-	Depending on the power plant and transmission line location, facilities or access road may have significant impacts on the natural landscape of the area and/or that viewed from the viewpoints. White smoke (water vapor from the geothermal wells and the power plant, may cause impacts on the natural landscape of the area. The same case as on other sites.
	Global Warning	D	A+	**During construction:** Activities of vehicles transporting equipment and materials during construction will exhaust a little greenhouse gas, thus the effect will be temporary and limited. **During plant operation:** Emission of small amount of CO2 contained in non-condensable gas with geothermal effluent is limited. Positive effects will be expected, as replacement of the fossil fuel will lead to reduction in greenhouse gas generation, and geothermal power generation involves lower greenhouse

				gas emissions compared with other types of steam-power generation.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.1(4) Basic scoping for Bugarama area

Item		Evaluation		Reason
		construction	operation	
Social Environment	Involuntary Resettlement and land acquisition	B-	B-	Depending on the location of power plant site and geothermal wells, it is expected that the involuntary resettlement may occur and land should be acquired for the Project. After identification of project sites, RAP should be prepared.
	People below the poverty line	C	C	These need further investigation through socio economic census after identification of site and confirmation of related facilities location. This census will carry out the income generating by households to be affected by the project then special consideration might be applied.
	Ethnic Minorities and Indigenous Peoples	C	C	This also should carry out by the above study. In this case, orphans, widows, people living below poverty line, elders and disabled peoples need to have particular consideration to them during implementation of the project.
	Local Economy as Employment, Livelihoods, etc.	A+	B+	**During construction:** Increase in employment opportunity created by construction work is expected to bring positive effects. We suggest that job opportunity should be prior to local people especially minorities. **During plant operation:** Increase in employment opportunity required for the operation and maintenance of the power plant is expected to bring positive effects. Capacity building and trainings should be given to local peoples in order to know how to use plant facilities.
	Land Use and Utilization of Local Resources	B-	B-	Utilization of land and local sources for construction and operation of power plant and transmission line, will affect on existing land use and local resources.
	Social capital and Local Social Institutions that make Decisions	C	C	At the current stage, the degree of impact by project implementation is unidentified.
	Existing Social Infrastructure and Services	C	B+	**During construction:** Damage of roads due to transporting equipment and materials during construction, is expected. Normally, the Bugarama road using in cement transportation from CIMERWA and supplying in different area of Rwanda. At the current stage, the degree of impact is unidentified. **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents, local government offices, schools, health facilities and agriculture industry. As to contribution to the local agriculture, electric power supply to the irrigation pump and thermal energy supply using geothermal for drying crop is a positive factor for agriculture.
	Disproportionate distribution of benefits and damage	C	C	In general, construction of power plant will be likely to render benefits to the society. However, it may cause some negative consequence to certain districts, specific group and/or individuals. It is necessary to confirm the degree of impact in the planned project area and surrounding areas.

	Conflicts of interest within the area	C	C	In general, when the project is carried out in a limited area, a possible consequence may emerge in such a way that opposite groups will cause a conflict regarding the implementation of project. It is necessary to study whether there is possibility of conflicts in terms of the plant construction in the planned project area and surrounding areas.
	Culture Heritage	C	C	At the current stage, the degree of the impact caused by the project implementation is not clear. It is necessary to study presence of possible cultural heritage and their positions, and conduct the (EIA) environmental impact assessment for them.
	Sanitation	C	D	**During construction:** Missing or shortage of sanitary facilities or lack of their capacity may cause temporary deterioration of the public health. At the current stage, the degree of impact is unidentified.
	Dangers Infectious Diseases like HIV / AIDS	C	C	During construction and operation phase, many outside construction workers will be engaged, which may arouse risk for infection or spread of HIV/ADS. At the current stage, the degree of impact by project implementation is unidentified.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.1(5) Basic scoping for Bugarama area

Item		Evaluation		Reason
		construction	operation	
Other	Accidents	C	C	**During construction:** It could cause traffic accidents due to the increase in the traffic during construction. Probability of accidents caused by leakage of H2Sgas and spouting of the geothermal fluid under exploration and construction is low, but cannot be denied. **During plant operation:** Probability of accidents caused by leakage of H2Sgas in operation is low, but can not be denied.
	Access roads	B-	B-	It depends on where the site and other infrastructures will be located but Bugarama road up to hot spring is well rehabilitated. If the location of facilities will need to create new roads, ground soil may erode during rainfall. Transmission lines may also involve soil erosion. Land alterations and the removal of plants involved in the construction of access roads may affect the environment.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.2(1) Basic scoping for Gisenyi area

Item			Evaluation		Reason
			construction	operation	
Pollution Control	Air Quality	H2S	B-	A-	**During construction:** Production test conducted for reservoir evaluation may invoke non condensable gas emission containing H2S, which will temporarily affect the surrounding areas. **During plant operation:** Since steam from the geothermal fluid origin which contains H2S will be used to generate electricity, H2S will be emitted with the steam through the cooling tower to the atmosphere, which will affect the living and natural environment. Monitoring will be required in order to know the quantity which will be generated by the plant.
		Dust	B-	D	**During construction:** Vehicles transporting equipment and materials during construction will cause dirt and dust clouds, but the affected area will be limited. **During plant operation:** Because of little traffic activity during this phase, it is not expected to cause any affects.
	Water Quality		A-	A-	**During construction:** Muddy water, generated from the drilling activity, will affect the surrounding water environment including water body in Kivu Lake. The surface soil runoff from bare field due to rainfall, will affect the generation of turbid water such as the river. The effluent from the camp site may adversely affect the surrounding water environment. This impact will also depend on location of project components such as drilling site, camp site… **During plant operation:** As geothermal fluid will be extracted from deep underground and separated thermal brine will be re-injected back to the deep underground, the impact is not expected. The effluent from the power plant may negatively affect Kivu Lake and other downstream in the region.
	Wastes		A-	A-	**During construction:** Some impact may occur during well drilling and construction of related infrastructures (Road, campsite, water storage tanks and preparation of water intake in Kivu Lake) **During plan operation:** The effluent from the power plant may adversely affect the Surrounding environment.
	Soil Contamination		D	D	It does not use materials which may cause the soil pollution, the impact is not expected. As geothermal fluid extracted from deep underground and hot water will be returned to the deep underground, the impact is not expected.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.2(2) Basic scoping for Gisenyi area

Item		Evaluation		Reason
		construction	operation	
Pollution Control	Noise and Vibration	A-	A-	**During construction:** It is expected that noise will be emitted during drilling, production test, construction work noise; vibration and noise from construction machineries and trucks will be present emitted from the construction infrastructures include road, site clearing, rig installation etc. However, such noise and vibration is only temporary, and thus deems to have only a minor impact on the environment. During construction noise and vibration will be generated from vehicles transporting equipment and materials will temporarily affect on the environment near the transportation route. **During plant operation:** Noise and vibration will be generated from the cooling towers, steam turbines, generators, workers noise and other such equipment, which will affect the private residence and the environment near the power plant.
	Ground Subsidence	C	C	**During construction:** Since production of the geothermal fluid from deep underground is limited to a short term, the impact is not expected. Thus rated as “D”. If the plan is to use underground water as drilling fluid, it could cause field subsidence surrounding production zone. However the consequence is hardly predictable, thus the degree of impact by project implementation is identified as ”C” **During plant operation:** Since geothermal fluid will be produced for long term, ground subsidence is forecasted in the neighborhood of the power plant. The degree of impact by project implementation is unidentified. Though in case underground water to be used for the power plant operation, ground subsidence may occur in vicinity of the water pumping region. But the degree of impact by project implementation is unidentified.
	Odor	B-	B-	**During construction:** It is assumed a possibility of unpleasant or foul odors of H2S generation during the well-production tests which may temporarily affect the surrounding areas. **During plant operation:** It is assumed a possibility of unpleasant or foul odors of H2S generation during the operating phase which may affect the surrounding areas. Settlement is very concentrate in project area because of Gisenyi city is under growing toward the project zone. Further investigation on odor pollution might be conducted.
	Sediment	C	C	At the current stage, the degree of impact by project implementation is unidentified.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.2(3) Basic scoping for Gisenyi area

Item		Evaluation		Reason
		construction	operation	
Natural Environment	Protected areas Ecosystem Biodiversity	C	C	At the current stage, the degree of impact by project implementation is unidentified.
	Groundwater	C	C	The degree of impact by project implementation is unidentified. When the groundwater is not pumped up, the impact is not expected. The impact on groundwater is identified "D".
	Lakes and rivers	A-	A-	**During construction:** In Gisenyi area, the water for drilling will be pumped up from Kivu Lake; some impact may be occurred during drilling. This will depend on location of site. When it will approach, the impact will be "A-" otherwise the impact will be "D" **During plant operation:** The operation of power plant may affect the environment of Kivu lake. When the plant will be far from Kivu, the impact might became "D"
	Topography and Geographical Features	A-	D	**During construction:** It is anticipated that drilling activity, power plant and transmission line tower construction work may cause some topographical impacts on land. This impact might also caused by the topography of the region. Gisenyi area is very hilly zone. **During plant operation:** It is expected to cause no change in topography and geographical features, thus to cause no impact.
	Soil Erosion	B-	D	**During construction:** The bare field and its surrounds formed during drilling activity, power plant and transmission line tower site development or access road construction may cause soil erosion due to rainfall. **During plant operation:** There is no significant earth work, thus the impact on the soil erosion is not expected.
	Landscape	B-	B-	Depending on the power plant and transmission line location, facilities or access road may have significant impacts on the natural landscape of the area and/or that viewed from the viewpoints. White smoke (water vapor from the geothermal wells and the power plant, may cause impacts on the natural landscape of the area.
	Global Warning	D	A+	**During construction:** Activities of vehicles transporting equipment and materials during construction will exhaust a little greenhouse gas, thus the effect will be temporary and limited. **During plant operation:** Emission of small amount of CO2 contained in non-condensable gas with geothermal effluent is limited. Positive effects will be expected, as replacement of the fossil fuel will lead to reduction in greenhouse gas generation,

				and geothermal power generation involves lower greenhouse gas emissions compared with other types of steam-power generation.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.2(4) Basic scoping for Gisenyi area

Item		Evaluation		Reason
		construction	operation	
Social Environment	Involuntary Resettlement	A-	B-	Depending on the location of power plant site and geothermal wells, it is expected that the involuntary resettlement may occur. In the Gisenyi area, settlement is now growing toward the project vicinities and we know that the area is not far from Rubavu City. This may cause a high number of household relocation.
	People below the poverty line	C	C	Except to conduct a special census in the project zone in order to get this information. Further investigation is required.
	Ethnic Minorities and Indigenous Peoples	B-	D	People might be relocated by the project and living below poverty line, households headed by women, orphans. These groups should be identified by census to be conducted in the project zone after identification of site location and special and particular consideration should be given to them.
	Local Economy as Employment, Livelihoods, etc.	A+	B+	**During construction:** Increase in employment opportunity created by construction work is expected to bring positive effects. Note that employment opportunity prior should be given to local people especially those who lose their assets because of project implementation. **During plant operation:** Increase in employment opportunity required for the operation and maintenance of the power plant is expected to bring positive effects. Training and capacity building should be given to local people in order to be familiar and know to use operation plant facilities.
	Land Use and Utilization of Local Resources	B-	B-	Utilization of land and local sources for construction and operation of power plant and transmission line, will affect on existing land use and local resources.
	Social capital and Local Social Institutions that make Decisions	C	C	At the current stage, the degree of impact by project implementation is unidentified.
	Existing Social Infrastructure and Services	C	B+	**During construction:** Damage of roads due to transporting equipment and materials during construction, is expected. At the current stage, the degree of impact is unidentified. Also roads should be constructed depending on the location of site. This is positive impact "A+" **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents, health centres, schools and agriculture industry. As to contribution to the local agriculture, electric power supply to the irrigation pump (Government priority) and thermal energy supply using geothermal for drying crop is a positive factor for agriculture.
	Disproportionate distribution of benefits and damage	C	C	In general, construction of power plant will be likely to render benefits to the society. However, it may cause some negative consequence to certain districts, specific group and/or individuals. It is necessary to confirm the degree of impact in the planned project area and surrounding areas.

	Conflicts of interest within the area	C	C	In general, when the project is carried out in a limited area, a possible consequence may emerge in such a way that opposite groups will cause a conflict regarding the implementation of project. It is necessary to study whether there is possibility of conflicts in terms of the plant Construction in the planned project area and surrounding areas.
	Culture Heritage	-	-	At the current stage, the degree of the impact caused by the project implementation is not clear. It is necessary to study presence of possible cultural heritage and their positions, and conduct the environmental impact assessment for them.
	Sanitation	C	D	**During construction:** Missing or shortage of sanitary facilities or lack of their capacity may cause temporary deterioration of the public health. At the current stage, the degree of impact is unidentified.
	Dangers Infectious Diseases like HIV / AIDS	C	C	During construction and operation phase, many outside construction workers will be engaged, which may arouse risk for infection or spread of HIV/ADS. At the current stage, the degree of impact by project implementation is unidentified.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.2(5) Basic scoping for Gisenyi area

Item		Evaluation		Reason
		construction	operation	
Other	Accidents	C	C	**During construction:** It could cause traffic accidents due to the increase in the traffic during construction. Probability of accidents caused by leakage of H2Sgas and spouting of the geothermal fluid under exploration and construction is low, but can not be denied. **During plant operation:** Probability of accidents caused by leakage of H2Sgas in operation is low, but can not be denied.
	Access roads	B-	B-	Exposed ground will be created with the construction of the access roads, and the ground soil may erode during rainfall. Transmission lines may also involve soil erosion. Land alterations and the removal of plants involved in the construction of access roads may affect the environment. The presence of access roads may impact the distribution of animals and their habitats.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.3(1) Basic scoping for Karisimbi and Kinigi area

Item			Evaluation: Construction	Evaluation: Operation	Reason
Pollution Control	Air Quality	H2S	B-	A-	**During construction:** Production test conducted for reservoir evaluation may invoke noncondensable gas emission containing H2S,which will temporarily affect the surrounding areas. **During plant operation:** Since steam from the geothermal fluid origin which contains H2S will be used to generate electricity, H2S will be emitted with the steam through the cooling tower to the atmosphere, which will affect the living and natural environment.
		Dust	B-	D	**During construction:** Vehicles transporting equipment and materials during construction will cause dirt and dust clouds, but the affected area will be limited. **During plant operation:** Because of little traffic activity during this phase, it is not expected to cause any affects. However, if there is a plan to make unpaved road to be paved, it is rated to"B +" as effect of dust is reduced.
	Water Quality		A-	A-	**During construction:** Muddy water, generated from the drilling activity, will affect the surrounding water environment. The surface soil runoff from bare field due to rainfall, will affect the generation of turbid water such as the river. The effluent from the camp site may adversely affect the surrounding water environment. **During plant operation:** As geothermal fluid will be extracted from deep underground and separated thermal brine will be re-injected back to the deep underground, the impact is not expected. The effluent from the power plant may adversely affect the downstream water environment. The estimated result will be "B-" or "A-" based on relative position between the affected object and the power plant.
	Wastes		A-	A-	**During construction:** Some impact may occur during well drilling. **During plant operation:** The effluent from the power plant may adversely affect the surrounding environment.
	Soil Contamination		D	D	It does not use materials which may cause the soil pollution, the impact is not expected. As geothermal fluid extracted from deep underground and hot water will be returned to the deep underground, the impact is not expected.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.3(2) Basic scoping for Karisimbi and Kinigi area

Item		Evaluation: Construction	Evaluation: Operation	Reason
Pollution Control	Noise and Vibration	A-	A-	**During construction:** It is expected that noise will be emitted during drilling and production test, and construction work noise and vibration will be present emitted from the construction equipment. However, such noise and vibration is only temporary, and thus deems to have only a minor impact on the environment. During construction noise and vibration will be generated from vehicles transporting equipment and materials will temporarily affect on the environment near the transportation route. In this case it may be rated as "B-". However, if private homes are present near the route, it will be rated as "A-". **During plant operation:** Noise and vibration will be generated from the cooling towers, steam turbines, generators and other such equipment, which will affect the private residence and the environment near the power plant. project area becomes the near Volcanoes National Park. It is important to carry out the consideration for the effect in the park of mountain gorillas, etc. on precious organism and ecosystem. At the current stage, the degree of impact is unidentified "C". It is necessary to rerate impact level based on the information of the further monitoring result.
	Ground Subsidence	C	C	**During construction:** Since production of the geothermal fluid from deep underground is limited to a short term, the impact is not expected. Thus rated as (D). If the plan is to use underground water as drilling fluid, it could cause field subsidence surrounding production zone. However the consequence is hardly predictable, thus the degree of impact by project implementation is identified as "C". **During plant operation:** Since geothermal fluid will be produced for long term, ground subsidence is forecasted in the neighborhood of the power plant. The degree of impact by project implementation is unidentified. Though in case underground water to be used for the power plant operation, ground subsidence may occur in vicinity of the water pumping region. But the degree of impact by project implementation is unidentified.
	Odor	B-	B-	**During construction:** It is assumed a possibility of unpleasant or foul odors of H2S generation during the well-production tests which may temporarily affect the surrounding areas.. **During plant operation:** It is assumed a possibility of unpleasant or foul odors of H2S generation during the operating phase which may affect the surrounding areas.
	Sediment	D	D	The work which affect the sediment, is not expected.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.3(3) Basic scoping for Karisimbi and Kinigi area

Item		Evaluation: Construction	Evaluation: Operation	Reason
Natural Environment	Protected areas Ecosystem Biodiversity	A-	A-	**During construction:** During the construction phase it is expected to cause temporary impacts on the flora due to noise, vibration and dust caused by work, noise, vibration, air pollution and emission of odor material(H2S) during production test, and polluted water disposal from drilling activity and altered bare land. Some locations may have impacts on removal of plants, distribution and habitat environment of the animals and the important plant species and their communities. At the current stage, the degree of impact is identified as "C". **During plant operation:** In power plant operation, noise and vibration, air pollution, offensive odor（H2S) and drainage will affect on the natural environment. At the current stage, the degree of impact is identified as "C". The existence of transmission line facilities may have some impact on birds, and may cause disruption of the ecosystem. **Kinigi and Karisimbi** project area becomes the near Volcanoes National Park. It is important to carry out the consideration for the effect in the park of mountain gorillas, etc. on precious organism and ecosystem. At the current stage, the degree of impact is unidentified(C). It is necessary to rerate impact level based on the information of the further monitoring result.
	Groundwater	C	C	The degree of impact by project implementation is unidentified. When the groundwater is not pumped up, the impact is not expected. The impact on groundwater is identified "D".
	Lakes and rivers	B-	D	**During construction:** In Karisimbi area, the water for drilling is pumped up from lake, some impact may be occurred during drilling. When there is no significant earth work which change in the structure and Hydrology of lake and river, the impact is not expected. The impact on lakes and rivers is identified "D". **During plant operation:** There is no significant earth work which change in the structure and Hydrology of lake and river, the impact is not expected.
	Topography and Geographical Features	B-	D	**During construction:** It is anticipated that drilling activity, power plant and transmission line tower construction work may cause some topographical impacts on land. **During plant operation:** It is expected to cause no change in topography and geographical features, thus to cause no impact.
	Soil Erosion	B-	D	**During construction:** The bare field and its surrounds formed during drilling activity, power plant and transmission line tower site development or access road construction may cause soil erosion due to rainfall. **During plant operation:** There is no significant earth work, thus the impact on the soil erosion is not expected.
	Landscape	B-	B-	Depending on the power plant and transmission line location, facilities or access road may have significant impacts on the natural landscape of the area and/or that viewed from the viewpoints. White smoke (water vapor） from the geothermal wells and the power plant, may cause impacts on the natural landscape of the area.
	Global Warning	D	A+	**During construction:** Activities of vehicles transporting equipment and materials during construction will exhaust a little greenhouse gas, thus the effect will be temporary and limited. **During plant operation:** Emission of small amount of CO2 contained in non-condensable gas with geothermal effluent is limited. Positive effects will be expected, as replacement of the fossil fuel will lead to reduction in greenhouse gas generation, and geothermal power generation involves lower greenhouse gas emissions compared with other types of steam-power generation.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.3(4) Basic scoping for Karisimbi and Kinigi area

	Item	Evaluation: Construction	Evaluation: Operation	Reason
Social Environment	Involuntary Resettlement	B-	B-	Depending on the location of power plant site and geothermal wells, it is expected that the involuntary resettlement may occur.In the Kinigi area, in particular, houses are spread over an extensive area, and measures need to be studied so that any impact would be minimized.
	People below the poverty line	D	D	In the plan area, no settlements of impoverished people who need particular consideration have been identified.
	Ethnic Minorities and Indigenous Peoples	D	D	In the plan area, no settlements of ethnic minorities and indigenous peoples who need particular consideration have been identified.
	Local Economy as Employment, Livelihoods, etc.	B+	B+	**During construction:** Increase in employment opportunity created by construction work is expected to bring positive effects. **During plant operation:** Increase in employment opportunity required for the operation and maintenance of the power plant is expected to bring positive effects.
	Land Use and Utilization of Local Resources	B-	B-	Utilization of land and local sources for construction and operation of power plant and transmission line, will affect on existing land use and local resources.
	Social capital and Local Social Institutions that make Decisions	C	C	At the current stage, the degree of impact by project implementation is unidentified.
	Existing Social Infrastructure and Services	C	B+	**During construction:** Damage of roads due to transporting equipment and materials during construction, is expected. At the current stage, the degree of impact is unidentified. **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents and agriculture industry. As to contribution to the local agriculture, electric power supply to the irrigation pump and thermal energy supply using geothermal for drying crop is a positive factor for agriculture.
	Disproportionate distribution of benefits and damage	C	C	In general, construction of power plant will be likely to render benefits to the society. However, it may cause some negative consequence to certain districts, specific group and/or individuals. It is necessary to confirm the degree of impact in the planned project area and surrounding areas.
	Conflicts of interest within the area	C	C	In general, when the project is carried out in a limited area, a possible consequence may emerge in such a way that opposite groups will cause a conflict regarding the implementation of project. It is necessary to study whether there is possibility of conflicts in terms of the plant construction in the planned project area and surrounding areas.
	Culture Heritage	-	-	At the current stage, the degree of the impact caused by the project implementation is not clear. It is necessary to study presence of possible cultural heritage and their positions, and conduct the environmental impact assessment for them.
	Sanitation	C	D	**During construction:** Missing or shortage of sanitary facilities or lack of their capacity may cause temporary deterioration of the public health. At the current stage, the degree of impact is unidentified.
	Dangers Infectious Diseases like HIV / AIDS	C	C	During construction and operation phase, many outside construction workers will be engaged, which may arouse risk for infection or spread of HIV/ADS. At the current stage, the degree of impact by project implementation is unidentified.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.3(5) Basic scoping for Karisimbi and Kinigi area

Item		Evaluation: Construction	Evaluation: Operation	Reason
Other	Accidents	C	C	**During construction:** It could cause traffic accidents due to the increase in the traffic during construction. Probability of accidents caused by leakage of H2Sgas and spouting of the geothermal fluid under exploration and construction is low, but can not be denied. **During plant operation:** Probability of accidents caused by leakage of H2Sgas in operation is low, but can not be denied.
	Access roads	B-	B-	Exposed ground will be created with the construction of the access roads, and the ground soil may erode during rainfall. Transmission lines may also involve soil erosion. Land alterations and the removal of plants involved in the construction of access roads may affect the environment. The presence of access roads may impact the distribution of animals and their habitats.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.4(1) Basic scoping for Karago area

Item			Evaluation: construction	Evaluation: operation	Reason
Pollution Control	Air Quality	H2S	B-	A-	**During construction:** Production test conducted for reservoir evaluation may invoke no condensable gas emission containing H2S,which will temporarily affect the surrounding areas. **During plant operation:** Since steam from the geothermal fluid origin which contains H2S will be used to generate electricity, H2S will be emitted with the steam through the cooling tower to the atmosphere, which will affect the living and natural environment. (As above)
		Dust	A-	D	**During construction:** Vehicles transporting equipment and materials during construction will cause dirt and dust clouds, but road creation is the main issue to generate dust because the Karago hot spring is not accessible anywhere by road except to go with feet. **During plant operation:** Because of little traffic activity during this phase, it is not expected to cause any affects. The impact will be low
	Water Quality		A-	A-	**During construction:** Muddy water, generated from the drilling activity, will affect the surrounding water environment (Bihinga, Boma, Karago Lakes and Nyamukongoro river). The surface soil runoff from bare field due to rainfall, will affect the generation of turbid water such as the river. The effluent from the camp site and other site facilities may adversely affect the surrounding water environment. **During plant operation:** As geothermal fluid will be extracted from deep underground and separated thermal brine will be re-injected back to the deep underground, the impact is not expected. The effluent from the power plant may adversely affect the downstream water environment. The estimated result will be "B-" or "A-" based on relative position between the affected object and the power plant.
	Wastes		A-	A-	**During construction:** Some impact may occur during well drilling as usually **During plan operation:** The effluent from the power plant may adversely affect the surrounding environment.
	Soil Contamination		D	D	It does not use materials which may cause the soil pollution, the impact is not expected. As geothermal fluid extracted from deep underground and hot water will be returned to the deep underground, the impact is not expected.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.4(2) Basic scoping for Karago area

Item		Evaluation		Reason
		construction	operation	
Pollution Control	Noise and Vibration	B-	B-	**During construction:** It is expected that noise will be emitted during drilling and production test, and construction work noise and vibration will be present emitted from the construction equipment. However, such noise and vibration is only temporary, and thus deems to have only a minor impact on the environment. During construction noise and vibration will be generated from vehicles transporting equipment, machineries and materials will temporarily affect on the environment near the transportation route. Machineries and truck during construction of road connecting main road and project site may generate noise **During plant operation:** Noise and vibration will be generated from the cooling towers, steam turbines, generators and other such equipment, which will affect the private residence and the environment near the power plant. No protected or sensitive area found during this survey.
	Odor	B-	B-	**During construction:** It is assumed a possibility of unpleasant or foul odors of H2S generation during the well-production tests which may temporarily affect the surrounding areas. But the advantage here is that the region is not high settled. **During plant operation:** It is assumed a possibility of unpleasant or foul odors of H2S generation during the operating phase which may affect the surrounding areas.
	Sediment	C	D	In the past, Karago lake met with sediment but now the lake is protected by planting trees on buffer of the lake. This was done by Ministry of Natural resources. We don't think if this project might cause any additional sediment.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.4(3) Basic scoping for Karago area

Item		Evaluation		Reason
		construction	operation	
Natural Environment	Protected areas Ecosystem Biodiversity	A-	B-	**During construction:** During the construction phase it is expected to cause temporary impacts on the flora due to noise, vibration and dust caused by work, noise, vibration, air pollution and emission of odor material(H2S) during production test, and polluted water disposal from drilling activity and altered bare land. Some locations may have impacts on removal of plants, distribution and habitat environment of the animals and the important plant species and their communities. At the current stage, the degree of impact is identified as "C". Normally, in Karago area, no protected site found except only lakes. It is not authorized to develop any project within 50 m from lake and 20 m from river except if developer has authorization from Minister in charge of environment. So this project should be developed out of the above buffer. **During plant operation:** In power plant operation, noise and vibration, air pollution, offensive odor (H2S) and drainage will affect on the natural environment. At the current stage, the degree of impact is identified as "C". The existence of transmission line facilities may have some impact on birds, and may cause disruption of the ecosystem.
	Groundwater	B-	B-	**During construction**: Potential temporary or permanent changes to surface water flow and drainage patterns during project construction **During plant operation**: Potential temporary or permanent changes to surface water flow and drainage patterns during project operation if not managed.
	Lakes and rivers	A-	D	**During construction:** In Karago area, three lakes found named Bihinga, Boma and Karago and the river of Nyamukongoro is found. The water for drilling should be taken in one of mentioned lakes and some impact may be occurred during drilling. This will depend on location of site. When there is no significant earth work which change in the structure and Hydrology of lake and river, the impact is not expected. The impact on lakes and rivers is identified "D". **During plant operation:** There is no significant earth work which change in the structure and Hydrology of lake and river, the impact is not expected.
	Topography and Geographical Features	A-	D	**During construction:** Karago area is very hilly region. This means that construction works of drilling infrastructures, power plant and transmission line tower may cause some topographical impacts on land. **During plant operation:** It is expected to cause no change in topography and geographical features, thus to cause no impact.
	Soil Erosion	A-	D	**During construction:** Actually, Karago area is now affected by soil erosion because of its topography of hills. To mitigate this issue, Nyabihu District takes decision of terracing hills in order to reduce this erosion sometimes cause lakes sediments. The implementation of this project may also cause erosion by construction of drilling facilities, power plant and transmission line tower and access road construction which is not exist currently. **During plant operation:** There is no significant earth work, thus the impact on the soil erosion is not expected.
	Landscape	B-	B-	Depending on the power plant and transmission line location, facilities or access road may have significant impacts on the natural landscape of the area and/or that viewed from the viewpoints. White smoke (water vapor from the geothermal wells and the power plant, may cause impacts on the natural landscape of the area.

	Global Warning	D	A+	**During construction:** Activities of vehicles transporting equipment and materials during construction will exhaust a little greenhouse gas, thus the effect will be temporary and limited. **During plant operation:** Emission of small amount of CO2 contained in non-condensable gas with geothermal effluent is limited. Positive effects will be expected, as replacement of the fossil fuel will lead to reduction in greenhouse gas generation, and geothermal power generation involves lower greenhouse gas emissions compared with other types of steam-power generation.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.4(4) Basic scoping for Karago area

	Item	Evaluation: construction	Evaluation: operation	Reason
Social Environment	Involuntary Resettlement	A-	B-	Depending on the location of power plant site and geothermal wells, it is expected that the involuntary resettlement and land acquisition may occur. Additional to this, number of people to be affected might increase because of land along the road to be created. The Karago zone is very hill and now some area are identified the District as high risk zone. This means that settlement is very low.
	People below the poverty line	C	C	Except to conduct a zone census through socio economic study, now is not easy to identify this group of people. This census should be conducted after site identification in order to determine the study area.
	Ethnic Minorities and Indigenous Peoples	C	C	This group of people should be carried out by the socio economic census. We will identify widow, orphans, elders, disabled people and people living with HIV/AIDS to be affected by the project. Particular consideration might be applied to them.
	Local Economy as Employment, Livelihoods, etc.	A+	B+	**During construction:** Increase in employment opportunity created by construction work is expected to bring positive effects. Priority should be done to local people especially the minorities groups which will be identified by socio economic census. **During plant operation:** Increase in employment opportunity required for the operation and maintenance of the power plant is expected to bring positive effects. Training to local people in order to know how to use and maintenance of plant facilities should be required.
	Land Use and Utilization of Local Resources	B-	B-	Utilization of land and local sources for construction and operation of power plant and transmission line, will affect on existing land use and local resources.
	Social capital and Local Social Institutions that make Decisions	C	C	At the current stage, the degree of impact by project implementation is unidentified.
	Existing Social Infrastructure and Services	B+	B+	**During construction:** Damage of roads due to transporting equipment and materials during construction, is expected. New road should be constructed from the road Mukamira-Muhanga to the site; the degree of impact is identified as "A+". **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents, health facilities, schools and agriculture industry. As to contribution to the local agriculture, electric power supply to the irrigation pump and thermal energy supply using geothermal for drying crop is a positive factor for agriculture.
	Disproportionate distribution of benefits and damage	C	C	In general, construction of power plant will be likely to render benefits to the society. However, it may cause some negative consequence to certain districts, specific group and/or individuals. It is necessary to confirm the degree of impact in the planned project area and surrounding areas.

	Conflicts of interest within the area	C	C	In general, when the project is carried out in a limited area, a possible consequence may emerge in such a way that opposite groups will cause a conflict regarding the implementation of project. It is necessary to study whether there is possibility of conflicts in terms of the plant construction in the planned project area and surrounding areas.
	Culture Heritage	-	-	At the current stage, the degree of the impact caused by the project implementation is not clear. It is necessary to study presence of possible cultural heritage and their positions, and conduct the environmental impact assessment for them.
	Sanitation	C	D	**During construction:** Missing or shortage of sanitary facilities or lack of their capacity may cause temporary deterioration of the public health. At the current stage, the degree of impact is unidentified.
	Dangers Infectious Diseases like HIV / AIDS	C	C	During construction and operation phase, many outside construction workers will be engaged, which may arouse risk for infection or spread of HIV/ADS. At the current stage, the degree of impact by project implementation is unidentified.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.4(5) Basic scoping for Karago area

Item		Evaluation		Reason
		construction	operation	
Other	Accidents	C	C	**During construction:** It could cause traffic accidents due to the increase in the traffic during construction. Probability of accidents caused by leakage of H2Sgas and spouting of the geothermal fluid under exploration and construction is low, but can not be denied. **During plant operation:** Probability of accidents caused by leakage of H2Sgas in operation is low, but can not be denied.
	Access roads	A-	B-	The Karago site is not accessible. From the existing road, its takes 2 hours go and back by feet. Here road should be created and the degree of impact is identified as "A+" but the ground soil may erode during rainfall. Transmission lines may also involve soil erosion. Land alterations and the removal of plants involved in the construction of access roads may affect the environment.

A+/-: Significant positive/negative impact is expected./negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: The degree of impact is unidentified, and future investigation for clarification is needed.
D: As the impact will be minimal, future investigation is unnecessary.

Table 4-6.5 Impact comparison among geothermal areas in Rwanda

Item			Karisimbi			Kinigi			Bugarama			Gisenyi			Karago		
			Evaluation		Reason	Evaluation		Reason	Evaluation		Reason	Evaluation		Reason	Evaluation		Reason
			Construction	Operation		Construction	Operation		Construction	Operation		Construction	Operation		Construction	Operation	
Pollution Control	Air Quality	H2S	B-	A-	**During construction:** Production test conducted for reservoir evaluation may invoke no condensable gas emission containing H2S. **During plant operation:** Since steam from the geothermal fluid origin which contains H2S will be used to generate electricity, H2S will be emitted with the steam through the cooling tower to the atmosphere, which will affect the living and natural environment. Especially attention should be paid for Gollilas and other biodiversity living in Volcano National Park (In 400m from Karisimbi site)	B-	A-	**During construction:** Production test conducted for reservoir evaluation may invoke no condensable gas emission containing H2S. **During plant operation:** Since steam from the geothermal fluid origin which contains H2S will be used to generate electricity, H2S will be emitted with the steam through the cooling tower to the atmosphere, which will affect the living and natural environment. Especially attention should be paid for Gollilas and other biodiversity living in Volcano National Park (About 1Km from Kinigi site)	B-	A-	**During construction:** Generally, production test may invoke emissions containing H2S. In vicinities of Bugarama site, we don't found any protected area and the region is not concentrate in settlement **During plant operation:** Normally, geothermal fluid contains H2S and this will contaminate atmosphere and surrounding area.	B-	A-	**During construction:** As mentioned for previous sites, H2S should also emit during test production. **During plant operation:** Operation will emit H2S from steam. Area to be affected includes a part of Gisenyi city (Critical), Bralirwa and Lake Kivu water body.	B-	A-	**During construction:** H2S will be invoked but in vicinities of the area is not full populated **During plant operation:** The same as previous sites, H2S will be generated by steam from geothermal fluid
		Dust	B-	D	**During construction:** Dust will be generated by construction activities. Road is well rehabilitated and most of equipment is still installed (Ware tanks, water pipeline and 3 sites are already cleaned) **During plant operation:** Trucks traffic	B-	D	**During construction:** Dust will be generated by construction activities (Road rehabilitation, site clearing and materials installation) **During plant operation:** Trucks traffic and rig removal after drilling activities	B-	D	**During construction**: Dust will be emitted by construction activities. **During plant operation:** Trucks traffic and removal of equipment after drilling	B-	D	**During construction**: Dust will be generated by construction activities **During plant operation**: Trucks traffic and equipment removal after drilling	A-	D	**During construction:** Dust will be generated by construction activities. No road exists to this site. This means that dust will be generated during road creation comparing to other sites **During plant operation**: Trucks traffic and removal of materials after drilling

	Water Quality	A-	A-	**During construction**: Muddy water, generated from the drilling activity, soil runoff from bare field due to rainfall and effluent from the camp site may adversely affect the surrounding water environment. No river or natural water spring found nearby Karisimbi site. **During plant operation**: The effluent from the power plant may adversely affect the downstream water environment.	A-	A-	**During construction:** Muddy water, generated from the drilling activity, soil runoff from bare field due to rainfall and effluent from the camp site may adversely affect the surrounding water environment. **During plant operation:** The effluent from the power plant may adversely affect the downstream water environment.	A-	A-	**During construction**: Rubyiro and Hot spring Lake might be affected by muddy water, soil runoff during construction phase. **During plant operation**: Rubyiro river is the main source of water uses in irrigation of Bugarama rise valley. Bad management of effluents from power plant should affect water and the valley in general	A-	A-	**During construction**: Kivu Lake may be affected by stated effluents **During plant operation**: Degree of effluent to be affected Kivu lake will depend on location of power plant. If it will far from Kivu lake, the impact will be classified as "B-"	A-	A-	**During construction**: Sewage stated in previous sites may also affecting water environment in Karago area. **During plant operation**: Waste water from power plant may affect Bihinga, Boma and Karago lakes and the river of Nyamukongoro which are found in the zone
	Wastes	A-	A-	**During construction:** Some impact may occur during well drilling but for Karisimbi most of activities are carried out by last drilling. **During plant operation:** Drilling muds, oily contaminated materials, Lubricating and auxiliary oils, paper and plastics may be resulted as waste during operation	A-	A-	**During construction**: Some impact may occur during well drilling but for Karisimbi most of activities are carried out by last drilling. **During plant operation**: Drilling muds, oily contaminated materials, Lubricating and auxiliary oils, paper and plastics may be resulted as waste during operation.	A-	A-	**During construction**: Some impact may occur during well drilling but for Karisimbi most of activities are carried out by last drilling. **During plant operation**: Drilling muds, oily contaminated materials, Lubricating and auxiliary oils, paper and plastics may be resulted as waste during operation	A-	A-	**During construction**: Some impact may occur during well drilling but for Karisimbi most of activities are carried out by last drilling. **During plant operation**: Drilling muds, oily contaminated materials, Lubricating and auxiliary oils, paper and plastics may be resulted as waste during operation. This case is the same for all sites but for Gisenyi, drilling should be far from Lake Kivu in order to reduce Lake contamination.	A-	A-	**During construction**: Some impact may occur during well drilling but for Karisimbi most of activities are carried out by last drilling. **During plant operation:** Drilling muds, oily contaminated materials, Lubricating and auxiliary oils, paper and plastics may be resulted as waste during operation
	Sediment	D	D	This impact is not expected	D	D	This impact is not expected	D	D	This impact is not expected	C	C	At the current stage, the degree of impact by project implementation is unidentified.	C	D	In Karago area, three lakes found named Bihinga, Boma and Karago and the river of Nyamukongoro is found. The water for drilling should be taken in one of mentioned lakes and some impact may be occurred during drilling. This will depend on location of site.

	Noise and Vibration	A-	A-	**During construction:** It is expected that noise will be emitted during drilling, production test and construction work noise and vibration will be present emitted from the construction equipment. **During plant operation:** Noise and vibration will be generated from the cooling towers, steam turbines, generators and other such equipment, which will affect the private residence and the environment near the power plant. Project area becomes the near Volcanoes National Park. It is important to carry out the consideration for the effect in the park of mountain gorillas, and other biodiversity on precious organism and ecosystem. Currently, the impact is unidentified "C".	A-	A-	**During construction:** It is expected that noise will be emitted during drilling; production test and construction work noise and vibration will be present emitted from the construction equipment. **During plant operation:** Noise and vibration will be generated from the cooling towers, steam turbines, generators and other such equipment, which will affect the private residence and the environment near the power plant. Project area becomes the near Volcanoes National Park. It is important to carry out the consideration for the effect in the park of mountain gorillas, and other biodiversity on precious organism and ecosystem. Currently, the impact is unidentified "C". Comparing with other sites, noise is a critical issue for Karisimbi and Kinigi because of nearby Park	A-	A-	**During construction:** As we mentioned in previous sites, Bugarama also will be affected by noise. **During plant operation:** As we said previously, drilling activities, machineries and generators might generate noise to be affected the surroundings. The project area is not high settled and this should reduce the number of receptors	A-	A-	**During construction**: Construction activities should generate noise and vibration as we said in previous sites. **During plant operation**: The Operation of plant as we said will emit noise and receptors might be high because of settlement concentration in Gisenyi City and the vicinities of the project	B-	B-	Geothermal project generates noise as we said for Karisimbi site (details) but the luck we have for Karago is that the project is not high settled
Odor		B-	B-	Well production tests may generate unpleasant foul or odors of H2S and ammonium. This issue is critical because the site approaching the Park.	B-	B-	Well production tests may generate unpleasant foul or odors of H2S and ammonium. This issue is critical because the site approaching the Park.	B-	B-	Well production tests may generate unpleasant foul or odors of H2S and ammonium. This impact is low and its sensitivity will depend on site location	B-	B-	Well production tests may generate unpleasant foul or odors of H2S and ammonium. This impact is medium because of big number of people living in project vicinities	B-	B-	Well production tests may generate unpleasant foul or odors of H2S and ammonium. This impact is low

Protected areasEcosystemBiodiversity	A-	A-	**During construction:** During the construction phase it is expected to cause temporary impacts on the biodiversity due to noise, vibration and dust caused by work, noise, vibration, air pollution and emission of odor material(H2S) during production test, and polluted water disposal from drilling activity and altered bare land. **During plant operation:** In power plant operation, noise and vibration, air pollution,offensive odor H2S) and drainage will affect on the natural environment. At the current stage, the degree of impact is identified as "C". **Karisimbi** project area becomes the near Volcanoes National Park. It is important to carry out the consideration for the effect in the park of mountain gorillas, etc. on precious organism and ecosystem. At the current stage, the degree of impact is unidentified(C). It is necessary to rerate impact level based on the information of the further monitoring result.	A-	A-	**During construction:** During the construction phase it is expected to cause temporary impacts on the biodiversity due to noise, vibration and dust caused by work, noise, vibration, air pollution and emission of odor material(H2S) during production test, and polluted water disposal from drilling activity and altered bare land. Some locations may have impacts on removal of plants, distribution and habitat environment of the animals and the important plant species and their communities. At the current stage, the degree of impact is identified as "C".**During plant operation:** In power plant operation, noise and vibration, air pollution,offensive odor H2S) and drainage will affect on the natural environment. At the current stage, the degree of impact is identified as "C". **Kinigi** project area becomes the near Volcanoes National Park. It isimportant to carry out the consideration for the effect in the park of mountain gorillas, etc. on precious organism and ecosystem. At the current stage, the degree of impact is unidentified(C). It is necessary to rerate impact level based on the information of the further monitoring result.	B-	B-	**During construction**: No protected area identified "C". As we said previously, noise, odor, vibration, air pollution and emission may affect ecosystem biodiversity **During plant operation**: In power plant operation, noise and vibration, air pollution,offensive odor H2S) and drainage will affect on the natural environment. At the current stage, the degree of impact is identified as "C".	C	C	At the current stage, the degree of impact by project implementation is unidentified.	B-	B-	**During construction**: No protected area identified "C". Preparation of infrastructures sitting, noise, odor, vibration, air pollution and emission may affect ecosystem biodiversity (The impact is about the same for Gisenyi, Bugarama and Karago) **During plant operation:** In power plant operation, noise and vibration, air pollution,offensive odor H2S) and drainage will affect on the natural environment. At the current stage, the degree of impact is identified as "C". (The sane for all sites)
Lakes and rivers	B-	D	**During construction**: In Karisimbi area, the water for drilling is pumped up from Karago lake; some impact may be occurred during drilling. When there is no significant earth work which change in the structure and Hydrology of lake and river, the impact is not expected. The impact on lakes and rivers is identified "D". **During plant operation**: There is no significant earth work which change in the structure and Hydrology of lake and river, the impact is not expected.	B-	D	**During construction**: Kinigi area may use water during drilling from Mpenge river. Some impacts may occur but could be avoided **During plant operation**: There is no significant impact which will change the structure and hydrology of Mpenge river	B-	B-	**During construction:** Bugarama area may use water during drilling from either hot spring lake or Rubyiro river; some impact may be occurred during drilling. When activities will appear bit far from the lake and when there is no significant earth work which change in the structure and Hydrology of lake and river, the impact is not expected. The impact on lakes and rivers is identified "D". **During plant operation:** Impact will depend on location of power plant. If it will be bit far from the lake, the impact will be classified as "D"	A-	A-	**During construction**: When geothermal drilling activities will be approaching the Kivu lake, the impacts may really occur but it activities will be bit far from the lake, the impacts should be minimal "D" **During plant operation**: The same for operation phase, the impact will depend of location of power plant. If also the power plant will be far from Kivu Lake, the impact will be classified as "D"	A-	D	**During construction**: Bihinga, Boma and Karago lakes and Nyamukongoro river are the main sources of water exist in project zone. The location of site will determinate the degree of impact. If activities will approach the lake, the impact may be "A-" otherwise, the impact will be "D" **During plant operation**: There is no significant earth work which change in the structure and hydrology of lakes and river, the impact is not expected.

Topography, soil erosion and Geographical Features	B-	D	**During construction**: It is anticipated that drilling activity, power plant and transmission line tower construction work may cause some topographical impacts on land and soil erosion. **During plant operation**: It is expected to cause no change in topography and geographical features, thus to cause no impact.	B-	D	**During construction:** It is anticipated that drilling activity, power plant and transmission line tower construction work may cause some topographical impacts on land and soil erosion. **During plant operation:** It is expected to cause no change in topography and geographical features, thus to cause no impact.	B-	D	**During construction:** It is anticipated that drilling activity, power plant and transmission line tower construction work may cause some topographical impacts on land and soil erosion. **During plant operation:** It is expected to cause no change in topography and geographical features, thus to cause no impact.	A-	D	**During construction:** It is anticipated that drilling activity, power plant and transmission line tower construction work may cause some impacts on land and soil erosion. It is anticipated that drilling activity, power plant and transmission line tower construction work may cause some topographical impacts on land. Because Gisenyi area is very hilly zone. **During plant operation:** It is expected to cause no change in topography and geographical features, thus to cause no impact.	A-	D	**During construction:** It is anticipated that drilling activity, road construction, power plant and transmission line tower construction work may cause some topographical impacts on land and also Karago is hilly area. **During plant operation:** It is expected to cause no change in topography and geographical features, thus to cause no impact.
Involuntary resettlement and Land acquisition	B-	B-	Karisimbi area is already leased and compensated to the GoR for drilling activities unless the location is changing, but this impact is low to this site. Land restoration will be applied after implementation of this project.	B-	B-	Depending on the location of power plant site and geothermal wells, it is expected that the involuntary resettlement may occur. In the Kinigi area, in particular, houses are spread over an extensive area, and measures need to be studied so that any impact would be minimized.	B-	B-	Land to be acquired here is for drilling sites, water tanks station, road rehabilitation and workers camp site. This impact is unavoidable	A-	B-	Gisenyi area is very settled because is the surroundings of Rubavu city. Here resettlement might cause conflicts during compensation process. RAP is compulsory to be prepared before the kick-off the implementation of any activity	A-	B-	Is not easy to access Karago hot spring site. Road should be created and this will acquire land along the road and the impact might affect lot of people. The reason why this case is classified as "A"
Minorities and Indigenous Peoples	D	D	Different socio economic studies identified Minorities, people living under poverty line and indigenous in Karisimbi.	D	D	Socio economic study and further investigation are needed to carry out those kind of vulnerable group and special consideration should be taken to them during land acquisition and resettlement	C	C	Socio economic study and further investigation are needed to carry out those kind of vulnerable group and special consideration should be taken to them during land acquisition and resettlement.	B-	C	People might be relocated by the project and living below poverty line, households headed by women, orphans. These groups should be identified by census to be conducted in the project zone after identification of site location and special and particular consideration should be given to them.	C	C	Socio economic study and further investigation are needed to carry out those kind of vulnerable group and special consideration should be taken to them during land acquisition and resettlement.
Local Economy as Employment, Livelihoods, etc.	B+	B+	**During construction**: Increase in employment opportunity created by construction work is expected to bring positive effects. **During plant operation**: Increase in employment opportunity required for the operation and maintenance of the power plant is expected to bring positive effects	B+	B+	**During construction:** New job to be created should increase local economy through construction activities. Priorities should be given to local people and special consideration should be taken to minorities, orphans and widows. **During plant operation:** Operation and plant maintenance should also bring additional jobs and training will be needed for local people to make them familiar of the infrastructures	A+	B+	**During construction:** New job to be created should increase local economy through construction activities. Priorities should be given to local people and special consideration should be taken to minorities, orphans and widows. **During plant operation:** Operation and plant maintenance should also bring additional jobs and training will be needed for local people to make them familiar of the infrastructures	A+	B+	**During construction:** New job to be created should increase local economy through construction activities. Priorities should be given to local people and special consideration should be taken to minorities, orphans and widows. **During plant operation:** Operation and plant maintenance should also bring additional jobs and training will be needed for local people to make them familiar of the infrastructures	A+	B+	**During construction:** New job to be created should increase local economy through construction activities. Priorities should be given to local people and special consideration should be taken to minorities, orphans and widows. **During plant operation:** Operation and plant maintenance should also bring additional jobs and training will be needed for local people to make them familiar of the infrastructures

Existing Social Infrastructure and Services	C	B+	**During construction:** Existing roads should be damaged by heavy trucks. New roads will be created "B+" **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents, schools, sanitations and health facilities and agriculture industry.	C	B+	**During construction:** Existing roads should be damaged by heavy trucks. New roads will be created "B+" **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents, schools, sanitation as and health facilities and agriculture industry.	C	B+	**During construction:** Existing roads should be damaged by heavy trucks. New roads will be created "B+" **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents, schools, sanitations and health facilities and agriculture industry.	C	B+	**During construction:** Existing roads should be damaged by heavy trucks. New roads will be created "B+" **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents, schools, sanitations and health facilities and agriculture industry.	B+	B+	**During construction:** New roads should be constructed **During plant operation:** Positive effects can be expected from presence of the power plant and other relevant facilities, such as road construction, its maintenance and management or availability of social services such as electric energy to the local residents, schools, sanitations and health facilities and agriculture industry.

4.7. Assessment Based on Map Data

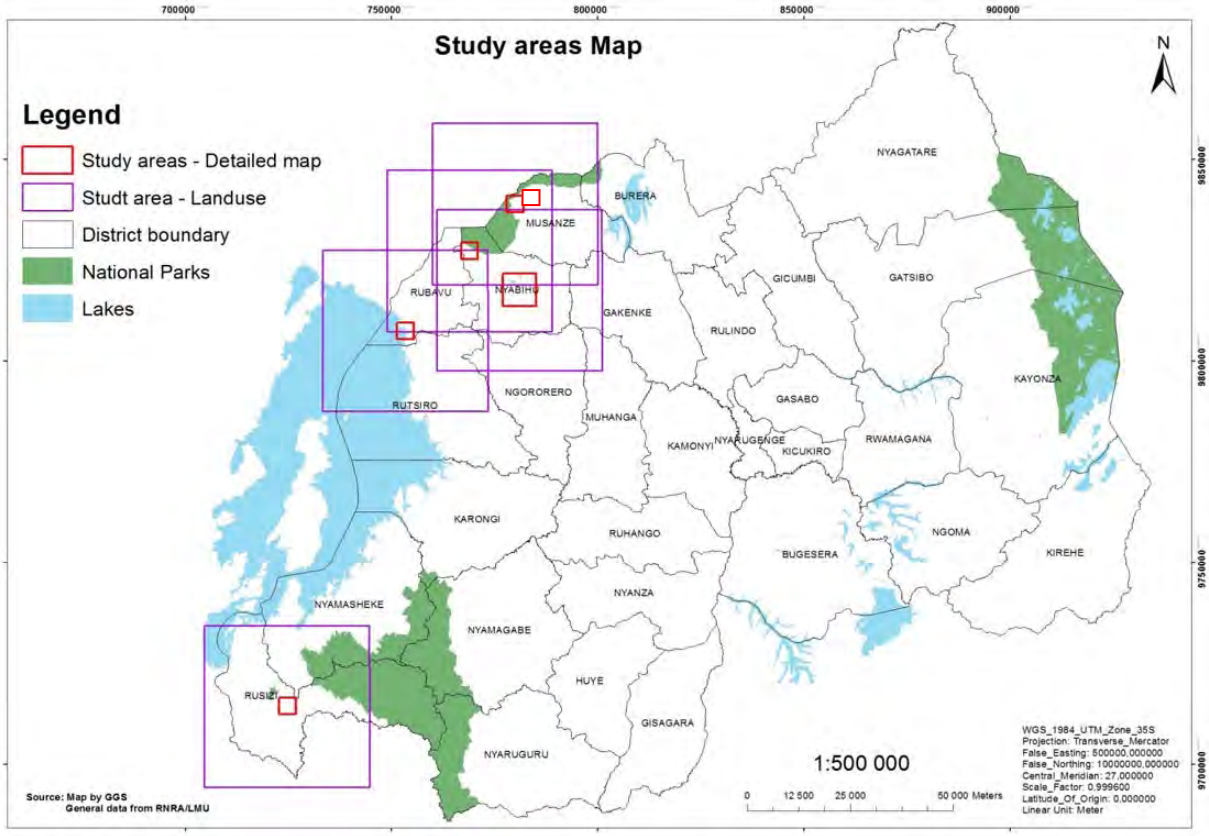


Fig. 4-7.1 Study area map

4.7.1. Bugarama

Located in Bugarama valley around the Mashyuza hot spring, Bugarama geothermal area is situated in Gitambi and Nyakabuye sectors, of Rusizi district. The topography of this area is basically a wide valley, part of the lowest land of the country, navigated by Rubyiro river and medium to small hills on both sides of the wide valley.

The Land use of this area is largely occupied by mixed agriculture of subsistence composed of banana, potatoes, cassava etc. This region also has the irrigated rice agriculture developed within the valley.

Having the biggest travertine quarry of the country, this study area has two travertine processing factories located near the quarry. The same quarry serves the cement factory, which is the biggest cement factory of the country, located within around 3 km from the study area.

A potential area of geothermal development in Bugarama is located on a plateau next to hills. Most of the area consists of bare grounds and the number of settlements is also limited. Social and environmental impacts by geothermal development in this area would be relatively limited if we could avoid settlement areas on hills in the north and rice fields in the south

Table 4-7.1 List of public facilities within Bugarama geothermal area

Designation	LATITUDE	LONGITUDE
Coffee Washing station	723477	9712555
Health Center	723180	9712791
Factory	724785	9713859
School	726151	9715500
Coffee Washing station	726324	9716073
Market	725799	9716319
Trade Center	723888	9715840
Factory	726088	9716168
Factory	725011	9713976
Health Center	726081	9715739
Health Center	725757	9716115
Bank	725720	9716120
Police Station	725803	9716178
Market	725844	9716165
Church	726483	9714394
Dumping site	725824	9716108
School	722929	9712849
Church	722990	9712699

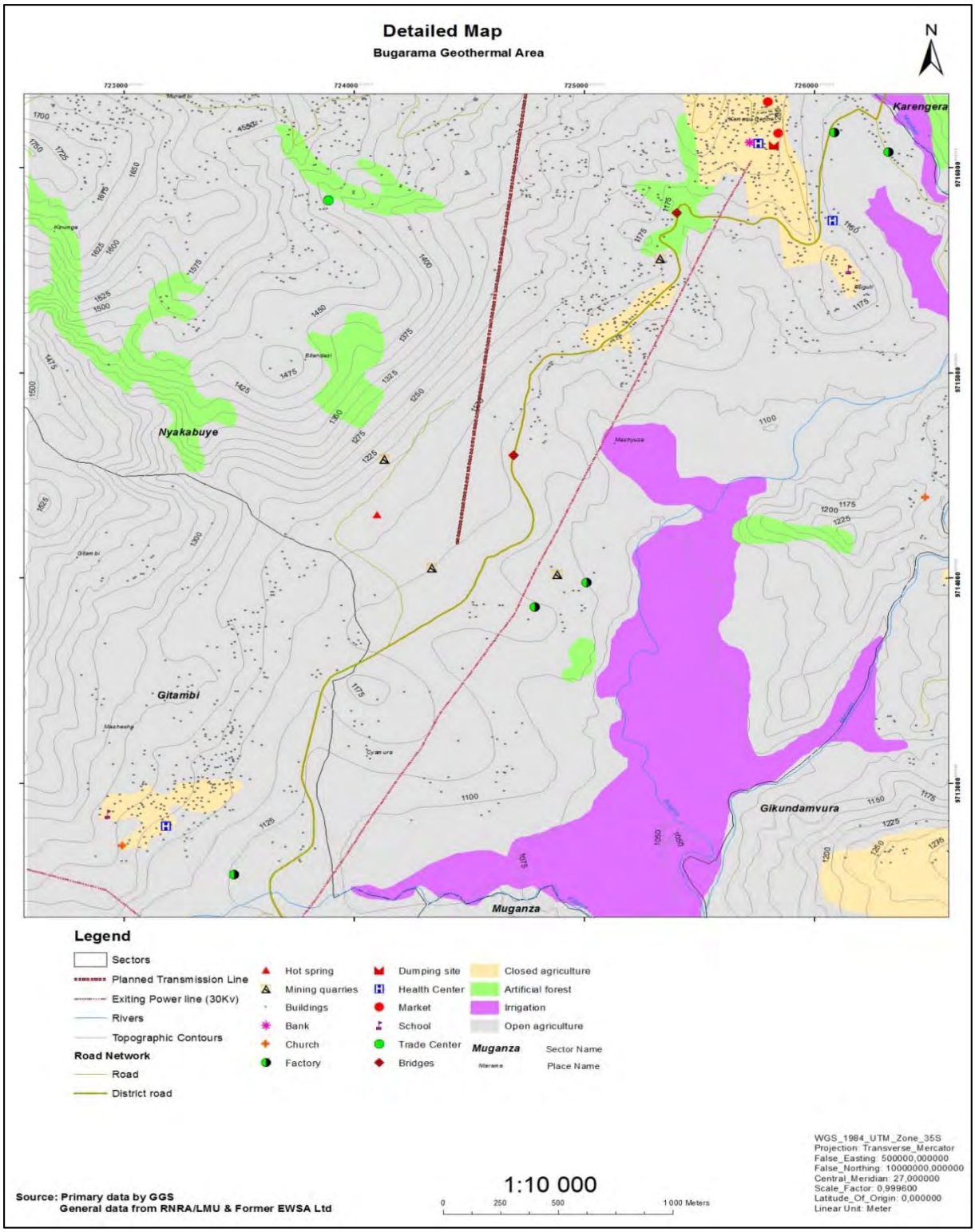


Fig. 4-7.2 Bugarama detailed map

Photo 4-7.1 Area around Bugarama project area

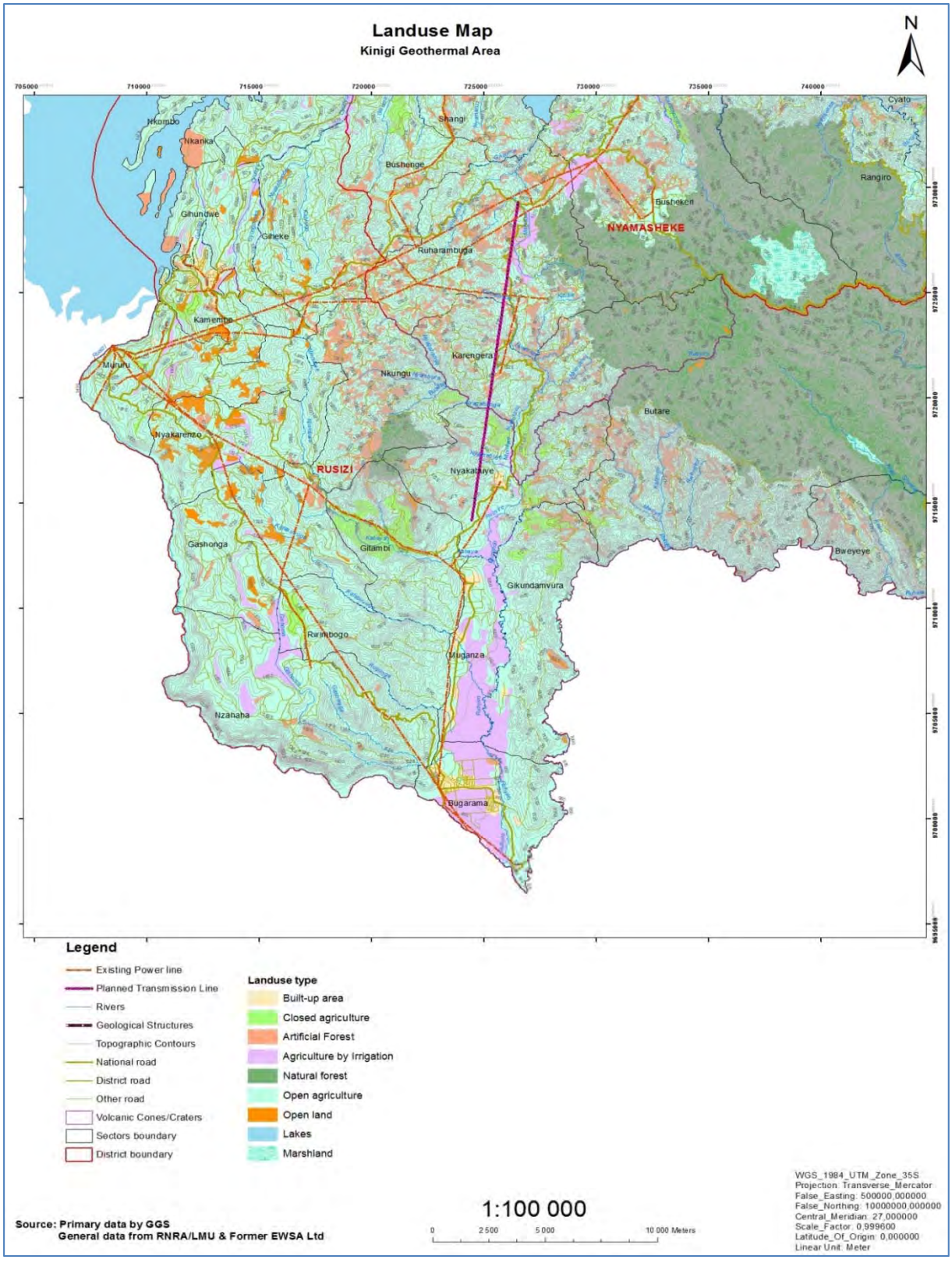


Fig. 4-7.3 Bugarama Land use map

4.7.2. Gisenyi

Gisenyi geothermal area is situated in the neighborhood of the Gisenyi hot spring on the Eastern shore of Lake Kivu. The study area is located in Nyamyumba sector, Rubavu district. Apart from the area occupied by lake water, the Land use in this area is dominated by high mixed agriculture, buildings and few forests. The infrastructure is many based on the tourism activities around the lake.

Table 4-7.2 List of public facilities within Gisenyi geothermal area

Designation	LATITUDE	LONGITUDE
Coffee Washing station	753565	9806739
School	754489	9805629
School	753440	9807587
Health Center	753498	9806304
Coffee Washing station	755302	9807535
Industry	753740	9807987
Church	753975	9809276
School	753848	9809176
School	753987	9809096
Church	752583	9809441
Mosque	753774	9805938
Hotel	753341	9806511
Police Station	753328	9808027
Church	753927	9806729
Church	753096	9808180
Hotel	752906	9808214
Church	752870	9808337
Hotel	752615	9808357
Hotel	752342	9808490
Hotel	752139	9808476
Hotel	751771	9808482
Hotel	752071	9808554
Hotel	751903	9809114
Church	754960	9807620
Trade Center	753587	9808160
School	753612	9807353
Church	753524	9807347
Church	754634	9809461
Scenic Spot	751934	9809198

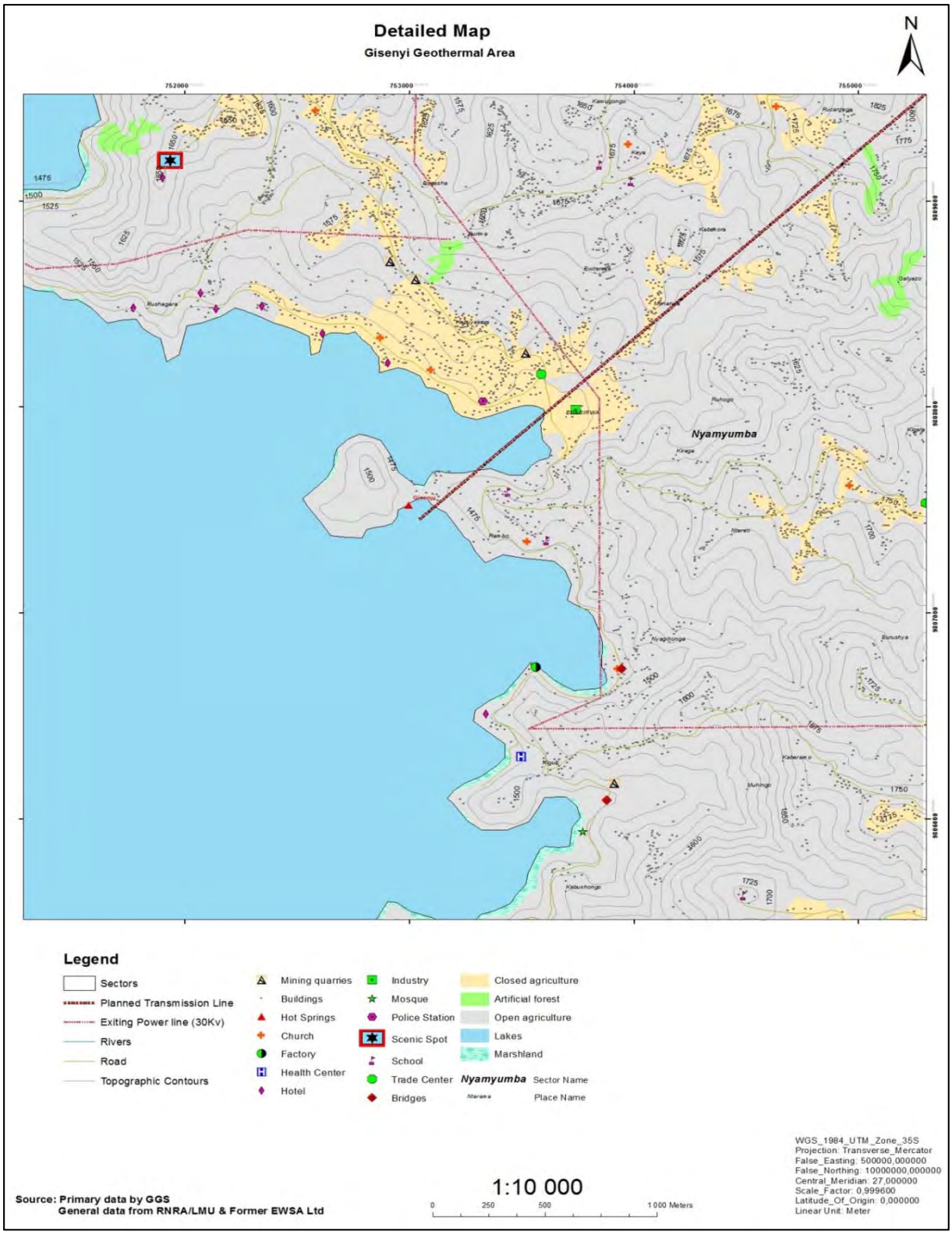


Fig. 4-7.4 Gisenyi detailed map

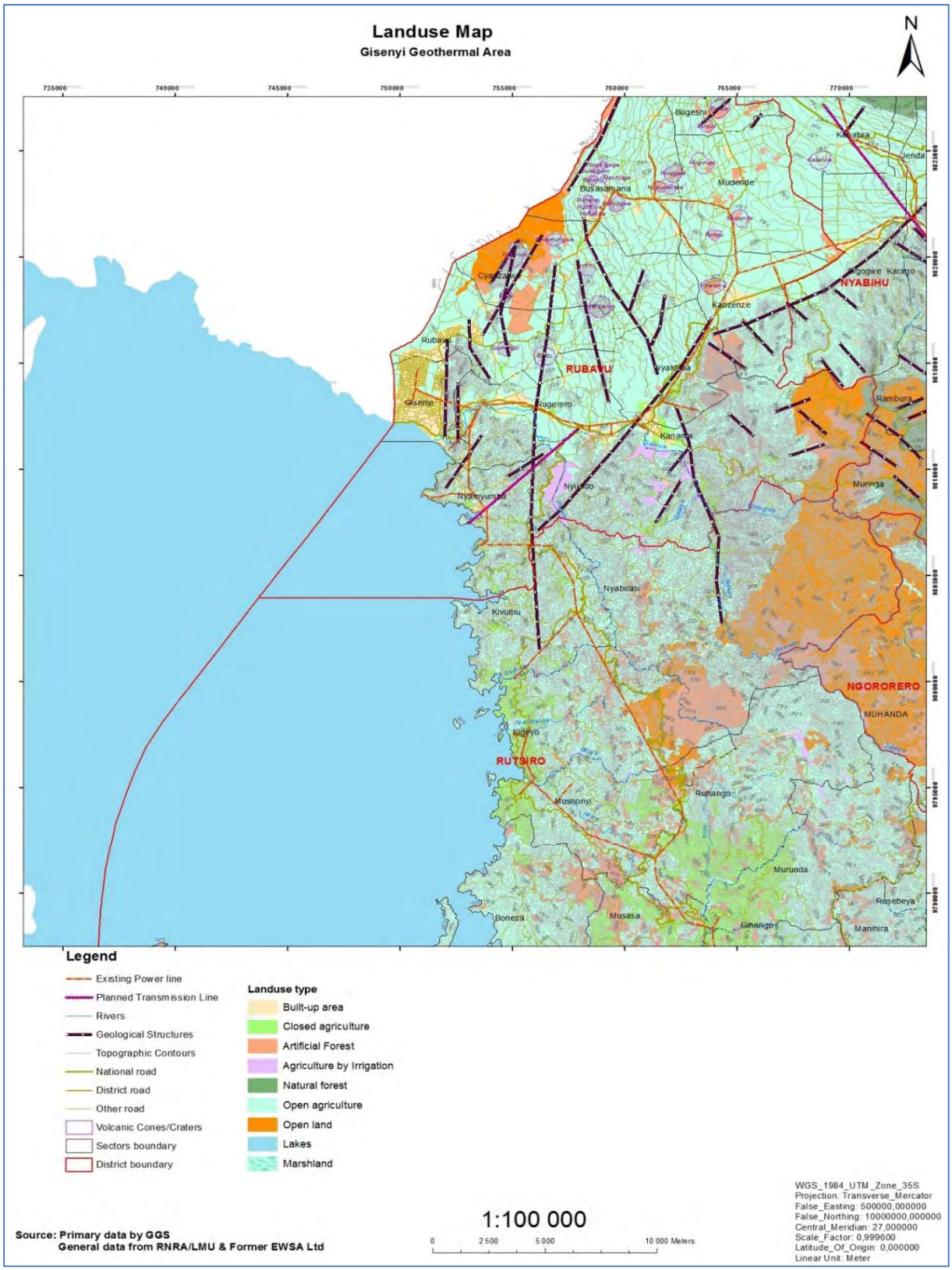


Fig. 4-7.5 Gisenyi Land use map

4.7.3. Karisimbi

Karisimbi geothermal area is located in the proximity of the Volcanoes National Park, on the slope of Karisimbi Volcano. This study area is located mainly in Kabatwa sector, Nyabihu district. The Land use in this area is dominated by agriculture (Irish potatoes and pyrethrum).

This area presents a high elevation ranging to 2,500m to 2,700m (below sea level), with a moderate slope which facilitates the settlements all along the roads.

Table 4-7.3 List of public facilities within Karisimbi geothermal area

Designation	LATITUDE	LONGITUDE
School	769467	9825769
Church	767462	9828473
Church	768011	9828553
Mosque	768745	9826614
Church	768877	9826491
Trade Center	769123	9826318
Trade Center	768479	9826791

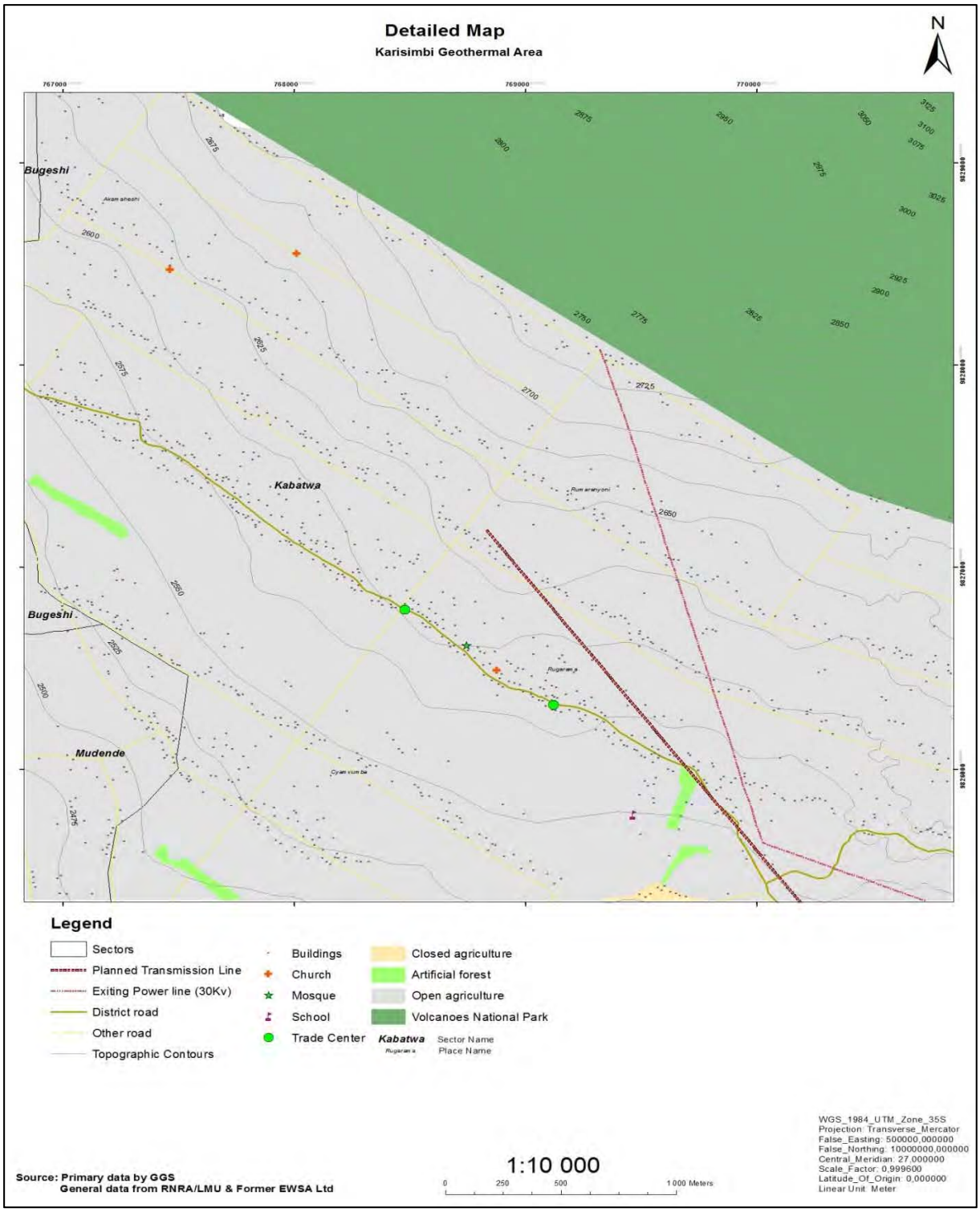


Fig. 4-7.6 Karisimbi detailed map

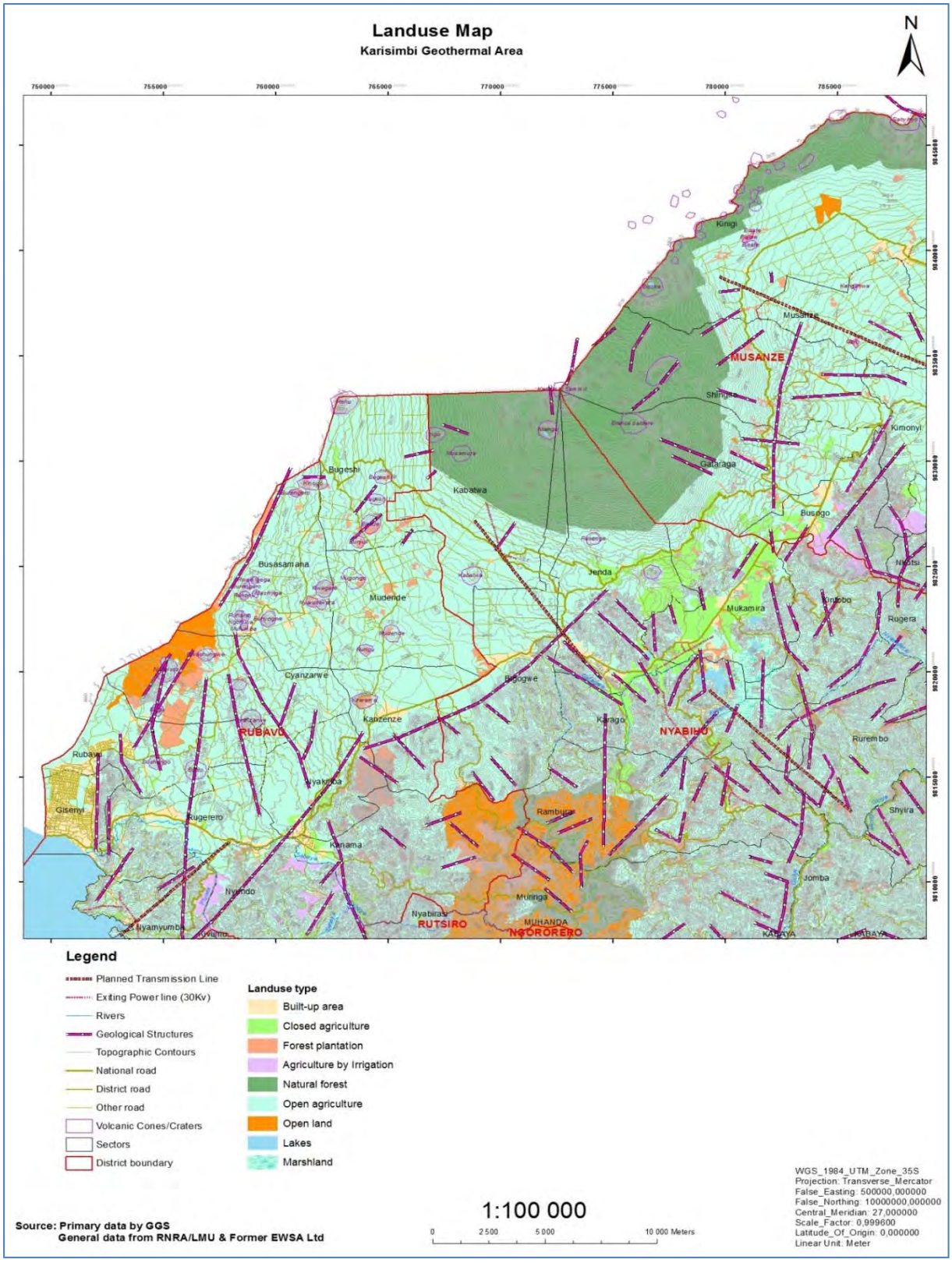


Fig. 4-7.7 Karisimbi Land use map

4.7.4. Kinigi

Kinigi geothermal area is located in the proximity of the Volcanoes National Park, on the slope of Visoke Volcano. This study area is located mainly in Kinigi sector of Musanze district. The Land use in this area is dominated by agriculture (Irish potatoes and pyrethrum).

This area presents a high elevation ranging to 2,400m to 2,600m (below sea level), with a moderate slope with facilitate the settlements all along the roads.

The tourism activities are remarkable in this area as evidenced by high traffic of tourists coming from all corners of the world to visit mountain gorillas. To note is also the existence of a research center (Karisoke) which is devoted to the wellbeing of the gorillas.

Table 4-7.4 List of public facilities within Kinigi geothermal area

Designation	LATITUDE	LONGITUDE
Coffee Washing station	723477	9712555
Health Center	723180	9712791
Factory	724785	9713859
School	726151	9715500
Coffee Washing station	726324	9716073
Market	725799	9716319
Trade Center	723888	9715840
Factory	726088	9716168
Factory	725011	9713976
Health Center	726081	9715739
Health Center	725757	9716115
Bank	725720	9716120
Police Station	725803	9716178
Market	725844	9716165
Church	726483	9714394
Dumping site	725824	9716108
School	722929	9712849
Church	722990	9712699

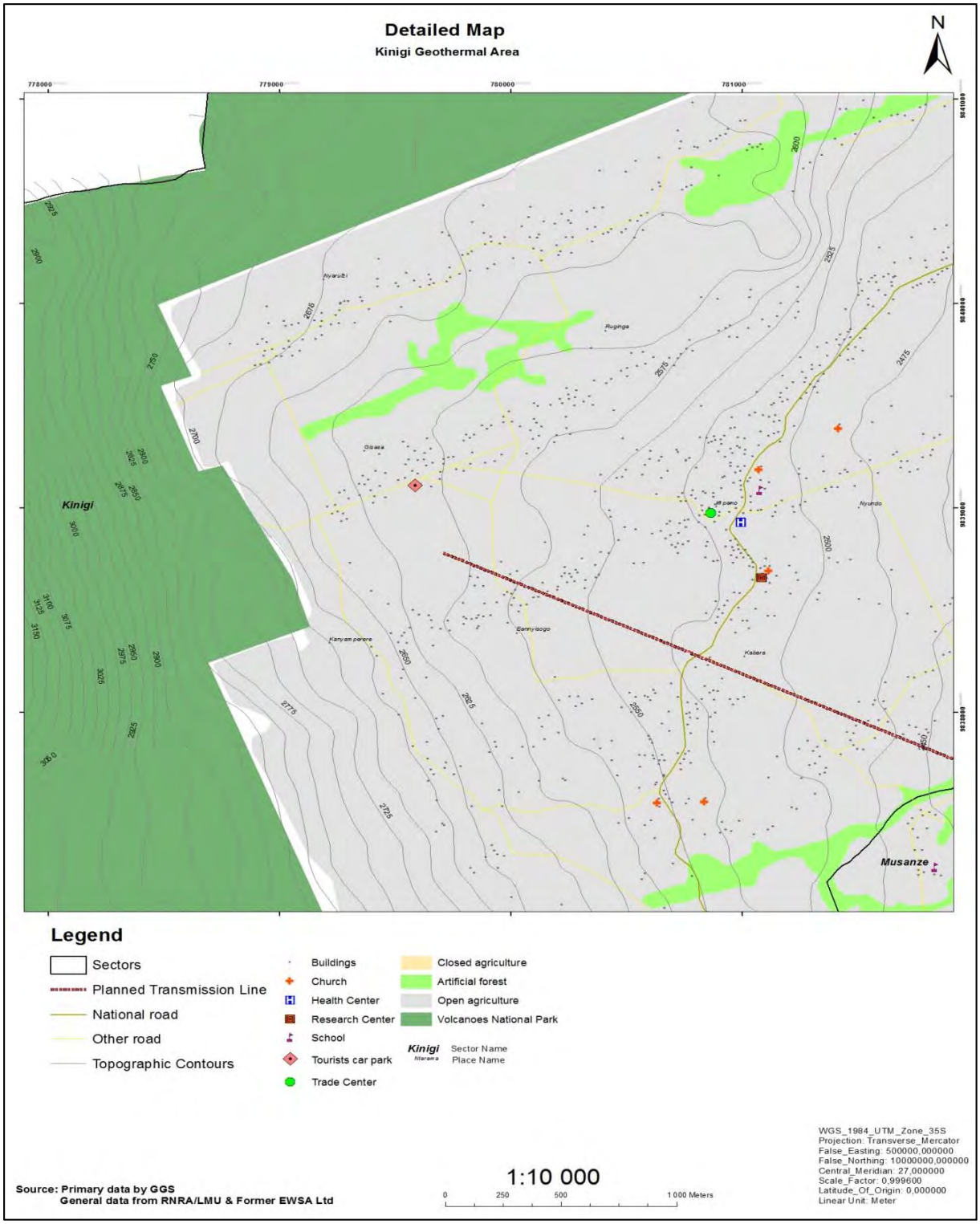


Fig. 4-7.8(1) Kinigi detailed map 1

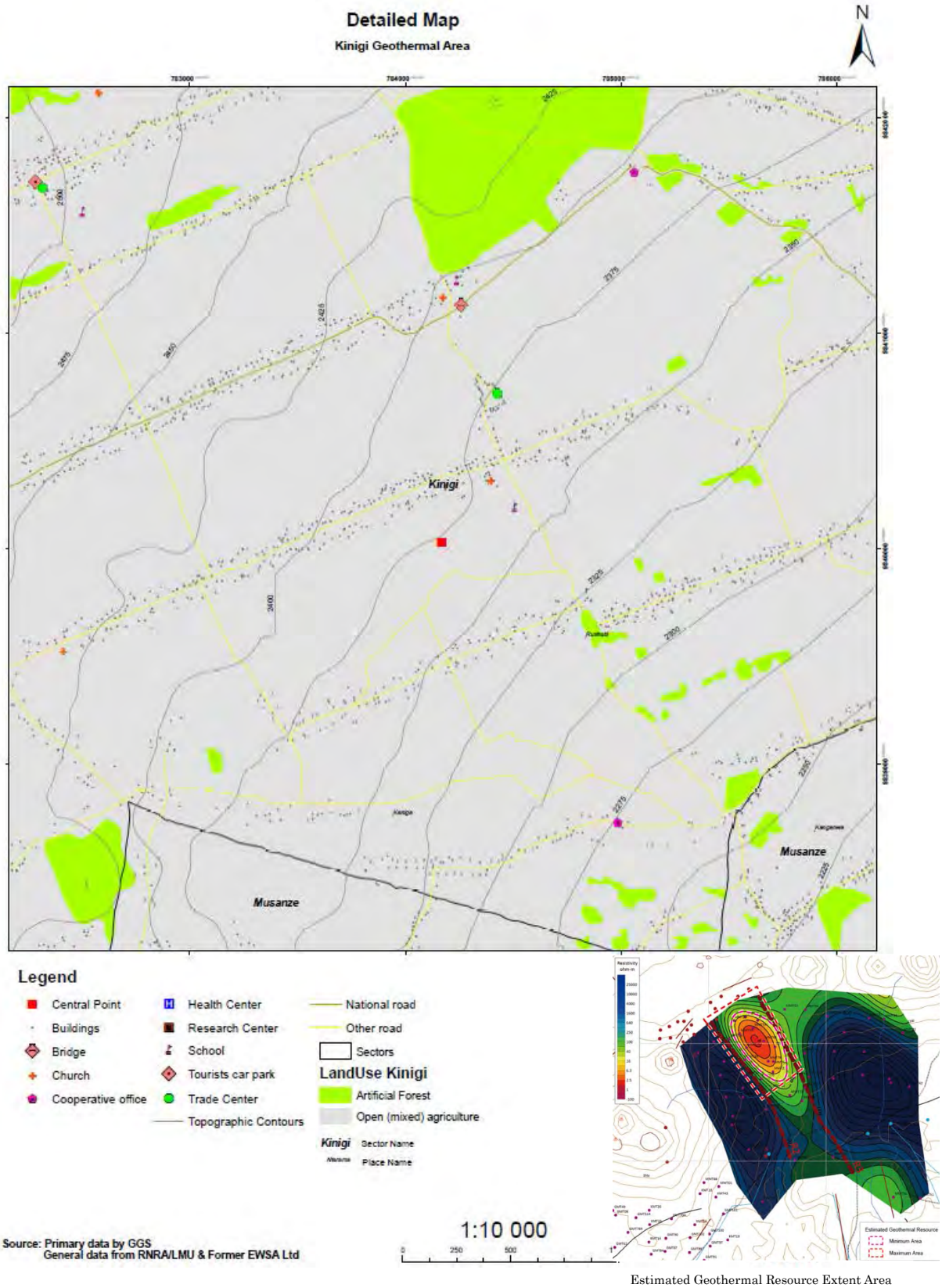


Fig. 4-7.8(2) Kinigi detailed map 2 (Estimated Geothermal Resource Extent Area)

Photo 4-7.2 Field at Centre point (Estimated Geothermal Resource Extent Area)

Photo 4-7.3 Village near center point (Estimated Geothermal Resource Extent Area)

According to GIS evaluation of land use, settlement, and locations of public facilities in the area of estimated geothermal resource extension, houses in this area are located along straight roads, and farmlands and forests are found between the parallel roads with the distance of 0.5 to 1.0km. The central point of the area is a pyrethrum field. At the area of a few hundred meters in the northeast from the central point, we observe a town center including a church and a school.

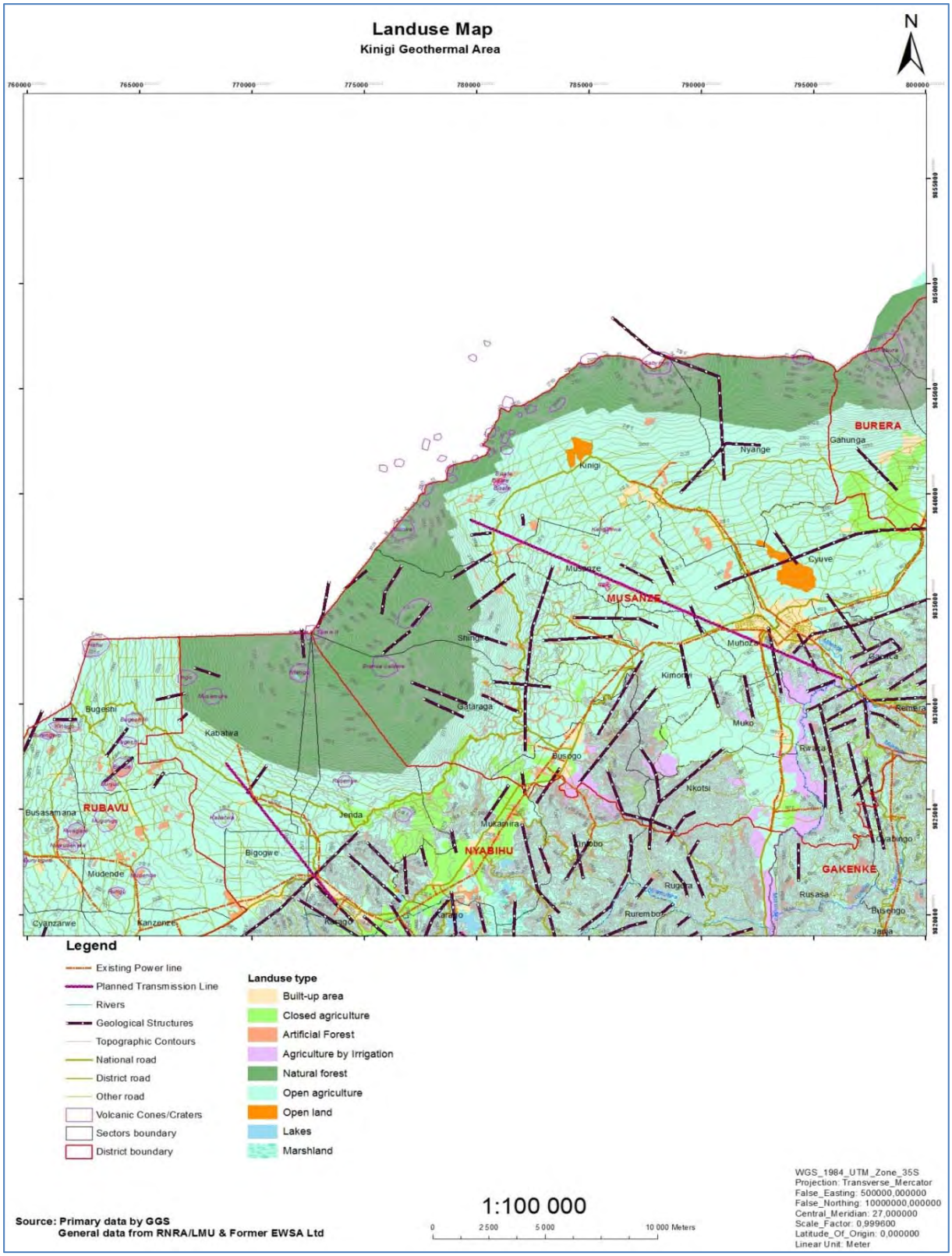


Fig. 4-7.9 Kinigi Land use map

4.7.5. Karago (as a water source point of Karisimbi)

Located around the Karago Lake, Karago geothermal area is found in Karago, Rambura, Rurembo, Kintobo and Mukamira sectors, of Nyabihu district. The topography of this area is dominated by medium to high elevated mountains with a high slope. The settlements and other buildings are generally found on the summits of mountains all along the roads.

The Land use of this area is largely occupied by mixed agriculture of subsistence composed of banana, potatoes, cassava etc. This region also has the open agriculture where mountain tea plantation dominates the wheat plantation which is starting to get planted on the slopes.

Among other infrastructure in this region the tea factory has a big influence on the economic activities.

Table 4-7.5 List of public facilities within Karago geothermal area

Designation	LATITUDE	LONGITUDE
Factory	779469	9816740
Factory	779764	9816672
School	780316	9817582
School	779040	9818181
School	778788	9818327
School	780351	9814233
School	780477	9814180
School	781004	9813929
School	784354	9815145
School	784080	9819023
School	777412	9814980
School	778554	9818381
School	778566	9820181
Market	777965	9821452
Factory	778456	9821309
Church	778167	9821265
Church	777461	9820716
Mosque	777974	9821380
Petrol Station	778393	9821389
Car Park	778501	9821415
School	778653	9821849
Church	778973	9817557
Factory	779392	9816630
School	784651	9821125
Church	781300	9821788
Trade Center	781251	9821768
Bank	778059	9821419
Military camp	779371	9820852
Youth Center	778813	9820034

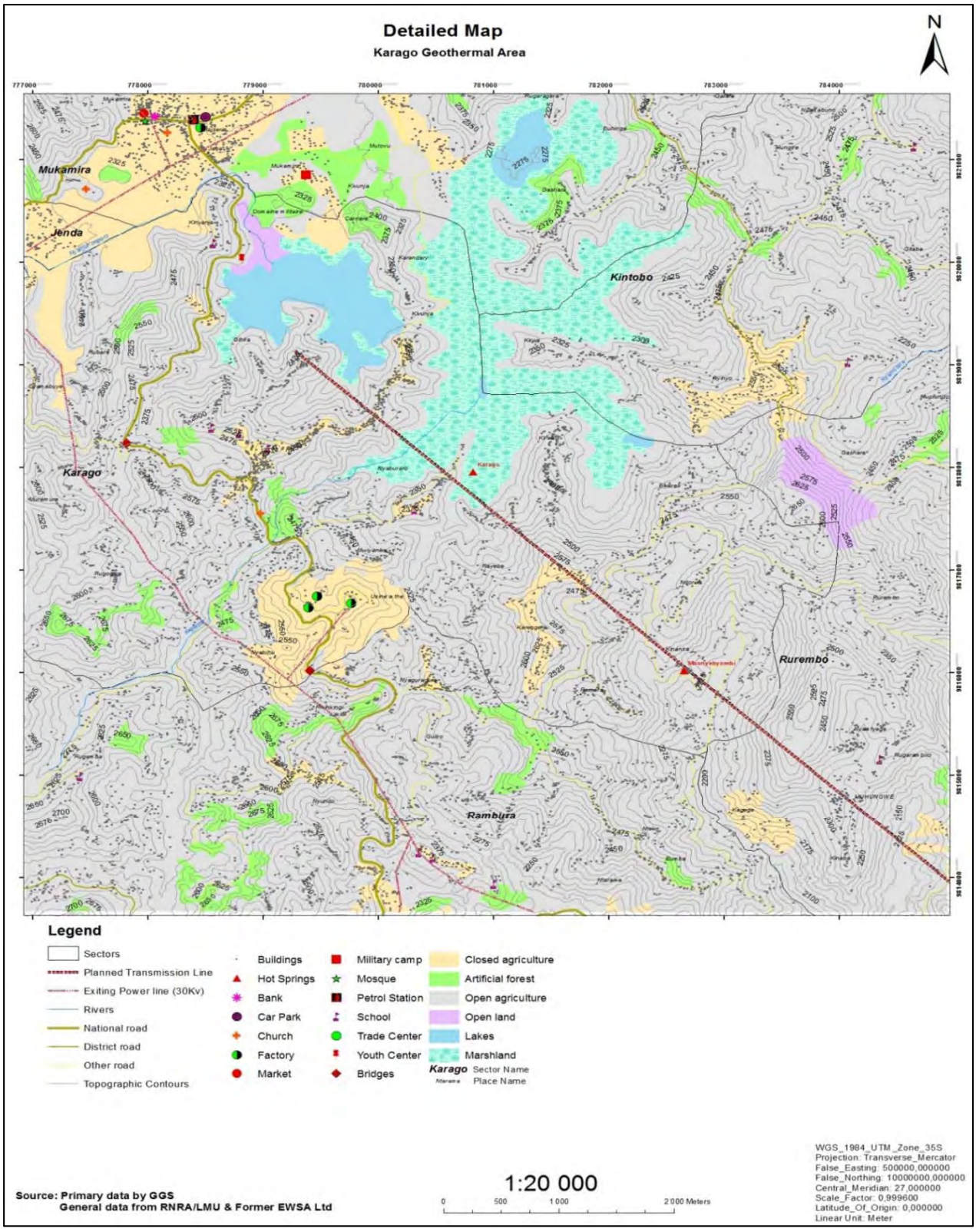


Fig. 4-7.10 Karago detailed map

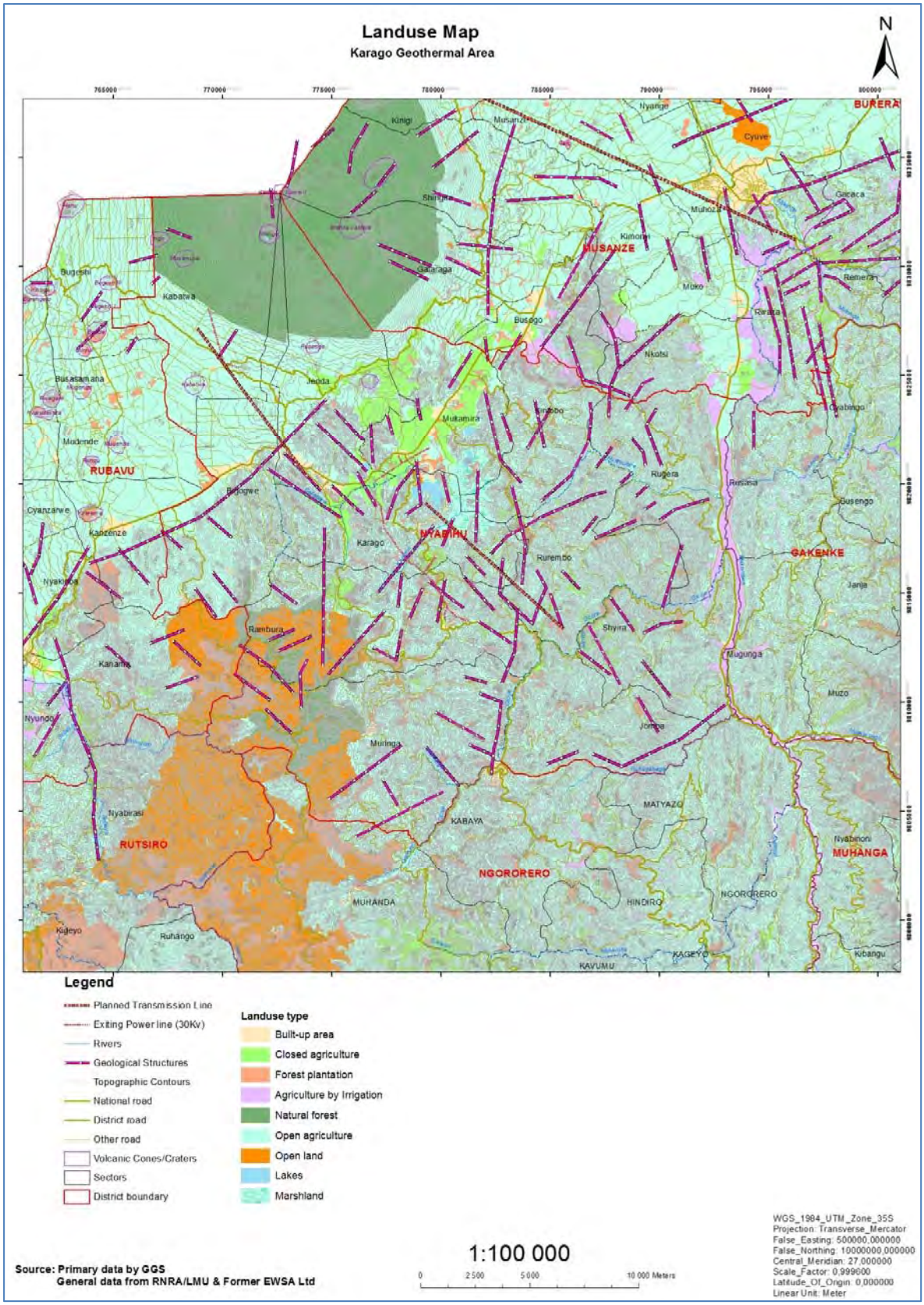


Fig. 4-7.11 Karago Land use map

4.8. Alternative Solution

Investigation was made about alternatives of geothermal development in Rwanda. The comparison was conducted with other major power generation modalities currently planned in Rwanda: hydro, methane, peat, and diesel （Table 4-8.1.）

This is a relative and qualitative assessment as the geothermal development area and scale are not yet confirmed. Additionally, a so-called zero option was analyzed by considering Kinigi area.

Geothermal development is more technically reliable and its land development area is smaller than other power generation options. Also, environmental negative impacts by its emission is also more limited than others. By considering other points additionally, we can conclude that geothermal development has well-balanced positive features. As the land area is small, this power generation modality is more suitable and environmentally friendly than other options especially in Rwanda.

As for power generation by peat, the relationship between the planned peat extraction site and its land use is illustrated in Figure 4.8-1. The planned site is overlapped with farmlands and wetlands, thus farmland compensation, resident resettlements, and impacts to the wetland ecosystem must be considered.

Table 4-8.1(1) Comparison of alternative electric power policy 1

Impacts	Geothermal power development	Hydro power development
Involuntary Resettlement	Minor	Significant (Creation of a Reservoir)
Local Economy	Minor	Significant (Creation of a Reservoir)
Land Use and Utilization of Local Resources	Moderate (Well drilling and geothermal power plant construction)	Significant (Creation of a Reservoir)
The Poor, Indigenous and Ethnic people	Minor	Significant (Creation of a Reservoir)
Cultural heritage	Minor	Significant (Creation of a Reservoir and Storage of water)
Infectious Diseases (HIV/AIDS)	Moderate (Not require large-scale civil engineering works and the number of construction workers will smaller)	Significant (Long construction period, the long-term inflow of construction workers into construction sites)
Hydrology and Hydrological Situation	Minor	Significant (Modification of river morphology and Changes in river flow by Storage of water)
Flora, Fauna and Biodiversity	Minor	Significant (Creation of a Reservoir, Floras and faunas such as the habitat loss by storage of water and impact and impact aquatic organism by changes in river flow)
Air Pollution and odor	Significant（H_2S emissions）	Minor
Water Pollution	Minor	Significant (Deterioration of water quality by storage of water)
Noise Pollution	Moderate	Minor
Topography and Geographical Features	Moderate	Significant (Creation of a Reservoir and Storage of water)
Waste	Moderate (Generation of industrial waste)	Minor（Floras loss)
Global warming	Minor	Moderate (Floras loss)
Technical reliability	Stability	Stability

Table 4-8.1(2) Comparison of alternative electric power policy 2

Impacts	Diesel power development	Methane power development
Involuntary Resettlement	Minor	Minor
Local Economy	Minor	Minor
Land Use and Utilization of Local Resources	Moderate (power plant construction)	Moderate
The Poor, Indigenous and Ethnic people	Minor	Moderate
Cultural heritage	Minor	Minor
Infectious Diseases (HIV/AIDS)	Moderate (Not require large-scale civil engineering works and the number of construction workers will smaller)	Moderate (Not require large-scale civil engineering works and the number of construction workers will smaller)
Hydrology and Hydrological Situation	Minor	Miner
Flora, Fauna and Biodiversity	Moderate	Moderate
Air Pollution and odor	Significant（Gas emissions）	Minor
Water Pollution	Minor	Moderate (CO2, Gas emissions)
Noise Pollution	Moderate	Minor
Topography and Geographical Features	Moderate	Moderate
Waste	Moderate (Generation of industrial waste)	Minor
Global warming	Moderate	Moderate
Technical reliability	Stability	Slightly unstable

Table 4-8.1(3) Comparison of alternative electric power policy 3

Impacts	Peat power development	Zero option
Involuntary Resettlement	Minor	None
Local Economy	Minor	None (None positive impacts)
Land Use and Utilization of Local Resources	Significant (Peat mining and power plant construction)	None
The Poor, Indigenous and Ethnic people	Moderate (Peat mining)	None
Cultural heritage	Minor	None
Infectious Diseases (HIV/AIDS)	Moderate (Not require large-scale civil engineering works and the number of construction workers will smaller)	None
Hydrology and Hydrological Situation	Minor	None
Flora, Fauna and Biodiversity	Significant (Peat mining)	None-Minor (Agriculture impact)
Air Pollution and odor	Significant（Gas emissions）	None
Water Pollution	Moderate(Peat mining)	None
Noise Pollution	Moderate	None
Topography and Geographical Features	Moderate (Peat mining)	None
Waste	Significant (Combustion residue)	None
Global warming	Moderate	None
Technical reliability	Slightly unstable	-

Next Page Figure illustrates peat distribution and land use around the major peat reserve in Rwanda, which is located near the national border in the south.

It is clear by this map that the peat distribution overlaps with irrigation agricultural terrain. Thus, when conducting peat extraction as a source of peat power generation, we must consider impact against agriculture and farmers relying on this agricultural activity. Also, irrigation sites play an important role as seasonal habitats for animals such as birds and amphibians, thus, it is assumed that there exists a valuable ecosystem especially for aquatic life. Peat extraction must be planned by minimizing negative impact to the natural environment by considering and capturing seasonal changes of fauna and flora.

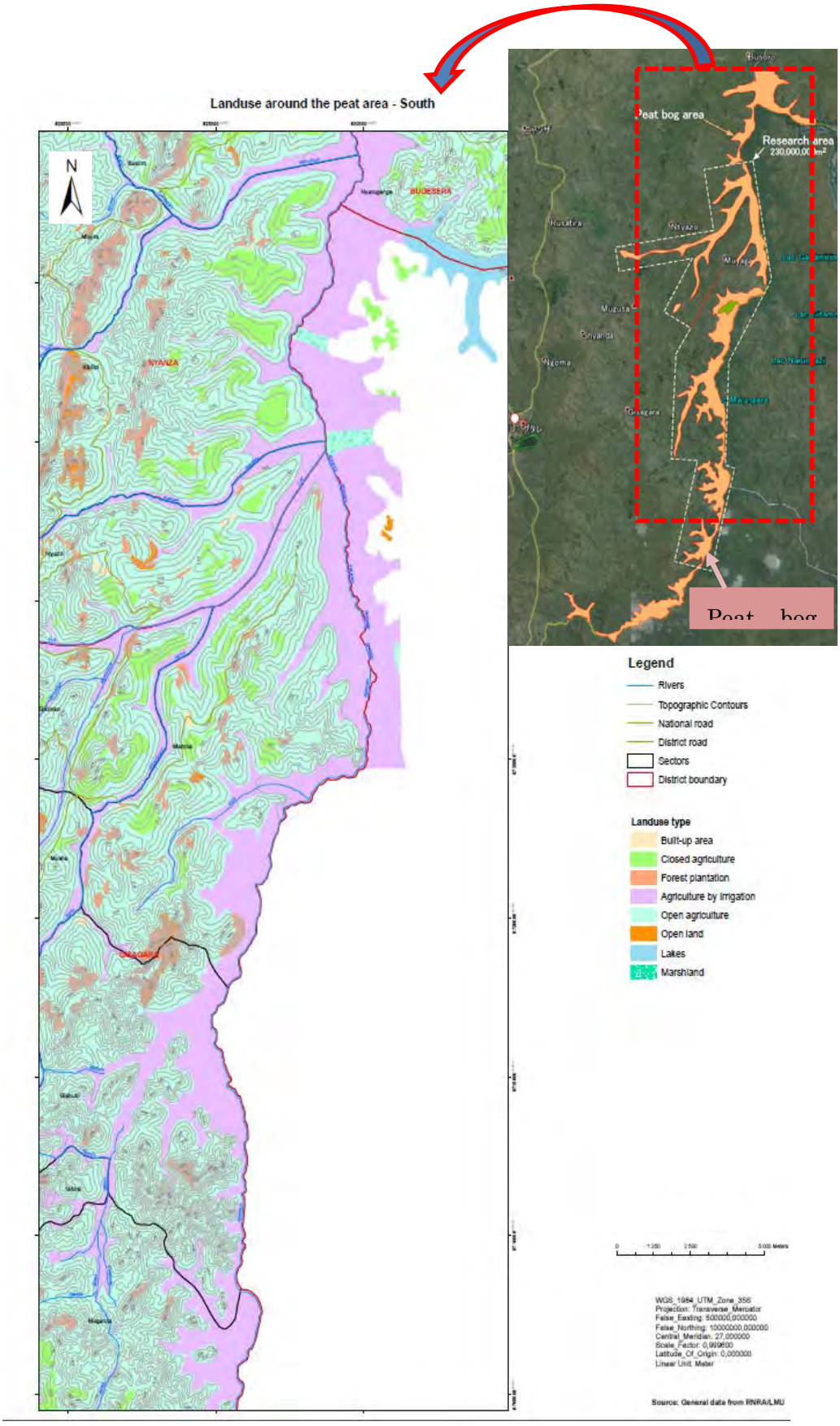


Fig. 4-8.1 Peat extraction planned sites and their land use

4.9. Environmental Monitoring Plan

The Environmental Monitoring Plan to be implemented during different phases of the project must take into account the characteristics of each project and the environmental situation of the area where the project is located. This plan is a technical mechanism for environmental control in determining and assessing parameters when monitoring the quality of different environmental factors, as well as the control systems and measurement of these parameters (Table 4-9.1).

Table 4-9.1 Environmental monitoring plan

Item	Parameter	Exploration, drilling and construction	Operation
Air Quality	H_2S	Location: 2-4 points in the surroundings of the drilling fields and 1-4 point in nearby house and public infrastructure of each community. Frequency: Monthly.	Location: 2-4 points in the surroundings of the plant and drilling fields and 1 point in nearby house or each community. Frequency: Monthly.
	PM_{10}, $PM_{2.5}$, NO_X	Location: 2-4 points in the surroundings of the plant construction site and 3 points in accesses roads. Frequency: Quarterly.	-
Noise	Noise level	Location: 4 points in the surroundings of the plant construction site and 1 point in each sensitive area (nearby house or community). Frequency: Quarterly.	Location: 4 points in the boundary of the plant site and 1 point in each sensitive area (nearby house or community). Frequency: Quarterly.
Surface Water Quality	Parameter of Rwanda standard	Location: Surroundings the plant construction site upstream and downstream of river and lakes. Frequency: Quarterly.	Location: Surroundings the plant upstream and downstream of river and lakes. Frequency: Quarterly.
Groundwater Quality	Parameter of Rwanda standard groundwater and high altitude wetlands levels	Location: 1-3 points in the surroundings of the project area (if there are well and lakes or wetlands) Frequency: Quarterly (water quality), Level (monthly).	Location: 1-3 points in the surroundings of the Plant and wells pad (if there are well and lakes or wetlands) Frequency: Quarterly (water quality), Level (monthly).
Effluents quality	Water temperature, pH, SS, BOD_5 and Oil and Grease	Location: Temporary grit chamber outlet Frequency: Monthly.	Location: Plant and domestic effluents outlet Frequency: Quarterly.
Hot spring	Temperature, pH, EC, Na^+, Ca^{2+}, Cl^-, SO_4^{2-} ,etc. and volume.	Location: Hot spring in the surroundings of the project area. Frequency: Monthly (before drilling started 3 months and exploration, drilling period). Evaluation method: Comparative analysis of survey results.	Location: Hot spring in the surroundings of the plant and well pad. Frequency: Quarterly period. Evaluation method: Analysis of survey results over time.
	H_2S (The case of in which H_2S was detected)	Location: Gushing point of hot spring in the surroundings of the project area. Frequency: Monthly (before drilling started 3 months and exploration, drilling period). Evaluation method: Comparative analysis of survey results.	Location: Gushing point of hot spring in the surroundings of the plant and well pad. Frequency: Quarterly period. Evaluation method: Analysis of survey results over time.
Subsidence	Ground elevation	Location: 4-6 points in the surroundings of the plant and well pad and 2-4 point in settlement site Frequency: Annually. Methods of measurement: Land elevation of the point from leveling. Evaluation method: Comparative analysis of survey results	

Item	Parameter	Exploration, drilling and construction	Operation
Flora, Fauna (If rare species are there)	Flora, Fauna (including birds) and diversity of flora and fauna.	Location: EIA baseline survey sites. Frequency: Twice a year (Rainy and dry seasons during the construction period) Survey of mountain gorilla movements before, during and after the development work	Location: EIA baseline survey sites. Frequency: Twice a year (Rainy and dry seasons) Survey of mountain gorilla movements
Hydrobiology	Algae and benthos and the relative abundance in the case of fauna.	Location: Surroundings the plant construction site upstream and downstream of rive and lakes. Frequency: 2 Twice a year ((Rainy and dry seasons during the construction period)	Location: Surroundings the plant site upstream and downstream of rive and lakes. Frequency: Twice a year (Rainy and dry seasons)
Archeological	Effect of archeological sites and cultural heritage	Location: Archeological and cultural heritage sites Frequency: 2 Twice a year ((Rainy and dry seasons during the construction period)	Location: Archeological and cultural heritage sites Frequency: 2 Twice a year ((Rainy and dry seasons during the construction period)

4.10. Recommendation on Environmental and Social Considerations through Geothermal Development

Potential local development advantages brought by geothermal development are significant, and include: job creation; the construction of infrastructure and public facilities; the production of dried agricultural products such as tea, pyrethrum and coffee achieved by utilizing waste heat and electricity; greenhouse cultivation; and groundwater being pumped up for use in agricultural irrigation. Considering the local context of Rwanda, we can propose the following activities for local development.

4.10.1. Linkage with Gorilla Conservation

Currently, farmlands in Kinigi extend up to the border of Volcanoes National Park, where protected mountain gorillas are located. Through our field survey, agricultural activities were observed near the park border. According to one NGO dealing with mountain gorilla conservation, there are some problematic cases where either local farmers enter the park, or gorillas come out of the park and enter the farms. For geothermal development in Kinigi, we recommend purchasing farmland near the national park border and using it as a buffer zone. This could have a positive impact on gorilla conservation, and help avoid the overlapping movements of humans and gorillas. Additionally, it might be a good idea to recruit local farmers for use as nature conservation field staff and nature guides. Then, we can ask them not only to protect the natural resources of the area but also to play a key role in building awareness of environmental protection with local farmers and citizens.

4.10.2. Prevention of Soil Erosion and Dust Emission

Potential geothermal development sites are located in rural areas, where there is a great deal of exposed ground, unpaved roads, and points of soil erosion at sloped surfaces alongside roads. As a result, the water in nearby rivers and creeks is filled with suspensions from the eroded soil. More specifically, in Bugarama, there is a major cement factory where many large trucks are used to transport cement products. The major roads there are unpaved, and dust raised by truck traffic is a serious concern. When we conduct geothermal development, we must implement various environmental protection measures starting from the time of geothermal facility construction. These measures could include tree planting, the improvement of exposed ground, the paving of roads, and the protection of sloped surfaces. This would contribute to an improved living environment in the community and the prevention of soil erosion, which is one of the key environmental challenges in Rwanda. When doing this, it is essential to work together with local citizens, local governments, and the nearby private sector, after first building consensus.

4.10.3. Networking of Potential Local Resources

The northern area (i.e. Kinigi and Gisenyi) and southern area (i.e. Bugarama) are home to many potential ecotourism and techno-tourism resources that are in need of development (or renovation) and better networks. A combination of various development activities, such as the preparation of scenic points, promotion of local cultural assets, identification of academically

valuable sightseeing spots and improvement of access roads, would be needed to attract visitors to the area. These activities must also consider other development projects, including tourism development at Lake Kivu and the cable car installation at Mt. Karisimbi.

In the northern area, linkage with existing mountain gorilla tourism is important, as well. Although it is difficult to increase the numbers of gorilla visitors under current conditions (according to an NGO involved in mountain gorilla conservation), our geothermal project can provide technical and financial support to construct infrastructure that will minimize the negative impact on mountain gorillas. This may include helping to build tourist facilities, a spa, roads, and other projects which could enhance the gorilla conservation activities of NGOs and NPOs. The geothermal plant can also be a hub for networking. We can design the facility to promote tourism, along with gorilla conservation, by adding an environmental awareness education program, shops for local products and other such enhancements to the facility. By using these efforts to differentiate Rwanda mountain gorilla tourism from that of the neighboring countries, we could contribute not only to local development but to the development of the country as a whole.

4.10.4. Protection and utilization of the Ecosystem Service

Recently, natural ecosystems are being re-evaluated globally from the point of view of their economic value, and this viewpoint reaffirms the concept that the ecosystem is providing various benefits to the human society (Ecosystem Service) and that it supports human well-being. The value of the global ecosystem service is estimated as 33 trillion US dollars on average per year, and financial trading of the service is emerging (Ecosystem Service Trade-Off). Precious ecosystems are well preserved in many areas in Rwanda, and recognizing those systems as a national asset and protecting/utilizing them would contribute to Rwanda's national development.

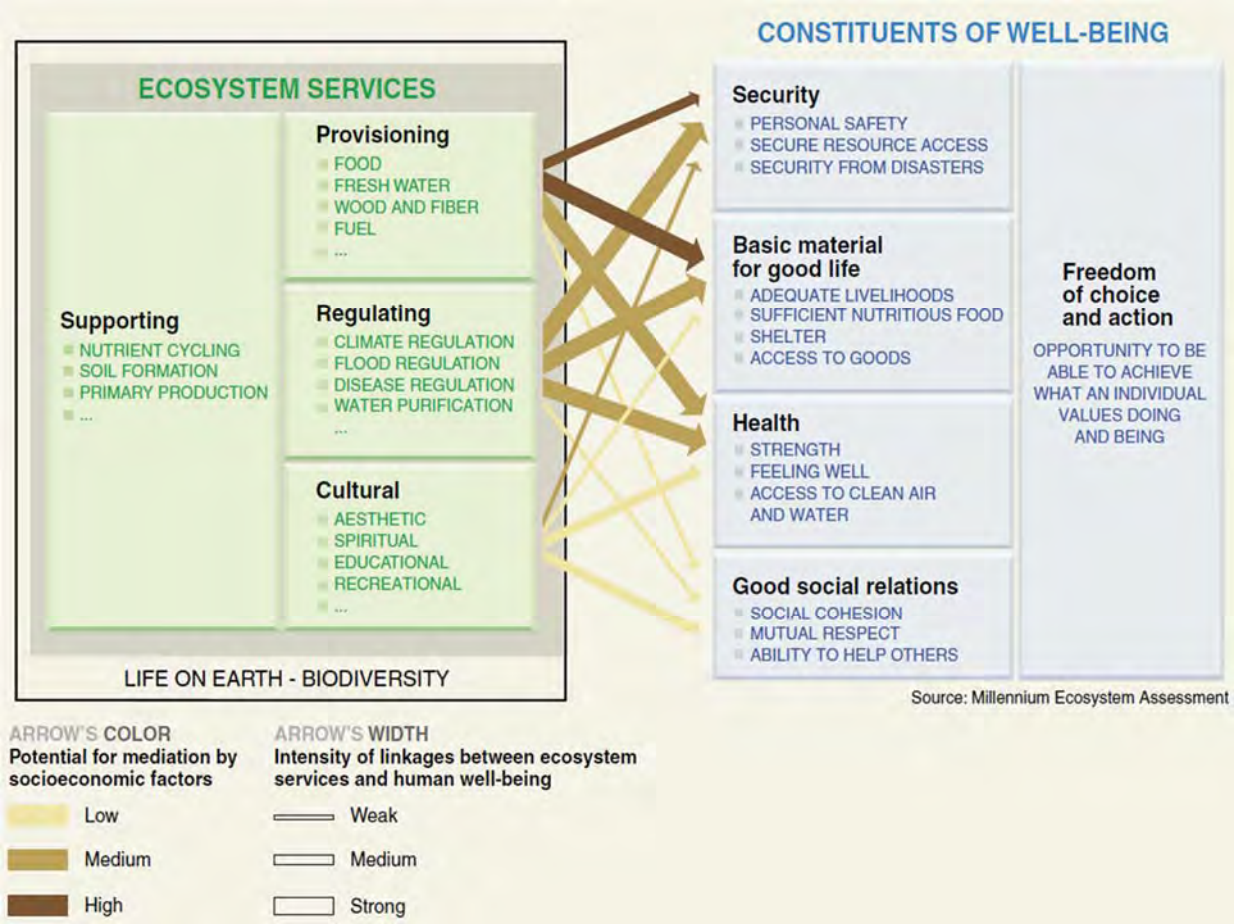


Fig. 4-8.2 Ecosystem Services