ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) STUDY FOR THE PROPOSED 18.5MW NYAMINDI CASCADE DEVELOPMENT IN KIRINYAGA COUNTY, KENYA

Environmental and Social Impact Assessment

NYAMINDI CASCADE DEVELOPMENT

ECO POWER HOLDINGS LIMITED
www.ecopowersrilanka.com

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ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) STUDY FOR THE PROPOSED 18.5 MW NYAMINDI CASCADE DEVELOPMENT IN KIRINYAGA COUNTY, KENYA

PREPARED FOR

rAREH NYAMINDI HYDROPOWER LIMITED

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PROJECT DETAILS

Project Name:	18.5 MW Nyamindi Hydro Power Cascade DevelProject, Kirinyaga County, Kenya	
Lead Implementing Agencies:	rAREH Nyamindi Hydropower Limited	
Funding Agencies:	rAREH Eco Hydropower Company Limited	
Consulting Engineers:	Eco Power Holdings Limited	
Target Areas:	River Nyamindi, Kirinyaga County	
NEMA Licensed Lead Expert:	Dr. George Gatere Ndiritu, Reg. No. 6250	
Specialists:	**Study Name**	**Specialists**
	Ecological Environment Impact Study:	Dr. George G. Ndiritu Dr. Charles M. Warui Mr. Geoffrey Wambugu Mr. Patrick Kirika Mr. Vincet Muchai Mr. Joseph Gathua
	Hydrology Study:	Dr. Henry K. Ntale,
	Geology and Soil Study:	Mr. Ashoka Herath
	Social Impact and Cultural Heritage Assessment Study:	Mr. L.P.D. Dayananda
	Civil Engineering Structural Design:	Mr. D.F.M Perera,

DISCLAIMER

This Environmental and Social Impact Assessment (ESIA) Project Report is submitted to the National Environment Management Authority (NEMA) in conformity with the requirements of the Environmental Management and Coordination Act, 1999 and the Environmental (Impact Assessment and Audit) Regulations, 2003

ACRONYMS AND ABBREVIATIONS

Acronym	Definition
CAACs	Catchment Areas Advisory Committees
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanisms
EARS	East African Rift System
EMCA	Environmental Management and Coordination Act
EPHL	Eco Power Holdings Ltd.
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
GHG	Greenhouse Gases
IFC	International Finance Corporation
IUCN	International Union for Nature Conservation
MEA	Multinational Environment Agreements
NCD	Nyamindi Cascade Development
NEP	National Environmental Policy
NIB	National Irrigation Board
OHSA	Occupational Health and Safety Act
PS	Performance Standard
RAP	Resettlement Action Plan
rAREH	ResponsAbility Africa Renewable Energy Holding
rEHCL	ResponsAbility Eco Power Holding
SHP	Small Hydro Power
TOR	Terms of Reference
WAB	Water Appeal Board
WRMA	Water Resources and Management Authority

WRUAS	Water Resources Users Associations
WSBs	Water Service Boards
WSPs	Water Services Providers
WSRB	Water Services Regulatory Board
WSTF	Water Services Trust Fund

TERMINLOGY AND DEFINATION

Terminology	Definitions
Weir	A weir is an underwater dam created to reduce, but not stop the flow of water in a river or stream.
Headrace channel	A watercourse that feeds water into a mill, water wheel, or turbine.
Fore bay Tank	A reservoir or canal between a mill race and a water wheel; the discharging end of a pond or mill race.
Surge Tank /Bay	Together with the headrace canal it provides a certain volume to minimize the down surge.
Penstock	The penstock is a large pipe that will convey water for power generation from the surge bay to the power house.
Power house	A facility for the generation of electric power.
Tailrace	This is the path through which water is pumped out of the hydro power plant after power generation.
Project Affected Persons	Those inhabitants of an area affected by a project who have the most to lose and the most to gain from the completion of the project, and whose concerns must be addressed in an environmental assessment.
Resettlement Action Plan	An action plan prepared as part of an ESIA to address issues of involuntary resettlement, compensation and rehabilitation of people and communities affected by a road project.
Chainage	Distance along a curved or straight survey line from a fixed commencing point, similar to mileage. Usually presented in “kilometres + meters” (e.g. 101+30).
Stakeholder	Any person or group having interest in or being directly or indirectly affected by a proposed or past project.

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EXECUTIVE SUMMARY

1.1 Introduction

River Nyamindi is one of the several perennial rivers that originate from the southern slopes of Mt Kenya eventually joining the River Tana system. ResponsAbility Renewable Energy Holding (rAREH) has initiated exploring the feasibility of generating electricity from head waters of River Nyamindi. They have also selected Eco Power Holdings Limited (EPHL) to provide technical assistance to carry out the feasibility studies and the environmental impact assessment. Both the rAREH and Eco Power Holdings, which forms ResponsiAbility Ecopower Holdinngs Company Ltd. (rEHCL), has sought approval from NEMA Kenya, to conduct the environmental and social assessment for the proposed cascade development project as per the statutory requirements of the Government of Kenya. (Environmental Management & Coordination Act of 1999). Under the proposed cascade development, the head waters of River Nyamindi will be utilized to generate electricity power when the river meanders through at least four sub locations of the sub county of Kirinyaga East of Kirinyaga County namely; Rungeto, Kabari, Ngiriambu and Ngerwe. The portfolio of the proposed cascade development projects includes three small hydro power projects along a stretch of 19 km of the Nyamindi River. The stretch under development will cut across the above sub locations.

1.2 Purpose of the project

The projects will be formulated and designed in a cascade formation for the development of three (03) small hydro power plants to generate a combined capacity of 18.5 MW of electricity. The annual generation is estimated to be to the tune of 98,509 MWh of electricity. Suitable locations with reasonable access from the existing roadways have been earmarked for these projects.

1.3 Description of the project

Each project will have a Flow Diversion Weir, Water Intake, Head Race Channel, a Sedimentation Tank, Forebay and a Power House together with a power evacuation plan. Each project will have a Tail Race to ensure that the waters shall join the river after generation of power. All the three projects can be accessed through the existing road network. They include highways, tarmac roads, (A2 & B 6), gravel and earth surfaced all weather roads. The cascade of the projects can be reached through the Embu Nairobi highway using A2 (to Kutus) and B6 highways for 120 km until the Kianjuru Trade Center. From the Kianjuru Trade Center it is the gravel and earth surfaced roads to the left along the gravel road towards Mbiri.

It is most likely that power evacuation would be via Kutus 132 / 33 kV Substation. Kutus 132/33 kV substation was established in 2013, intersecting the feeder from Sagana towards Embu

Primary Sub Station. The Grid Study dated July 6th 2017 has been submitted as a separate document.

Generic description of each of the above mentioned structures will be provided followed by specific dimensions of the same in the preceding tables. All projects will have access roads to access to the main project infrastructure. Details of each project are provided in Chapter (11) of the EIA Report. Following are the coordinates of the projects:

	Main structures	GPS Coordinates
Project (1) Gitie	Project (1) Weir coordinates	0°23'59.00"S, 37°23'13.80"E
	Forebay tank coordinates	0°24'15.25"S , 37°23'37.89"E
	Power House coordinates	0°25'28.44"S, 37°23'42.06"E
Project (2) Kiamutugu	Weir coordinates	0°26'12.53"S, 37°23'54.28"E
	Forebay tank coordinates	0°27'12.83"S, 37°24'14.06"E
	Power House coordinates	0°28'35.91"S, 37°23'53.70"E
Project (3) Mbiri	Weir coordinates	0°29'12.20"S, 37°23'53.00"E
	Forebay tank coordinates	0°30'18.10"S, 37°23'29.87"E
	Power House coordinates	0°30'50.60"S, 37°23'30.28"E

Direct Impact (Influence) Area

The Direct Impact Area (DIA) is the area that will receive primary impacts resulting from project activities. The DIA includes: Weir area (including its area of inundation), the area under the Head Race Channel, the Forebay area, the Penstocks area, the Power House area, the Tail Race, Workers Main Camp, the project's site office area including stores, materials stockpiled areas and the power evacuation line with its way leave.

1.4 Associated facilities

The project will have supporting facilities such as staff accommodation for the staff engaged during the operational periods. There will be a temporary project office and temporary storage facilities for the construction materials, temporary staff accommodation (labor camps) and a parking area for construction vehicles facilitated by a washing bay. The land for such facilities will be obtained on lease. The land will be restored to its original state after the construction phase will be completed and handed to the owners.

1.5 Alternatives considered

The following alternative aspects are considered for the proposed developments.

- Technology: relates to improved efficiencies durng operation
- Location: what is the best site for the proposed development and any infrastructure associated with it.
- Project Impacts to peoples' assets and sources of livelihoods
- No-go option: implications of not preceding with the project

Above alternatives were assessed on the basis of the available information and found that the final lay out of the proposed projects as well as the technology to be applied are the viable options. In addition, the "No Project Alternative" was considered not a viable alternative for the development initiative.

1.6 Environmental, social and cultural heritage impact assessment

Baseline information was collected under following specialist studies

Specialist Study	Study Limit
Terrestrial ecology	Project footprint area and its immediate environs
River and associated riparian zone ecology	River channel and associated riparian zone, specifically the microhabitats along the river of river run, water pools and rocky banks
Hydrology	Project footprint area and its immediate environs; Project catchment areas; Rain Fall gauge stations
Geology	Project footprint area and its immediate environs (Secondary information sought to establish regional geology)
Socio Economic	Project immediate Influence Area and Administrative boundaries of Kirinyaga county (secondary data) (e.g. Kiamutugu etc.)
Occupational Health and Safety	Project footprint area and its immediate environs
Public safety	Project area and immediate surroundings

During the data collection process, several data collection methods were adopted. They were more pertinent to each of the speciality study areas. These methods have been described under each of the special studies in the relevant chapter. The complete Geological Investigation report as well as the Hydrological report has been given in the annexure 13.2 and 13.3, which explains the methods adopted in conducting the respective studies.

1.7 Key findings of the specialists' studies

1.7.1 Biodiversity impacts

Bio diversity impacts have been assessed and documented. This was done under different components such as higher and lower plants associated with riparian habitats which includes among others Aquatic Macro-invertebrates & Fish. Terrestrial ecology and habitats include among others, avifauna, herpetofauna and Invertebrate Fauna. In terms of the ecosystems, the bio diversity studies revealed that there are three major habitats namely: natural forests, riparian forest and farmlands in the project area. Of the three, forests and riparian forest were considered as critical habitats for biodiversity conservation. The upper part of the project lies within Mt. Kenya Forest, which is an important Bird Area.

The construction of the project structures such as the powerhouses, head race canals, flow diversion weirs, access roads and the power evacuation line need land preparation which will result in clearing existing vegetation that will have an impact on the biodiversity habitat. The uppermost part of the project where the weir and part of the channel that directs water to the penstock is within the forest reserve. Approximately 200m of the channel will go through the forest. Forest trees are expected to be cleared to pave way for construction of the head race canal.

There are no likely impacts to higher plants in the riparian zone. However, lower plants may be adversely affected by increased levels of sedimentation that are likely to moderately affect photosynthesis of water submerged liverworts. This will also affect fish as a result of decreased water quality and reduction in the food base. Mosses and hornworts are not likely to be affected.

Some forest birds may be affected by this modification. This will result in loss of breeding sites for amphibians which congregate on riparian zone where the actual powerhouse building location will be. These impacts have been explained under each of the components in the body of the report.

1.7.2 Impacts on soils

The project will require land clearing and excavation and will generate a large quantity of spoils. Once excavation is done, the newly excavated areas will be prone to mud slides during the rainy seasons. The tipping of spoils on the river banks can cause soil erosion. Sediments will flow into the river. These construction activities could adversely affect the water quality of the river and surrounding drainage system which will also impede efficient storm water drainage relief. Impacts on the soils have been also explained in respect of each construction site as follows:

Weir sites

All weir sites inspected have fresh outcrops of olivine basalt on the river bed and the flanks. The rock mass is sparsely jointed and forms stable abutments. Very favorable geotechnical conditions were assessed for all selected weir sites in terms of foundation and abutment rock mass condition and water tightness.

Powerhouse sites

Selection criteria for the powerhouse locations include favorable geotechnical conditions, favorable topography for access, stability of the slopes, minimizing the excavations and the ease of locating the penstocks and other structures. With these facts in mind some river terraces consisting of alluvial deposits have been selected where foundation rock does not outcrop at surface but expected to be found at a shallow depth.

Water conveyance routes

The physiography of the area is characterized by low hills, small ridges and spurs and small plateaus. Steep slopes were observed only on some sections of the river valley. Typically, the soil cover is thin. Some old earth slips and one recent slide were observed but confined to the river valley only.

1.7.3 Surface and ground water impacts

River Nyamindi is a source of water (for daily consumption) and for irrigation. Water quality tests carried out revealed that the bacteriological components are present in excess of the required standards. There will be three (03) number of flow diversion weirs constructed crossing the river at three locations, requiring rock blasting, deep excavation and clearing of vegetation. There will be machinery working in the middle of the river engaged in removing boulders and excavaton. Construction of the weir needs diversion of river flow using coffer dam materials. Dewatering

processes may affect the river water if not properly filtered. There will also be liquid wastes such as the waste from sewage system (temporary toilets); waste water from the kitchen of the temporary labor camps, if received by water bodies, leads to pollution. The result of these activities will be that the water will be further polluted and the down-stream water users will be impacted as a result.

1.7.4 Waste Management

Waste generated from construction sites is usually of non-hazardous nature. Construction wastes includes paper, plastic bottles (mostly drink/ water bottles), excess fill materials from excavation activities, scrap wood, sawdust, waste concrete, scrap metal, paper, cloths and food scraps. They can be recyclable and can be disposed properly. Other hazardous wastes such as chemicals, containers used for paint and used oil, empty cement bags. They can be a risk for the workers who are exposed to the work environment. There is a possibility that the vehicle lubricants, oil and wash bay effluents can contaminate the adjacent water sources during the construction period. Oils and fuels from machines, generators and vehicles plus other chemicals used during construction and in the operation may accidentally spill on the site. This spillage if collected by rainwater will eventually accumulate and if not well disposed will end up in the river or in other habitats.

1.7.5 Social-Economic and Cultural Heritage Impacts

The project will have positive impacts specially by way of providing employment opportunities. During the construction phase it is expected that the three proijevcyts will commence construction parallel to each other hence the number of workers required for construction phase will be high. Labor requirements for all three projects will be around 400 – 500 unskilled and semiskilled labor. They will be recruited from the local areas. At present the unemployment is very significant in the local villages. The base line information revealed that the employable work force is about 60% of the local population.

As far as negative social impacts are concerned, land acquisition for the project will deprive the the subsistence income and permanent income from trees to the project affected persons. There will be local community members whose crops will be affected by the excavation work, rock blasting, and storage of materials which may affect their crops / animals. The community members will face crop damages due to the movements of machinery. When some of the land plots will be required for the temporary structures on long leaseholds, the owners will lose their seasonal income although they get a lease income from the Developer or the Civil Contractor.

The fisherman can lose subsistence income from the fishing activities during the construction as well as operational phases. Since the local community depends on river water especially during the dry season, they may not have adequate water from the river when the construction work is

in progress. It is expected that during construction time there may be a greater probability that the river water may be polluted.

The baseline study revealed that the schools close to the river also fetch water from the river. School children come to the water points, through foot paths, it appeared. Safety of the children should be ensured as there will be obstruction to access to the water points and crop lands when the construction will be in progress.

The public receptors such as the schools, trade centers will be affected by construction traffic with increased dust during the dry spells. During the rains, the gravel roads become slippery and will affect badly when the heavy machinery and trucks are required to be moved along those roads. These impacts are temporary in nature and can be mitigated.

Motorists will be affected when the roads are blocked while structures are constructed across the roads. Irrigation waters are abstracted at the downstream of the river close to Mbiri project where there is a parallel community road running towards the irrigation water points. During the construction these community roads may be temporarily blocked.

1.7.6 In-migration of Workers

The project during the construction phase will engage a large work force. While some of them will be from the local areas others will be migrating to the local areas from locations or sub locations elsewhere. In addition, there will be in-migrating labor who may offer various support services. The suppliers of construction materials send drivers/assistants to the site areas who will spend at least one or two days in the local areas. Their presence will indirectly attribute to increased incidence of HIV Aids. Already the area has recorded a growth of the prevalence of HIV AIDS by 15% according to the health officials. Lack of awareness and not having any strict measures to control unethical social integration will lead to this situation. The impact will be that the children and the population general in the project area can be exposed to HIV AIDS. The area has very limited facilities for HIV tests and one needs to travel at least 10-15 km for a suitable hospital.

1.7.7 Land Acquisition Involuntary Resettlement

The proposed development will require at least 22 ha of land (60 acres) for the construction of its structures under the proposed projects in the cascade. Land belongs to the individuals, the Coffee and tea factories and / or the Kenya Forest Services. The land acquisition will deprive the people income from them and thereby cause economic displacement. The project will not expect to cause any physical displacement. After completing a cadastral survey, it is necessary to identify the project affected persons, who need to be compensated. There should be Resettlement Action Plan prepared thereafter, on which basis the payment of compensation can be effected.

1.7.8 Occupational Safety and Health

Especially working in an environment where there is forest, workers will expose to threats from wild life. Working on high-rise platforms when constructing the weirs, power houses, can have the risks of falls unless the workforce is provided with required training and safety equipment (PPE). In summary, the workers should be protected from been exposed to:

- Burns (Welding/hot works, etc.)
- Falls from working at heights or wet surfaces
- Electrocution
- Injury from fly rocks e.g. at quarry sites or debris
- Noise and body vibration from equipment

1.7.9 Climate change and Green House Gas (GHG) impacts

The project area has a tropical climate and an equatorial rainfall pattern. This climatic condition is influenced by the county's position along the equator and its position on the wind ward side of Mt. Kenya. The project will be environmental friendly with no GHG emissions (carbon zero). Therefore, the project will be compatible with renewable energy. However, the vegetation clearing will have temporary impacts on carbon sequestration process, which can be mitigated by the proposed improvisation of the project catchment areas.

1.8 Mitigation measures

A series of mitigation measures have been proposed under each of the above impact occurng areas. They have been described more in detail in the respective chapters. The brief descriptions of the mitigation action under each area of impact are provided as follows:

1.8.1 Location of the project

Locations of the projects have been surveyed and finalized to ensure that there should not be any houses displaced as a result of the siting of the structures of the respective projects. The cadastral survey will reveal, if any houses will fall in the way leave. If found, they will be compensated according to the negotiated prices agreed with the house occupants.

1.8.2 Design of the project

All three projects in the cascade development have been designed to ensure that they are run of the river projects with no extensive inundation on the impounded areas. The hydrology of the projects has been sufficiently assessed and the optimum water requirements for each of the project have been determined. The design of each of the flow diversion weir will be such that they will have each, an environmental flow pipe to allow an environmental flow (free flow) sufficient to sustain the ecosystem functions and the community water needs.

1.8.3 Climate change and Green House Gases

It will be necessary to protect the immediate catchments of the project by planting trees. This should be carried out with WRMA and WRUAs and the community in general. The hydro power projects have the advantage of not causing GHG emissions.

1.8.4 Biodiversity

With a view to conserving biodiversity, a range of mitigation actions have been proposed which include the measures such as minimizing the vegetation cleareance, retaining the forest areas as much as possible so that the environmental foot print affected by the project will be minimal. Translocating animals that move slowly have been proposed. However, due to water pollution there could be temporary impacts on the aquatic fauna and flora which can be mitigated by not polluting the river waters.

In order to protect fish species following measures have been proposed:

- Construction of fish passes to reduce the entrainment and also allow way for migratory fish
- Installation of fish and eel passes (including bypass channels), so the pumps can be safely avoided
- Installing systems to discourage fish from entering abstraction equipment, including acoustic barriers, lighting barriers and bubble curtains.

1.8.5 Soils

To prevent erosion of soils, several mitigation measures have been suggested, namely:

- Excavation should be limited during the rainy (wet) season when animals are breeding
- All spoils should be dumped into one or more designated spoil yard/s and they should be graded and compacted if they are not used for land filling purposes.
- Top soil to be kept aside for use in replanting and landscaping
- Reestablish original habitat patterns to improve surface water runoffs before commencing operations
- Establish erosion prevention measures on sloping areas to prevent soil erosion on loose soils after excavation.
- Avoid using heavy machinery especially in the forest areas to prevent extensive damage to the forest
- Where possible use already established tracks and roads
- Use of human labour (non-mechanized) during construction inside the forest to minimize damage to the forest habitat.
- Paving/tarring the roads and water sprinkling, sheeting of spoil stockpiles are other measures.

1.8.6 Surface and Groundwater

In order to ensure that surface water is free from pollutants, construction of settlement ponds, tanks etc. has been suggested prior to allowing dewatered effluents back into the river. Similarly, the wash bay and other chemical storage areas (including fuel storage areas) have been required to equip with silt traps and settlement tanks. All the temporary toilets need to be sited according to the local regulations that require minimum distance from surface water bodies. A water quality monitoring programme should be implemented at least every six months to ensure that construction and operational activities of the project will not interfere with river water quality.

1.8.7 Waste Management

Waste management is important aspect during both the construction phase as well as during the operational phase. Mitigation measures suggested are that:

- During construction phase a waste management plan that include: Separation of wastes according to their hazardous and non-hazardous nature & treatment and disposal of solid wastes with special attention paid to any hazardous wastes (according to the standards stipulated by NEMA); has been proposed. It will include such interventions as:
    - Wastes from construction work should be minimized by reusing most of the recyclable materials.
    - Pollution prevention and waste minimization shall be made key aspects of a wider construction waste management policy.
    - Implement in-house waste management programme by installing facilities e.g. waste containers/bins etc. on site during construction phase. This should be based on a procedure for waste segregation.
    - The contractor should work hand in hand with the Local Authority of the sub location for the collection of sewage and other hazardous waste appropriately as per the NEMA stipulated regulations.
    - NEMA Registered Vendors should be recruited to manage hazardous wastes (example Cement Bags, Used oil) and their final diposal.

1.8.8 Social-economic and cultural heritage

A number of mitigation measures have been suggested which include among others:

- Comply with statutory requirements such as the Land Act and pay compensation to the project affected persons.
- Payment of prompt compensation to the community members whose crops will be damaged due to the construction, temporary acquisition of crop lands, and due to rock blasting activities;
- Implementation of a proper traffic management plan to ease public inconveniences when the construction of the structures will have an impact on the road users.

- Provide alternative water sources when the construction at the weir points can increase turbidity of the river water which is used by people downstream.
- Provide public safety by way of road humps, sign boards and no access limits for the public.
- Appointment of a Grievance Committee and implement grievance handling mechanism.

1.8.9 Land acquisition and involuntary resettlement

A Resettlement Action Plan (RAP) will be prepared to address issues arising from any involuntary resettlement. Ths can be completed once the land extent and ownership of land impacted will be determined. Compensation for the acquisition of land will be made based on the RAP. It is also essential to form a Grievance Management System in each of the project sub-location.

1.9 Environmental and Social Management Plan (ESMP)

Environmental & Social Management Plan (ESMP) and Environmental Monitoring Plan (EMP has been prepared to aid the civil contractor and the Developer's project staff to implement various impact mitigation measures in a specified time period. The ESMP has taken into consideration the IFC performance standards. The compliances will be based on more stringent standards after comparing the country standards and IFC standards. Responsibilities of implementing the ESMP and the EMP will be with the Civil Contractor and the Developer.

1.10 Public / Stakeholders consultation

Stakeholders have been identified and the methods of their engagement have been documented.

1.11 Conclusion

The Nyamindi River Cascade Development project intends to generate 18.5 MW of electricity on completion of its construction. The elelctrcty will be stepped up into the national grid. The land required for the total project (include ng the project corridors) for construction purposes is approximately 60 acres. EIA reveals that the project will have impacts which are both positive and negative. Those negative impacts can be managed either through mitigation actions or through avoidance. In view of the long term sustainable development objectives that need to be cherished, the proposed project will be beneficial to the country in general. Since there are statutory instruments that require the developer to comply with in mitigating the negative impacts, subject to same and subject to the implementation for the mitigation actions in the ESIA report the project is recommended for environmental clearances.

1 INTRODUCTION

Kenya has a population of 45.5 million, growing at a rate of 3%. Gross Domestic Product (GDP) of Kenya is US $70.8 billion.[1] The average electricity consumption per capita was 167kW in 2014 (World Bank 2014) and approximately 58% (745MW) of this energy is obtained from hydroelectric sources. The economy of Kenya is growing at an average rate of 5.8% per annum and this has implications on the demand for electricity, which is currently inadequate. To fill this gap, the Kenyan Government has put in place the necessary legal, regulatory and institutional framework to encourage speacilly the private sector investors into the power generation sector.

Government funded energy sector feasibility studies have shown that Kenya has the capacity to produce 6,000MW of hydropower with half of it (3,000MW) being generated from small-scale installations or Small Hydro Power (SHP). SHPs are sites that generate less than 30 MW. Indeed, the government recognizes the value of SHPs, which can: (i) be used to supplement the Government's rural electrification program; (ii) assist industries that are in close proximity to this resource to make substantial savings in their electricity bills; and (iii) add excess electricity generated from the small hydro schemes to the National Grid.

Challenges facing SHP have been identified as high installation cost averaging US$ 3,000 per KW, inadequate hydrological data, effects of climate change, unsustainable use of the environment, and limited local capacity of companies to manufacture small hydro power components. However, SHPs are environmentally friendly and categorized as Clean Development Mechanisms (CDM) sources of energy; implying that those investing in CDMs sources of energy are eligible to earn carbon credits. In addition, their products are favorably rated in the markets because of embracing green economy principles.

ResponsAbility Renewable Energy Holding (rAREH) has initiated exploring the feasibility of generating electricity from head waters of River Nyamindi. They have also selected Eco Power Holdings Limited to provide technical assistance to carry out the feasibility studies and the environmental impact assessment. Both the rAREH and Eco Power Holdings which forms rEHCL has sought approval from NEMA Kenya, to conduct the environmental and social assessment for the projects as per the statutory requirements (Environmental Management & Coordination Act of 1999).

This request was made in the month of January 2017 and the same was approved by NEMA by letter dated 20.01.2017. This report is therefore prepared according to the TOR approved by NEMA. The letter of approval received from NEMA is annexed. (Refer Appendix 13.1).

[1] http://www.focus-economics.com/countries/kenya (Kenya Economy Data)

Upon approval of the EIA report, the rAREH will be able to design, develop and construct three small hydro power plants in cascade formation with a capacity to produce a total of approximately **18.5 MW** of electricity using the waters of River Nyamindi in Kirinyaga County (Figure 1.1 & 1.2).

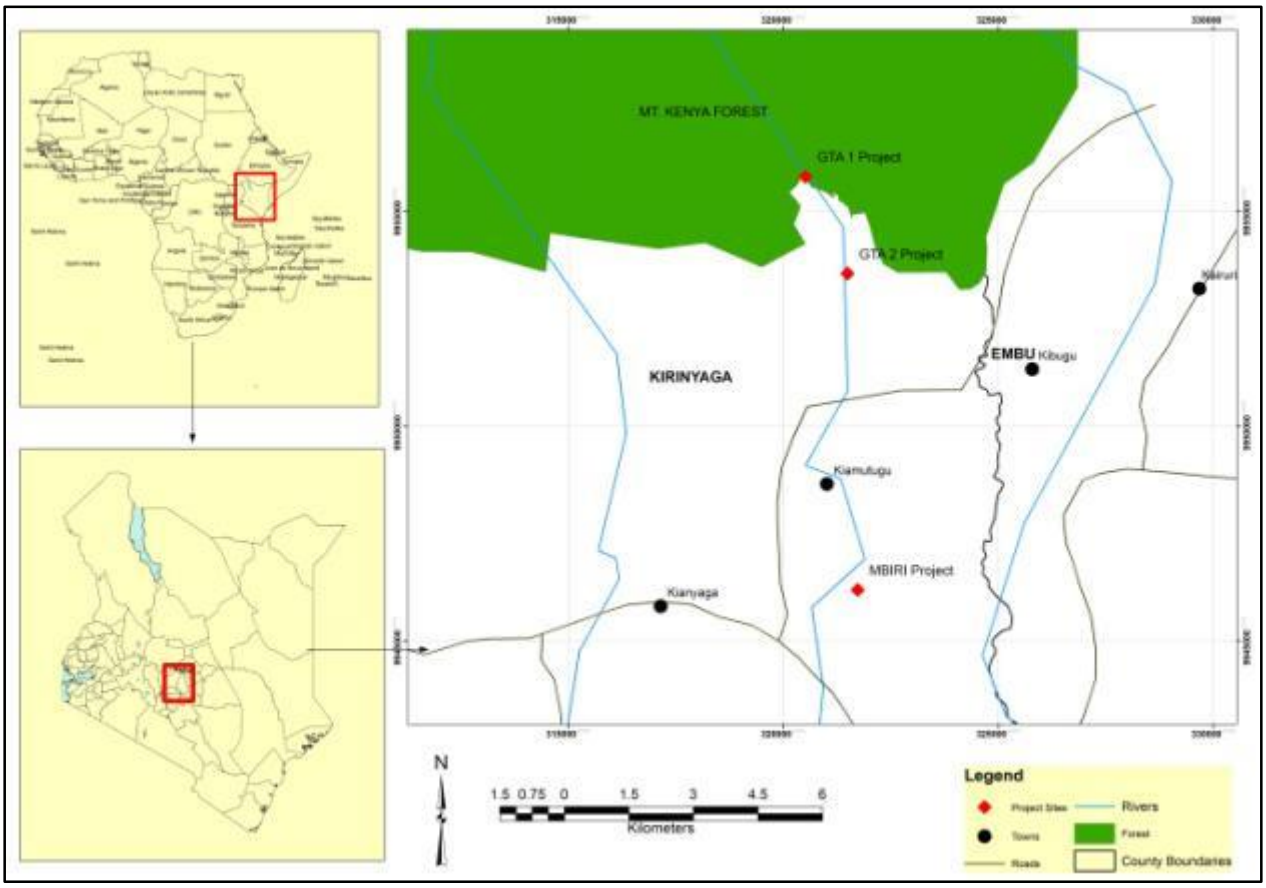


Figure 1.1: A map showing the locations of the proposed small hydro power plants

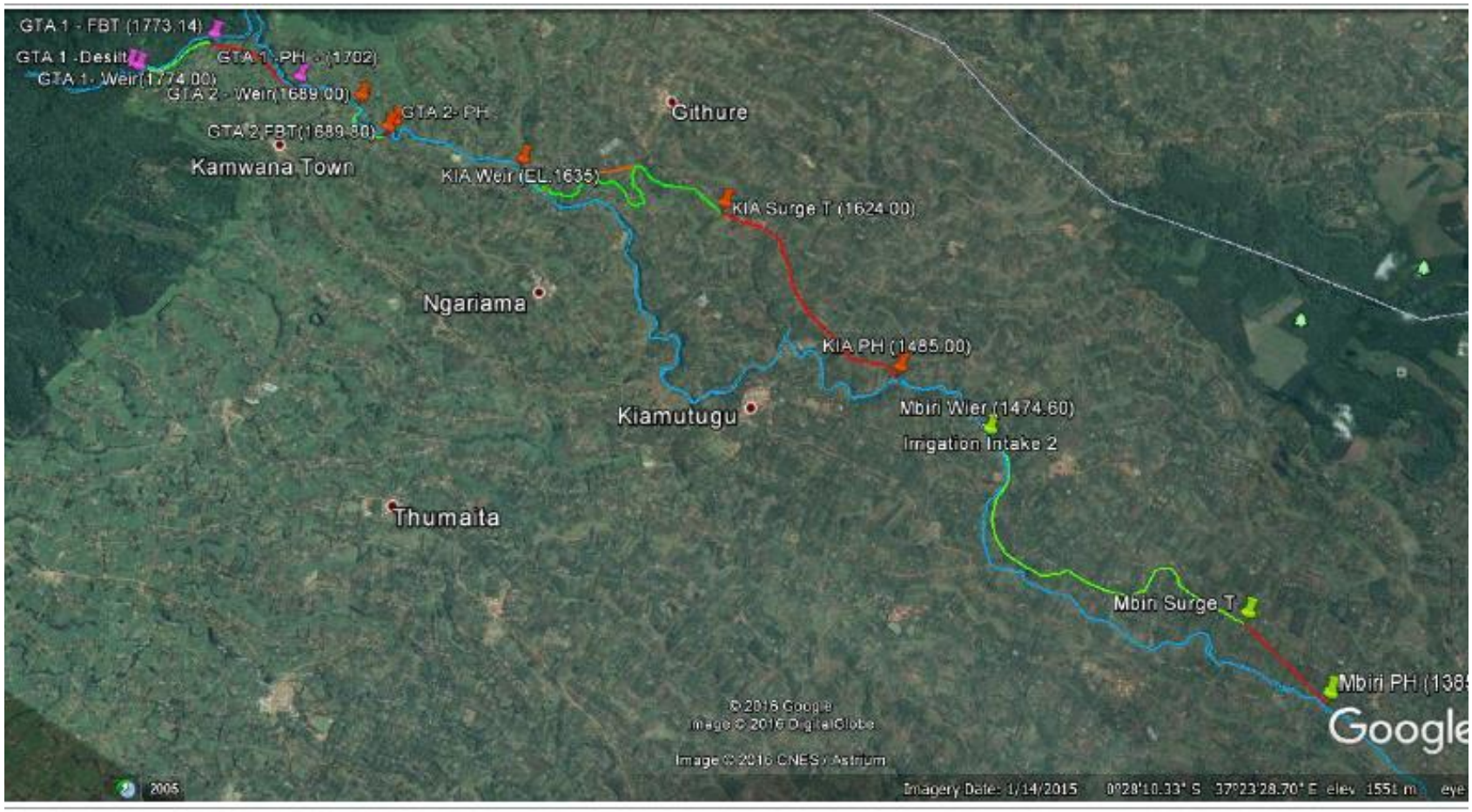


Figure 1.2: Google map of the project locations

2 PROJECT DESCRIPTION AND LAYOUT PLAN

The Kirinyaga County is blessed with six (06) rivers, which originate from Mount Kenya. River Nyamindi is one of the several perennial rivers that originate from the southern slopes of Mt Kenya and eventually joining the River Tana system. The river has been a principal source of water for irrigation, micro hydro generation and a consistent portable water source for the county. Under the proposed cascade development project, the head waters of R. Nyamindi will be utilized to generate electricity power with three small hydro power projects. The combined capacity of the three SHPPs is 18.5 MW. The annual generation is estimated to be to the tune of 98,509 MWh of electricity. Suitable locations with reasonable access from the existing roadways have been earmarked for these projects.

The project will cover four sub locations in the Sub County of Kirinyaga East of Kirinyaga County. They are the Sub Location of Rungeto, Kabari, Ngiriambu and Ngerwe. The R. Nyamindi emerges from Mt Kenya at Kathandenie Forest and traverses through a number of villages which are human dominated landscapes. The river channel is characterized by several distinctive geological features such as level drops, waterfalls, mountains, valleys and several tributaries. Occasional swampy areas are found along the river channel. The undulated land formations and many rapids and level drops present topography suitable to harness cascade waters to develop run-of–the–river hydro power projects.

A small section of the first project (Gitie Project) in the cascade is within the forest area. The rest of the project's meandering path traverses through a number of human settled areas. The surroundings is entirely human settled, modified and cultivated, predominantly with coffee, tea, maize, beans, arrowroot and other crops that comprises of landscape of ridges and steep-sided valleys. There can be impacts on agricultural crops that local population depends on for livelihoods and the natural environment due to the construction of the projects. However with mitigation mesures introduced, the adverse impacts can be reduced.

A detailed environmental and socio economic assessments were conducted, baseline information gathered and analyzed. The likely impacts have been identified. The EIA report has included all relevant information. All potential impacts appraised for their significance with a view to mitigating them (where avoidance is not possible). During the initial topographical surveys, the project corridors have been selected with the aim of avoiding adverse effects on the village communities in terms of physical displacements.

As mentioned above, there will be three (3) hydro power run-of-the-river projects under this cascade development programme. Details of the studies carried out are provided in the following sections. The initial land survey was concluded, the hydrological assessments were carried out

and the appropriate sites for the Weir, Power Houses and other major structures have been identified along the cascade.

The locations of the three projects under the NCD are provided in Table 2.1 and Figure 2.1 and Figure 2.2

Table 2.1: GPS coordinates of the project main structures

	Main structures	GPS Coordinates
Project (1) Gitie Combined	Project (1) Weir coordinates	0°23'59.00"S, 37°23'13.80"E
	Forebay tank coordinates	0°24'15.25"S, 37°23'37.89"E
	Power House coordinates	0°25'28.44"S, 37°23'42.06"E
Project (2) Kiamutugu	Weir coordinates	0°26'12.53"S, 37°23'54.28"E
	Forebay tank coordinates	0°27'12.83"S, 37°24'14.06"E
	Power House coordinates	0°28'35.91"S, 37°23'53.70"E
Project (3) Mbiri	Weir coordinates	0°29'12.20"S, 37°23'53.00"E
	Forebay tank coordinates	0°30'18.10"S, 37°23'29.87"E
	Power House coordinates	0°30'50.60"S, 37°23'30.28"E

Figure 2.1: **Google map indicating all the sites**

(INP1- Intake Project 1; PS1- Penstock 1; PH1- Powerhouse1; INP2- Intake Project 2; PS2- Penstock 2; PH2- Powerhouse 2; INP3- Intake Project 3; PS3- Penstock3; PHP3- Powerhouse

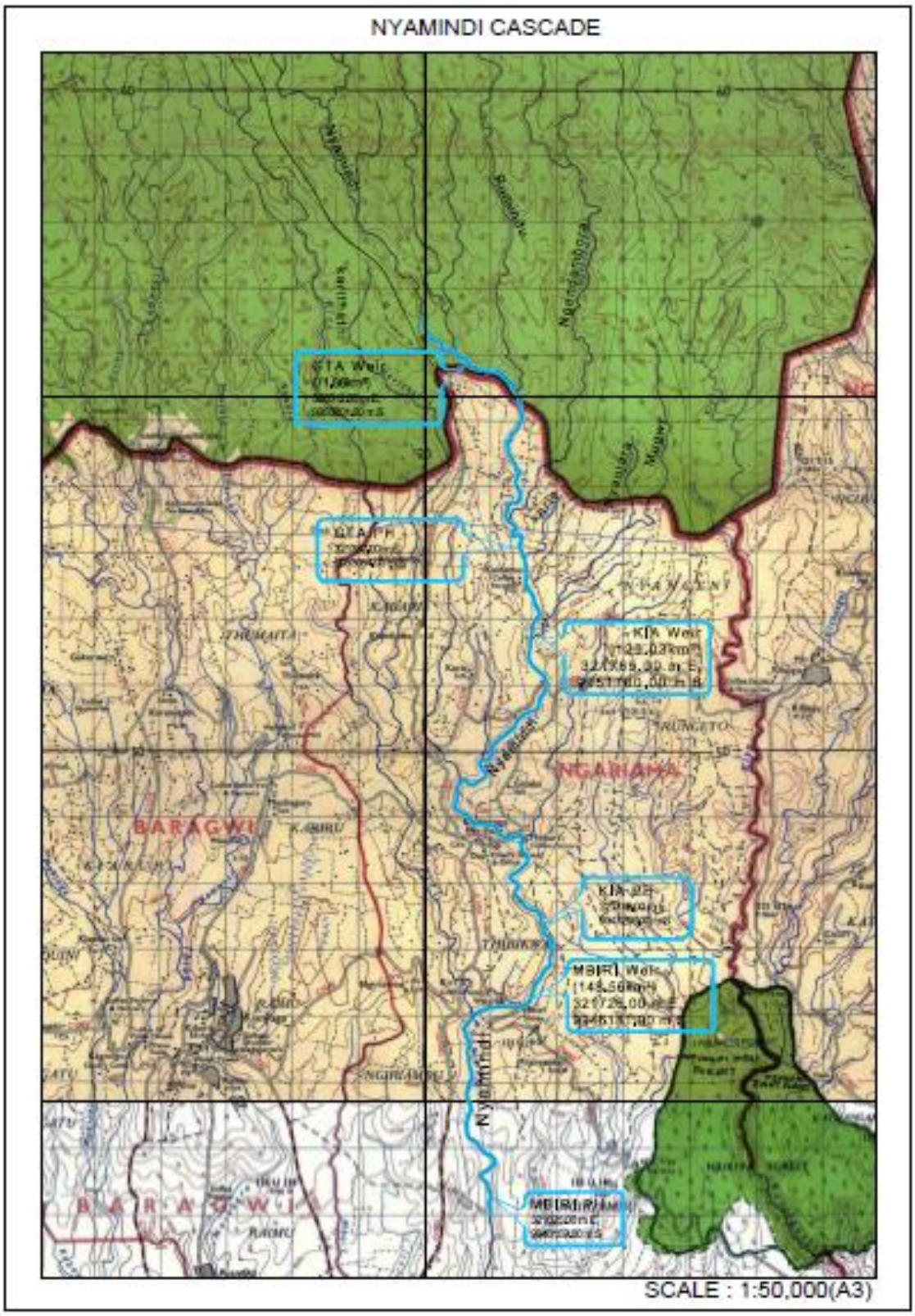


Figure 2.2: Lay out of the projects in the Nyamindi Cascade Development (1:50,000 Topographical Map)

2.1 General characteristics of the proposed projects:

Each project will have a Flow Diversion Weir, Water Intake, Head Race Canal, a Sedimentation Tank, Forebay and a Power House together with a power evacuation plan. A Tail Race will be constructed to ensure that the waters shall join the river after generation of power. Generic description of each of the above mentioned structures are provided followed by specific dimensions of the same in the tables below. All projects will have access roads to access to the main project infrastructure.

Weir Characteristics (General)

The Flow Diversion Weir of the respective SHPP will be an Ogee type mass concrete section. The selection of the location of the weir is based on topographical, hydrological, sociological and geological consideration as well as cost considerations. Suitable foundation conditions have been assessed in the geological studies. It is observed that bed rock is exposed at some parts of the bank downstream of selected location of the weir but not visible at selected location. Sub-surface investigation including geological strata of the banks of the river at the diversion structure has been carried out in order to find out the type of rock and the stability of the banks as the weir has to be anchored to the banks while founding on a non-permeable stable base.

The concrete gravity section of the weir is made to allow overflowin of waters during floods and during machine shutdowns without inundation of the surrounding and upstream banks. In addition to the main concrete weir a gated intake structure combined with de-silting structure has been designed appropriately. Manually operated slide gates will be installed in the intake structure as they would be closed only for the maintenance of the diversion canal and downstream civil structures.

The methodology adopted in the hydraulic design of the weir is that, the weir should be able to pass floods over its crest without flooding large area outside the river banks by limiting the flood heights to the natural conditions. The extended spill section is provided on left bank of the weir to ensure that no effect of excessive pounding occurs as a result of the weir. Accordingly, the weir is designed so as to be hydraulically efficient to get rid of floods whilst structurally sound to withstand the considerable water pressures under extreme conditions.

Further, even during low flow periods, a certain minimum environmental flow must be maintained between the weir and the tail water point at the power house. Therefore, to facilitate this requirement, an uncontrolled opening is provided as a by-pass with pipes of the diameter of (100mm) steel to ensure release of environmental flow to satisfy environmental regulations. Environmental flow pipe will be fitted to the weir at 1.5m high from the bottom of the river at the same level of the intake gate bottom level. However, there will be additional flow into the river

diverted reach to sustain its ecological function since there are a few natural streams laid to fall in between. Fencing and Steel railings will be erected along the left bank from the point of the possible inundated area up to the Forebay to prevent public enter for safety.

Intake

The intake structure will be designed as a reinforced concrete structure. For the design of concrete structure, it is necessary to determine the forces which are expected to affect the strength and stability of the structure. The loads that have to be considered in the strength and stability analysis of the intake structure are:

a) Water pressure

b) Soil pressure

c) Uplift pressure depending on the foundation conditions; and

d) Weight of the structure.

e) Impact due to floating debris and

f) Stability of the structure under 100-year flood condition.

At the detailed design stage, all these forces will be evaluated with the relevant factors of safety to design the structure to perform the duties without any problem.

The Structural Design of the Intake Structure has to be carried out according to the guidelines and recommendations given in international design codes.

Head Race Canal (HRC)

There will be concrete channel section with a freeboard to convey water to the Forebay from the Intake for each of the hydro power plant. The length and the approximate path of the Flow Diversion Canal have already been fixed (details are given in the respective tables below) and much deviation from the fixed meandering path is not expected. This reinforced concrete channel will be covered with a concrete reinforced section to avoid falling of debris and also for the public safety. The velocities computed from the flow simulations for different discharges are checked to ensure that the correct velocities are obtained.

Sedimentation (De-silting) Tank

It is necessary to have a Sedimentation Tank in run - of- river hydropower projects to settle the sand particles which is harmful to the turbine blades. As the slopes are considerably steep and the ground in the upstream catchment area of Gitie SHPP is the forest area, lot of sediment can be expected during rainy periods and high flow conditions. Therefore, at the end of the Head Race

Canal, a de-silting structure shall be constructed to settle the sand particles. The De-Silt Tank shall also be incorporated with flush gates to wash out the settled silt in the tank. A short concrete canal up to the river or a stream will be constructed to pass water during flushing times. A Thrash rack with a platform for removal of trash will be provided at the end section of the silting area and the layout of the de-silt structure.

Forebay Tank

Fore bay structure will be provided at the end of the water conveyance structures from the Water Intake and will be a reinforced concrete structure to store and maintain a storage before water is conveyed to the PH.

Penstock Pipes

Water will be conveyed to the Power House of each of the project with a single penstock. Pipe will be bifurcated close to the power house and will be constructed using spiral welded steel pipes. Each of the penstock will be supported with anchor blocks at all directional change points and with support piers at each 6m intervals. The detailed hydraulic and structural design of the penstock will be carried out according to the accepted design standards and strict welding and painting procedures will be maintained during construction. Areas where footpaths and roads are crossing, the pipe will be buried. Since the excavation is limited to the size of the pipe, no significant impacts will be encountered. Furthermore, it is proposed to turf the soil exposed sections around all anchor supports to form better stabilization for structures and soil erosion could be controlled. As the penstock ends at the Power House, the uphill wall of the Power House will be designed to support Penstock.

Power House

An open air type Power House (PH) shall be constructed under each of the project to house all electro-mechanical equipment, control panels, operator rooms. Each PH will have facilities to accommodate two turbines, generators and other equipment and auxiliaries. It will have a space for loading bay, other auxiliary equipment, switch gear, control panels etc. The setting level of turbine will also be determined by parameters of turbine as well as the flood levels of the river downstream of the power house.

Level and the location for each of the PH have been identified considering the high flood level of the river and other relevant hydrological and geological considerations. The main axis of the PH, along the turbine centers, will lie parallel to the river, while the main entrance and the loading bay will be directed to the access road and the elevations are maintained to suit the ground topography.

There will be High Voltage (HV) switch yard and gantry located on the penstock entry side of the PH, which will contain the transformers, HV isolators lightening arrestors and other associated components. The area shall be leveled with suitable concrete retaining walls, and fenced with plastic coated steel fencing. The entire floor area of the switch yard shall be covered with a 300 mm layer of 15 mm aggregate with suitable drainage in case of transformer oil leakage. All supporting structures and foundations for the transformers shall be in reinforced concrete, while all mounting brackets, poles and other steel components shall be in Galvanized Mild Steel. A lockable gate shall be incorporated to provide access to the gantry.

Tail Race Canal

The discharge from the generating unit is led to the Tail Race which carries water back to River Nyamindi. The Tail Race Channel will be perpendicular to the river, and the length of the tail race will depend on the distance between the power house and the river. The tailrace will be designed to ensure minimum tail water level required for operating the Turbine. In order to prevent scouring of the river bank, the river bank at this point will be stone pitched and concrete lined.

2.1.1 Project Influence Area

The Direct Impact Area (DIA) is the area that will receive primary impacts resulting from project activities. The DIA includes: Weir area (including its area of inundation) of the respective project, the area under the Head Race Channel, the Forebay area, the Penstocks area, the Power House area, the Tail race, workers Main Camp, the Project's site office area including stores, materials stockpiled areas and the power evacuation line with its way leave.

The project influence area consists of the sub county of Kirinyaga East which consists of 3 Divisions, 10 locations and 27 sub locations. In terms of political administration, the Gichgu Constituency has several county assembly wards. Those villages in the sub locations within Kirinyaga East are considered the indirect area of influence.

2.2 Specific characteristics of each of the proposed projects:

Brief description of each of the project is provided below.

2.2.1 Project (1) Gitie SHPP

First project in the cascade is Gitie. This will facilitate generating 5.5 MW of electricity. The Flow Diversion Weir and the Intake of this project will be located upstream of the river within the forest area. Exact weir location is close to the confluence of River Nyamindi with a tributary (River Rumindu). The project corridor or the Head Race Canal will meander along the Right Bank almost parallel to the electric fence and the perimeter for the forest land. Head Race Canal (about 1 km)

will cross through the forest border. The Fore bay will be located on a land outside the forest but on a land which is also partly under tea cultivation. It will be on a land in the village called Kithima. The HRC will be equipped with one or more aqueducts due to the valleys within the Section. The 2.2 km long penstock pipes will convey water to the power house and will meander through croplands (tea and other cultivated lands including macadamia, banana and coffee) owned by private individuals.

Below in Table 2.2 provides additional and very specific details with a few visuals of the project's locations (Figures 2.7 to 2.10) and engineering drawings showing the correct dimensions of the structures (Figure 2.3 to 2.6).

Table 2.2: Descriptions of Project Components

Components	Quantity
Energy Production	
Design Flow (m^3/s)	**5.50**
Gross Head (m)	**120.00**
Capacity (MW)	**5.00**
Plant Factor (%)	**61%**
Total Energy (MWh)	**27,012**
Structures	
Weir	
Spill Level(msl)	**1774.00**
Length (m)	**13**
Height (m)	**4.32**
E- flow pipe diameter	**To e determined**
Head Race Channel	
Length (m)	**1110.64**
Internal Width (m)	2.40
internal height with freeboard (m)	1.60
Slope	**0.001645**
Sedimentation Tank	
Length (m)	**47.60**
Internal Width (m)	**6.00**

Height (m)	5.00
Forebay Tank	
Length (m)	32.20
Internal Width (m)	6.00
Height (m)	6.80
Penstock line	
Penstock Diameters (m)	1.4 / 1.6/1.8
Penstock Length (m)	2284.00
No of Anchors	41.00
No of Supports	245.00
Power House	
Length (m)	30.00
Width (m)	9.00
No of turbines(Francis)	2.00
Tail Water Level (msl)	1654.00

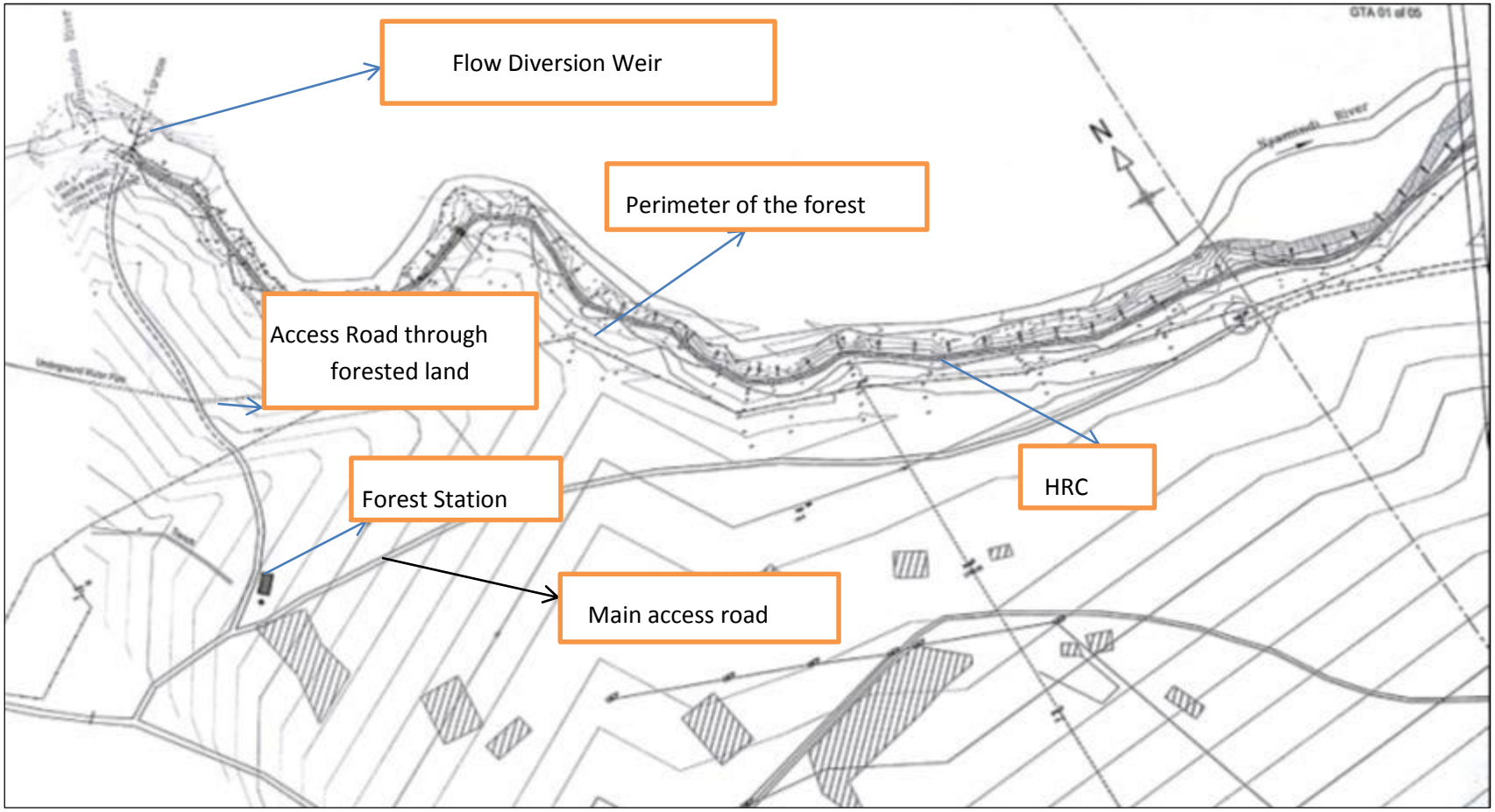


Figure 2.3: Project (Gitie) Weir Location

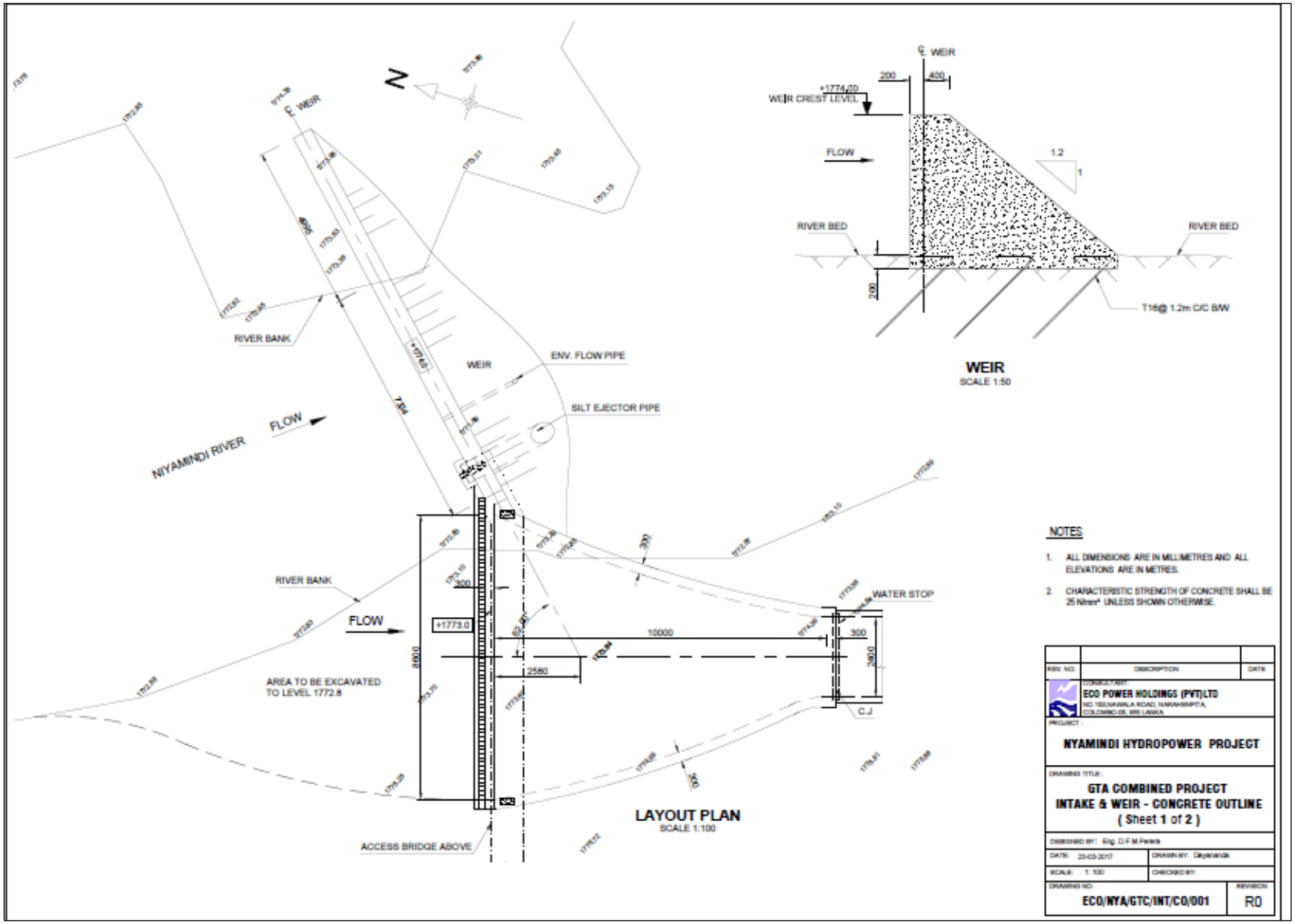


Figure 2.4: Drawing of the Weir

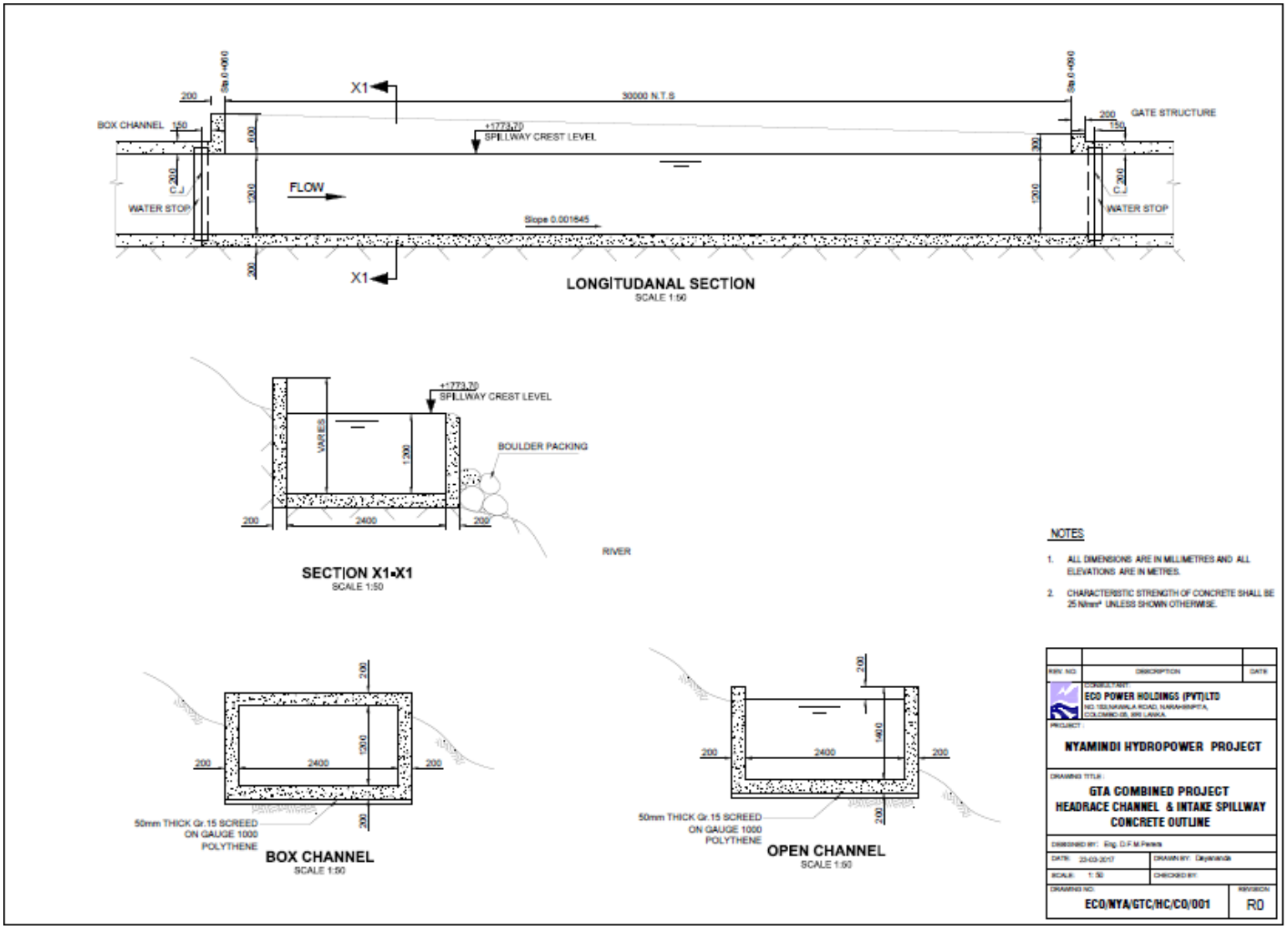


Figure 2.5: Cross profile of the channel section

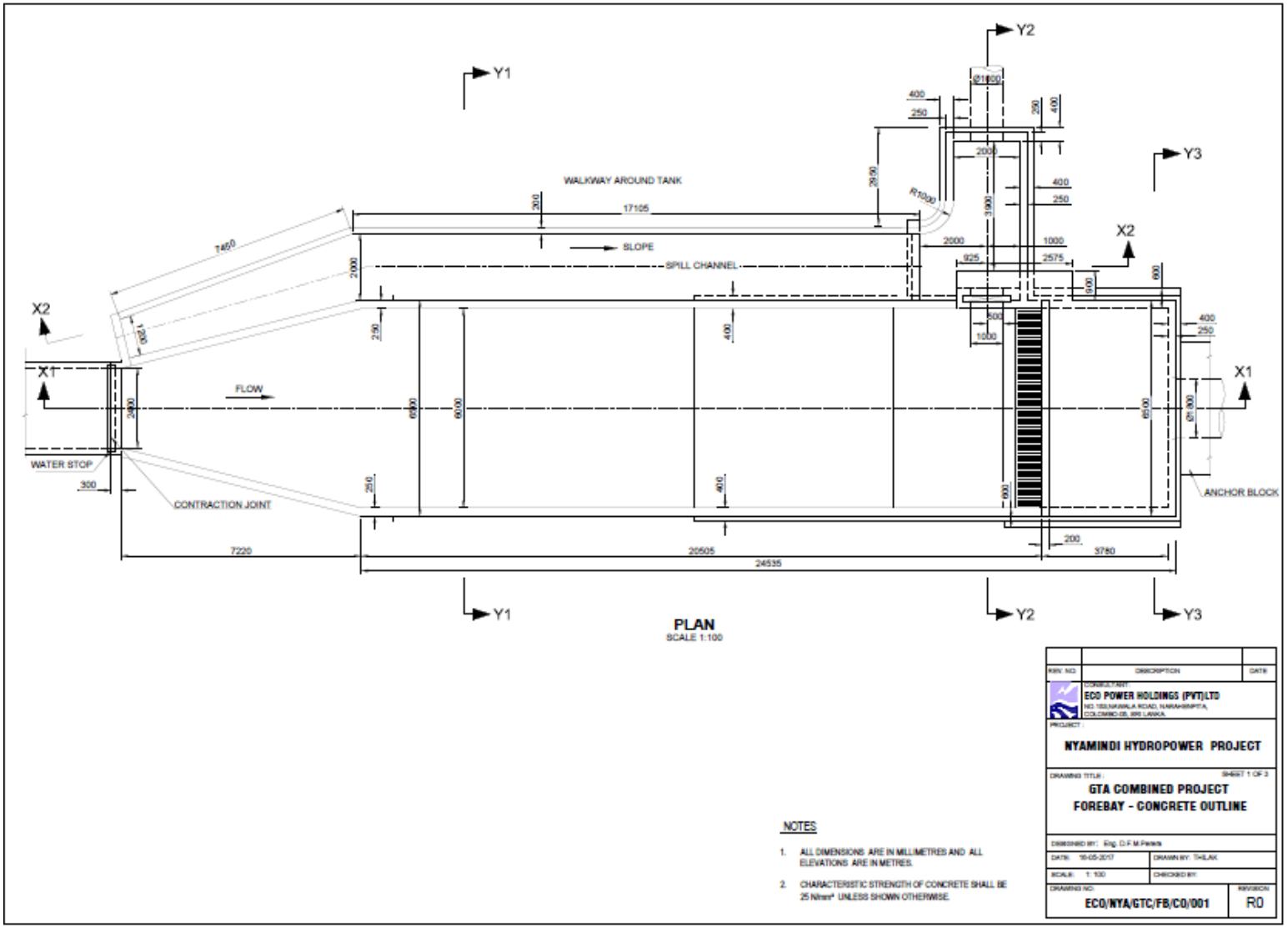


Figure 2.6 Drawing of the Fore bay

Figure 2.7: Weir Location

Figure 2.8: Location for the Fore Bay

Figure 2.9: Land use along the penstock pipe laying areas

Figure 2.10: Location for the Power House

2.2.2 Project (2) Kiamutugu SHPP

This project falls in the middle of the cascade. The Weir and the Intake of this project will be located just upstream of the position where the river transforms into a waterfall. This would be at a site about one (1) km downstream from the power house location of the 1st project. About 400 m downstream further is a small tributary called Kirimbo Stream which feeds into River Nyamindi. Access to the weir and the intake will require developing a new 200m long road. A sedimentation tank will also be constructed at cha 0+260 point. The project corridor will traverse along the left bank of the river. The proposed Headrace Channel (2.3 km long) together with the 2.8 km long penstock pipes will cross the main road at several points. The HRC will intersect the main road at least three locations.

In addition, the structures also will cross several community roads and crop lands. There will be at least two aqueducts to be built since the water conveyance will pass through valleys. Penstock pipes will be laid underground at certain points. The access to the Power House can be obtained by developing a new road from the community road, which is located about 300m away. Following figures in in Table 2.3 provides specific details of major components. Also provided are details of the structures Figure 2.11 **to 2.14**, **with** pictures of Figure 2.15 **and 2.16** showing the visuals of the proposed locations.

Table 2.3: Descriptions of Major Components

Components	Quantity
Energy Production	
Design Flow (m^3/s)	**8.00**
Gross Head (m)	**151.00**
Capacity (MW)	**9.20**
Plant Factor (%)	**61%**
Total Energy (MWh)	**49,118**
Structures	
weir	
Spill Level (msl)	**1637.00**
Length (m)	**16.3**
Height (m)	**6.5**
E- flow pipe diameter	**0**

Head Race Channel	
Length	**2350.00**
Internal Width (m)	2.70
internal height with freeboard (m)	1.70
Slope	**0.001431**
Sedimentation Tank	
Length (m)	**52.60**
Internal Width (m)	**7.00**
Height (m)	**6.50**
Forebay Tank	
Length (m)	**33.20**
Internal Width (m)	**7.00**
Height (m)	**8.70**
Penstock line	
Penstock Diameters (m)	**1.6/1.8/2.0/2.2**
Penstock Length (m)	**2864.00**
No of Anchors	**53.00**
No of Supports	**305.00**
Power House	
Length (m)	**30.00**
Width (m)	**9.00**
No of turbines(Francis)	**2.00**
Tail Water Level (msl)	**1486.00**

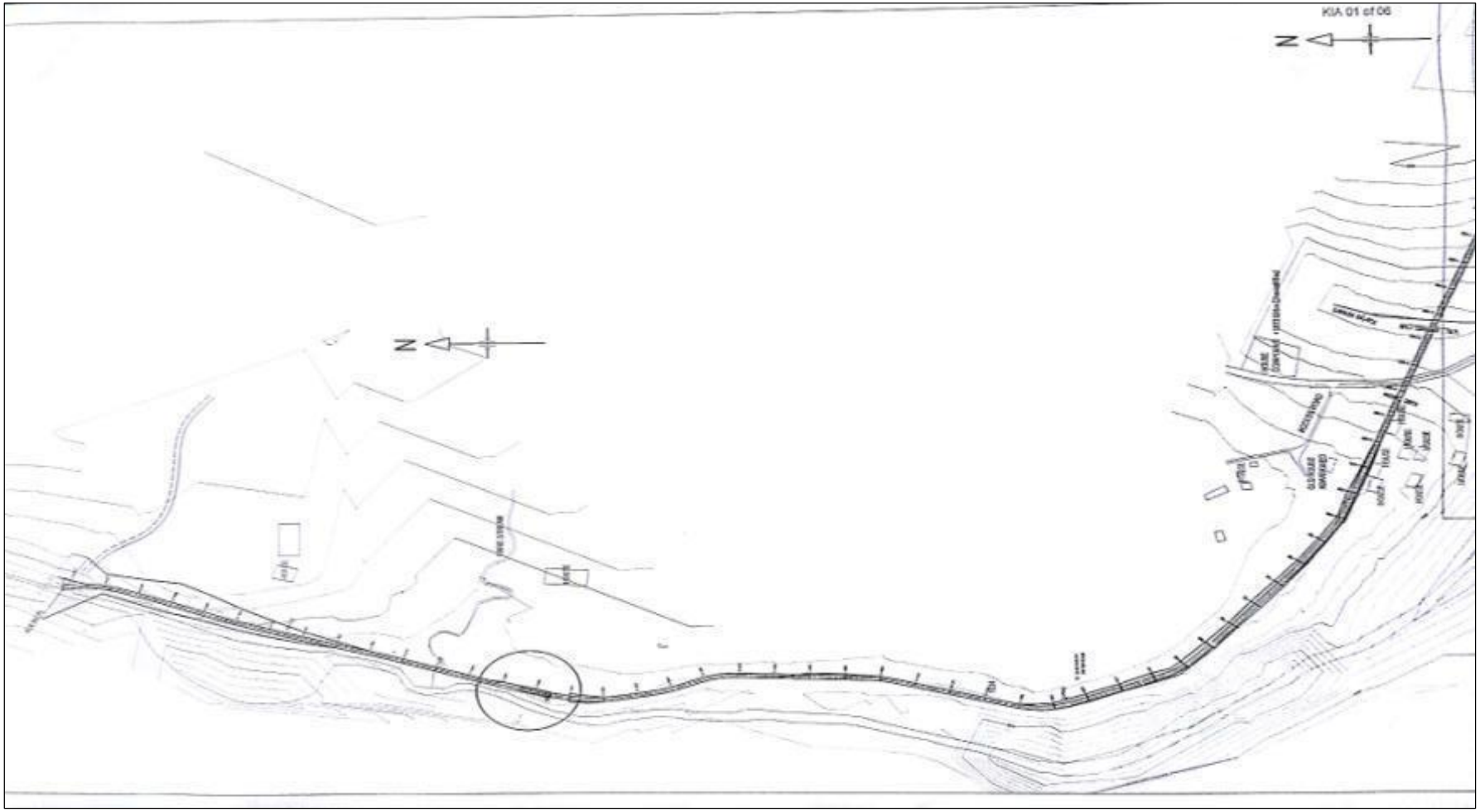


Figure 2.11: Weir Lay out

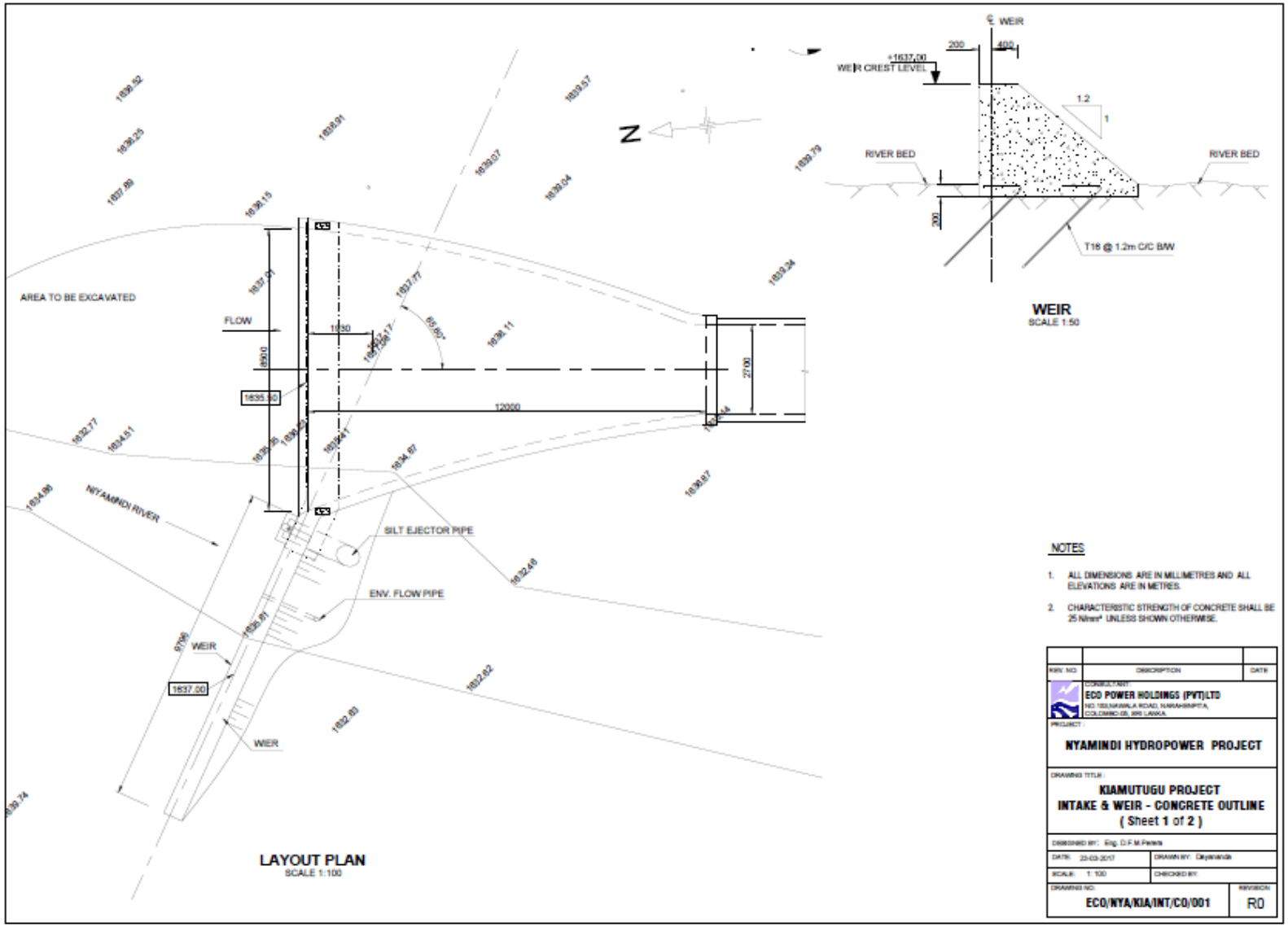


Figure 2.12: Weir Cross section

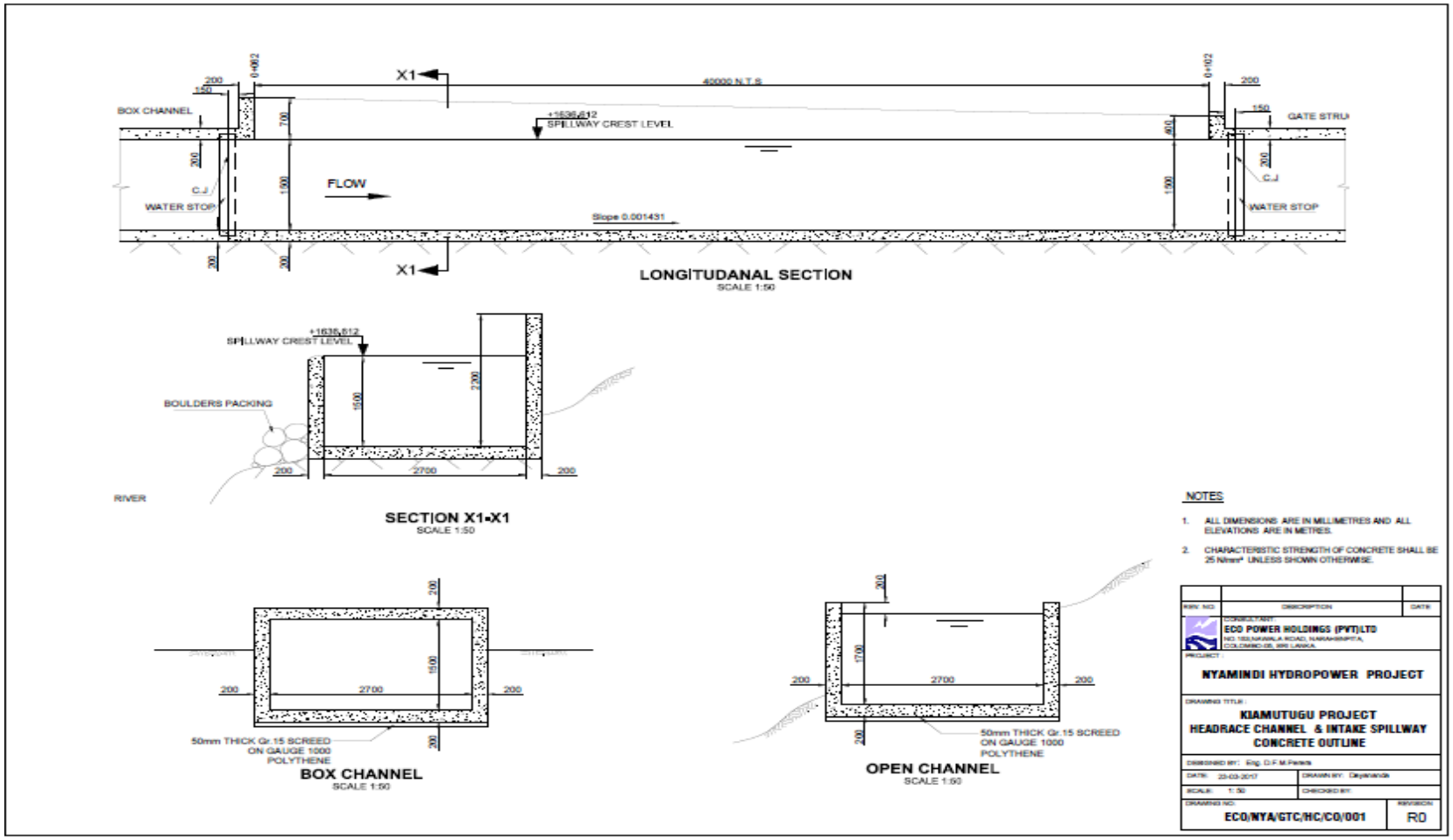


Figure 2.13: **Cross section of the HRC**

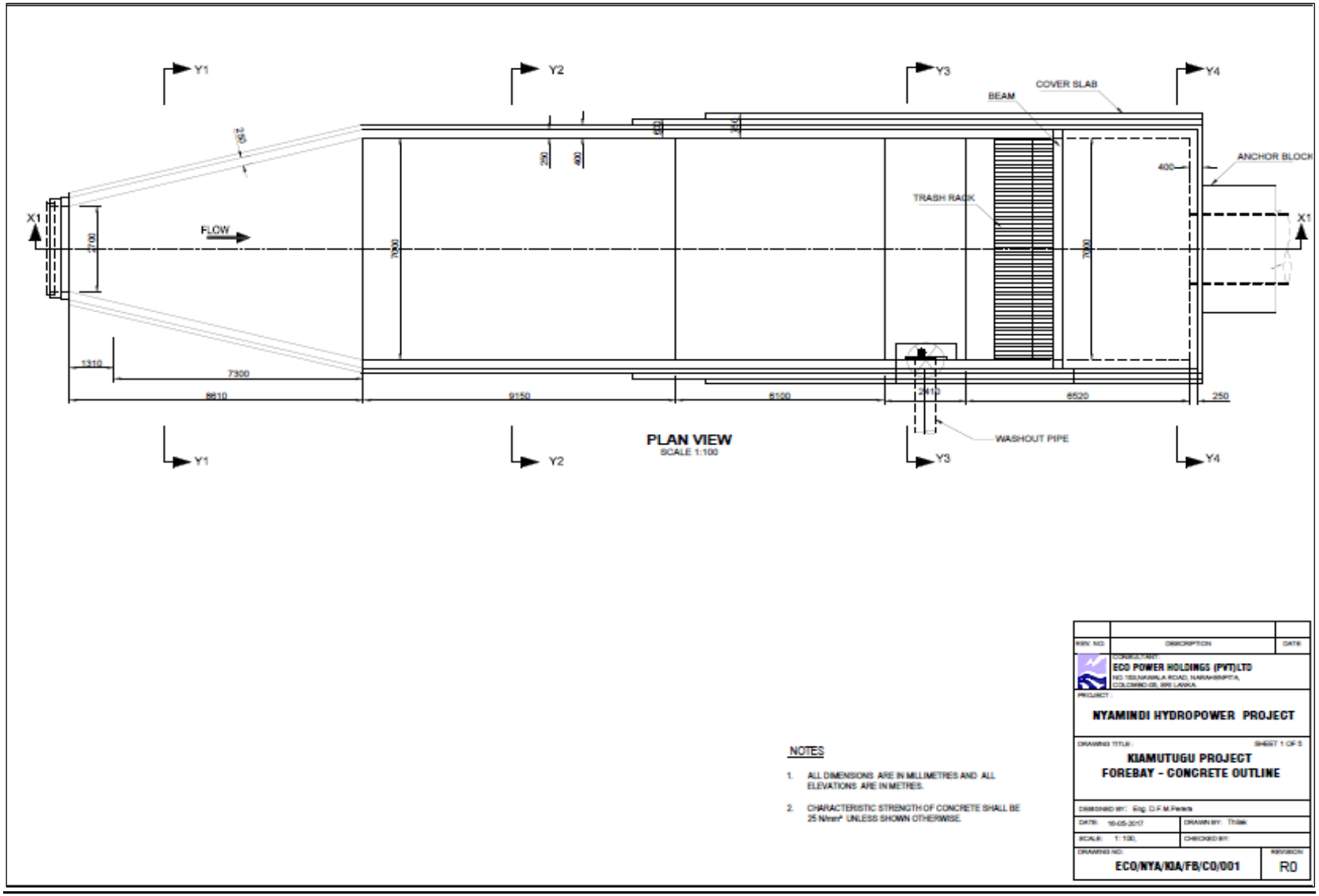


Figure 2.14: **Cross Section of the Forebay**

Figure 2.15: Weir Location

Figure 2.16: Fore bay Location

2.2.3 Project (3) Mbiri SHPP

This is the 3rd project in the cascade and will be located on the downstream in Mbiri. As shown in the visuals in the tables 2.4 below, and the drawings below (Figure 2.21 to Figure 2.22), the Weir and the Intake of the project will be located downstream of the two irrigation weirs located in this river at coordinates **0°29'12.20"N, 37°23'53.00"E.** The project's weir will avoid the section of the irrigation schemes in order to facilitate uninterrupted water for the irrigation requirements.

The project corridor would be located on the left bank and will cross the main road and several other community roads. The Head Race Canal which is about 2.7 km long will cross the main road within a distance of 420 m from the weir site. The section of the road is very close to the bridge. The road needs to be elevated from the present level considering the elevation of the HRC as the HRC will cross the road at this point. The 1.057 km long Penstock also crosses a valley and need to be provided with high pier supports and aqueducts. The Forebay and the Power House will be on private lands. The PH will need to have a new section of access road of about 200 m.

Table 2.5 below provides dimensions of the major components. **Figures 2.17 to 2.20** provide drawings for the weir location (with additional details, a cross section of the weir, a cross section of the HRC and the Forebay). Visuals in of location for the Weir and Forebay, the typical stretch of land use affected by areas for the pipe laying and the location of the Power House are provided **in Figures 2.21 and 2.22.**

Table 2.4: Description of Major Components

Components	Quantity
Energy Production	
Design Flow (m^3/s)	8.88
Gross Head	67.00
Capacity(MW)	4.50
Plant Factor (%)	57%
Total Energy(MWh)	22,379
Structures	
weir	
Spill Level (amsl)	1474.60
Length (m)	10
Height (m)	2.2
E- flow pipe diameter	0
Head Race Channel	
Length	2771.00
Internal Width (m)	2.80
internal height with freeboard (m)	1.80
Slope	0.001353
Sedimentation Tank	
Length (m)	56.60
Internal Width (m)	7.00
Height (m)	6.50
Forebay Tank	
Length (m)	33.00
Internal Width (m)	7.00
Height (m)	8.90
Penstock line	
Penstock Diameters (m)	1.6/1.8/2.0
Penstock Length (m)	1057.00

No of Anchors	**22.00**
No of Supports	**111.00**
Power House	
Length (m)	**30.00**
Width (m)	**9.00**
No of turbines(Francis)	**2.00**
Tail Water Level (msl)	**1407.60**

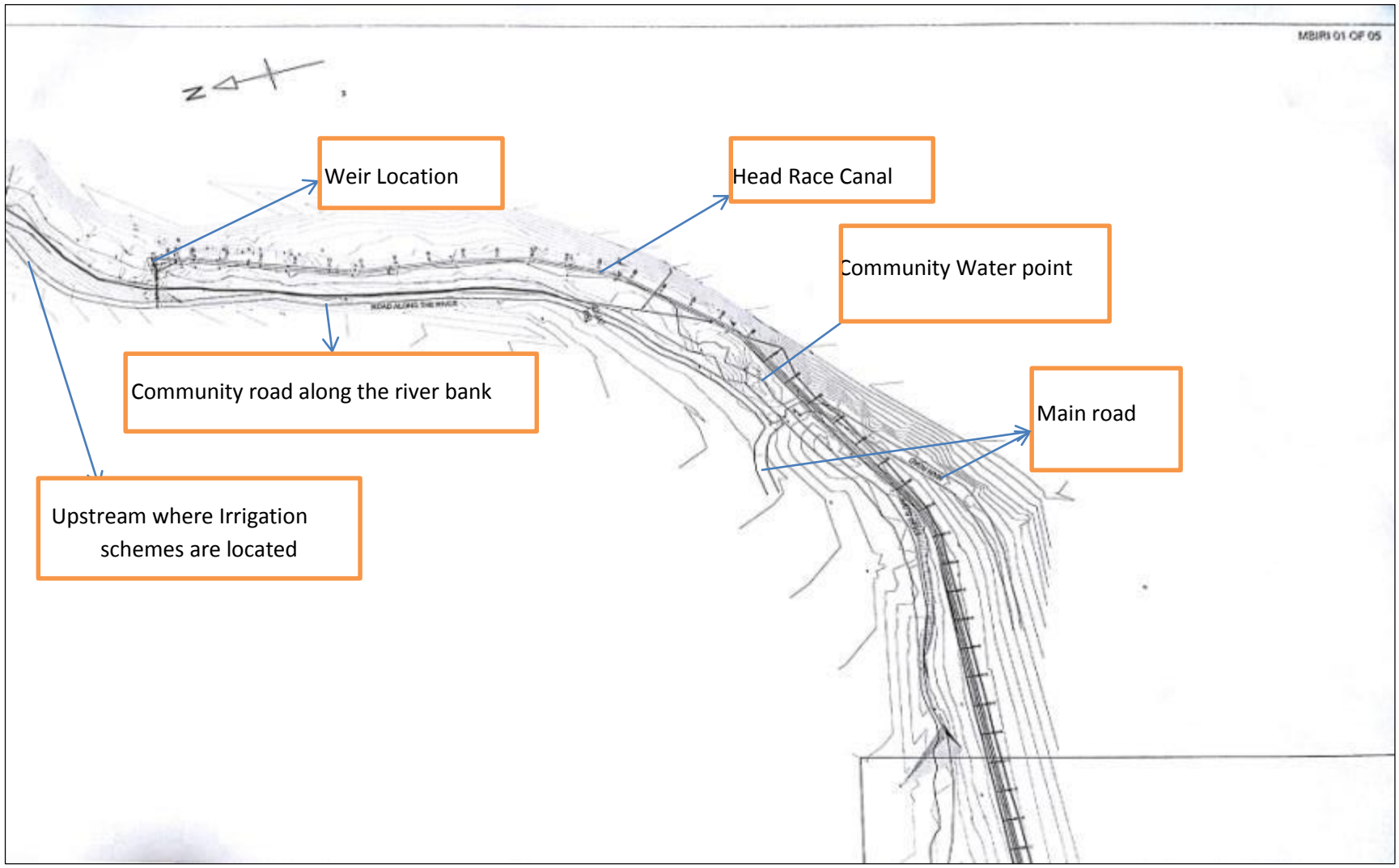


Figure 2.17: Weir Location with other details

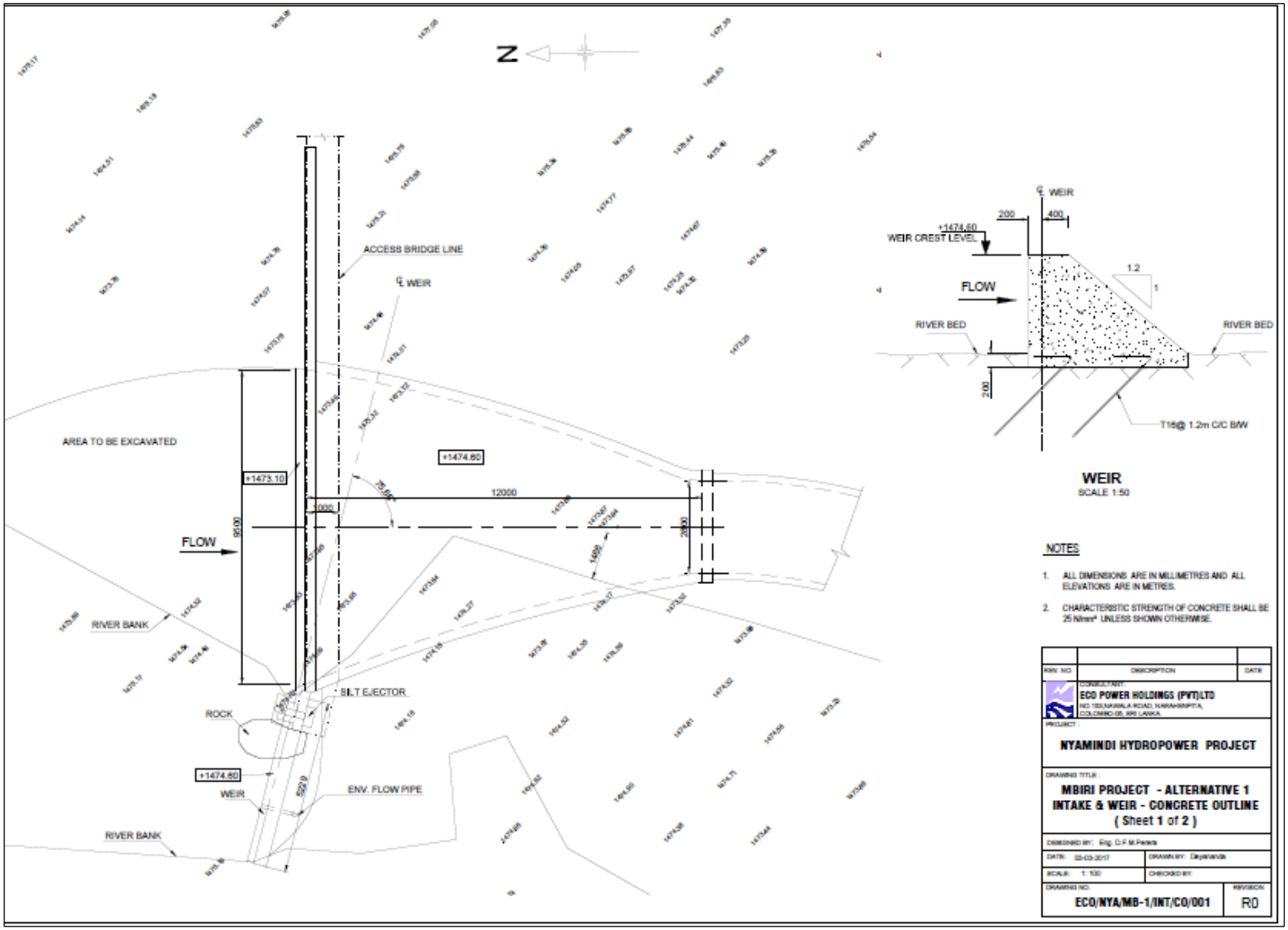


Figure 2.18: Cross section of the Weir

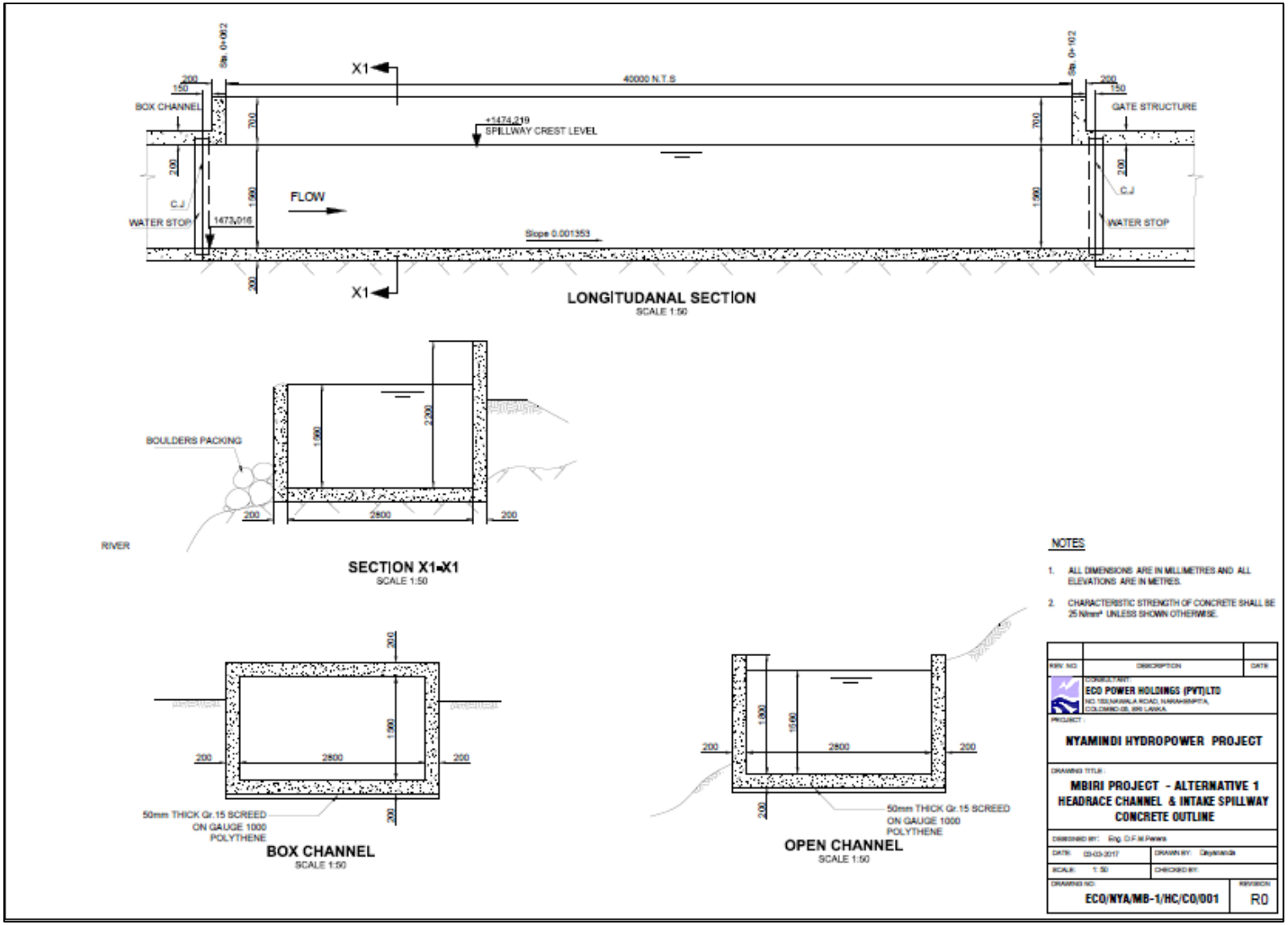


Figure 2.19: Cross section of the HRC

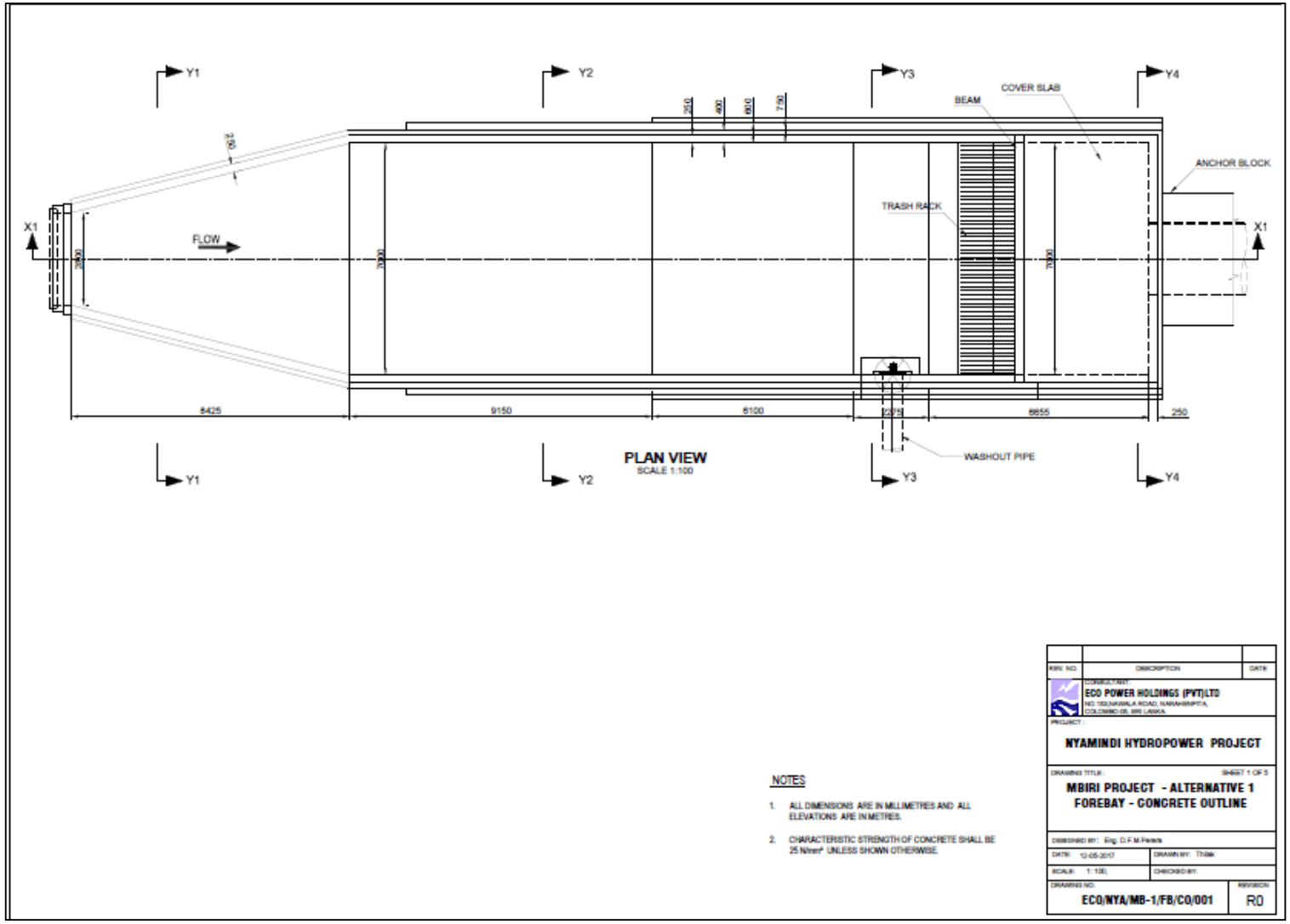


Figure 2.20: Drawing of the Forebay

Figure 2.21: Weir Location

Figure 2.22: Power House Location

2.3 Land requirements

Total land required for the projects in the cascade will be approximately 60 acres. **(Table 2.5).** Land will be purchased from the occupants who are private land owners. Land in the forest area belonging to the Kenya Forest Authority will be negotiated on leasehold and compensation will be paid to the Forest Authorities. No houses are expected to be affected due to the cascade development project, however depending on the cadastral (strip) map any other structures if affected will be paid compensation. A separate Resettlement Action Plan will be prepared after conducting the cadastral survey.

Table 2.5: Land required for Nyaminidi Cascade Development SHPPs

	Nyamindi cascade development - Land Area			
		Gitie Project	Kiamutugu Project	Mbiri Project
1.0	Intake	430	1,086	311
2.0	HR Channel	17,684	35,558	37,291
3.0	Channel Spill	-	1,441	1,246
4.0	Forebay Tank	2,303	2,591	990
5.0	Penstock	31,320	38,810	13,265
6.0	Power house	3,674	19,667	20,493
7.0	Access Roads	2,000	1,200	800
8.0	Material yard	3,300	8,400	6,000
	Total in square meters	60,711	108,753	80,396
	Total in acres	**15.00**	**26.87**	**19.87**

2.4 Supporting facilities

Supporting facilities will include construction of staff accommodation for the staff engaged during the operational period. Suitable land will be purchased for such purposes. In addition, for the construction phase, there will be a temporary project office and temporary storage facilities for the construction materials, temporary staff accommodation (labor camps) and a parking area as well as washing bay for construction vehicles. The land for such facilities will be obtained on lease. The land will be restored to its original state after the construction phase and will be handed over to the owners.

2.5 Project Access Roads

All the three projects can be accessed through the existing road network. They include highways and tarmac roads, (Class A2 and B6 roads), gravel and earth surfaced all weather roads. The projects can be reached through the Embu Nairobi highway using A2 (to Kutus) and B6 highways (drive for 120 km) until the Kianjuru Trade Center. From the Trade Center it is the gravel and earth surfaced roads to the left along the gravel road towards Mbiri.

Mbiri SHPP can be accessed by travelling along the gravel and earth surfaced public road. One has to turn to the left from Kianjuru Trade Center and travel about 3.6 km distance to the weir location. The power house location can be accessed even before that along the weir location. A stretch of about 200 m of land needs to be opened up as new access to the Power House.

Proceeding further from the Mbiri, one can reach Gitie 1 SHPP travelling along the same road to some distance until one reach Kiamutugu / Kamwana Road at Kiamutugu Junction. The project's weir location area can be reached north east passing Kiamutuga Trade Center along Kiamutugu / Kamwana Road. From the point of highway to the Gitie SHPP weir, the distance is about 18 km. Kiamutugu / Kamwana Road is an all-weather (gravel) road. To reach the weir location, the existing foot path within the forest area (about 500m) needs to be improvised. The Forebay can be reached through the community access road to the Kithima Tea Collection Center.

The access to Kiamutugu SHPP (Project 11) is easy from existing B6 main road. The project is located parallel to the river and can be accessed after driving about 10 km along Kianyaga / Kiamutugu Road. From Kiamutugu trade center to the Power House of the project is about 5 km. This road is leading to Giture. The intake is about 900 m close to Kainamuri Coffee Factory.

All gravel roads are not suitable for motor traffic during the rainy periods as they become slippery. Nevertheless almost all the three projects are easily accessible using existing road networks.

2.6 Material spoils

There will be material spoils both rock and soil due to construction related excavations. **Table 2.6** shows quantity of spoils estimated from such excavation for all three projects. All the excavated materials can be used to fill the depressed areas and for the construction activities. Any spoils which will be left in the spoil yards will be graded compacted and the land will be restored with natural vegetation. Spoil dumping yard/s will be identified immediately before the construction phase.

Table 2.6: Quantities of spoils to be excavated:

Excavations						
	Project (1)		Project (2)		Project (3)	
	Soil and Soft rock excavation	Rock Excavation	Soil and Soft rock excavation	Rock Excavation	Soil and Soft rock excavation	Rock Excavation
	m^3	m^3	m^3	m^3	m^3	m^3
Weir Access road	100	25	200	25	100	25
Forebay tank Access road	100	15	100	25	100	20
PH Access road	525	225	1050	450	630	270
Total Excavation for Access Roads	725	265	1350	500	830	315
Weir	10	5	13	4	5	13
Pipe line or HRC including Access	8129	3484	25274	10832	10112	4334
Forebay tank	102	44	181	77	242	104
Anchors	732	81	1361	151	1228	136
Forebay Tank to Power house Trace including Access	6780	2906	8275	3546	2489	1067
Power House	900	600	900	600	900	600
Total excavation for project	17377.7	7384.8	37353.3	15710.7	15804.8	6568.2

(Source: Eco Power Engineering Estimates)

2.6.1 Construction materials

The projects will require substantial quantities of construction materials and quantities that will be required for each project are shown in **Table 2.7.**

Table 2.7: Construction Materials

Project	Gravel Required	Sand Required	Aggregates Required	Cement Required
Project (1)	300 Cu.m	3714 Cu.m	6190 Cu.m	55000 Nos
Project (2)	400 Cu.m	4800 Cu.m	8000 Cu.m	75000 Nos
Project (3)	350 Cu.m	3360 Cu.m	5600 Cu.m	66192 Nos
Other facilities	350 Cu.m	300 Cu.m	250 Cu.m	2500 Nos

(Source (Eco Power Engineering Estimates)

No borrow pits will be envisaged as the excavated spoils could be used to supplement the gravel required for filling depressed areas. All other construction materials will be sourced from vendors. There will not be any stone crushing plant at the site, but rock boulders salvaged from the excavation will be broken to small pieces through breakers and through manual labor. This will be used for construction of the anchors, anchor piers etc.

A materials yard to store aggregates, sand and other construction materials will be obtained on leasehold. Necessary security and dust prevention and spill protection measures will be introduced.

2.6.2 Equipment to be used for construction

The project will use a fleet of heavy vehicles for transport purposes and, heavy machinery for excavation and for construction work. There will be a wash bay which will have required facilities for the vehicle servicing. Other than the vehicles owned by the company, there will be hired vehicles for passenger transport and for other purposes. The car parking facilities will be provided in the office compound and will have a capacity to park least 15 vehicles of long wheelbase type, high cab or land vehicles. The heavy machinery and other equipment will be manned by expatriate staff as well as local staff. The adequacy of their training and experience to operate such machinery will be well established in order to prevent accidents.

During the construction phase, it is expected that the following construction machinery and equipment will be used (but not limited to).

- Land vehicles
- Dump trucks and lorries
- Pump cars
- Ready mixed Concrete pumping trucks

- Excavators and Wheel Loaders (for the excavation of the foundation trenches)
- Road rollers and Compactors
- Motor Grader
- Compactors such as trench plate compactors (plate tampers)
- Concrete mixers
- Poker vibrators
- Compressors
- Electric drills and saws
- Mobile Cranes (to install the roofing material and Equipment)
- Electricity generators and Welding Transformers

2.6.3 Transmission Line and Grid Connection

A power evacuation study has already been undertaken and completed. This had evaluated several options and suitable recommendations have been made as to the evacuation of power to the national grid. Option (4) of the report , that is Gitie SHPP-Kainamo Juction-Kamwangi Road(Green Roof)-Ryamathakwa Junction-jogoo Junction-Kiamutugu SHPP BB-Mbiri -Kiamutugu Road-Kiri Junction(RIGHT TURN Coffee factory road)-Mbiri SHPP BB - KUTUS132 (Using West of R.Nyamindi) has been recommended. The lines will be erected along the public roads. Payment of compensation for the way leave (only to erect poles) has been assessed and said to be approximately US $ 8925. There will be new switching station to be introduced at the interconnection points between the lines coming from each plant. The lines will have following distances: Gitie SHPP -Kiamutugu SHPP (7.8km) Kiamutugu SHPP-Mbiri SHPP (5.3km) Mbiri SHPP-Kutus132KV (5.1km)

2.6.4 Other key Project Attributes

No.	Project activity	Project attributes
2	Method of construction	Pre-qualified Contractors selected based on competitive bids (for civil works) International manufacturers and suppliers for Electro Mechanical works
3	Additional services (electricity, emergency services etc.)	Will have Backup Facilities such as generators. There will be proper occupational health and safety arrangements for the workers engaged in the civil and mechanical works of the project
4	Project's potential for accidents, hazards and emergencies (construction and operation)	Policy of the Developer is to ensure Zero Accidents.

5	Estimated land take up by the project	Around 60 acres (22 ha) with additional requirements yet to be assessed for temporary buildings.
6	Estimated number of construction workers and visitors both construction and Operations	Local labor force: 400-500 Visitors: 10-15 per week Total labor force during operations : (provided separately)
7	Means of transporting construction of workers	Using transport (land vehicles from the close by Trade Centers / Villages)
	Material transport	By means of medium to small construction equipment and machinery combined with manual means
8	Proposed waste management including disposal.	See Waste Management Chapter

2.7 Manpower requirements during construction and operations phases

The construction phase will take about three years from 2018. There will be an overlapping period of construction of all three projects. When the construction overlaps in all the three projects there need to be around 500 workers needed to be engaged.

The operation phase is expected to be at least 20 years after the completion of the construction phase. Operations will be commenced immediately after the completion of the individual plants. Recruitment of staff, arrangement of all the backup facilities will be ready by then. The following cadre of staff will be the required for the daily operations of the three power plants:

- Gitie Project: - Three (3) Operators and six (6) Helpers
- Kiamutugu Project: Three (3) Operator and twelve (12) Helpers
- Mbiri Project: Three (3) Operator and six (6) Helpers

In addition, three (3) Site Plant Superintendents and Drivers as well as supporting staff including an Accountant will be engaged. Staff will be provided with health care facilities and necessary training. Staff will have permanent accommodation, dining and cooking facilities, other basic utilities such as drinking water and running water for toilets will be provided.

All toilets will be of permanent nature with sewage directed to the septic tank and soakage pit system. Rain water harvesting will be arranged which will add water for landscaping work.There will be domestic wastes and wastes from annual and regular maintenance work of the plant and

machinery. There will also be wastes from the Trash Tracks. A proper waste collection and disposal systems will e introduced during the operational phase. Licensed Vendors will be selected for the disposal of all recyclable wastes such as paper, plastic, glass and oils.

A contingency management plan will be developed in order to ensure that specific contingencies during the operational phase are properly managed. It will address among other, contingencies such as sudden plant shut down, floods, break downs etc. There will be backup generators to supply minimum power during the plant shut down.

Maintenance and running repairs of the plant and equipment and monitoring of the implementation of all the environmental and social impact mitigation actions which are expected during the operational phases will be the key responsibilities for the developer. A programme of monitoring the environmental and social mitigation actions which are due in the operational phase will be monitored and reported under the monitoring and reporting plan.

2.8 Decommissioning Phase

Decommissioning means the decommissioning of the construction phase activities. All temporary structures built to facilitate the construction activities will be dismantled and materials salvaged and disposed during the decommissioning phase. Land which will be temporarily held or leased for such purposes will be reinstated and will be given to the owners. Lands used for spoil yards, borrow pits (if any) that will need to be restored accordingly. Temporary roads will be closed and any obstruction made to divert the natural gullies will be cleared and opened up. All salvaged materials and wastes collected will be properly disposed.

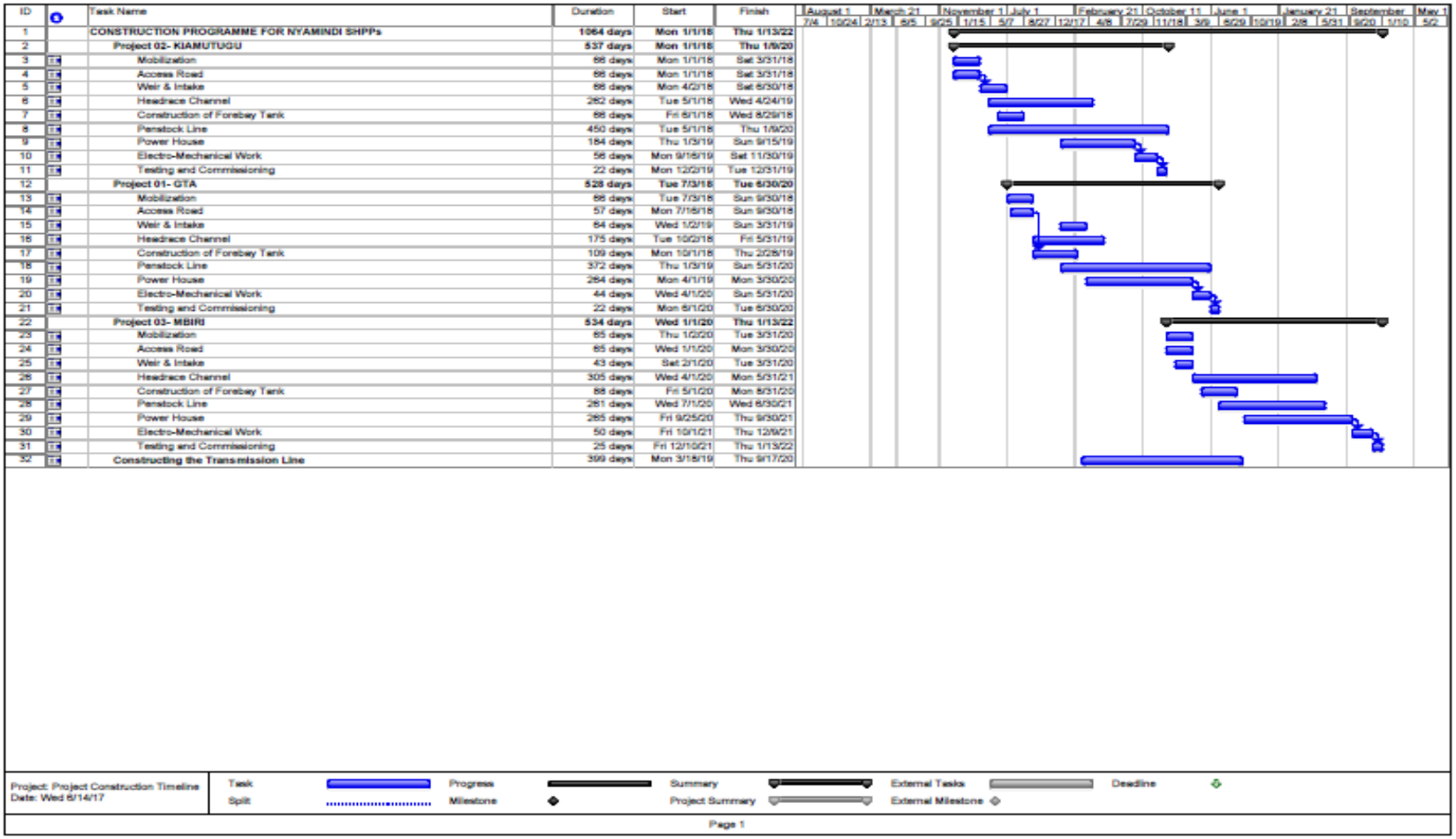
The labor engaged during the construction phase will be phased out. The statutory payments to staff will be paid and the cadre of the workers should be down sized to ensure that only the staff needed for the operational phase will be retained. In addition all dues owned to the suppliers will be settled and contracts will be terminated.

A proper Environmental Management Plan (EMP) for the Decommissioning Phase will be prepared. It is expected that the decommissioning will take for more than six (6) months in order to ensure that all three projects complete the decommissioning activities.

2.9 Construction Schedule

A construction schedule (Gantt chart) is provided in Fig (2.23) below. According to the same, a total of three years will be required to complete the civil works and electro mechanical work of the cascade development with SHPPs. The construction of the project will start with Gitie in Kiamutugu with the other two to follow thereafter.

2.9.1 Construction schedule



ID	Task Name	Duration	Start	Finish
1	CONSTRUCTION PROGRAMME FOR NYAMINDI SHPPs	1064 days	Mon 1/1/18	Thu 1/13/22
2	Project 02- KIAMUTUGU	537 days	Mon 1/1/18	Thu 1/9/20
3	Mobilization	88 days	Mon 1/1/18	Sat 3/31/18
4	Access Road	88 days	Mon 1/1/18	Sat 3/31/18
5	Weir & Intake	88 days	Mon 4/2/18	Sat 6/30/18
6	Headrace Channel	262 days	Tue 5/1/18	Wed 4/24/19
7	Construction of Forebay Tank	88 days	Fri 6/1/18	Wed 8/29/18
8	Penstock Line	450 days	Tue 5/1/18	Thu 1/9/20
9	Power House	184 days	Thu 1/3/19	Sun 9/15/19
10	Electro-Mechanical Work	56 days	Mon 9/16/19	Sat 11/30/19
11	Testing and Commissioning	22 days	Mon 12/2/19	Tue 12/31/19
12	Project 01- GTA	528 days	Tue 7/3/18	Tue 6/30/20
13	Mobilization	88 days	Tue 7/3/18	Sun 9/30/18
14	Access Road	57 days	Mon 7/16/18	Sun 9/30/18
15	Weir & Intake	84 days	Wed 1/2/19	Sun 3/31/19
16	Headrace Channel	175 days	Tue 10/2/18	Fri 5/31/19
17	Construction of Forebay Tank	109 days	Mon 10/1/18	Thu 2/28/19
18	Penstock Line	372 days	Thu 1/3/19	Sun 5/31/20
19	Power House	264 days	Mon 4/1/19	Mon 3/30/20
20	Electro-Mechanical Work	44 days	Wed 4/1/20	Sun 5/31/20
21	Testing and Commissioning	22 days	Mon 6/1/20	Tue 6/30/20
22	Project 03- MBIRI	534 days	Wed 1/1/20	Thu 1/13/22
23	Mobilization	85 days	Thu 1/2/20	Tue 3/31/20
24	Access Road	85 days	Wed 1/1/20	Mon 3/30/20
25	Weir & Intake	43 days	Sat 2/1/20	Tue 3/31/20
26	Headrace Channel	305 days	Wed 4/1/20	Mon 5/31/21
27	Construction of Forebay Tank	88 days	Fri 5/1/20	Mon 8/31/20
28	Penstock Line	281 days	Wed 7/1/20	Wed 8/30/21
29	Power House	265 days	Fri 9/25/20	Thu 9/30/21
30	Electro-Mechanical Work	50 days	Fri 10/1/21	Thu 12/9/21
31	Testing and Commissioning	25 days	Fri 12/10/21	Thu 1/13/22
32	Constructing the Transmission Line	399 days	Mon 3/18/19	Thu 9/17/20

Figure 2.23: Construction Schedule for all three projects

3 POLICY LEGAL AND ADMINISTRATIVE FRAMEWORK

This ESIA study will be prepared in accordance with the requirements of both national policy, legal and institutional framework and and in keeping with international established practices. Therefore, this section assesses relevant existing policies, regulations and laws that govern establishment and management of infrastructural projects at different stages in Kenya.

3.1 POLICY PROVISIONS

3.1.1 Constitution of Kenya

Article 42 of Bill of Rights of the Kenyan Constitution provides that every Kenyan has a right to a clean and healthy environment, which includes the right:

(a) To have the environment protected for the benefit of present and future generations through legislative and other measures, particularly those contemplated in Article 69; and

(b) To have obligations relating to the environment fulfilled under Article 70.

The Constitution of Kenya provides for sound management and sustainable development of all of Kenya's development projects, both public and private investments. It calls for the duty given to the Project Proponent to cooperate with state organs and other persons to protect and conserve the environment as mentioned in Part (11). The proposed project should be environmental friendly and any adverse effect will be addressed as outlined in the mitigation plan.

3.1.2 Kenya Vision 2030

Kenya Vision 2030 is the current national development blueprint for period 2008 to 2030 and was developed following the successful implementation of the Economic Recovery Strategy of Wealth and Employment Creation which revived and restored economy growth from 0.6% in 2002 to 7% in 2007. Vision 2030 is the national long-term development policy that aims to transform Kenya into a newly industrialized, middle-income country by 2030. The Vision comprises of three key pillars: economic, social, and political. The economic pillar aims to achieve an average economic growth rate of 10 per cent per annum and sustaining the same until 2030.The social pillar seeks to engender just, cohesive and equitable social development in a clean and secure environment, while the political pillar aims to realize an issue-based, people-centered, result-oriented and accountable democratic system. This project is expected to contributed positively to two of the three key pillars; economic and social pillars through creation of employment and thereby improving the living standards of communities living in project area.

3.1.3 National Environmental Policy (NEP)

The NEP (2013) set out important provisions relating to management of ecosystems and sustainable use of natural resources. Specifically NEP recognizes the intense pressures the environment is facing due to inappropriate human activities; including issues and problems relating to environmental governance, loss of biodiversity, valuation of environment and natural resources; rehabilitation and restoration of environmentally degraded areas; urbanization, waste management and pollution; climate change, energy, security and disaster management; public participation, environmental education and awareness; data and information; poverty; and chemical management. The NEP observed that better quality of life for present and future generations is achievable through sustainable management and use of the environment and natural resources. Production of clean energy is the hallmark of this project as it will produce energy with minimal impacts on the environment such as emission of green-house gases and environmental destruction and loss of biodiversity.

3.1.4 National Land Policy 2009

Chapter (3) of the National Land Policy is linked to constitutional reforms; regulation of land ownership and property rights. It is vested in the government by the Constitution with powers to regulate how private land is used in order to protect the public interests. The government exercises these powers through compulsory acquisition and development control. Compulsory acquisition is the power of the State to take owned private land for public purposes. However, the Government must make prompt payment for compensation that the ESIA will rolled-out under Resettlement Action Plan Strategy (RAPS). This overall aim is to secure and conserve affected household's sources of livelihoods and cultural beliefs.

3.1.5 Education Sector Policy on HIV and AIDS 2013

HIV and AIDS is one of the key threats not only to educational achievements but also to the general population. This Policy recognizes that HIV and AIDS prevalence deplete resources meant for individuals, families, communities and society as a whole. Managing HIV and AIDS require the whole society and this policy document discuss it in several thematic areas. The first theme discusses the prevention of new HIV infections among learners and education staff at all levels. The second theme deals with comprehensive treatment, care and support for learners, youth below 24 years and education staff living with HIV. The third theme is on the HIV and AIDS at the work place with focus on stigma and discrimination. The fourth component deals with managing HIV and AIDS response with reference to the management and leadership structures and programs at all levels within the education sector. This policy borrows heavily from all previous HIV and AIDS management approaches in Kenya including Kenya Vision 2030, Constitution of Kenya (2010), the Public Sector Workplace Policy on HIV and AIDS (2010), The HIV and AIDS

Prevention and Control Act (2006), National Aids Control Council Act (2006), and the Kenya National HIV and AIDS Strategic Plan II of 2009/2010. All the above policies and strategies of combating and managing HIV and AIDS in Kenya will be invoked during this project; considering HIV prevalent tend to be high in areas with high rates immigration.

3.1.6 Gender Policy 2011

The overall aim of the Gender Policy 2011 is to mainstream gender concerns in the national development process in order to improve social, legal/civic, economic and cultural conditions of women, men, girls and boys in Kenya. The policy has identified priorities areas. One of the priorities is to ensure that all ministerial strategies and their performance frameworks integrate gender equality objectives and indicators and identify actions for tackling inequality. Moreover, each program will develop integrated gender equality strategies at the initiative level in priority areas. Within selected interventions, the policy will also scale-up specific initiatives to advance gender equality. This policy will be referred to during project implementation especially during hiring of staff to be involved in the project, procuring of suppliers and sub consultants as well as sub-contractors of the project.

3.1.7 Kenya Legislations

3.1.8 Environmental Management and Coordination Act (EMCA) 1999

This act provides for the establishment of legal and institutional framework for the management of the environment and for matters connected therewith and incidental thereto. The new Constitution and EMCA obligates the Project's Executing Agency and Contractor to work in a clean environment and not to contravene the right of any person within its zone of influence to the environment. Below are relevant EMCA subsidiary legislations and guidelines to govern environmental management during implementation of this NCD SHP project.

- The Environmental (Impact Assessment and Audit) Regulations, 2009 Legal Notice No. 101.
- The Environmental Management and Coordination (Waste Management) Regulations, 2006 Legal Notice No. 121.
- The Environmental Management and Coordination (Water Quality) Regulations, 2006 Legal Notice No. 120.
- The Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2006 Legal Notice No. 61.
- The Environmental Management and Coordination (Conservation of Biological Diversity and Resources, Access to Genetic Resources and Benefit Sharing), Regulations, 2006.

- Environmental Management and Coordination (Wetlands, River Banks, Lake Shores, and Sea Shore Management), Regulations, 2009.
- Environmental Management and Coordination (Air Quality), Regulations 2014, Legal Notice No. 34.
- Environmental Management and Coordination (Fossil Fuel Emission Control) Regulations 2006, Legal Notice No. 131.
- Environmental Management and Coordination (Controlled Substance) Regulations 2007, Legal Notice No. 73.

3.1.9 Water Act 2002

Theater Act of 2002 is being reviewed to align the water sector with the new Constitution under Water Bill 2014. The Water Act of 2002 is guided by three main aspects:

- The management, conservation, use and control of water resources
- The acquisition and regulation of rights to use water, and
- The regulation and management of water supply and sewerage services.

Meanwhile the Water Act creates various institutions with separate functions/ mandates and starts by first removing the Government from service provision and leaving it with the role of making policies. A product of the Water Act is Water Resources Management Rules 2007, which provides rules and procedures for obtaining water use permits and the conditions placed on permit holders. Sections 54 and 69 of the Water Resources Management Rules 2007 impose certain statutory requirements on water infrastructure, owners and users. This project will be guided by these legislations especially before abstracting water from River Nyamindi by obtaining relevant licenses from Water Resources and Management Authority (WRMA).

3.1.10 County Government Act No. 17 of 2012

The Act established the County Government after the enactment of the Kenya's new constitution of 2010. Part 11 of the Act empowers the county government to be in charge of functions described in Article 186 of the constitution (county roads, water and sanitation, health). Part XI of the Act vests the responsibility of planning and development facilitation to the county government in collaboration with the national government. This arrangement has been adopted for interventions in order not to conflict with provisions of the Kenyan Constitution. Implementation of this project will also seek goodwill and approval of County Government of Kirinyaga because the project will affect lives of population of this county.

3.1.11 Physical Planning Act 1996 (286)

Section 29 of the Physical Planning Act 1999 empowers Authorities (now county governments) to reserve and maintain all land planned for open spaces, parks, urban forests and green belts as well as land assigned for public social amenities. The same section allows prohibition or control of the use and development of an area. Section 30 states that any person who carries out development with development permission will be required to restore the land to its original condition. It also states that no other licensing authority shall grant licenses for commercial or industrial use or occupation of any building without a development permission granted by the respective Local Authority. As observed above (County Government Act No. 17 of 2012) approval from County of Kirinyaga will be required before implementation of this project.

3.1.12 Occupational Health and Safety Act (OHSA 2007)

This legislation provides for protection of workers during the construction and operation phases. The Environmental Social Management Program (ESMP) to be prepared in the ESIA has provided specific health and safety aspects to be complied with during implementation of the project.

3.1.13 The Public Health Act (Cap. 242)

Part IX, section 115 of the Act states that no person / institution shall cause nuisance or condition liable to be injurious or dangerous to human health. Section 116 requires local authorities to take all lawful, necessary and reasonably practicable measures to maintain in their jurisdiction clean and sanitary conditions to prevent occurrence of nuisance or condition liable for injurious or dangerous to human health. Such nuisance or conditions are defined under section 118 and include nuisances caused by accumulation of materials or refuse that include in the opinion of the Medical Officer of Health, are likely to harbor pests. All measures will be outlined in ESMP so that all Public Health Act provisions are complied with during implementation of the project.

3.1.14 Eviction Way-leave and Rehabilitation Bill (2014)

This Bill of 2014 is building on the revised Wayleave Act of 2010. Chapter 292, which if passed provides procedures for the eviction of unauthroised occupants from private or public land and the resettlement of displaced persons coerced or involuntary displaced and for matters incidental or related thereto.The areas zoned for communication lines, sewer lines, power lines, water pipes etc are known as wayleaves. The Wayleave Act prohibits development of any kind in these designated areas. Thus any developer is bound by this Act to see to it that no development takes place in these areas. This project will be guided by these regulations provisions when creating way leave.

3.1.15 The Forest Act 2005

The Act provides for the establishment, development and sustainable management, including conservation and rational utilization of forest resources for the socio-economic development of the country. The Act recognise that forests provide habitats for Kenya's biological diversity and is a major habitat for wild animals. Meawhile Kenya is committed to the inter-sectoral development and sustainable use of forestry resources under international conventions and other agreements to promote the sustainable management, conservation and utilization of forests and biological diversity. Therefore this NCD project will observe the Internation Finance Cooporation (IFC) Performance Standards (PS) of conserving biodiversity.

3.2 Institutional Structure of the Water Sector

The Water Act 2002 and several other policies guide water resources management in Kenya. The Water Bill 2014 will realign Water Act 2002 with the requirements of the new constitution. Water management in Kenya is under the Ministry of Environment, Water and Natural Resources that is primarily responsible for policy development, sector coordination, monitoring and supervision. The ministry executes its mandate through the following institutions:

- Water Services Regulatory Board (WSRB): provides general oversight of service provision and regulate water allocation.
- Water Appeal Board (WAB): an independent institution that solve disputes and conflicts that may not be solved by WRMA and WSRB.
- Water Services Trust Fund (WSTF): is mandated to help finance the provision of water in areas without adequate water supply. It is supposed to mobilize funds from the Exchequer or donors. The Fund will help finance provision of water in marginalized and poor areas and thus increase water and sanitation access.
- Catchment Areas Advisory Committees (CAACs): their work is to help the WRMA in water and environmental conservation activities through the regional managers.
- Water Resources Management Authority (WRMA): is charged with responsibility for managing, regulating, protecting, apportioning and conserving water resources naturally, including transboundary waters.
- Water Service Boards (WSBs): These Boards have been established at the regional level and delineated on the basis of catchments, administrative boundaries and economic viability. They are responsible for efficient and economical water and sewerage service provision in their areas of jurisdiction. To support their role, they are to maintain and acquire assets, plan, develop and manage the systems in their areas. Boards' effect their mandate by contracting the Water Service Providers (WSPs) as agents for this purpose. They are to monitor and enforce provision agreements with the WSPs in accordance with the license requirements.

- Water Services Providers (WSPs): contracted by WSBs to provide water and sewerage services. They are commercial organizations with the sole mandate of retailing water and sewerage services to consumers.
- Water Resources User Associations (WRUAs): are at the basin level and their main work is to harmonize water with agriculture and other competing uses and upstream and downstream users to avoid conflicts over water. This means that some base flows have to be maintained for sustenance of the ecological systems downstream. Since Water Act 2002 has taken the management of water resources down to the communities, it is expected that communities will act as policing agents /custodians within their areas and be active participants in water resource management.

3.3 International Policies, Guidelines and Standards

Environmental and Social Management Plan (ESMP) will strictly observe the IFC Performance Standards (PS). As noted in section 3.2.1 the ESIA study will consider the whole area of project's influence including associated facilities and auxiliary structures. Key IFC's Performance Standards that will be triggered and complied with to guide the ESIA process, include the Resettlement Action Plan (RAP) and the ESMP.

Applicable PSs for this project are:

- PS 1: Social and Environmental Assessment and Management Systems
- PS 2: Labor and Working Conditions
- PS 3: Pollution Prevention and Abatement
- PS 4: Community Health, Safety and Security
- PS 5: Land Acquisition and Involuntary Resettlement
- PS 6: Biodiversity Conservation and Sustainable Natural Resource Management
- PS8: Cultural Heritage

Specific objectives of the ESMP as per IFC PS (1) are as follows:

1. To identify and evaluate environmental and social risks and impacts of the project including cumulative impacts as the case may be.
2. To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, Affected Communities, and the environment.
3. To promote improved environmental and social performance of clients through the effective use of management systems.
4. To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately.

5. To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.

Performance Standard (2) recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers. Specific objectives are:

1. To promote the fair treatment, non- discrimination, and equal opportunity of workers.
2. To establish, maintain, and improve the worker-management relationship
3. To promote compliance with national employment and labor laws
4. To protect workers, including vulnerable categories of workers such as women, migrant workers, workers engaged by third parties, and workers in the client's supply chain.
5. To promote safe and healthy working conditions, and the health of workers.
6. To avoid the use of forced labor and child labor.

Performance Standard (3) recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels. Specific objectives are:

1. To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
2. To promote more sustainable use of resources, including energy and water.
3. To reduce project-related GHG emissions.

Performance Standard (4) recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. Specific objectives are:

1. To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances.
2. To ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the Affected Communities.

Performance Standard (5) recognizes that project related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Specific objectives are:

1. To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs.
2. To avoid forced eviction.
3. To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by
    a. providing compensation for loss of assets at replacement cost and
    b. Ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.
4. To improve, or restore, the livelihoods and standards of living of displaced persons.
5. To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.

Performance Standard (6) recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. Specific Objectives are:

1. To protect and conserve biodiversity.
2. To maintain the benefits from ecosystem services.
3. To promote the sustainable management of living natural resources through the adoption of practices that integrates conservation needs and development priorities

IFC Performance Standard (8) on Cultural Heritage deals with Graves and other objects of cultural significance. This will require preparing a Chance Find Procedure. Relevant supplemental management plans to cover the performance standards (based on the guidelines provided) will be prepared in the ESMP under section (4).

3.4 Relevant Multinational Environment Agreements (MEAs), Conventions and treaties

SHPs are classical examples of renewable energy sources that are key to green economy. Undertaken in the framework of IFC standards, SHP projects are consistent with several international and regional agreements that seek to conserve the environment; including:

- The United Nations Framework Convention on Climate Change (UNFCCC) 1994: This is an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases.
- Convention on Biological Diversity (CBD) 1992: This was inspired by the world community's growing commitment to sustainable development. CBD has three main objectives: conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources. Mt Kenya is endowed with rich biodiversity and CBD guide activities associated with this project.
- World Heritage Convention 1972: The Convention links together in a single document the concepts of nature conservation and the preservation of cultural properties. The Convention recognizes the way in which people interact with nature, and the fundamental need to preserve the balance between the two. The upper sections of Mount Kenya National Park have been designated as a World Heritage Site.
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 1960: It is an international agreement between governments and aims to ensure that international trade in wild animals and plants, or their parts, does not threaten their survival. A number of animals found in Mount Kenya are protected under CITES including African Elephants, all species of orchids, and *Prunnus africana,* this project will advocate for conservation of their habitats and ecosystems in case they are interfered with.
- The IUCN Red List of Threatened Species 1994: It is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. From its small beginning, the IUCN Red List has grown in size and complexity and now plays an increasingly prominent role in guiding conservation activities of governments, NGOs and scientific institutions. As observed above and under IFCs, all species recorded in the project area will be assessed using IUCN Red List of Threatened Species.

4 ENVIRONMENT AND SOCIAL SETTINGS

This chapter will present the general environmental characteristic in the project area. Specifically, it will describe the physical, biological, social and cultural environment. The ESIA study will discuss the likelihood of the hydropower project to alter or impact the aforementioned environmental settings.

4.1 Setting the study limits

The study limits for the proposed small hydropower system vary from one bio-physical and social element to another. Each specialist study has required setting up of its own study limit based on the project design, site reconnaissance visits; and secondary data sought from the literature reviews. Following Table 4.1 presents the study limit for each type of specialist study undertaken in the ESIA.

Table 4.1: Setting the Study Limits for the ESIA

Specialist Study	Study Limit
Terrestrial ecology	Project footprint area and its immediate environs
River end Riparian ecology	River channel and associated riparian zone, specifically the microhabitats along the river of river run, water pools and rocky banks
Hydrology	Project footprint area and its immediate environs; Project catchment areas; Rain Fall gauge stations
Geology	Project footprint area and its immediate environs (Secondary information sought to establish regional geology)
Socio Economic	Project immediate Influence Area and Administrative boundaries of Kirinyaga County (secondary data) (e.g. Kiamutugu etc.)
Occupational Health and Safety	Project footprint area and its immediate environs
Public safety	Project area and immediate surroundings

4.2 Physical settings

4.2.1 Climate

The project area has a tropical climate and an equatorial rainfall pattern. This climatic condition is influenced by the county's position along the equator and its position on the wind ward side of Mt. Kenya. Mount Kenya has two rainy seasons, the long rains that occur from March to May and the short rains which occur from October to December. The long rains average 800 mm while the short rains average 650 mm. The amount of rainfall received declines from the high altitude slopes of Mt. Kenya towards the semi-arid zones in the Eastern part of Mwea Division. The temperature ranges from a mean of 8°C in the upper zones of Mt Kenya to 30°C in the lower zones during the hot season.

4.2.2 Drainage and Topography

The project area is characterized by steep slopes and deep valleys, with the physiographic conditions influenced by Mount Kenya. Kirinyaga County slopes from the North-West towards East and South-East, with a few isolated hills such as Kiambere, Kianjiru and Kiang'ombe. The County lowlands are at about 515 m above sea level at the Tana river basin in the East and raises to steep highlands of over 4,570 m above sea level in the North West that are part of Mt. Kenya. Steep slopes are attributed to strong erosion capacities of rivers aided by heavy rains and deep soils. Where rivers encountered intrusive rocks along the valleys, magnificent and spectacular water cascades and falls are formed. The Southern part of the County is covered by the Mwea plains.

4.2.3 Noise

The noise levels in the project area were not measured but there prevails a very tranquil environment free of any noise as the area is far away from any noise making receptors **(See Appendix 13.10)**. The only noise that could be heard was the noise from the river when the waters clatter while flowing on areas where there are drops, and occasional noise of the birds.

4.2.4 Geology and Soils

A preliminary geological investigation was undertaken by the Project Proponent **(Appendix 13.2).** It covers the aspects of regional geology and the geology in respect of each of the locations demarcated for the associated structures of the three projects. The report is summarized herein below:

4.2.4.1 Physiography of the region

The project area lies on the southern slopes of Mount Kenya. The Mt Kenya Ecosystem represents one of the most important pristine mountain ecosystems in the world and the most impressive landscapes in East Africa due to its mountain peaks with rugged glacier-clad summits and diverse forests. Mt. Kenya was formed as a result of volcanic activity and it has a base diameter of approximately 120 km. The Mountain is the country's highest mountain and second highest in Africa. Its two highest peaks Batian (5,199 m) and Nelion (5,188 m) are located in the Mt Kenya National Park. It is broadly cone-shaped with deeply incised valleys radiating from the peaks. There are significant differences in altitude within short distances, which determine significant variations in climate over relatively small distances.

As shown in Figure 4.1 below, the upper Tana Catchment has all its perennial rivers originating from the Aberdare Range and Mt. Kenya. The Mt. Kenya sub-catchment drains the Mt. Kenya side of the upper Tana catchment. The main rivers in this sub catchment include the Rupingazi, Nyamindi, Thiba, Rwamuthambi, Ragati, Sagana, Thego and Nairobi which have tributaries within their systems. These rivers flow through the forests, tea and coffee zones, joining the other rivers downstream. The Tana River's Mt. Kenya sub catchment comprises Kirinyaga County, and parts of Nyeri, Mbeere and Embu counties.

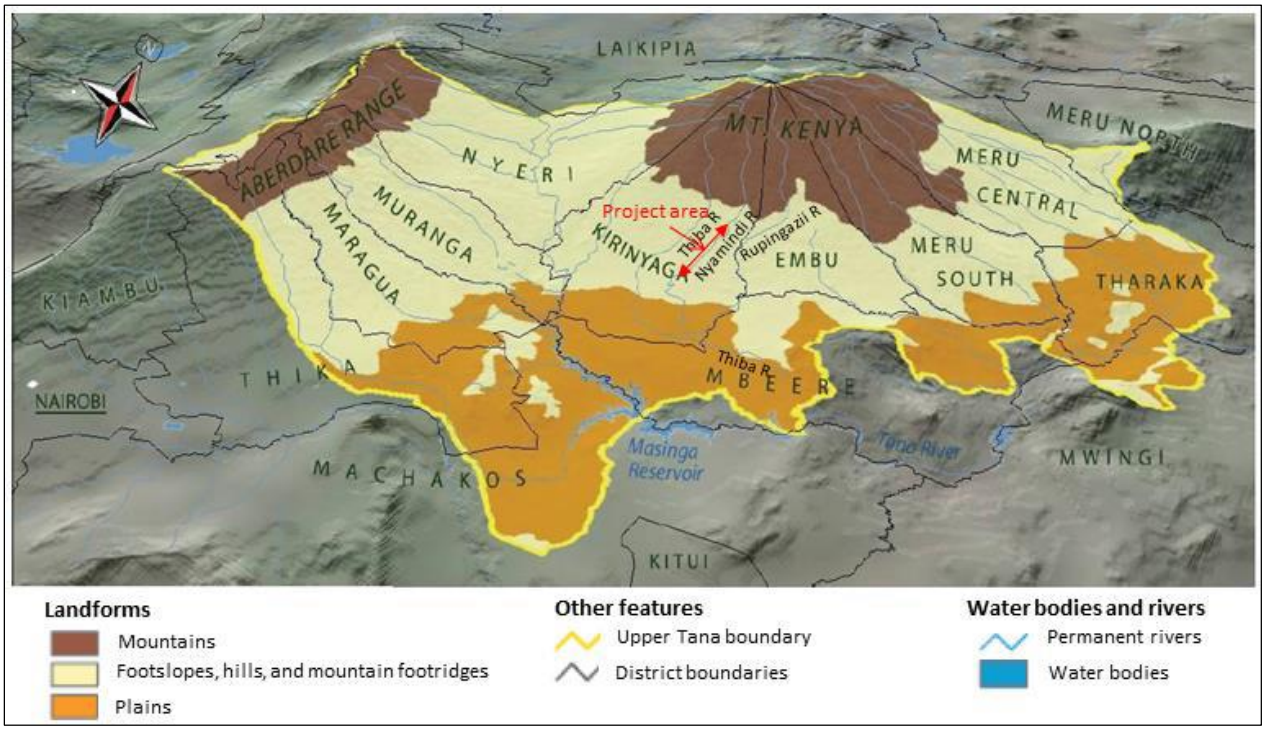


Figure 4.1 Upper Tana River Catchment

4.2.4.2 Physiographic zones

Mt Kenya slopes can be divided into three broad physiographic/ecological zones. The lowland areas fall between 1,158 meters to 2,000 meters above sea level, the midland areas lie between 2,000 meters to 3,400 meters above sea level and the highland comprising areas falling between 3,400 meters to 5,200 meters above sea level. The lowland area is characterized by gentle rolling plains. The midland area is characterized with rolling low hills, ridges and some plateau like landscapes. The highland area covers the whole steep mountainous alpine and glaciated zones.

4.2.4.3 Geology of the Nyamindi River Cascade (NRC)

An enlarged section of the Mt Kenya geological map showing the NRC is presented in Figure 4.2**,** which shows that erosion has exposed the underlying rock; porphyritic basalt and olivine basalt in the bottom of the river valley along the entire length of the Nyamindi River Cascade envisaged for hydropower development.

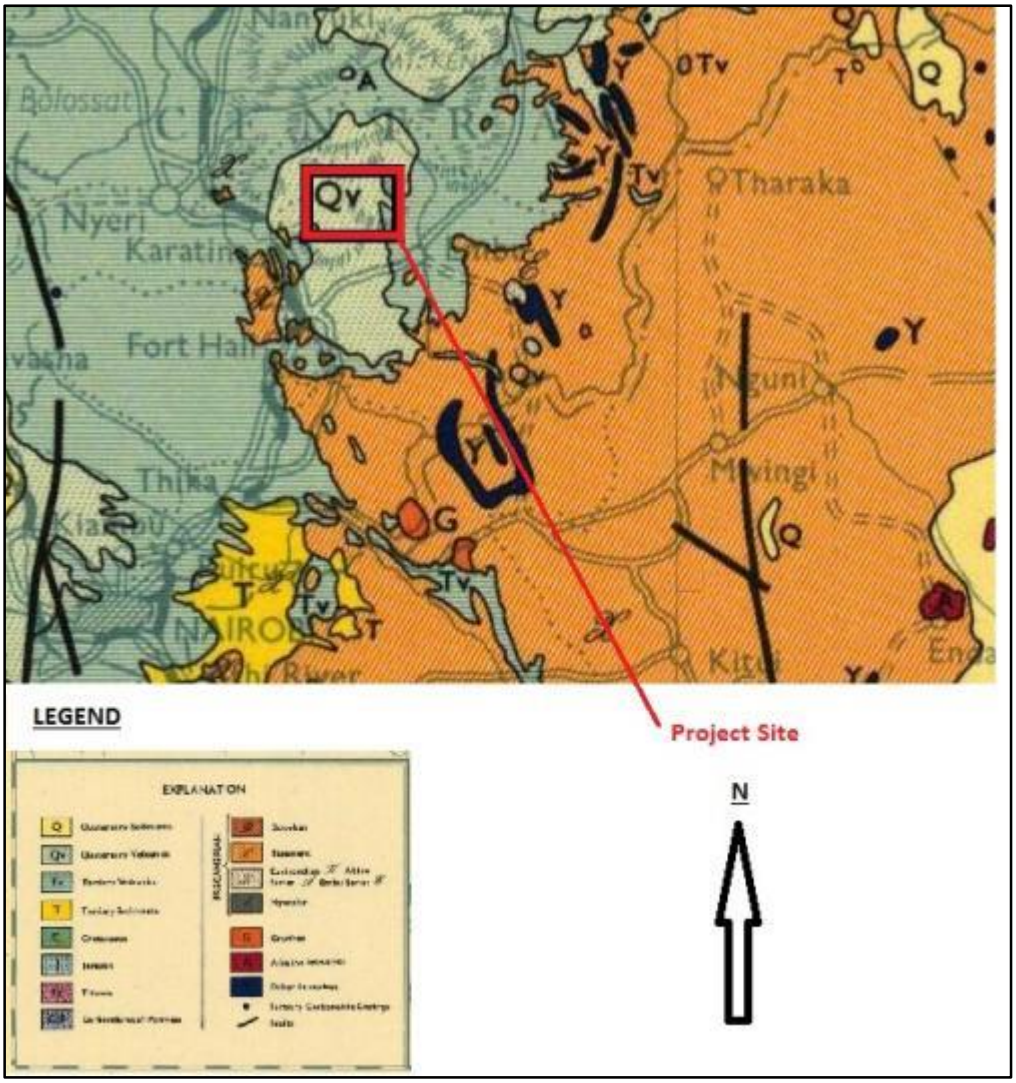


Figure 4.2: Geology of the study area

(Source: Chief Geologist Mines and Geological Department, Nairobi.)

The upper section of the valley consists of the overlying porphyritic phonolites and agglomerates (Plp3) and the residual soils derived from in situ weathering. A schematic geological section is presented in the Figure 4.3 below.

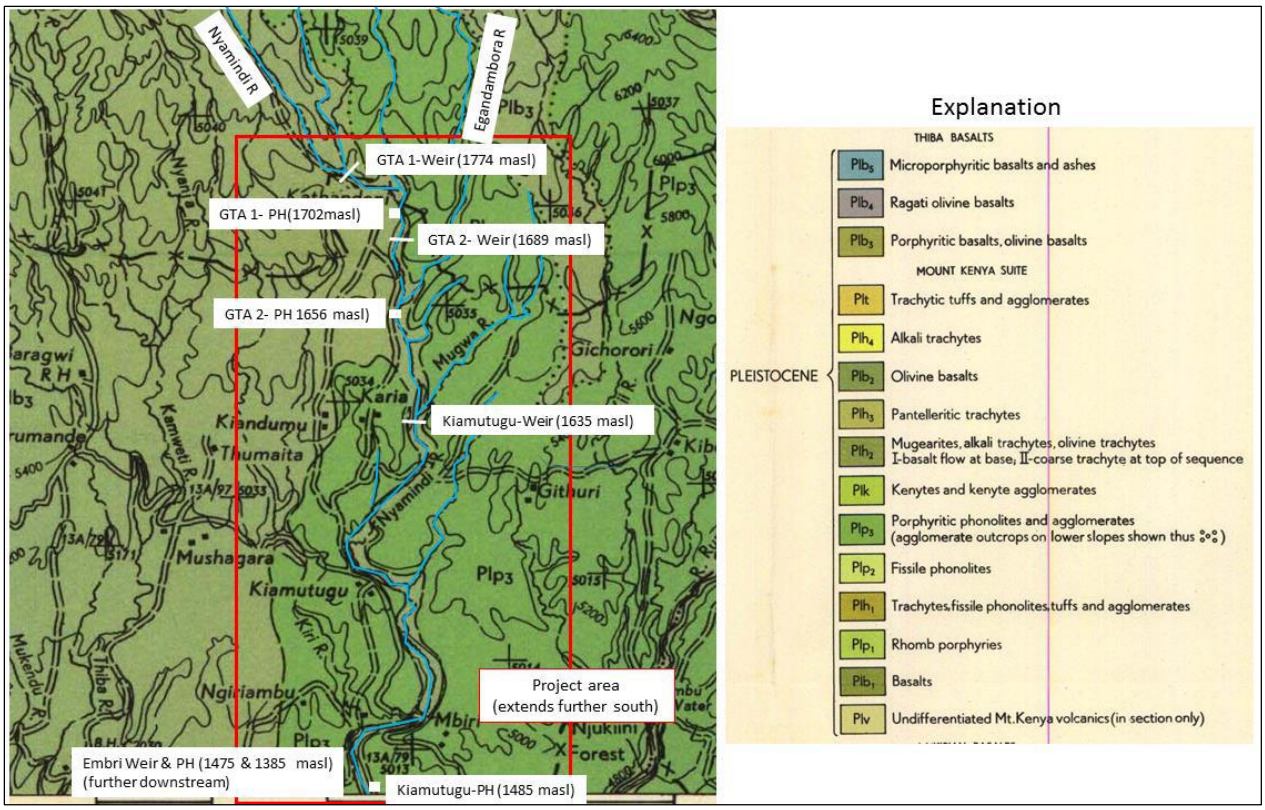


Figure 4.3: **Schematic Geological sections of the cascade of the project area**

4.2.4.4 Rock types

The rocks in the NHC are described in the following sections.

Olivine basalt (Plb3): Fresh, dark to pale grey, fine grained, olivine basalt which characteristically outcrops all the way along the entire Nyamindi cascade. They generally appear as massive outcrops with some widely spaced joints. Flow structures and layering were observed in some areas. It is a very hard rock. Several blows from the geological hammer are required to break a hand specimen.

Phonolite and agglomerate (Plp3): Fresh rock outcrops were not observed but moderately weathered outcrops where found in several places. They vary from grey-green to medium and dark grey, and are often finely mottled. Brown (1967) described the phonolite to be a "remarkably homogeneous" group. They are invariably porphyritic, carrying feldspar and nepheline phenocrysts in greenish grey to grey compact fine-grained matrices. No agglomerates were observed in the project area. **Pumice:** Boulders of pumice were observed in some areas. They are

generally moderately to highly weathered, light brown to pale grey in color, and highly vesiculated. It probably occurs within the phonolites.

4.2.5 Geological structure

Approximately 150 km west of Mt Kenya, there are few significant tectonic structures in Kenya, most notably; some north west – south east trending regional shear zones (Mulawa 2012). The structure of the Mt. Kenya volcano and its satellites is that of a large volcanic pile with radial outward dips centered on the plug, which forms the present peak of the mountain. It appears that the young volcanic rocks in the Mt Kenya area have not been subjected to significant tectonism or deformation and hence are devoid of major structures. Baker (1967) suggests a fracture or fissure running across the southern slopes of the mountain by the occurrence of ten of the basaltic craters of this area nearly on a straight line trending east-north-east. The Nyamindi River cuts through the volcanic rocks and there are no major liniments or deeply incised gorges to suggest any major geological structures such as faults or shear zones. There are fresh rock outcrops in the river bed along most of the cascade within the project area. Also there are some sections where the river bed consists of a thin layer of alluvial gravel and boulders. Large boulders are also commonly observed in the river bed. The project area has no major river terraces or flood plains yet formed. Minor terraces generally have deposits of alluvial gravel.

4.2.6 Rock strength

No rock strength testing was undertaken during the current evaluation except tactile assessment of the intact rock strength. Olivine basalt is a homogeneous crystalline rock and on the basis of the field estimation of intact strength it falls into the ISRM[2] *'very strong'* category where the unconfined compressive strength falls between 100 to 250 MPa.

4.2.7 Geomorphology of the project area

The Nyamindi River traverses approximately north – south, cutting across the young volcanic formations. The project area lies within the foothills of the volcanic mountain. The landscape is characterized with low hills and ridges to plateau like areas. The river valley has eroded through fresh basalts and incised valley sections have formed in some sections with rock bluffs on both banks. The side slopes above the bluffs are inclined at about 50° and can be up to 30 m high. Ridge crests have flatter gradients, generally 10° to 20°, with maximum slopes about 30°.

[2] Geological report (Annex 2) provides explanation to all the abbreviations

4.2.8 Soils

Kirinyaga County has red deep loamy soils that have great potential for agriculture depending on the climatic conditions. Soils are red deep loamy soils that have great potential for agriculture depending on the climatic conditions. The area is very popular with farming of cash crops, mainly tea and coffee as well as food crops and horticultural crops. Soils in the area project area are well drained through drainage becomes impaired as one goes eastwards **(**Figure 4.4**)**.

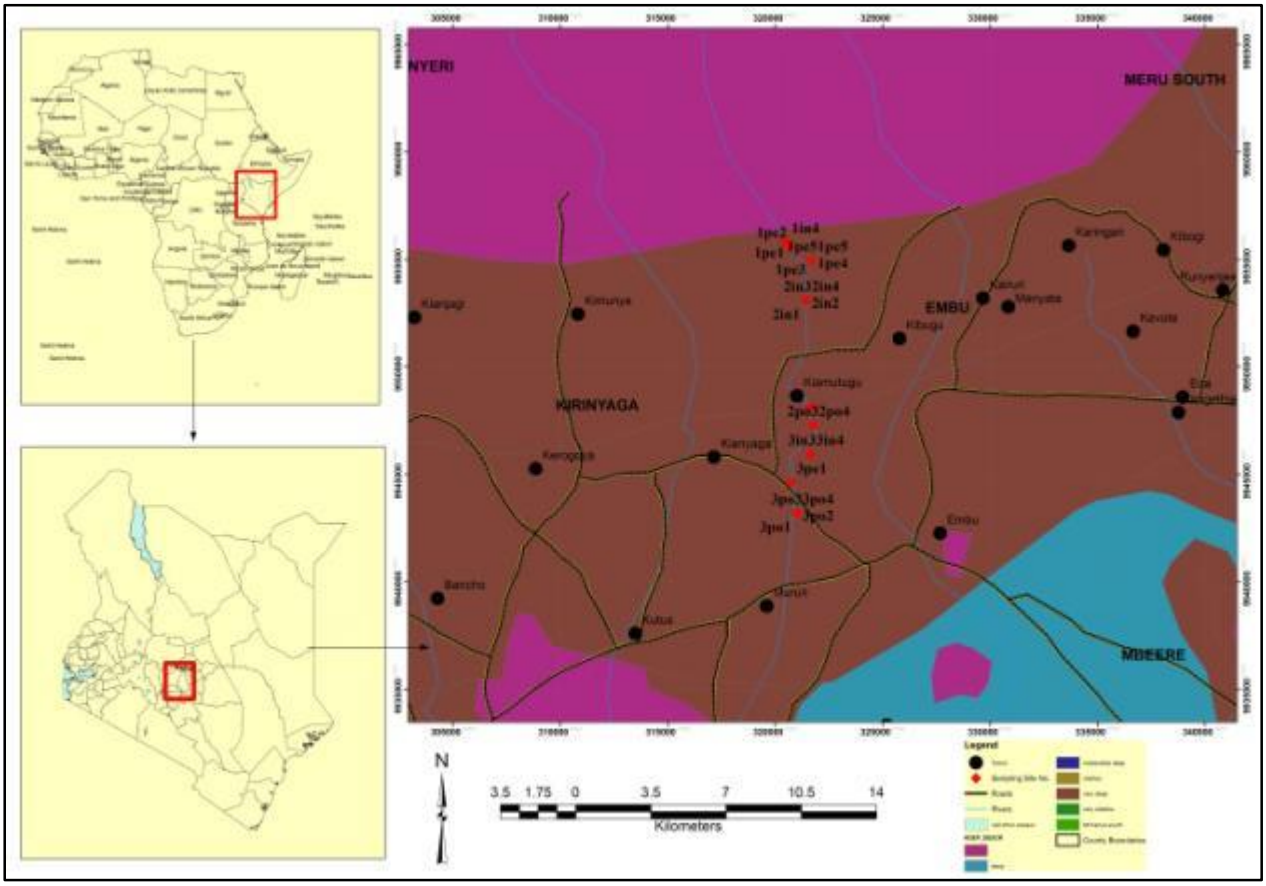


Figure 4.4: **Drainage characteristics of soils of Kirinyaga County and the project site**
(Modified from Survey of Kenya and World Resources Institute base maps)

4.2.9 Seismicity

The seismically active East African Rift System traverses approximately 150 km west of the project area. However, the available information suggests that the area has a low level of seismicity. The 10% in 50 years 'peak ground acceleration' falls in the range of 0.2 to 0.4 g for the study area.

4.2.9.1 Structural set up and level of seismicity

The structural set up and the earthquakes of the region are controlled by the activities of the East Africa Rift Valley System, EARS (Figure 4.5**).** The EARS bifurcates at the boarder of Ethiopia and Kenya, the eastern arm traverses through western Kenya, and the western arm follows the Lake Albert-Lake Edward-Lake Tanganyika Rift Valley and the uplifted Rwenzori Mountains on the Ugandan side.

There are number of active volcanoes on the eastern arm of the Rift Valley on the Kenyan side, and Mt Elgon, at the boarder of Kenya-Uganda, is an extinct volcano which is part of the EARS. The volcanic activities began in the middle Tertiary, concurrently with the formation of the EARS. Mt Elgon was formed about 23 million years ago. Mt Kenya, an extinct volcano located approximately 150 km east of the EARS, was formed more recently, about 3 million years ago, at the same time as the Ruwenzori Mountains in Uganda.

High levels of seismic activity are recorded along the western arm of the EARS, whereas the eastern arm shows little seismicity especially in Kenya, in spite of large number of active volcanoes along the East Rift. As such the project area lies in a low seismic zone. As presented in Figure 4.5**,** the level of seismicity in the project area is low. The 10% in 50 years '*peak ground acceleration*' falls in the range of 0.2 to 0.4 g (USGS 2014).

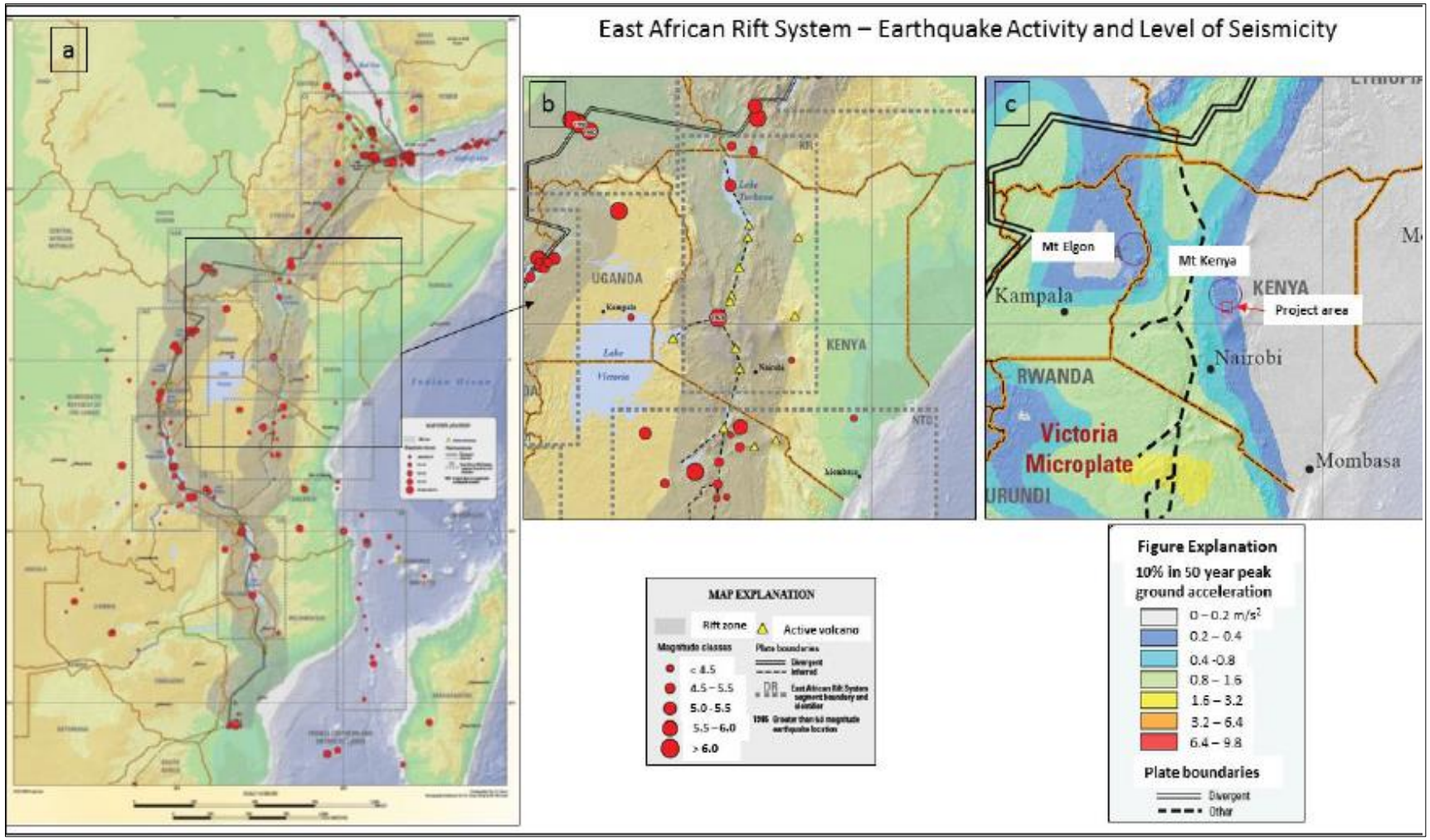


Figure 4.5: **Distribution of the EARS and level of seismicity of the project area (USGS 20143)**

4.2.10 Geotechnical conditions at each selected site:

4.2.10.1 Gitie SHPP

This project is located on the most upstream of the river.

Weir

The weir site is located at the border of the Mt Kenya Forest Reserve and immediately downstream of the confluence of Nyamindi River and River Rumindu tributary. The weir site location will be at an elevation of 1774 masl. Fresh rock outcrop is observed at the weir location (looking downstream) on both banks and also in the river section. There is a prominent joint set parallel to the river, with 1 m spacing and three other randomly oriented joint sets. Although there are some fracturing areas, foundation rock mass is considered to be a massive rock. Good foundation conditions are expected at this site.

Desilting Tank

The right bank slope (looking downstream convention) gradually rises from the weir location assuming about 30° slope towards the crest and flattens to a plateau like landscape. The desilting tank is located on this slope, only a short distance downstream of the weir site. The slope consists of weathered rock with a thin soil cover, and is very stable in this area. No geotechnical issues are expected in excavating the slope to establish the desilting tank.

The Forebay

The Forebay will be located on the crest of the river valley in the plateau. The valley slope is stable. There are indications that the red clayey soil profile can be relatively thick in this area therefore some investigations in terms of test pits will be required to assess the Forebay foundation conditions and material properties.

Power House:

PH will be located at an elevation of 1702 masl. Fresh basalt rock outcrops on both banks and on the river bed at the selected location for the power house, where excellent foundation conditions can be expected. No geotechnical issues are anticipated on the penstock slope which is expected to be very stable.

4.2.10.2 Kiamutugu SHPP

This project lies between the Gitie and Mbiri Projects.

Weir site (1635 masl)

Several alternative sites were geo-technically inspected for the Kia weir. At the currently chosen site, the river has eroded a narrow gorge in the basalt rock mass which is several meters high. The geotechnical conditions were fairly similar at the alternative sites considered, that is fresh rock outcrops on the river and the banks and gentle slopes. The selection was based on maximizing the hydraulic head for the project.

The rock mass at the selected site shows flow structures, is blocky to massive and is very competent. No adverse geotechnical conditions were observed. Depending on the height of the structure, a geotechnical investigation programme should be designed in the next stage of studies to assess the foundation conditions and water-tightness.

Water conveyance route and penstock line

A brief terrain evaluation was conducted in the area where a contour pipeline and a surge tank are envisaged. The geomorphology of the terrain is characterized by small ridges and spurs with gentle slopes. As such the pipeline has a winding outline which is far from ideal. However, slope stability issues are not observed in this terrain, except evidence of a few old failures on the river valley slopes.

Powerhouse location (1485 masl)

Several alternative sites were inspected for the powerhouse location. The selected location has a seemingly favorable topography to establish the penstock line, and easy access to the powerhouse at the base of the slope. Weathered rock is exposed on the valley slope, which is assessed to be stable. Fresh rock outcrops on the right bank of the river and is expected to occur at shallow depth under the terrace on the left bank, where the powerhouse is envisaged. Geotechnical drilling will be required to establish foundation rock depth and rock mass conditions.

4.2.10.3 Mbiri SHPP

The Mbiri project is envisaged at the lower stretch of the R. Nyamindi cascade with a total head of about 90 m.

Weir

Weir site is located at an elevation of 1475 masl. The location of a weir site for the Mbiri project is constrained by an irrigation weir located a few hundred meters upstream of the Mbiri Bridge. The hydropower weir had to be located below the irrigation weir to maintain unrestricted flow

for the irrigation scheme. Similar to all other areas along the cascade, fresh basalt rock outcrops along the river and on both banks are observed. At the selected weir location fresh, massive basalt outcrops in the river and on both banks. Highly weathered rock is exposed up on the slopes which have a thin soil cover. Overall, excellent foundation conditions can be expected at this location.

Water conveyance route and penstock

The water conveyance route is located away from the immediate river valley and no slope stability issues are anticipated.

Powerhouse site

Several alternative sites were evaluated and the current location is geo-technically sound and provides the maximum head for power generation. The river assumes a bend and has formed a wide flood plain at the location. The location is easily accessible without major excavation. Weathered bedrock is exposed on the slope which is assessed to be stable. Fresh rock is exposed at the base of the valley on the right bank. Foundation rock under the left bank terrace is not expected to be too deep. However further investigation will be required to confirm the depth.

Water tightness of weir foundations

The water tightness is determined by the overall permeability of the rock formation. The permeability of a rock mass is related principally to the presence of rock discontinuities such as open joints, faults, shear zones, solution cavities, and interconnected fractures. Joint openness and continuity determine how readily water seeps through the rock mass. Typically, the olivine basalt rock mass which constitutes the R. Nyamindi cascade is sparsely jointed and massive. In some areas, volcanic flow structures and blocky rock was observed. Generally, the leakage potential through the basalt rock mass can be considered to be very low. However, there are some risks if volcanic ash or weak layers such as pumice are included within the basalt rock mass. These can increase the risk of potential leakage. Depending upon the height of the weirs envisaged, some detailed geological investigations will be required. Generally, all weir sites considered constituted with massive fresh, strong basalt. The field observations led to the conclusion that there are no foundation and abutment stability issues for the construction of concrete gravity structures.

4.3 Hydrology

Detailed hydrological assessments were conducted for River Nyamindi to facilitate informed decisions on the design flow quantity and reliability for purposes of designing the proposed hydro-electric power facilities. It also provides estimate required environmental flow which will be allowed to be released to support the existing environmental functions. *(Hydrology Assessment*

of R.Nyamindi by Vala Associates Ltd, Tuesday 29 May 2017, full report provided in Appendix 13.2.)

4.3.1 Catchment Characteristics

The River Nyamindi catchment behind the WRMA 4DB05 station straddles a wide range of altitudes from the mountain peaks to the lower plains. The highest altitude of the catchment is 4701 m on the southern peaks of Mt Kenya while the lowest (at the gauging station 4DB05) is 1201m.

About 55% of the catchment is covered by evergreen forests while the upper most 11% is covered by barren cold rocky lands of the Mountain. The rest of the catchment further south is intensively farmed with a wide range of agricultural crops. The shape of the catchment assumes a longitudinal profile which is determined by the topography of the slopes **(**Figure 4.6**)**

Nyamindi catchment is located near the equator, which accounts for the minor variations in monthly temperature and the occurrence of two rainy seasons, which coincide with the passing of the Inter Tropical Convergence Zone. There is a difference in altitude between extreme north and south of the catchment of about 3500 meters; the altitude has a pronounced effect on the climate. With increasing altitude, the amount of rainfall increases up 2286 masl; thereafter it begins to decrease as the altitude increases further up the mountains.

Both temperature and evaporation decrease monotonically as the altitude increases. During the long dry season, especially in July, the area tends to have a persistent cloud cover, which results in a relatively lower temperature and evaporation.

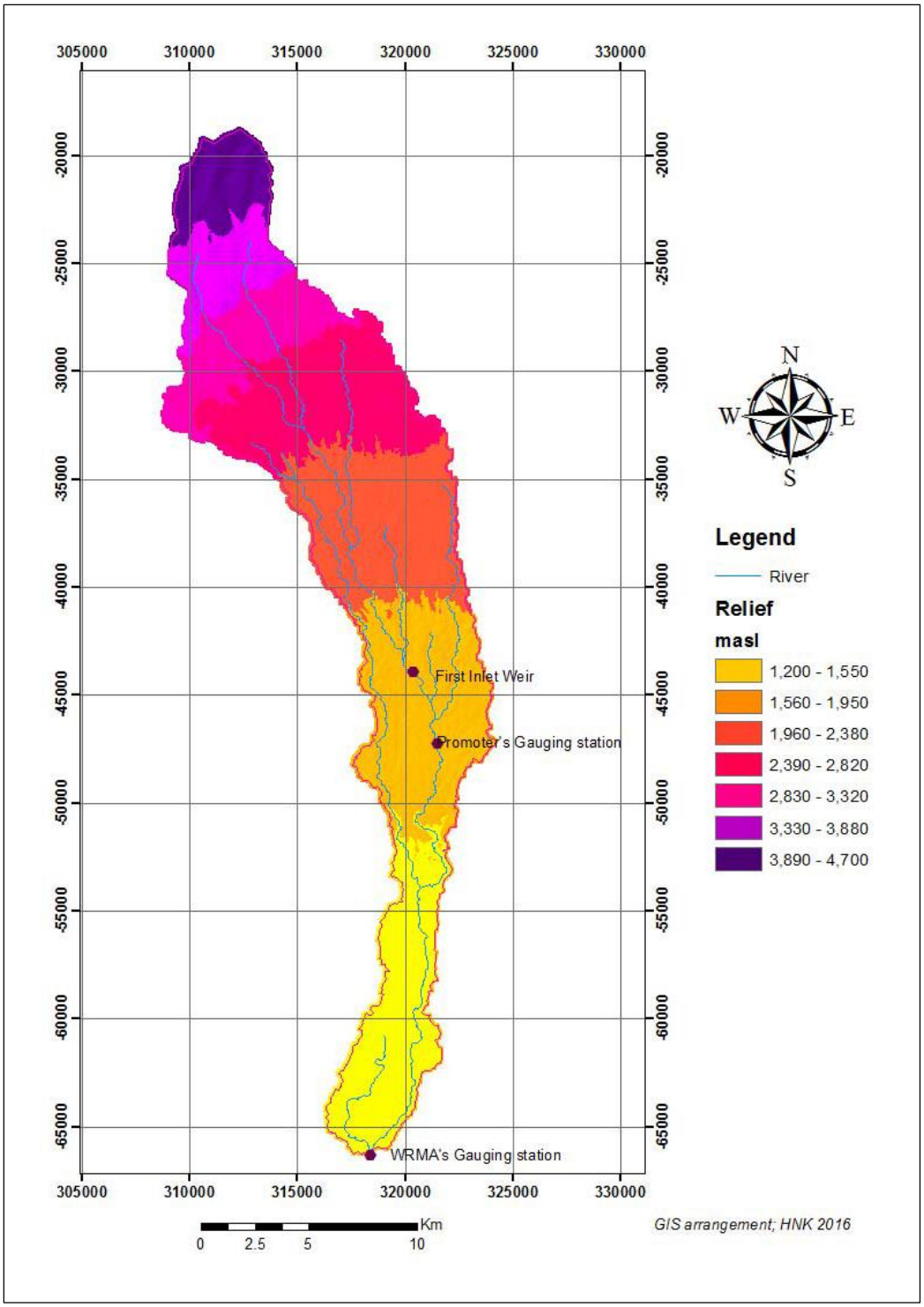


Figure 4.6: **The Nyamindi Catchment (upstream of the WRMA 4DB05 station)**

4.3.2 Rainfall in the Nyamindi Catchment

The long-term-annual average Rainfall (according to the Kenya Meteorological Department) in the Catchment is shown in **Figure (4.7).**

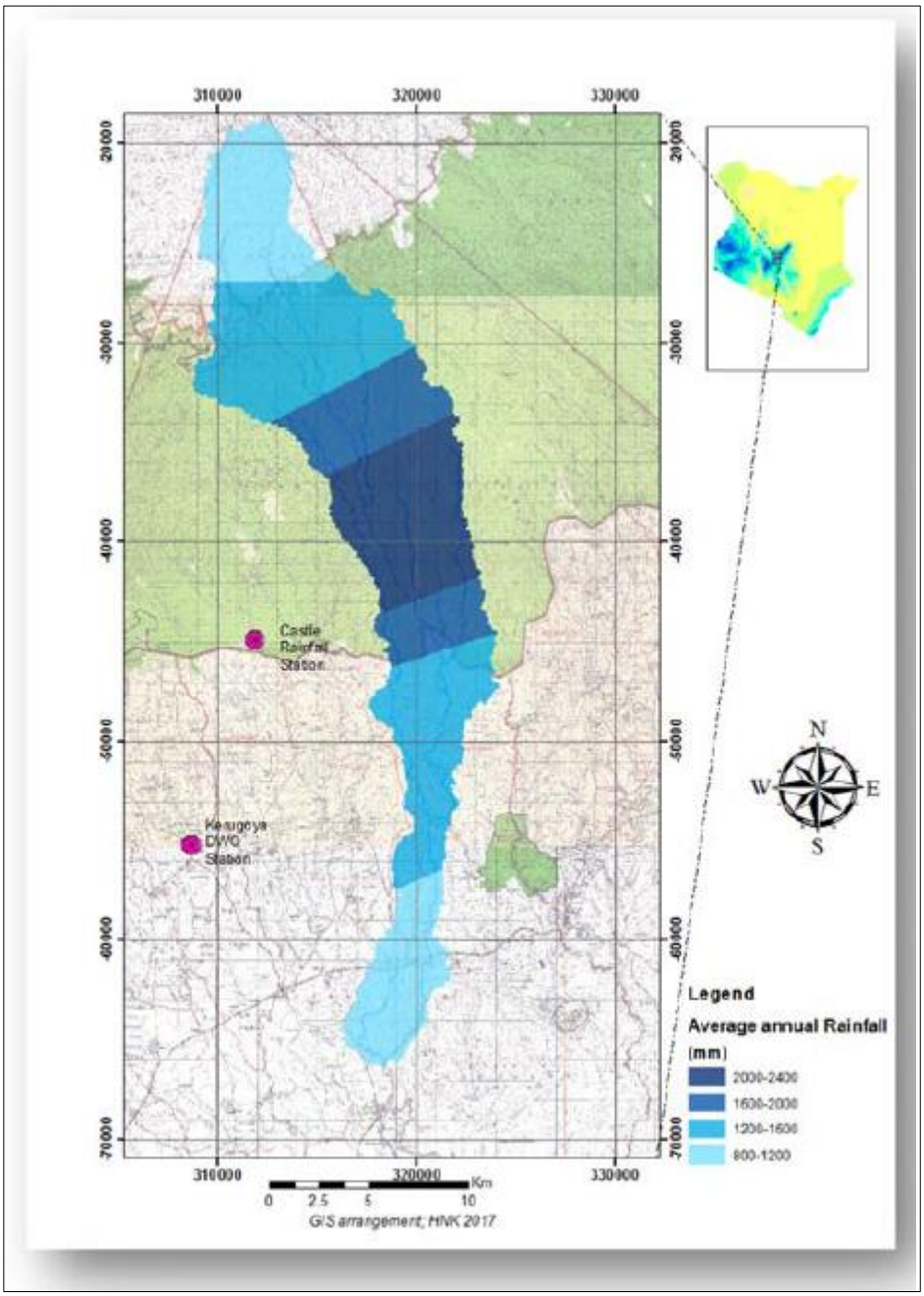


Figure 4.7: Mean Annual Rainfall distribution in the Nyamindi catchment area

The following characterize the spatial distribution of rainfall in the project area:

- There is a wide variation of rainfall distribution in the catchment ranging from 800mm to 2400mm
- The maximum rainfall occurs in the forest reserve portion of the catchment on the slopes of Mt Kenya
- The rainfall tapers off as one goes higher to the snow-capped Mountain Kenya and as one descends to the mouth of the river.
- There are no rain-gauging stations in the forest areas with the highest precipitation.

4.3.2.1 Analysis of precipitation records for the Nyamindi area

Rainfall data has been collected for two stations which have close proximity to the project area. Their locations are Kerugoya DWO and Castle Rain Forest Station as indicated in **Figure 4.8.** The datagram showing the availability of the data is indicated in **Table 4.2.**

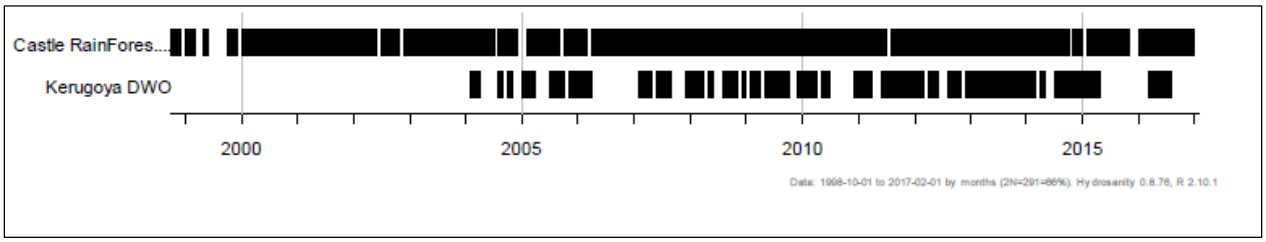


Figure 4.8: **Datagram showing missing records at Kerugoya and Castle rain stations**

Table 4.2: **Rainfall Data obtained for the Project**

Station ID	Station Name	Period	Type of data	Percentage missing
9037031	Kerugoya DWO	2004-2016	Daily values	10.4%
9037115	Castle Rain Forest Station	1998-2016	Daily values	7.5%

4.3.2.2 Rainfall distribution

The seasonal rainfall distribution of the two stations is shown in **Figure 4.9** Annually four different seasons can be distinguished, notably a short dry season in January and February, a rainy season from March to May, a long dry season from June to September and a rainy season from October to December. At higher altitudes the rainy periods start 20 to 30 days earlier than in the lower

parts of the catchment. The mean monthly rainfall totals for April tend to be the highest in the year. Whereas the May rainfall may be high, it has larger variability compared to that of April.

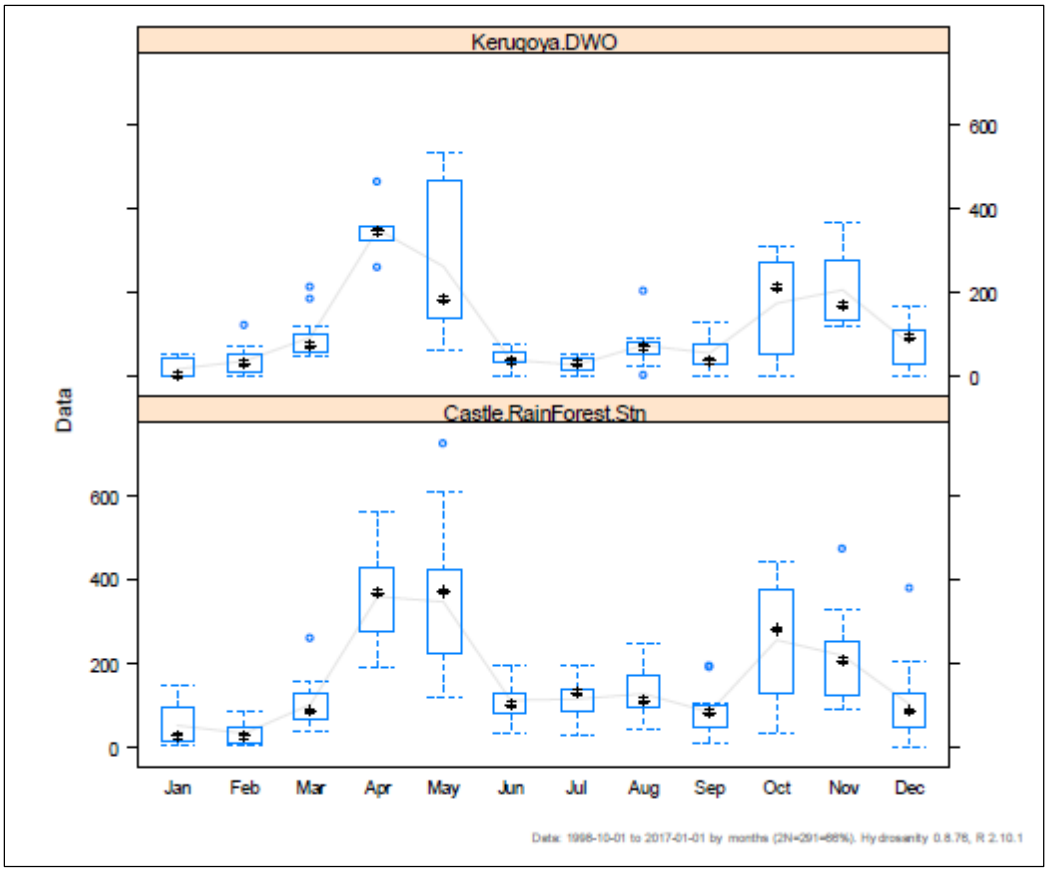


Figure 4.9: Seasonal rainfall distribution of the two stations

4.3.2.3 Evaluation of obtained river flow data and gauged data

The primary interest of the hydrology assessment for this hydropower project is to establish, *with reasonable accuracy,* the discharge properties of R. Nyamindi at selected locations at proposed weir abstraction points. The starting point is the historical records at station 4BD05 operated by WRMA. The flow rating curve for this station was provided for WRMA for the period 1982-1991 (**Figure 4.10).** Station 4BD05 was rehabilitated in 2009 and data collection resumed that year. WRMA has provided some spot discharge measurements that were done on the rehabilitated station in the years 2013-14. Subsequently a number of discharge measurements have been carried out over the last eight months culminating in the development of the rating curve for the new rehabilitated station (**Figure 4.10**).

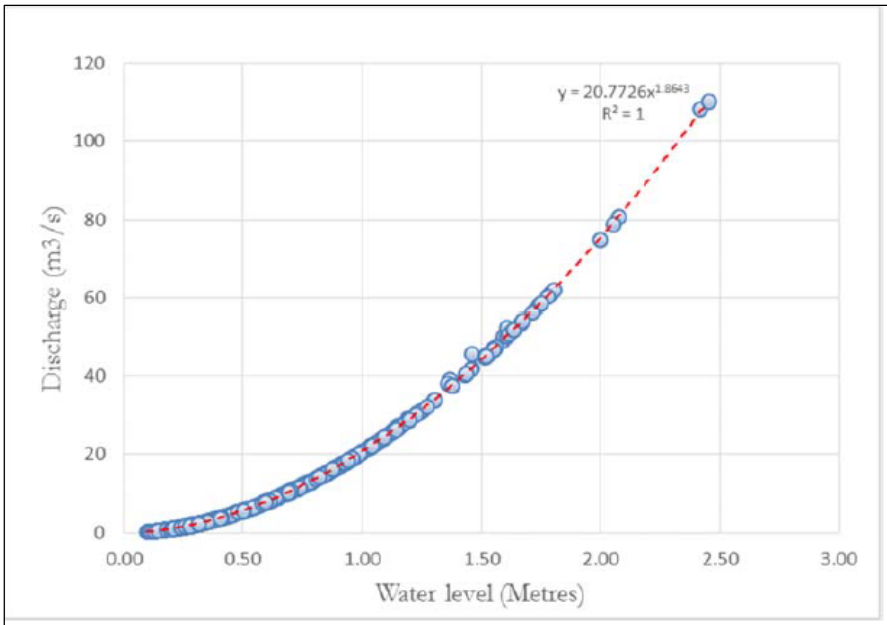


Figure 1-7 Rating curve for 4DB05 for the years 1982-1991

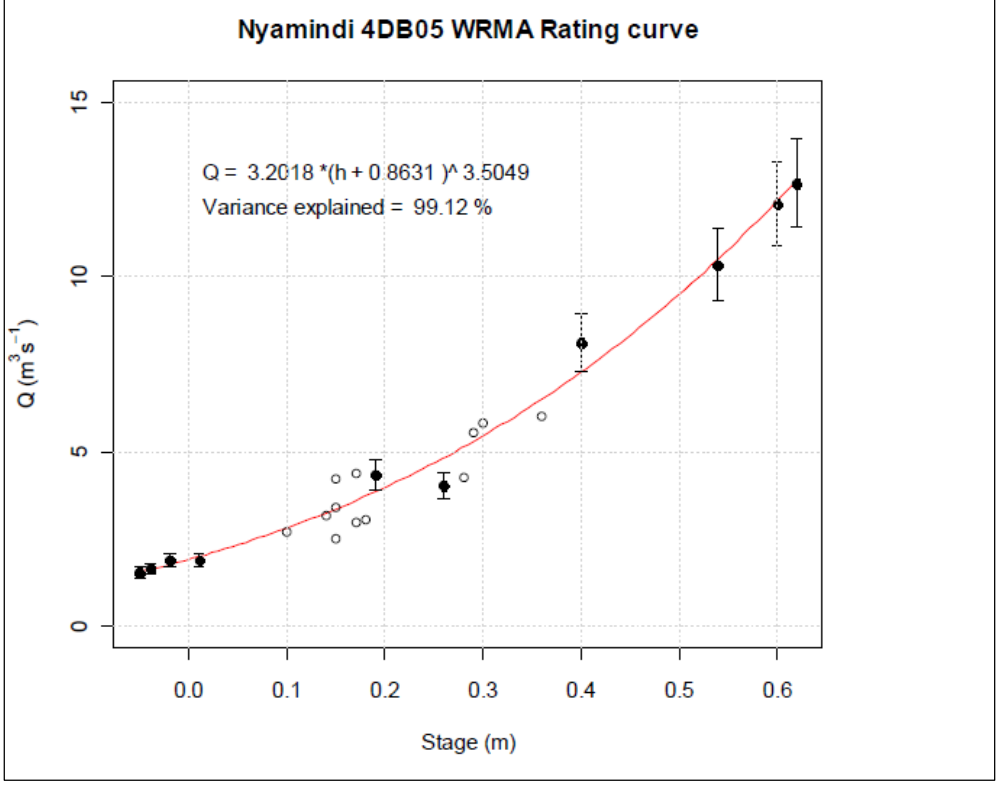


Figure 4.10: Flow rating curves at the 4DB05 station (2009-2016)

The hydrological assessment also produced another rating curve based on the information collected from the gauging station organized by the Developer. The detailed description of the datum and the comparison is made in the full hydrology report (**Appendix 13.3**). The discharges at both the gauging stations were computed using the respective rating curves for the period 10/2015 to 9/2016 and subsequently compared **(See Figure 4.11).** The results are realistic where most of the time the discharge at 4DB05 is found higher.

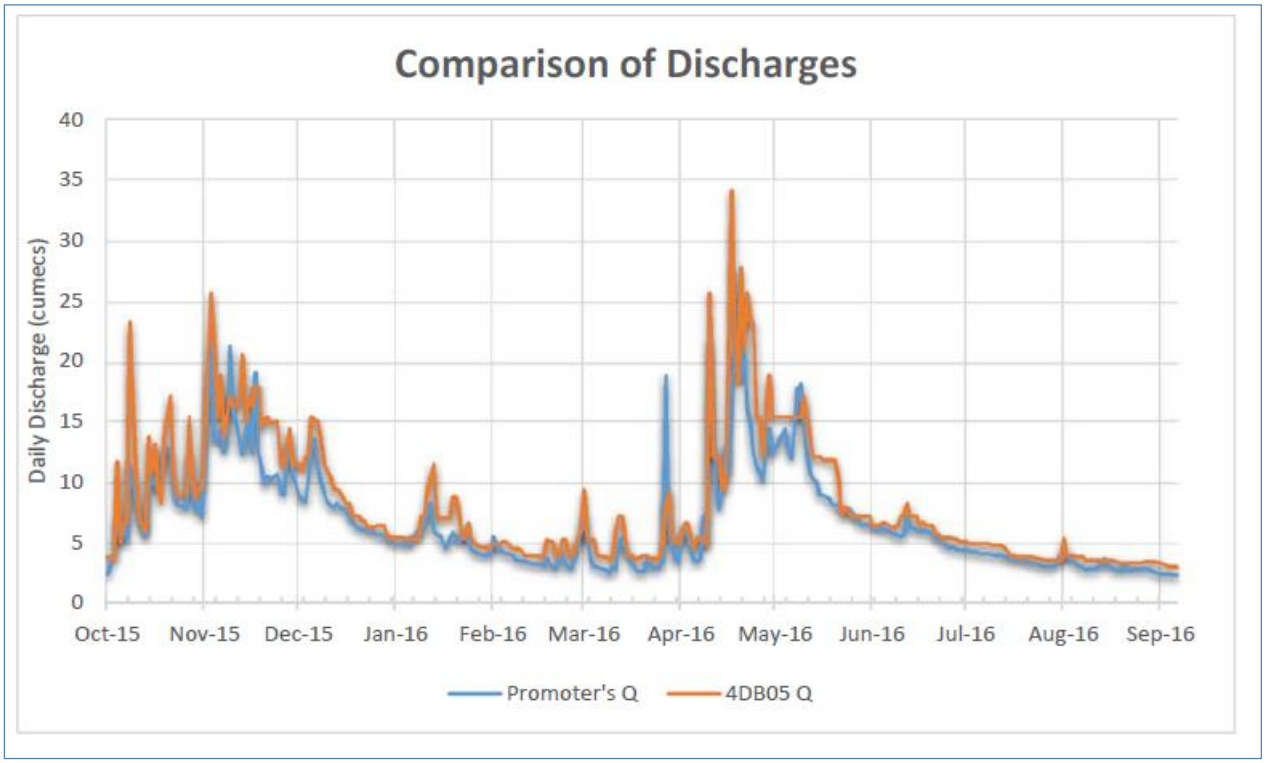


Figure 4.11: Comparison of two discharges

4.3.3 Water Flow Availability

4.3.3.1 Derivation of the Weir Flows

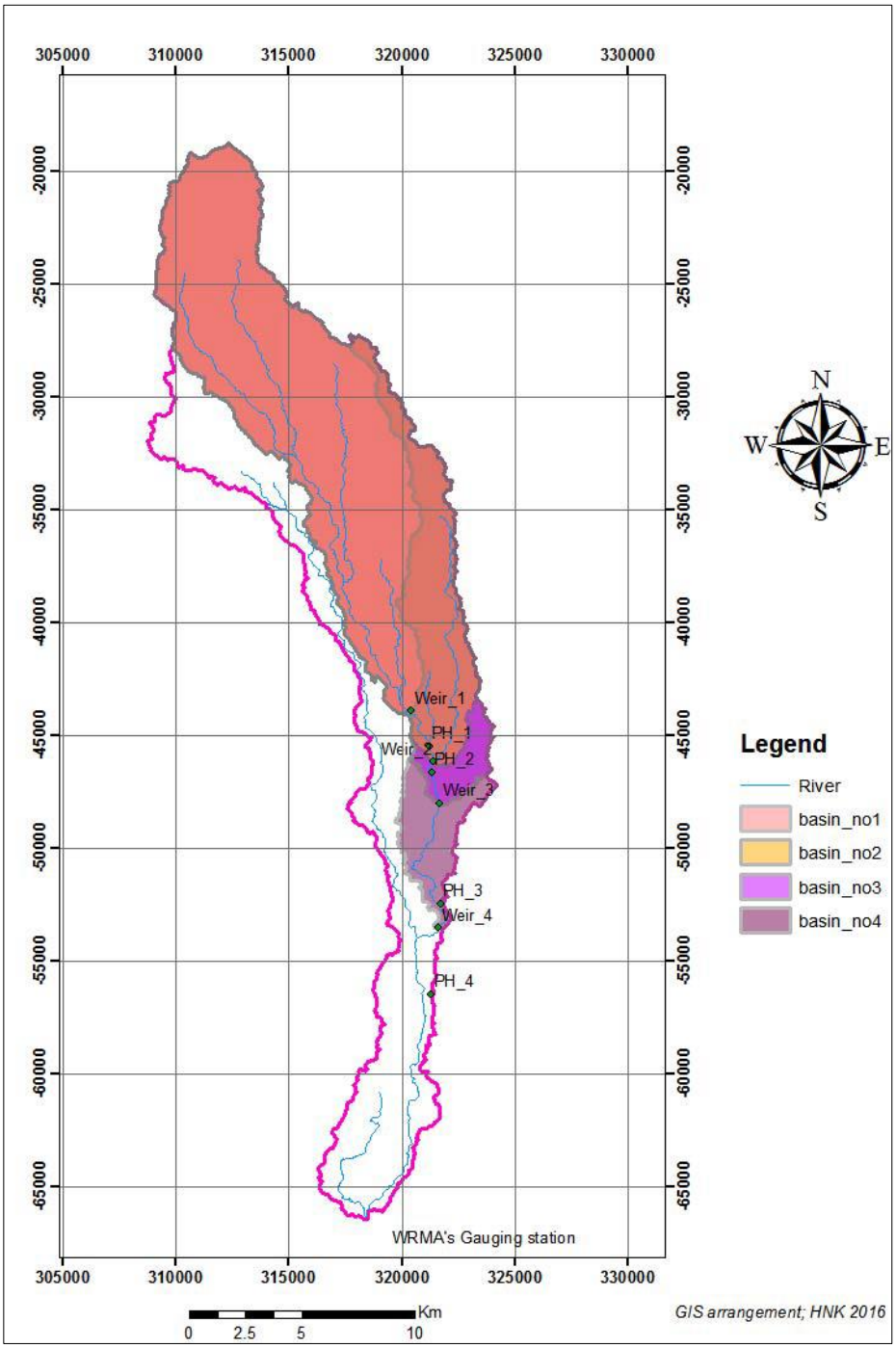


Figure 4.12: The Sub-basins associated with each of the proposed weir locations

Sub basins (Catchment) associated with each of the project is provided in **Figure 4.12.**

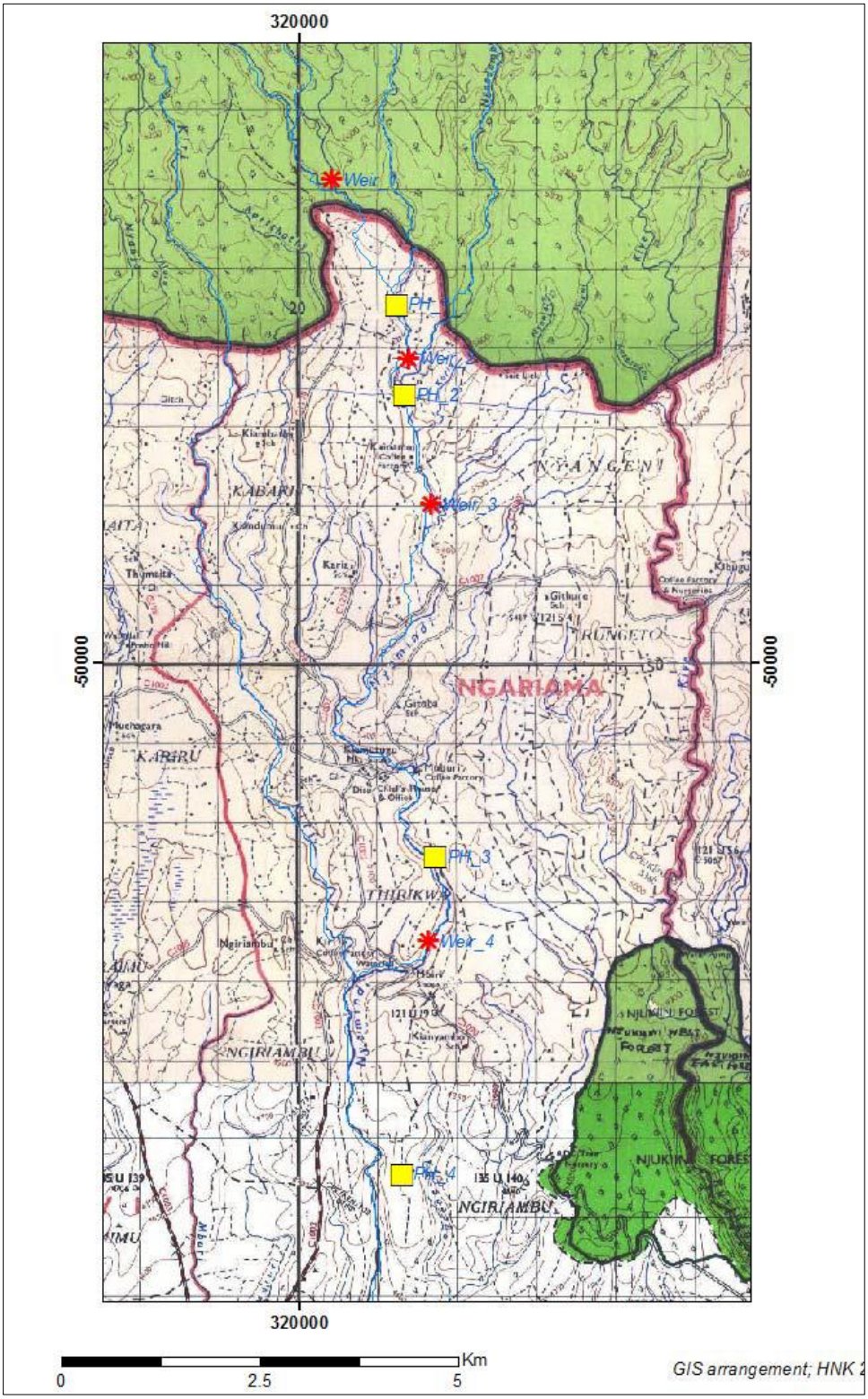


Figure 4.13: **Location of proposed Weir, Intakes and Powerhouses on the Nyamindi**

The physical characteristics of the catchments associated with the weir intake points are given in Table 4.3

Table 4.3: Catchment Characteristics at the selected projects

Point	AREA (Km2)	Average Slope (%)	Minimum Elevation (m)	L equivalent (km)	Annual Total Mean Precipitation (mm)	Area*mean Precipitation (km2.mm/y)	Weighted Ratio
Weir 1	139.88	24.08	1788	30.065	1510.82	211333	**0.765**
Weir 2	170.52	22.06	1692	32.417	1603.94	273504	**0.990**
Weir 3	178.36	21.541	1631	35.202	1602.43	285809	**1.035**

(Source: Adapted from the Table (3) of the Hydrological Report)

4.3.3.2 Flow Duration Curve

The flow duration curves (FDC) of the resultant time series at the respective proposed weirs are shown in Table **4.4 and Figure 4.14.**

Table 4.4: Percentage of time flow equaled for the various proposed weirs

% of time flow equaled or exceeded	Weir 1	Weir 2	Weir 3
99%	0.66	0.86	0.87
95%	1.24	1.60	1.62
90%	1.49	1.93	1.95
85%	1.76	2.28	2.30
80%	2.07	2.67	2.70
75%	2.22	2.88	2.91
70%	**2.46**	**3.19**	**3.22**
65%	2.70	3.49	3.53
60%	2.95	3.82	3.86
55%	3.24	4.20	4.24
50%	3.58	4.63	4.67
45%	3.84	4.97	5.02
40%	4.31	5.58	5.64
35%	4.80	6.22	6.28
30%	5.28	6.83	6.90
25%	6.08	7.87	7.95
20%	**7.09**	**9.17**	**9.27**
15%	8.36	10.82	**10.93**

10%	10.13	13.11	**13.24**
05%	13.40	17.34	17.52

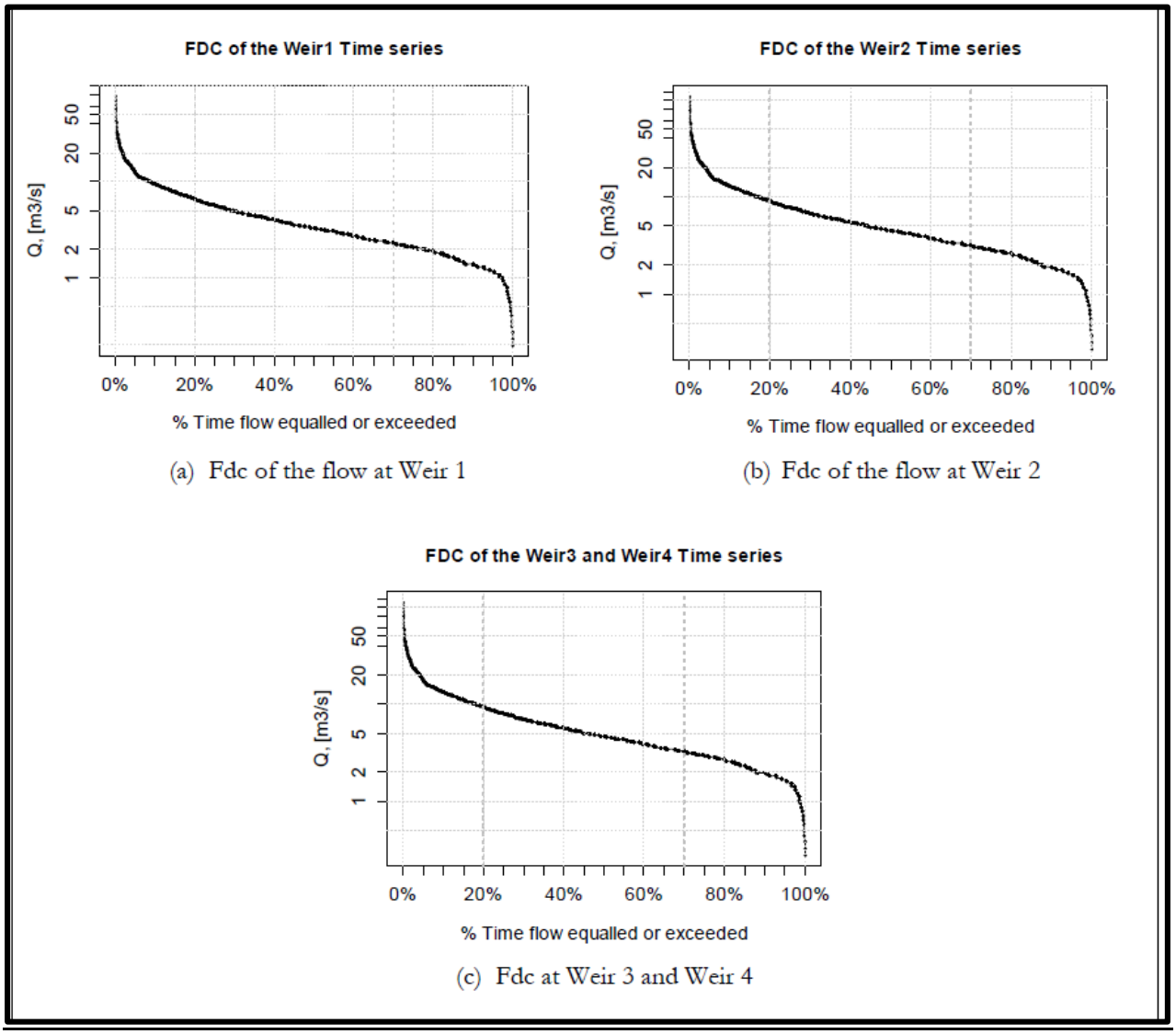


Figure 4.14: **Respective FDCs for all the three projects**

4.3.3.3 Sediment yield in the catchment

The sediment yield of the catchment is found to be very low. This is expected particularly since the upper portion of the catchment is covered by protected forests and rocky mountain slopes.

Figure 4.15 shows the Sediment Yield in the Nyamindi catchment according to the AGWA-SWAT output.

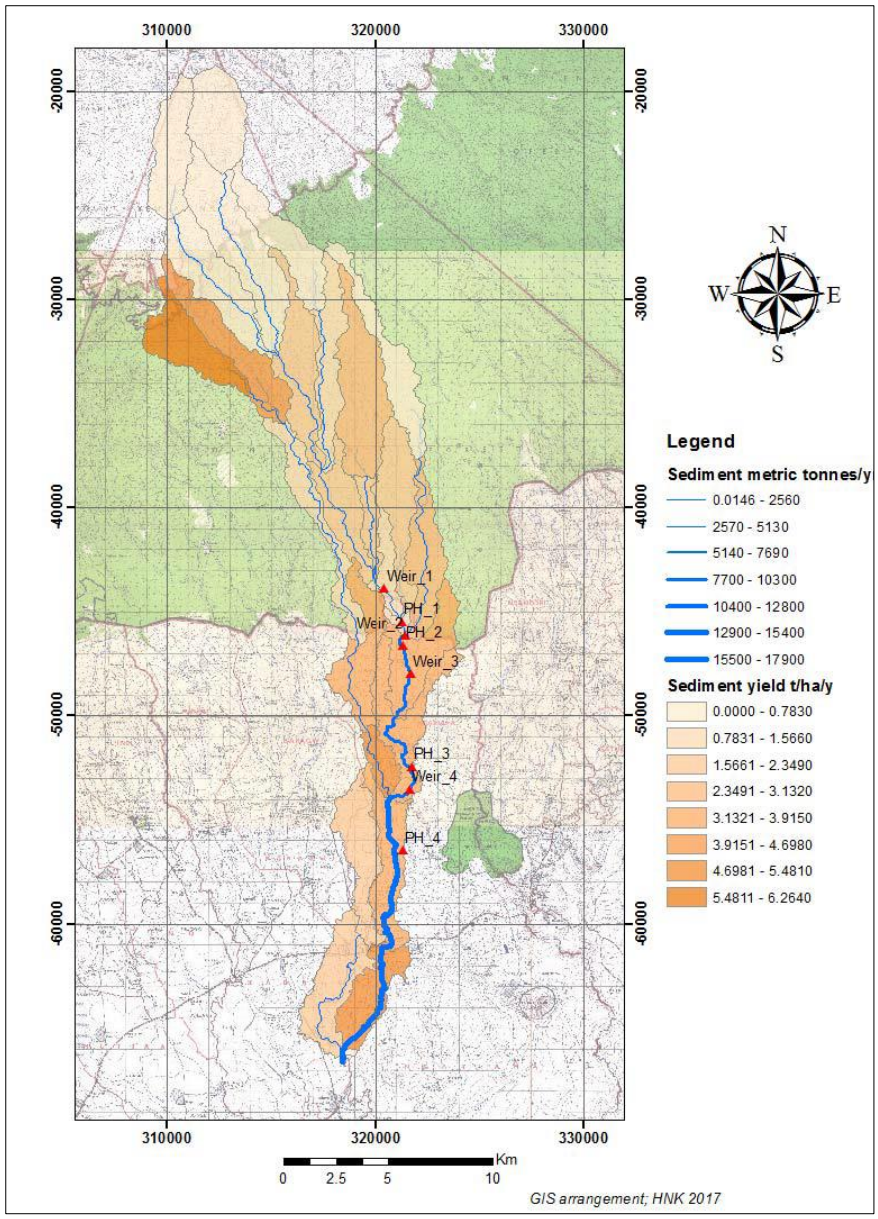


Figure 4.15: Sediment Yield in the Nyamindi catchment according to the AGWA-SWAT output

It is observed that sediment concentration of 3mg/l to 300mg/l is relatively very low and would not present any hazard to the impeller turbines nor silt up the head race or tail race.

4.3.4 Water Resources

The County is well endowed with flowing surface water in the form of rivers. River Nyamindi is one of the major rivers and drains into River Tana. Other rivers converging to River Tana are Thiba and Mrubra **(Figures 4.16).** These rivers are the principal source of water in the County. In addition, there are ground water sources which are unique in terms of the content of mineral contents that affect their water quality.

Domestic water has been tapped from these rivers using piped schemes. In the lower zones, river water has been harnessed through canals and used for irrigation especially in Mwea. Generally, water quality is of good quality as it is direct from the Mount Kenya forests where the environment is still pristine or with minimal human activities. Mineral water sources are used by the people in the area for medicinal purposes.

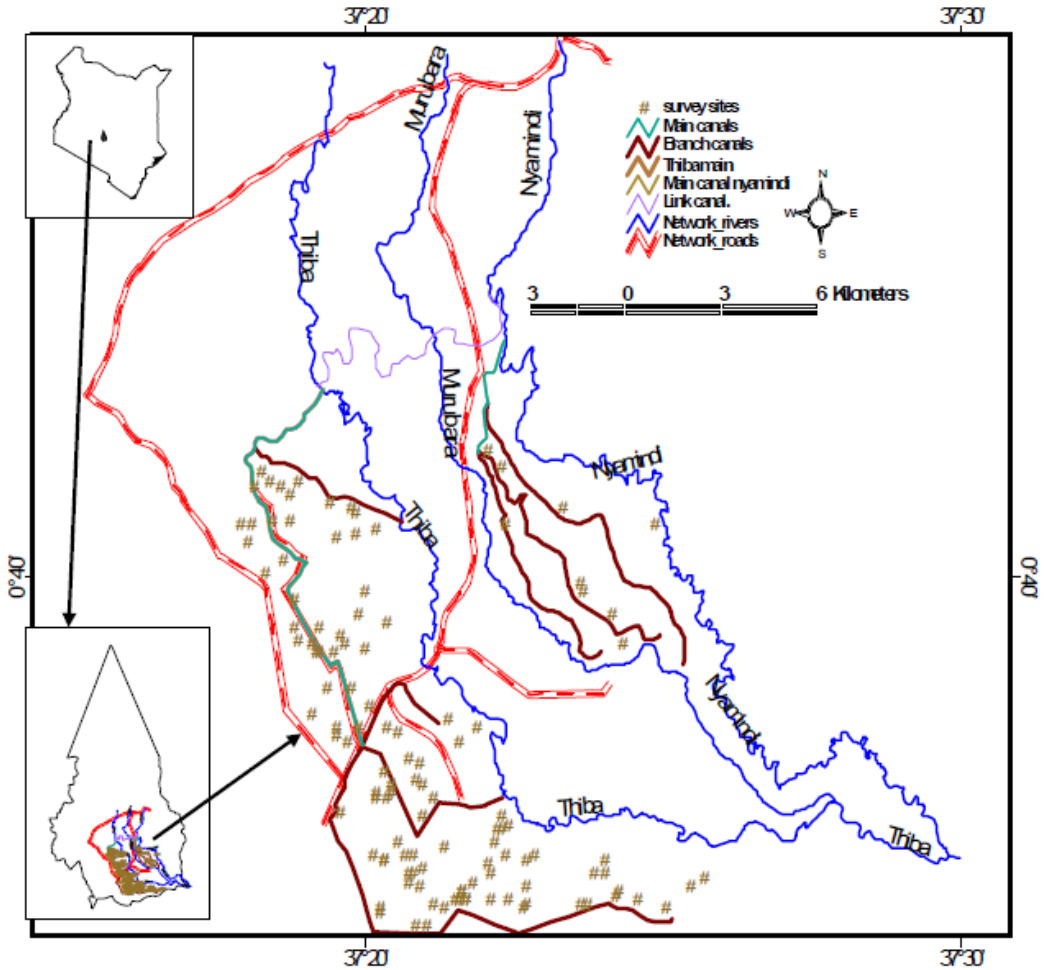


Figure 4.16: **Major Rivers in Kirinyaga County converging to River Tana**

4.3.5 Water Quality

Existing water quality of the surface water sources of project area was tested using samples drawn from the river. These samples were drawn from four (4) points along the river to represent the location of the projects. The samples were drawn in Oct 2016 and were tested for drinking water parameters **(Table 4.5)**. This is logical since; the river water is used for drinking purposes.

Table 4.5: **River Water Quality tested for KS EAS 153**
East African Standard Specification for bottled Drinking Water tested

Water Quality Parameters	Standards	Sample Point 1	Sample Point 2	Sample Point 3	Sample Point 4
Chlorides	mg/L 250Max	0.71	1.42	2.13	1.42
Fluoride	mg/L 1.5Max	0.28	0.32	0.32	0.34
Iron as Fe	mg/L 0.3 max	0.01	0.002	0.004	Not Detected
Nitrates	mg/L 45 max	5.95	11.27	6.65	4.14
pH	6.5-8.5	6.91	6.97	7.15	7.06
Sulphates as S04	mg/L 400 max	1.64	1.89	2.09	1.63
Total Dissolved Solids	Ppm. 1500max.	16.1	22.4	26.6	28.7
Coliforms	/250ml- Nil	Detected	Detected	Detected	Detected
E.Coli	/250ml - Shall be absent	Detected	Detected	Not Detected	Detected
Pseudomonas Aerugios	/250ml- Shall be absent	Detected	Detected	Detected	Detected
Salmonella	/250ml -Shall be absent	Not Detected	Not Detected	Not Detected	Not Detected
Shigella	/250ml – 1Min	Not Detected	Not Detected	Not Detected	Not Detected
Staphylococcus asreus	/250ml - Shall be absent	Not Detected	Not Detected	Not Detected	Not Detected
Streptococcus faecalis	/250ml- Shall be absent	Not Detected	Not Detected	Detected	Detected

Whereas the water quality was good quality, bacteriological counts in some station indicated the river water was unsuitable for domestic use without treatment. However, the river water is suitable for primary and secondary uses such as swimming and fishing.

4.3.6 Water Abstraction in the Nyamindi catchment

A number of locations where there were abstractions of water directly from the river for irrigation of small holder fields along the river have been observed. Many of these were using motorized small pumps to withdraw the water (**Figure 4.17).** It is thus a fact that there are a number of legal and illegal abstractions of water from the Nyamindi downstream of the proposed first intake weir. The net sum of the allocations is 341,510 m^3 /d of which 293,242 m^3/d is non-consumptive hydropower use. On further scrutiny of the location of the withdrawals it was realized that the hydropower schemes and Riagicheru Irrigation /Domestic Water Project are below the proposed 4th Power house. Thus the true consumptive water withdrawal the project should accommodate is 43,754 m^3/d or 0.506m^3/s.

Figure 4.17: Equipment used by the community members to abstract water

The location of these water withdrawals in relation to the various weir points is shown in **Figure 4.18.** A physical survey of the locations of these abstractions was made and the results, corroborated with data from WRMA (**Figure 4.18 and Table 4.6)**.

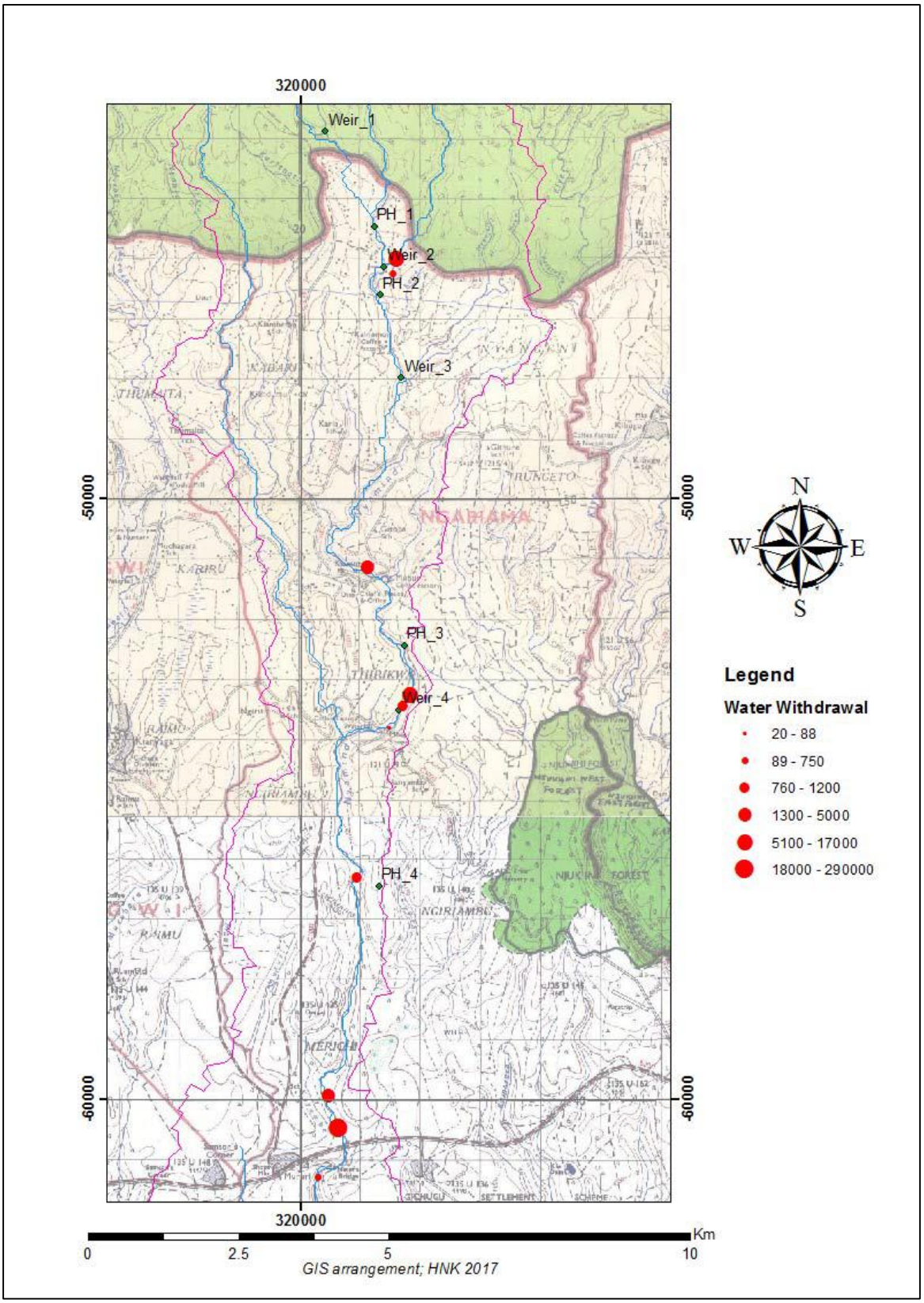


Figure 4.18: Water abstraction points along the river

Table 4.6: Existing water users and the permit status along the river

Water User Name	Status	Water Use	Allocation (M3/day)	UTM x	UTMy
Kenera Women Water Project	Permit Issued	Domestic And Irrigation	698.55	0320942	9943692
Ngariama Njukini Water Project	Deferred	Domestic Water Use	538.9	0321539	9953734
New Ngariama Farmers Co-Orperative Society Limited	Pending RO Verification	For Domestic, Commercial And Industrial Use	17208.68	0321594	9953980
Riagicheru Irrigation /Domestic Water Project	Extension of Time Issued	Irrigation Water Project	4512.95	0320470	9940058
Kathataini Irrigation Water Project	Authorization issued	Irrigation Water Project	3156	0321116	9948846
New Ngariama Farmers Co-Orperative Society Limited	Permit Issued	Water For Coffee Pulping	88	0321594	9953980
Kamiuu Irrigation Water Project	Permit Issued	Water For Commercial Irrigation	750	0321717	9946554
Ngucwi Mwangaza Quarry Self Help Group	Authorization Issued	Water For Hortcultural Irrigation	27.27	0320799	9929114
Mutungara Irrigation Water Project	Permit Issued	Water For Irrigation	1170.3	0321717	9946554
Tana Water Service Board (Kiriwasco)	Received Inspection Report	Water For Public Water Supply	14000	0321825	9946717
Nyamindi Utugi Small Irrigation Self Help Group	Authorization Issued	Water For Subsistence Irrigation	1097.28	0320942	9943692
County Government Of Kirinyaga	Illegal	Public	5000	0321825	9946717
Mr. John Kombo	Illegal	Subsistence Irrigation	20	0321477	9946182
Urumandi Micro Hydro Power Project	Authorization Issued	Water For Hydro Power	606.3	0320300	9938700
Kimunye Tea Factory	Authorization Issued	Water For Hydro Power Generation	292636	0320631	9939523
TOTAL			**341,510**		

4.3.7 Environmental water flows

Environmental flows are the water that is left in a river ecosystem, or released into it, for the specific purpose of managing the condition of that ecosystem. It is primarily concerned with the

direct effects of flow on ecological functioning of rivers and the management of water quantity. The Kenyan national water policies and laws call for protection of a reserve in all aquatic ecosystems. The reserve is generally defined as the minimum water levels that must be left in the system in order to sustain, as a first priority, basic human needs and aquatic ecosystems.

The Kenya Water Resources Management Act 2002, defines the reserve "in relation to a water source, [as] that quantity and quality of water required (a) to satisfy basic human needs for all people who are or may be supplied from the water resource; and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the water resource". The Water Resources Rules of 2007 indicate that the reserve quantity for streams and rivers **shall not be less than the flow value that is exceeded 95% of the time as measured by a naturalized flow duration curve at any point along the water course.** Subsequently, where water resource records are not available, the Water Resource Management Authority shall establish the reserve guided by:

- Ecological vulnerability;
- Vulnerability of local populations dependent on that water resource;
- Local observations with respect to the naturalized flows or water levels of minimum values observed during periods of prolonged droughts;
- In all instances where water flow is known to be normally perennial, then the Reserve Quantity shall be sufficient to ensure perennial flow;
- Consultations with the water resource users' associations, if such exist.

Analysis of Environmental Flow

From the flow duration curve analysis, Nyamindi River has fairly high flood flows which could be utilised for hydropower generation with no negative impacts to the environment.

The project hydrology report proposes to allow for an environmental flow of 5% of the mean flow at each weir point during low flows. Based on the hydrological analysis conducted for the project, the mean discharge at each intake location is as shown below.

Table 4.7: Environmental Reserve flow and Total reserve at the various weirs

Proposed Intake	Proposed Project	Long-term Mean annual Flow m3/s	Environmental Flow m3/s
Weir 1	Gitie	5.25	**0.26**
Weir 2	Kiamutugu	6.79	**0.34**
Weir 3	Mbiri	6.86	**0.34**
WRMA Gauge 4DB05		8.42	

Thus resulting in an environmental flow of approximately 0.26m3/s (22,464m3/day) for weir 1 and 0.34m3/s (29,376m3/day for both 2nd and 3rd weir.

The project intends to abstract a maximum of 5.5 m3/s (475,200m3/day) for the 1st Weir and 8m3/s (691,200m3/day) of flood flow for 2nd and 3rd weirs. The water will be diverted through a canal for approximately 3.4 km, 5.1 km and 3.7 km for Gitie, Kiamutugu and Mbiri projects respectively before 100% of the water is returned to the river at the power house of every project. . With the exception of the bypassed sections of the river between the intakes and powerhouses, the diversions will not have any impact on the rest of the river. The environmental flow of 0.26m3/s & 0.34m3/s respectively will remain to maintain environmental integrity. In addition to the proposed environmental flow, the bypassed sections receive considerable amounts of recharge from several small tributaries.

Further, the environmental flow is supported by the following considerations:

- The project is run of the river which is considered non consumptive with 100% of water returnable.
- The intake structure shall be a self-regulating weir with an ecological flow opening that allows for the automatic release of the reserve flow throughout the year. This will ensure that only the amounts exceeding the set environmental flow shall be diverted from the river for hydropower generation
- There are no abstractors between the first weir and the third weir and both the downstream and the upstream water users won't be affected by the abstraction.

- The actual amount diverted shall vary downwards based on the available flow and the plants design anticipates that one or both of the generating units will be switched off during low flows.

Through implementation of environmental flow, the proposed project can achieve a flow regime, or pattern, that provides for human uses and maintains the essential processes required to support a healthy aquatic ecosystem between the weir and the power house.

(Appendix 13.3) provided the Detailed Hydrology Report.

4.4 Aquatic Ecology and Habitats

Water life is synonymous with rivers and wetlands. Generally, rivers and wetlands support water and life, which have both renewable and non-renewable resources that primarily benefit humans. Crucially rivers and wetlands play critical roles in the environment including supporting, providing and regulating ecosystems services such as habitats of biodiversity, water purification, water storage and flow regulation, water provision and carbon sequestration (Millennium Ecosystem Assessment 2005). At the global level, the Ramsar Convention, encourages member states including Kenya to ensure their conservation and wise use through local, national and regional actions (RAMSAR 2010). MEA (2005) a UN report observed that environmental degradation was more prominent within aquatic systems than any other ecosystems on earth.

Key to sustainable management of aquatic ecosystems is the availability of relevant information and data; specifically, on their environmental health. Major impediment to wetland conservation and management in Kenya is inadequate data on their environmental conditions and the problems threatening their continued existence. Any development activity is likely to have an impact on biodiversity and related ecosystems services. However, such adverse impacts can be managed by having biodiversity data. First, the data can be used to identify environmental problems in wetlands as such can help to identify possible and appropriate mitigation measures. Secondly, the data can be used to assess and evaluate wetland ecosystem services in wetlands and in so doing contribute in formulation of policies that will guides their conservation and management (Groot et al., 2006; MEA, 2005). These benefits range from ecological, socio-cultural to economic values (Higgs, 1998; Hansson et al., 2005; MEA, 2005; Groot et al., 2006).

4.4.1 Higher and lower plants associated with Riparian habitats

In order to characterize riparian vegetation, eleven study areas along River Nyamindi were established next to key project infrastructure of intake, penstock and powerhouse.

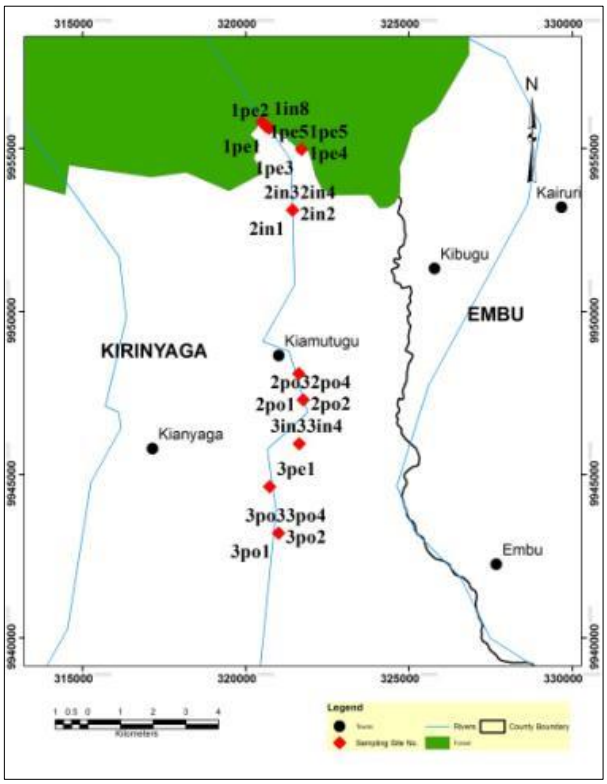


Figure 4.19: Location of sampling sites for riparian and associated higher plants

In each study areas, two transects were made. The first transect, was a 100m long grad sect along the river in which all riparian associated plants were observed and recorded. The second transect run across the river width. The field survey involved describing the topography, substrate of the river bed along transects, estimation of water depth and recording of vegetation. For each study area the dominant species were used to describe that zone or area. Three study areas were made in Project (1) Intake, while the rest eight stations were established near corresponding areas for Intake, Penstock and Power House for Project One, Two and Three were to be erected (Figure 4.20).

Ecological information obtained was corroborated with government records and published data and literature in journals and reports. The IUCN red list for threatened species was used to determine species of conservation importance within the project zone of influence. The conservation status of species was determined by searching the scientific names of observed species on IUCN's online database. Emphasis was laid on species that were Critically Endangered, Endangered, Vulnerable, or Near-Threatened. In addition, national checklists were also used to document vulnerable species.

Figure 4.20: **Nyamindi River characteristics**
Nyamindi River was fast flowing with rocks and boulders characterizing its channel. Wetland associated vegetation were found on the river banks / edges and sheltered microhabitats

All habitats recognized as important and critical for biodiversity conservation within Upper Nyamindi River Systems were identified and their biodiversity concerns within them profiled. These included National Reserves and Important Bird Area (IBA). The likelihood of species ranging into the proposed project site was also reviewed. A total of 37 wetland associated taxa were recorded (**Table 4.8**). None of the recorded vegetation was water dependent, with most of them being weedy species or wayside flowers species (Ivens 1968, Sapieha 2008). Only two species (*Impatiens meruensis* and *Lipocarpha chinensis*) were listed under IUCN as of Least Concern (LC).

Table 4.8: Higher wetland plants of River Nyamindi

Site area		1in1	Iin2	Iin3	Ipe4	1po	2in	2pe	2po	3in	3pe	3po	
Latitude		0.39963	0.40092	0.40138	0.40728	0.4241	0.42411	0.4694	0.4767	0.4889	0.50076	0.51363	
Longitude		37.38697	37.38815	37.38891	37.3979	37.39537	37.39542	37.397	37.39835	37.39727	37.38912	37.39155	
Taxa	Common name												IUCN
Achyranthes aspera	Devil's Horsewhip											+	
Acmella spp.	Toothache Plant						+						
Alchemila spp.	Lady's Mantle						+						
Caesalpinia decapetala	Mysore Thorn					+							
Centella asiatica	Centella	+						+					
Colocasia esculenta	Arrowroots							+					
Commelina spp.	Wondering Jew				+	+						+	
Conza bonariensis	Hairy Horseweed				+			+					
Cyperus alternifolius	umbrella papyrus, sedge or palm											+	
Cyperus spp.	Sedges	+	+		+			+			+	+	
Desmondium repandum	Desmodium				+	+			+				
Echinochloa stagnina	Hippo Grass						+		+	+		+	
Ensete edule	Ethiopian Banana	+	+	+	+	+	+	+					
Ficus sur	Cape fig					+							
Hypericum roeperanum					+	+	+						
Impatiens meruensis		+					+						LC
Impatiens spp					+								
Kyllinga spp	Spikesedges							+					
Lipocarpha chinensis								+					LC
Ludwigia spp					+							+	
Melanthera scandens							+						
Momordica foetida	Wild Cucumber				+								

Site area		1in1	Iin2	Iin3	Ipe4	1po	2in	2pe	2po	3in	3pe	3po
Murdannia simplex							+					
	African Basil											
Ocimum gratissimum						+						
Pennisetum clandestinum	Kikuyu Grass						+					
Pentas spp												+
Phyllanthus spp					+	+			+			+
Plantago palmata		+		+	+		+			+		
Polygonum spp		+						+	+	+		
Pteris spp			+			+	+	+	+		+	
Rauvolfia caffra						+						
Sanicula elata					+							
Solanum nigrum	Black Nightshade				+							
Sporobolus pyramidalis	Giant Rat's Tail Grass		+		+							+
Trifolium spp	Clover							+				
Triumfetta tomentosa							+					
Zingiberaceae	Wild Ginger								+	+	+	+
Number of species		**6**	**4**	**2**	**14**	**10**	**12**	**10**	**6**	**4**	**3**	**10**

4.4.2 Characterization of Habitats in River Nyamindi

River Nyamindi has very unique channels and landforms that owed their origin to unique geological set-up and aggressive nature of erosion processes driven by continuous availability of water from Mount Kenya. Differential erosion of rocks occasioned by presence of volcanic intrusive rocks with different hardness has given rise to formation of water runs over erosion resistant rocks and deep water cut channels that retain pools of water after encountering another erosion resistant rock **(Figure 4.21 and 4.22).**

Figure 4.21: **Water falls and water pools in River Nyamindi**
Section of River Nyamindi showing river runs, then water falls leading to formation of water pools

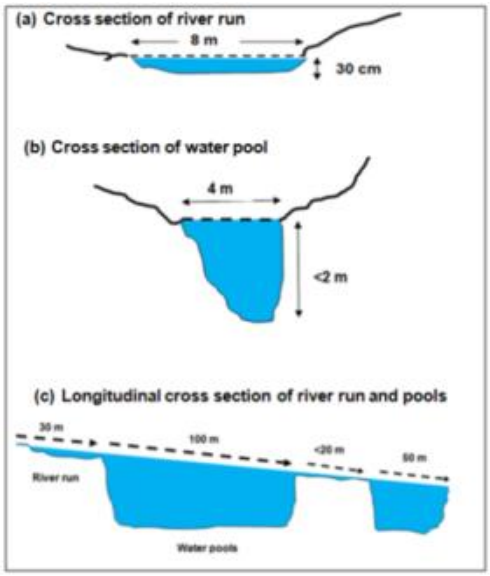


Figure 4.22: **Illustrations of cross section of river run and water pools at River Nyamindi**

4.4.3 Lower plants of River Nyamindi

The rocks and boulders in the presence of water provided habitats to number of lower plants, mostly the non-vascular plant including bryophytes (mosses, liverworts and hornworts). Their occurrence on rocks and boulders were determined by water levels in the river. For instance, the mosses and hornworts were well represented on rocks in forested areas and their populations decreased downstream. Higher population of mosses and liverworts on rocks in the forest areas were attributed to mainly two factors (i) presences of propagules from mosses and hornworts growing on forest tree trunks and (ii) suitable wet habitats provided by shading trees (**Figure 4.23**).

Liverworts were well represented and tended to prefer moderate to soft rocks substrates

Figure 4.23: **Habitats of mosses, liverworts and lichens.**
Clockwise top left: is mosses and hornworts growing on boulders and branches, top right: green patches on the rock are mosses and hornworts and white patches are lichens, bottom right show lichens

Indeed on the rocky banks of the river mosses and hornworts populations were higher near the water level mark and decreased as one moved towards the dry land. It is widely reported that mosses and hornworts are understory components on the ground or as epiphytes in forests worldwide, but flourish most luxuriantly in moist warm tropical habitats. Many of the liverworts and some species of mosses are pioneers species on new ground while still other mosses colonize bare rock surfaces where their presence accelerates the erosion of rock to soil (Smith 1982). Mosses and liverworts decreased downstream in response to decreasing riparian vegetation. As observed some mosses and hornworts tolerate extended periods of dryness and resume growth upon the return of moisture. Other opportunistic and pioneer organisms found growing with byrophytes were lichens and blue green algae shallowly submerged in flowing water **(**Figure 4.24**)**. They are water dependent, but seemed to have adapted to fluctuating river water levels by migrating by following moisture or physiologically becoming dormant.

Figure 4.24: **Habitats preferred by liverworts in R. Nyamindi.**
From top left: classical example of liverwort species, top and bottom right: liverworts growing on submerged rocks in shallow flowing water, drying liverworts due to decreasing water levels

4.4.4 Aquatic macro-invertebrates

This invertebrate survey in the upper R. Nyamindi intends to provide baseline data that will be used to guide the management of R. Nyamindi during the construction and operation of the three small hydropower projects. The utility of using aquatic macro invertebrates is widely documented in monitoring changes in ecological health and conditions of aquatic ecosystems. Ecological data on aquatic macro invertebrates will inform how they are likely to respond and adapt to reduced water levels and associated development activities in R. Nyamindi.

Aquatic macro-invertebrate's ecological data can be used to predict the successional stages in wetlands after disturbance. Ruhi et al (2012) proposed three successional stages of disturbed or newly created wetlands, each with typifying species: (i) taxa with short life cycles and active dispersal mechanisms dominate wetland at the early stages e.g., true flies, red worms and water boatman; (ii) at intermediate stages are filter feeders e.g., worms, crustacean, may flies, dragon flies and damselflies. etc.; and (iii) species with longer life-cycles are common in wetlands at advanced stages of development, the stage at which species community in disturbed or man-made wetlands resemble those of natural wetlands e.g., true bugs and beetles.

This survey was primarily interested in documenting aquatic macro invertebrates from different microhabitats with an objective of predicting how they would react to reduced water levels in the river channel. This was done by considering different microhabitats; with a hypothesis that different microhabitats support different species. In case of reduced water levels, species are likely to migrate to new locations and microhabitats as is expected when water levels fluctuate during different seasons.

A total of 36 microhabitats from 11 study areas were studied **(**Figure 4.27**).** For each study area, four microhabitats were considered in case they were present. Common microhabitats in the river channel were water pools, boulders, river run, and dead wood**.** Boulders were found in the river edges with very low water levels, water pools were shallow, sheltered habitats on the edges of river and had debris and decomposing organic matter; river run were in the middle sections of river with ample flowing water while wood were found anywhere in the river channel. Five study areas were established in Project 1, and three study areas each in Projects (11) and Project (111). Aquatic macro invertebrates were sampled using appropriate technique depending on microhabitats (Malcolm and Drake 2013). A pond net was used to sample macro invertebrates in water run areas and pools whereas those dwelling on boulders, stones and woods were either manually removed or scratched from surfaces with hand brush. Aquatic macro invertebrates collected were preserved in 70 % alcohol and later transported to National Museums of Kenya for sorting, counting, preservation, identification and storage.

A total of 54 taxa of macro-invertebrates belonging to 36 families were collected in the 11 study sites (4.30, full list provided as Appendix 13.5). Abundant orders were Ephemeroptera or may or shade flies, Diptera or true flies, Odonata or dragon flies, Coleoptera or beetles, Trichoptera or caddies flies, Plecoptera or stone flies, Turbellaria, and Decapoda or crustaceans e.g., crabs. Similarly Orders with high numbers of individuals also had somehow higher number of families. All microhabitats considered supported number of species with aquatic macro-invertebrates occurring across all microhabitats.

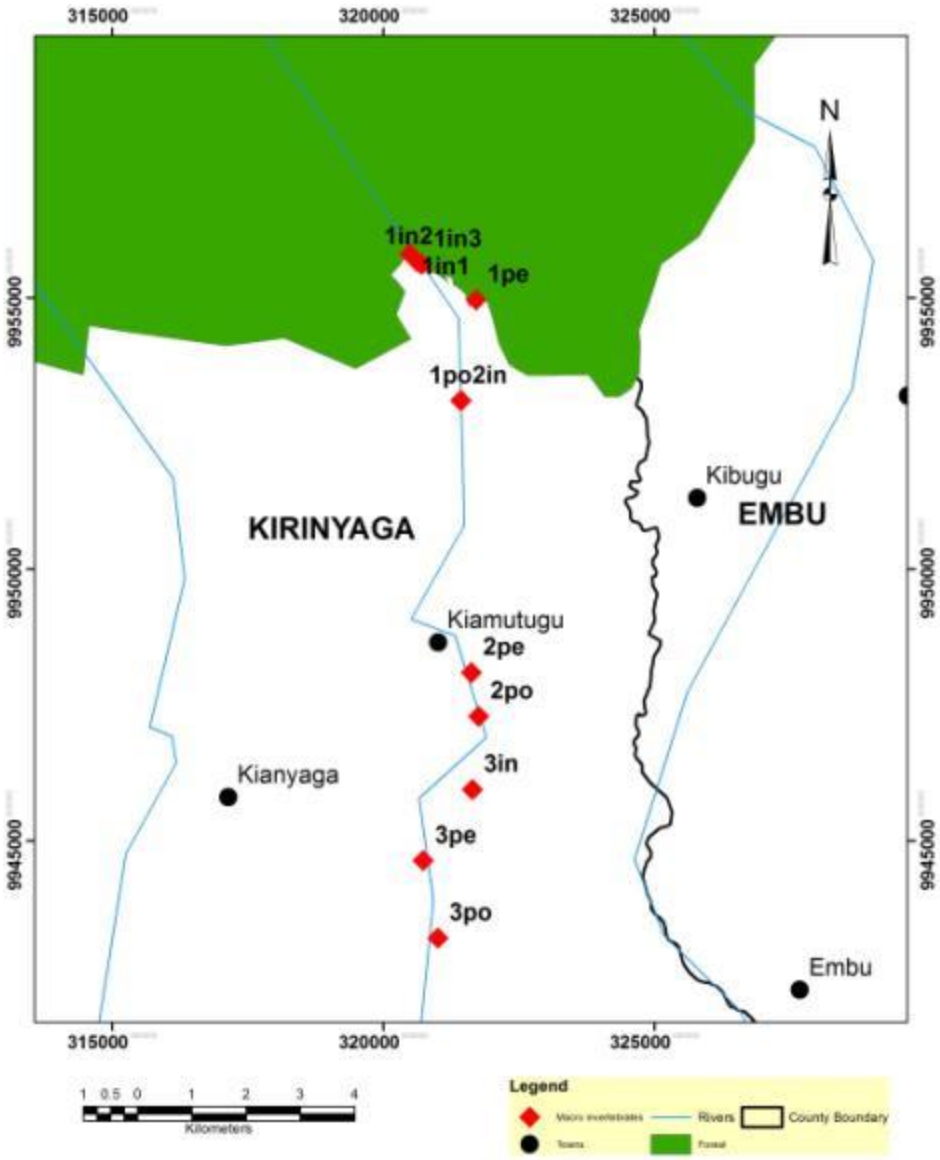
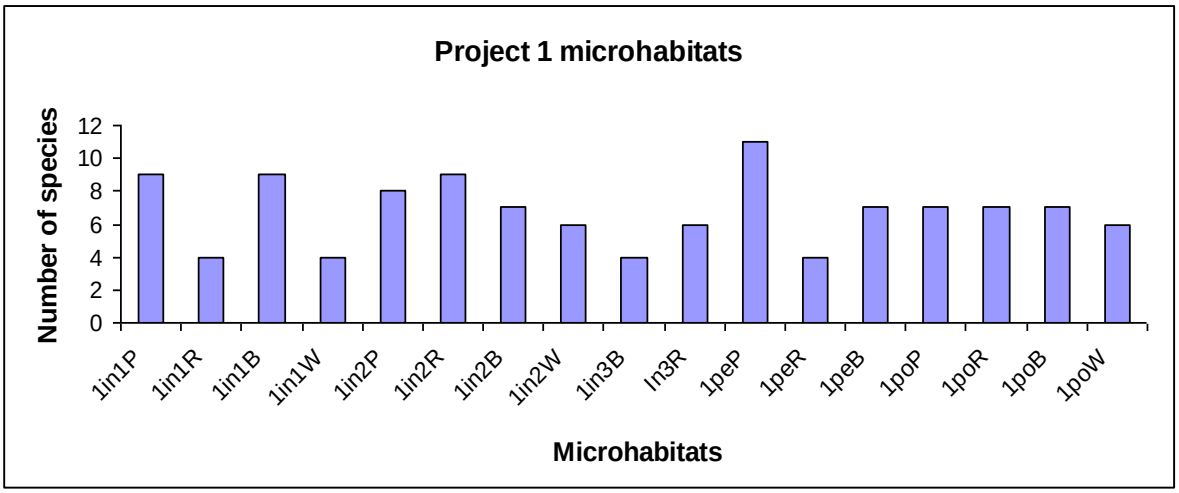


Figure 4.25: Sampling areas for aquatic macro invertebrates

Figure 4.26: **Microhabitats where aquatic macro-invertebrates were sampled in R. Nyamindi**
Top left: boulders /stones on the river edges with minimal water, top rift: sampling of macro-invertebrates using pond net using, bottom right: on the right of the image is ty



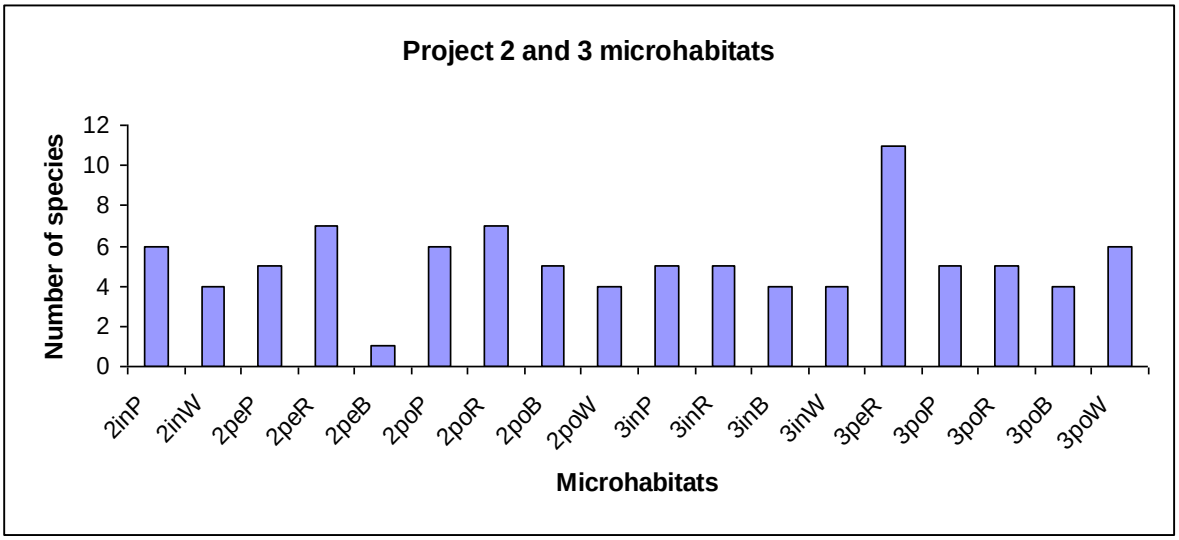


Figure 4.27: **Number of aquatic macro-invertebrates obtained per microhabitats.**
For microhabitats sites the first number represent Project (1 or 2 or 3), following two letter is project section that is intake for (in), penstock (pe) and power house (PH). Last letter signifies microhabitat: P (pool of water), R (river run), B (boulders or stones), W (wood debris)

This survey recorded an impressive 54 taxa in the upper section of R. Nyamindi. This was attributed to adoption of an extensive and all-inclusive sampling strategy where all microhabitats that are known to support aquatic macro-invertebrates were considered. Consideration of diverse microhabitats also improved the sampling effort and as is demonstrated by the high number of species obtained. Finally, most of the taxa encountered were good indicators of pristine ecological conditions. For instance environment sensitive orders found were e.g., Ephemeroptera, Plecoptera and Trichoptera, EPT, as well as Odonata **(Figure 4.28)**

Ephemeroptera: mayflies or shadflies are found in waters of good quality.

Trichoptera: caddisflies or sedge-flies or rail-flies are found in waters of good quality.

Odonata: dragon flies and damselflies are generally found in waters of fairly good quality.

Diptera: are true flies and are commonly found in impaired or organically polluted waters.

Coleoptera: Beetles and are found in waters of fair to good quality.

Turbellaria: Planariidae are found in waters of good quality

Figure 4.28: Common aquatic macro-invertebrates found in Upper Sections of River Nyamindi

4.4.5 Fish

River Nyamindi has fish species with affinity of the Greater River Tana Catchment, which include freshwater Eel Fish-*Anguilla spp,* a migratory fish; Rainbow trout *Oncorhynchus mykiss* and Brown Trout *Salmo trutta* expected in the upper sections whereas Mountain Catfish *Amphilius uranoscopus* and Straightfin Barb *Barbus paludinosus* occurred the middle and lower section of the river.

Fish samples were obtained in same study areas where aquatic macroinvertebrates were collected **(Figure 4.25).** Different methods were applied to sample fish depending on suitability of the river habitats. Hooks and line, monofilament gillnets, dip nets and direct observations were all employed. In the pools, monofilament gillnets of different mesh sizes were placed and left for a minimum of 2 hours. They were observed at intervals of 30 minutes to avoid damage of fish in case the net catches more than required. The fish were removed from the net and kept in a bucket

with water for some time. Hooks and line were baited with worms and dry bait, placed in the river at different intervals, and observed regularly for the catch. Dip nets were used in river banks, areas with vegetation and rocky habitats. Where fish of the same species were caught, some were removed from the nets and returned into the river.

The fish were labeled, then immersed into a container with 10% formalin for fixation and taken to Ichthyology section of National Museums of Kenya in Nairobi for species verification, then preserved in 70% ethanol as reference collections (Coad, B.W, 1995). More information was obtained by interviewing local community within the study sites, who provided information on trout fishing, angling and sports fishing within the Nyamindi River. Other form of information obtained included species distribution, the fish size (total length) and the species diversity in respect to river habitats, water temperatures and the flow rate.

Rainbow trout was recorded in the higher altitudes in the Project (1) and Project (2) **(Table 4.7) and Figure 4.29.** Project (1) will be located with Mt Kenya Forest and immediate neighboring agricultural landscapes. Both adult and fingerling of Rainbow Trout were recorded, indicating study areas found in Project (1) and partly Project (2) provided good feeding and breeding grounds for the species. Rainbow trout was recorded in lower densities in the farmland compared to the forested lands, and this was attributed to degraded river banks along the farmed areas. Meanwhile a reduction in altitude could also be a cause of low populations of Rainbow Trout in the study areas within Project (2). The Mountain Catfish and the Straight-fin Barb were recorded in Project (3), which was situated in the lower sections of R. Nyamindi within agricultural landscapes. Mountain Catfish and the Straight-fin Barb are listed by IUCN red data list as of Least Concern (LC) while Rainbow Trout are not listed.

Table 4.7: Fish species recorded along River Nyamindi within the proposed project area

Site	Common name	Scientific name	IUCN status	Human use
Project 1	Rainbow trout	*Oncorhynchus mykiss*	NE	Food; Angling/Sports fishing. Potential pest
Project 2	Rainbow trout	*Oncorhynchus mykiss*	NE	Food Angling/Sports fishing Potential pest
Project 3	Straight-fin Barb Mountain catfish	*Barbus paludinosus* *Amphilius uranoscopus*	LC LC	Food; Potential food Aquarium potential

LC=Least concern; NE=Not evaluated

Figure 4.29: **Fish species of upper sections of R. Nyamindi.**
Top: Mountain Catfish (Amphilius uranoscopus), Middle: Straight Fin Barb (Barbus paludinosus) and Bottom: Rainbow Trout-(Oncorhynchus mykiss)

4.5 Terrestrial Ecology and Habitats

4.5.1 Vegetation and Plants

The vegetation types of Mt. Kenya are a function of temperature, amount of rainfall, topography, geology and human-induced disturbances. The study area is characterized by humid climate and has tropical montane mixed forest with the dominant tree species changing with elevation. The land surrounding Mt. Kenya is densely populated with intensive farming activities that over the past have extended into the forested areas depending on suitability for cultivation. The low and mid-elevation forests are protected as forest reserves and are managed by the Kenya Forest Service (KFS), whereas the alpine zone is a national park managed by the Kenya Wildlife Service (KWS). One of the popular forest management approaches is subsistence use of forest resources by the local communities, which includes collection of firewood and plant parts for medicinal purposes, livestock grazing, and harvesting of honey.

A combination of desktop research and field data collection was used to obtain vegetation and plant data for the project site. The desktop survey particularly utilized data from the 'Recorded Plants of Kenya: A Reference Manual Giving Plant Names and their Locations in Kenya', (Waliaula, 1991) and the 'Plant Specimen Database of the East African Herbarium', a Botanical Research and Herbarium Management (BRAHMS) software support, which gives detailed account of plant species diversity and distribution.

The plotless method (Hall and Swaine, 1981), modified by Mwachala, et al. (2004) was used to record the plant species from 9th to 14th February 2017, 2017. All plant species encountered were identified using botanical keys found in botanical literature; i.e. Kenya Trees Shrubs and Lianas and the Upland Kenya Wild Flowers. Vascular plant species were recorded and specimens collected using standard methods (Foreman and Bridson, 1992). All identified plants species were documented and those that could not be identified in the field were collected and identified later at the East African herbarium (EA) Nairobi. Identification of indigenous vascular plants followed Agnew (2013), Beentje (1994) and the various publications of 'Flora of Tropical East Africa (FTEA)', (Polhill, 1952-2012) which together with the 'List of East African Plants (LEAP)', (Mwachala et al. 2011) were useful in taxonomic authentication and species distribution.

Three different habitat types were identified; these comprised lower montane forest, riparian vegetation and farmlands **(Figure 4.30).** Plant species of conservation interest under the International Union of Conservation for Nature (IUCN) were identified. A rich diversity of about 180 species of vascular plants was recorded in the study area, and comprised species with different lifeforms i.e. trees, shrubs, lianas and herbs from different families of flowering plants (**Appendix 13.4 is a Checklist of plant species)**.

Sections of Project (1) are situated in the conservation area of Mt Kenya Forest, with natural vegetation of lower montane forest type that has now been modified by anthropogenic disturbances such as logging, grazing and cultivation.

Figure 4.30: **Types vegetation found along R. Nyamindi.**
The top panel show typical vegetation with Mount Kenya Forest while the middle and lower panels show vegetation types agricultural landscapes

Dominant tree layers of this area comprised of *Syzygium guinensis*, *Macaranga kilimanscharica, Albizia gummifera, Tabernaemontana stapfiana*, *Casaeria battiscombei* and *Anthocleista grandiflora* while the shrub layer was dominated by *Agelaea pentagyna*, *Clerodendrum johnstonii*, *Piper capense*, *Senna didymobotrya*, *Vernonia auriculifera* and the herb layer was dominated by *Leucas* spp., *Conyza bonariensis*, *Saniculaalata*, *Impatiens* spp., *Phaulopsi simbricata*, *Pteridium aquiliniu* and *Polygonum spp*.

Vegetation within the project areas in the anthropogenic landscape was divided into two: farmlands and riverine riparian that were left with remnants of original vegetation because they too steep and unsuitable for agricultural activities. Common crops in the farmlands were tea, coffee, macadamia, fruit trees, and timber trees while the thin strip of riparian vegetation was represented by *Ficus sur*, *F. sycomorus*, *Bridelia micrantha*, *Dracaena steudneri*, *Cordia africana*, *Aframomum zambesiacum*, *Clausena anisata*, *Milletia dura*, *Trema orientalis*, *Aspilia mossambicensis*, *Tithonia diversifolia* and *Desmodium spp.* In the farmlands, crop plants comprised of coffee, tea, macadamia, bananas and tomatoes, while cultivated trees included *Grevillea robusta*, *Cordia africana* and *Eucalyptus spp*.

Invasive plant species were common and widespread in the entire study area; among the species recorded were: *Lantana camara*, *Caesalpinia decapetala*, *Psidium guajava*, *Solanum mauritianum, Targetes minuta, Conyza bonariensis, Pteridium aquilinum.*

Species recorded in the study area that are of conservation interest and found in the IUCN red list of threatened speciesinclude; *Prunus africana* (Red Stinkwood) which is listed as vulnerable, *Sysygium cordatum* and *Impatiens meruensis* are listed as of least concern. *Prunus africana* occurred in plenty in the forest area with both mature trees and samplings observed in the forest. The tree was also widely planted in farmlands as agroforestry species.

4.5.2 Avifauna

The avifauna survey included three main methods of data collection.

Prior to the commencement of the field survey, an initial desktop review of information held at the Ornithology Section, National Museums of Kenya (NMK) was conducted. This was aimed at developing a profile of bird populations on the site and their likely sensitivities. During the review information on probable bird species that occur on site, their habitats (thus bird communities) and any designated sites (e.g. Important Bird Areas, Protected Areas) was collated from the Kenya Bird Atlas (Lewis and Pomeroy 1989), NMK ornithological collection and various other databases including grey literature.

Two types of survey methods were used to build an inventory of the bird species and their relative abundance at the proposed site for Nyamindi small hydro power project. The two methods helped build a species list for the site, record numbers, status (conservation, breeding and migratory status) and distribution of birds.

These were:

a) Fixed width point counts (PCs): These are for estimating bird numbers and densities. PCs were set every 200m along 2km transect running NS across the site. Three (03) transects were set at the project site and planned buffer zone (**see Figure 4.31 below**). The variables recorded for each such fixed point count included time, species, number (number of adults/juveniles/chicks), activity (flushed, flying-display, flying-commute, perched-calling), cue i.e., seen or heard, distance to bird (m), height above ground, fixed radius of count (m), additional notes.
b) Timed species counts (TSCs): TSCs method is ideal for building complete species lists quickly, and to establish the relative abundance of canopy and mid-level bird species. As many as possible 40-minute TSCs will conducted across the facility site and adjacent areas to cover all the different microhabitats on site. TSCs are essentially repeated lists on which are indicated the first time each species is first positively identified by sight and sound. For analysis species receive a cumulative score according to when they were first sighted on each count.

Two field personnel were used (a spotter and recorder) for the field survey work. The following specialized equipment was used for gathering data accurately, quickly and efficiently.

- Binoculars, Bushnell 10x42
- Spotting scope KOWA TSN-2 60x
- Field Guides: Birds of Kenya and Northern Tanzania (Zimmerman et al, 1999), Birds of East Africa (Stevenson and Fanshawe, 2002).
- A hand-held Global Positioning System (Garmin e-trex 30)
- A digital camera (Nikon Coolpix L830)

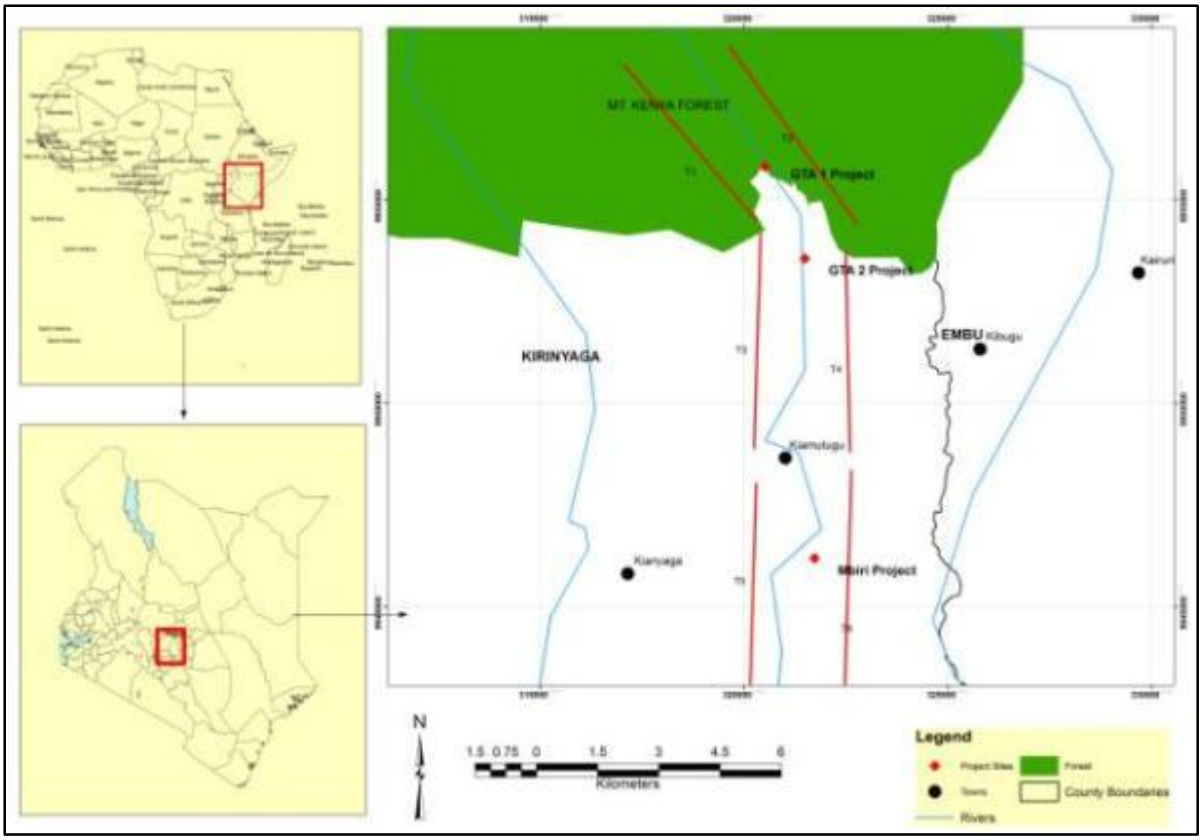


Figure 4.31: **Line transects on which Point Counts were conducted during the survey**

4.5.2.1 Description of avifauna composition

The proposed site for development of the Nyamindi hydro power lies within two ecologically distinct habitat types. The upper part of the project (part of the channel of project one) lies within Mt. Kenya Forest. The forest is one of the most important water catchment areas in Kenya, supplying the Tana and Northern Ewaso Ng'iro systems. The project site lies within the southern slopes, which receive rainfall up to 2,500 mm per year and hold luxuriant rain forest up to 2,400 m. The forest has valuable indigenous trees such as Camphorwood *Ocotea usambarensis*.

Mt Kenya is a stronghold for the threatened and little-known Abbott's Starling *Poeoptera femoralis*, even though there are few recent records. It has a rich montane bird fauna, with 53 out of Kenya's 67 African Highlands biome species, at least 35 forest-specialist species (Bennun et al), and six of the eight species that make up the Kenyan Mountains Endemic Bird Area. The African Green Ibis *Mesembrinibis cayennensis* feeds in marshy forest glades and the rare and little-known race graueri of the African Long-eared Owl *Asio abyssinicus* has been recorded from the high forest. The Scarlet-tufted Malachite Sunbird *Nectarinia johnstoni* is particularly common on

the high moorland. Table 1 shows a list of birds of conservation importance in Mount Kenya Forest IBA. A list of all bird species recorded in the field survey is shown in **Appendix 13.6**.

Small areas of natural riparian zones include plants such as *Triumfetta tomentosa*, *Croton macrostachyus* and *Cyperus rotundus*. The riverine bush has occasional areas of indigenous trees, including *Prunus africana, Ficus natalensis* and *Millettia dura*. On the edges of cultivations, thickets of the exotic *Lantana camara* occur. *Lantana camara* also occur on fallow farmland and unweeded coffee plantations, and some inaccessible parts of the valleys.

The project traverses Kianyaga valleys, another Important Bird Area and the centre of abundance for the threatened, restricted-range Hinde's Babbler *Turdoides hindei*, a species endemic to central part of Kenya spotted twice during the survey **(Figure 4.32).** The babblers live in groups in the river valleys and swamps, and depend on small thickets of the exotic *Lantana camara* for shelter and nest sites. The diversity of other birds is low; a six-month study carried out in 1993 recorded only 94 species, all characteristic of disturbed habitats in the central highlands.

Figure 4.32: **Hinde's Babbler**
A threatened endemic only found in Central Kenya, with the project area traversing its stronghold

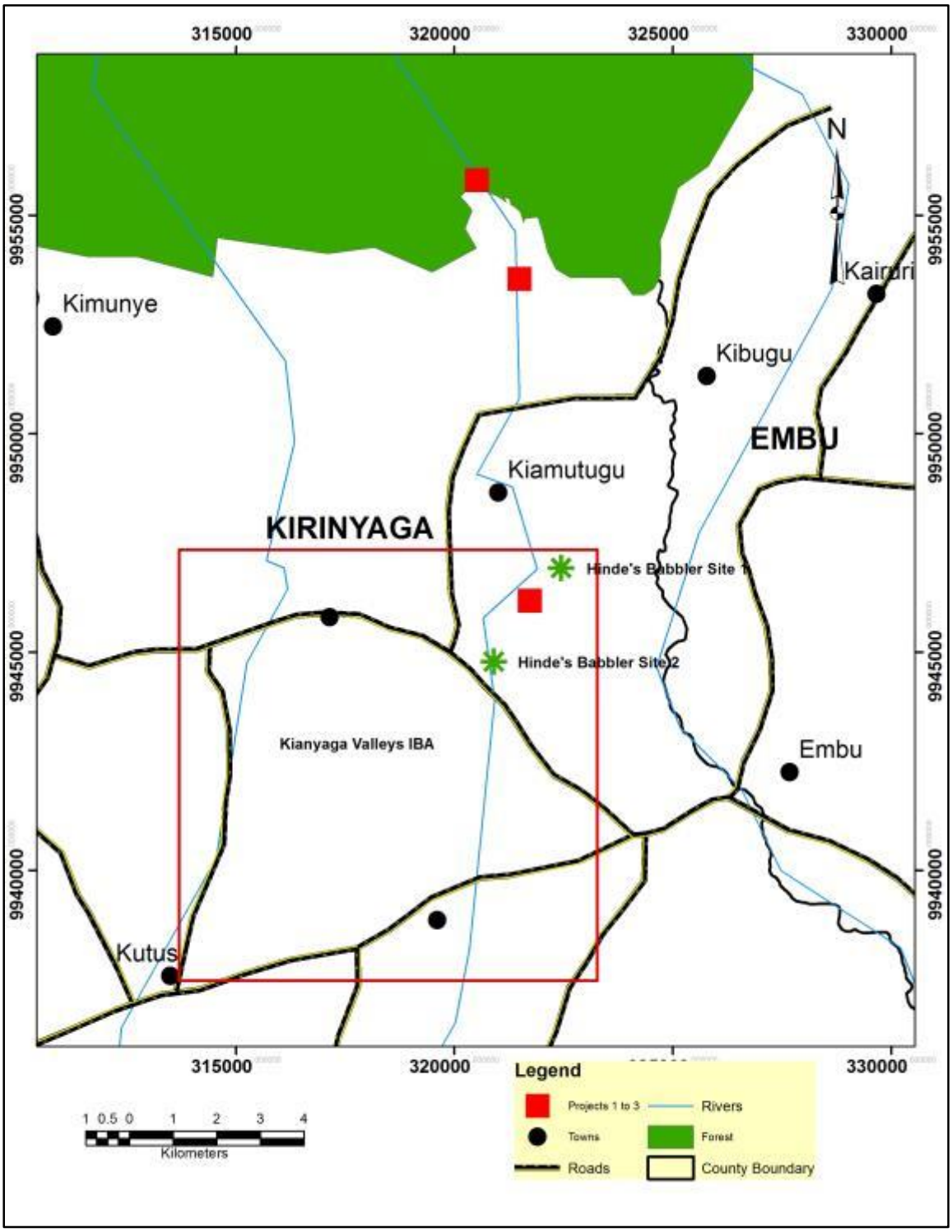


Figure 4.33: **Location of Kianyaga Valleys**
An IBA that is traversed by the project, and sighting of Hinde's Babbler during the survey

Figure 4.34: **some of the birds recorded at the project site**
African Black duck, African Dusky Flycatcher, Silvery-cheeked hornbill

Table 4.9: Birds Species of Conservation Importance in the area surrounding the project site

Species	Habitat	Threat Status	IUCN Designation	Notes	Recorded during the Survey
Hinde's Babbler	Valleys with adequate thicket cover	Globally threatened/ restricted range	Endangered	Babbler groups occupy many of the valleys and swamps, with an estimated total population size of 500+ (Bennun and Njoroge, 1999)	Yes
Abbott's Starling	Forest	Globally threatened/ restricted range	Vulnerable	Sporadic records; probably nomadic in search of fruiting trees (Bennun 1994b)	No
Jackson's Francolin	Forest	Restricted-range species	Least Concern	Common in montane forest and scrub	No
Hunter's Cisticola	Forest	Restricted-range species	Least Concern	Common in forest-edge habitats and scrub	Yes
Kenrick's Starling	Forest	Restricted-range species	Least Concern	Apart from the nearby Nyambeni Hills, Mt Kenya is the only Kenyan site for this species	No
African Green Ibis	Forest	Regionally threatened species (Vulnerable)	Least Concern	Scarce resident, foraging in forest glades and along streams	No
Ayres's Hawk Eagle	Forest	Regionally threatened species (Vulnerable)	Least Concern	Scarce resident	No
African Crowned Eagle	Forest	Regionally threatened species (Vulnerable)	Least Concern	An important site for this low-density species	Yes
African Grass Owl	Forest	Regionally threatened species (Vulnerable)	Least Concern	No recent records	No
Purple-throated Cuckoo-shrike	Forest	Regionally threatened species (Vulnerable)	Least Concern	Uncommon in montane forest	No

4.5.2.2 Avifauna abundance and diversity

A total of 100 bird species in 43 families were recorded during the survey. Based on our analyses, the commonest bird species was yellow-whiskered Greenbul. The ten most encountered birds are shown in **Figure 4.35.**

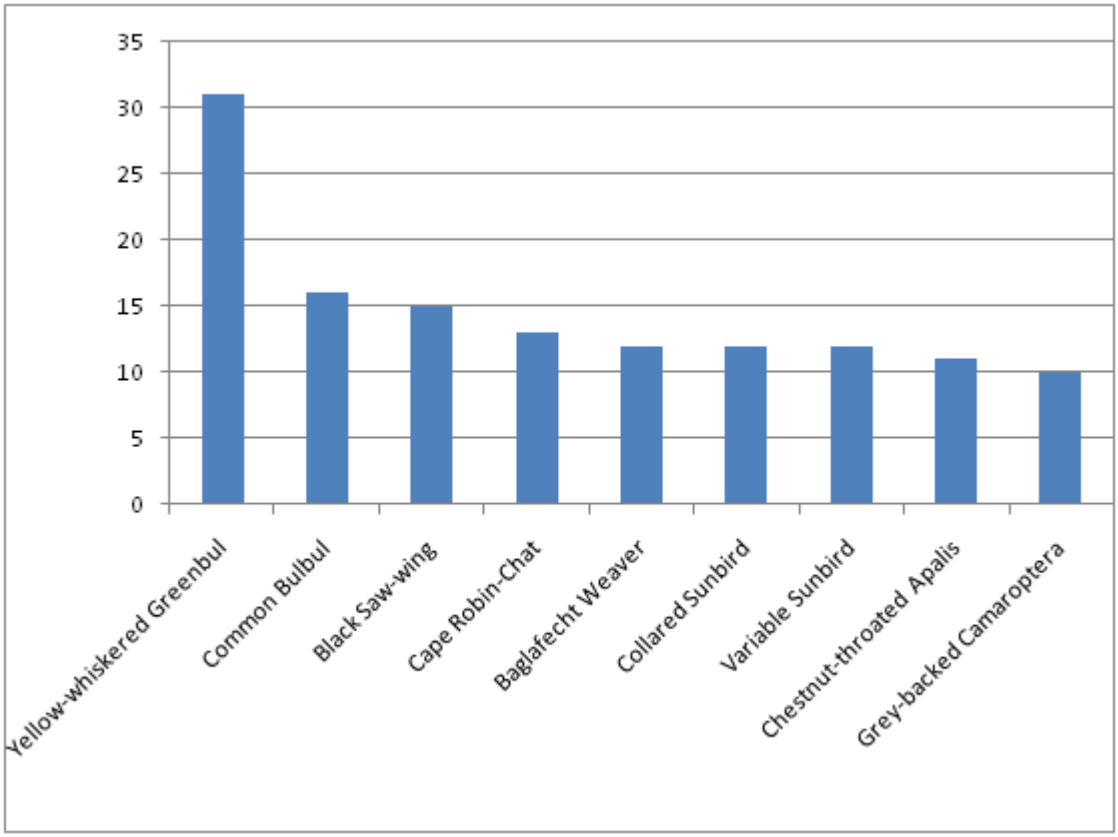


Figure 4.35: Common bird species found in NCD project area

4.5.3 Herpetofauna

Two groups of animals easily affected by habitat modification are reptiles and amphibians. This is because of their preference for particular habitats, delicate reproductive and their body temperatures are environmental dependent (ectotherms) plus thermoregulation biology being restrictive. Major threats to these organisms are habitat modification, which also significantly causes changes in the distribution and density[3]. Naturally, some are good indicators of environmental change (bio indicators) and ecological health. For instance, amphibians are susceptible to changes in the local environment because of their low agility (movement) and

[3]Branch & Harrison 2004; Collins & Storfer, 2003; Mazerolle, 2003; Murray & Hose 2005)

strong philopatry. Their skins are thin and highly permeable to chemical and easily affected by physical changes in both terrestrial and aquatic habitats[4]

The herpetofauna ecological field study encompassed: identification of habitats and microhabitats, identification of species of conservation importance as indicated by IUCN, and identification of adjacent sites and microhabitats of Conservation Importance. A combination of field visits and review of published literature including reports, scientific papers, maps and databases from National Museums of Kenya were used. This survey primarily concentrated on areas where major project installations and infrastructures will be erected: intake, penstock and the powerhouse.

Since not much herpetofauna studies have been carried out especially along River Nyamindi, this study should be viewed as the first one to provide baseline data on reptiles and amphibians of R. Nyamindi. In addition, the project area is in the high altitude montane ecological zone, and all the herpetofauna data used was based on the available information from the counties of Embu and Kirinyaga restricting to the lower altitude data. The on-site study of the area was for a limited number of days (precisely six working days) and night sampling did not always happen due to security reasons. The onsite study was in the dry season and no data for the wet season is available. In this report, we assume that there will be a steady flow of water left in the river after diversion for power generation.

Amphibian and reptile sampling of species and habitats were accomplished by use of the following standardized methods:

a) Timed limited searches (TLS)- A 30-minute sampling period making up one time limited search (TLS) by one observer were carried out in different parts of the study site. Searches were done in all possible and amphibian micro-habitats such as, wetlands, tree barks, under stones, decomposing logs, tree stumps, holes, shrubs, bushes including digging within loose soils, etc. (Karns1986, Sutherlands 1986, Heyer et al. 1994; Dodd,

[4]Pineda & Halffter, 2004; Bell & Donnelly, 2006).

Figure 4.36: Examples of different microhabitats where reptiles and amphibians were found

(Description of Figure 4.36 - left to right: pools with water holding amphibians, tea zone belt between farmland and forest, a stream feeding the main river, an amphibian breeding zone inside the Mt. Kenya forest, a bushy area where chameleons were found and an arrow root garden with grasses where grass frogs, reed frogs and reed frogs were recorded next to the river)

All the different species and number of reptiles and amphibians found recorded. All the time-limited searches were during the day. Visual encounter surveys (VES)- This un-standardized method was used only for qualitative and semi-quantitative data mainly for presence or absence of species (Rödel and Ernst, 2004). Due to its flexibility and being opportunistic, it contributes a lot in generation of species inventories. This was the main method applied in this study due to the large areas to be covered.

Voucher specimens were fixed in 10% formalin after euthanasia. All the materials collected were deposited at National Museums of Kenya (NMK), Nairobi herpetological collection. Global Positioning System (GPS) data for each point where specimens and important habitats was recorded using a Garmin receiver.

In addition to the above methods, interviews were conducted to supplement herpetofauna information. Locals were asked question pertaining the reptiles and amphibians that they found in the area. Initially the locals were asked to describe the species, and later shown the animals pictures in the available guides (i.e. Spawls et al. 2002 and Channing and Howell, 2006).

The IUCN red list for threatened species was used to determine species of conservation importance within the project site. The conservation status of species was determined by searching the scientific names of observed species on IUCN's online database. Emphasis was laid on species that were Critically Endangered, Endangered, Vulnerable, or Near-Threatened. In addition, national checklists were also used to document vulnerable species.

Using data from previous studies, databases and collections in the area, a total of 30 species are known to occur in the project area. In the field survey, only nine species were confirmed, from the nine, four were amphibians (frogs) and the rest were reptiles (7 lizards and 1 snake) **(Table 4.10).** All the species known from the region and those confirmed in the study only two species *Hyperolius cystocandicans* (Silver bladder reed frog) and *Kinyongia excubitor* (Mt. Kenya hornless chameleon) are of IUCN concern as they are categorised as Near Threatened and vulnerable respectively. The other species were categorised as of least concern or not assessed.

Figure 4.37: Species of IUCN concern left to right: Kinyongia excubitor and Hyperolius cystocandicans

The species known from the area are mostly generalists except a few who are of IUCN importance. These species are able to migrate to other habitats except the few mentioned who have special habitat requirements. These species were distributed all over the different habitats that were sampled **(Figure 4.37 & Figure 4.38)**

Many of the herpetofaunal community species recorded are dependent on particular microhabitats for survival. Majority of the amphibians were restricted to the river or other streams which are both sites for breeding and foraging for food. Many of the reptiles would frequent wetland areas in search of their prey (small mammals, other reptiles and amphibians) that as well converge to these ecologically rich micro-habitats for plants resources. This makes them more vulnerable when their habitats are affected by the project. The animals that will be greatly affected will be specialists of habitats as once their habitats are affected they will take a downward spiral in terms of numbers.

Table 4.10: Species found in the area during the survey and their IUCN conservation status

SCIENTIFIC NAME	COMMON NAME	IUCN STATUS
Xenopus borealis	Northern clawed frog	Least Concern
Amietia angolensis	Angolan river frog	Least Concern
Ptychadena anchietae	Anchieta's ridged frog	Least Concern
Ptychadena mascareniensis	Mascarene Grass Frog	Least Concern
Trachylepis varia	Variable skink	Least Concern
Leptosiaphis kilimense	Kilimanjaro five-toed skink	Least Concern
Adolfus kibonotensis	Mt. Kilimanjaro forest lizard	Least Concern
Trioceros jacksoni xantholophus	Yellow-crested Jackson's chameleon	Least Concern
Trioceros jacksonii	Jackson's chameleon	Least Concern
Kinyongia excubitor	Mt. Kenya hornless chameleon	Vulnerable
Philothamnus irregularis	Spotted bush snake	Least Concern

Most of area set for the project is within farmland where various farming activities are already taking place therefore the impacts will not be severe as compared to pristine and protected areas where activities need to be carried with extra care. Knowledge of hydropower effect on herportafauna in Kenya is very limited therefore; a well-structured monitoring plan of the herportafauna taking into consideration the wet and dry seasons is required. This should take place at least four times a year in the first two years of project operation to note the changing in diversity and abundance. This can be scaled down to twice annually to cover all the seasons and later biannually.

Figure 4.38: **Species known from the area and found during the study**
left to right: Trioceros Jacksonii xantholopus, Amietia angolensis, Adolfus kibonotensis, Ptychadena mascareniensis, Mochlus sundevalii and Hyperolius viridiflavus

4.6 Invertebrate fauna

Invertebrates are important indicators of environmental quality (Warui et al 2005) and continue to be used for environmental impact assessments (Rosenberg et al 1986). Hydropower projects are necessary for community resources but nevertheless have negative global negative impact on biodiversity (Rudberg et al 2015). The current study investigates the impacts of a hydropower project on invertebrate community and attempts to provide possible mitigative strategies that promote sustainable development and enhances conservation of biodiversity. The overall aims were

i. evaluate potential impacts of Hydropower project on invertebrate diversity and provide information on sensitive invertebrate species that could be affected by the study
ii. Provide feasible recommendations including future monitoring plans

The study area was a 19km stretch of land along river Nyamindi commencing in Kathandeni forest of Mount Kenya National Park. The area was divided into three study projects (designated as Project 1 (within Kathandeini forest), project (11) (reserve area immediately after the forest) and project (111) (agricultural land). Each of the projects were further subdivided into three transects designed as Intake **(In),** Penstock **(T),** Powerhouse **(W),** and riparian **(R)**. Sampling for invertebrates occurred in all the three transects. For the purpose of labeling, samples from aerial nets were designated as A, Pitfall traps as P, and Pan traps as (Pan)

4.6.1 Methods used in Sampling of Invertebrates

4.6.1.1 Aerial butterfly trapping for butterflies

Baited (fermenting bananas and pineapple) aerial butterfly traps (Hughes *et al* 1998) were used in all the study sites. At each transect two baited traps were mounted on a high point (**Figure 4.39**). The butterflies caught were removed from the net after 24 hrs. and stored in butterfly envelopes. The traps were removed from the site after two nights.

<u>Pitfall traps</u>

The researcher trapped invertebrates by pitfall traps (Sutherland 1996), (**Figure 4.40)**. Each trap consisted of two cone-shaped plastic containers 8 cm wide at the mouth and 13 cm deep, one inside the other, buried to their rim. Five pitfalls were established five meters apart for each of the study transects. Similar trapping has been used in the past to sample insects (Uetz & Unzicker 1976). One of the cups (inner) was filled with water plus some little ethanol to ensure specimens are well preserved. The researcher left the active traps for two nights before emptying. A domestic sieve and appropriate vials were used for collecting the invertebrates which were later stored under 70% ethanol as a preservative.

Figure 4.39: **Baited a butterfly trap and removal of butterflies captured in the aerial net**

Figure 4.40: **Pitfall trap in the field**

Pan traps

Pan traps are usually used to trap visually oriented invertebrates such as bees that are often attracted by color and the method is widely used (Nuttman *et al* 2011). In the current study we used blue, white and yellow pans (Fig 4.44) that were half filled with soapy water plus little ethanol, yellow and blue. The traps were left on for two nights before emptying. A domestic sieve and appropriate vials were used for collecting the invertebrates which were later stored under 70% ethanol as a preservative and sorted and identified in the lab.

Figure 4.41: Pan Trap in the field

Sweep netting

Sweep netting was done along the transect and beyond targeting the flying insects **(Figure 4.42).** It involved walking through the herb layer swinging a sweep net through the vegetation for a standard number of times (Dippenaar-Schoeman *et al*. 1999). The net was 40 cm in diameter and sweep-netting was done randomly to contribute to the checklist only. After every ten sweeps, samples were emptied on a plain sheet of cloth and all invertebrates collected with a pooter.

Figure 4.42: Sweep net

4.6.2 Species Identification

The researcher tentatively identified some butterfly species in the field through use of available field guide (Martins 2015) as well as a taxonomic expert from National Museums of Kenya. Initially the butterfly material was separated from other insects and identified to the lowest possible taxonomic level (often family and sub-family initially), using the most recent keys (Larsen 1996). Most of the specimen was stored for further analysis in the lab which included relaxing, pinning and identification. Other invertebrates were also further sorted into morph species, based mainly on a combination of morphological characters as indicated in relevant literature (Dippenaar-Schoeman & Jocqué 1997). Comparisons were made with voucher collections held at the National Museums of Kenya (NMK) and taxonomic manuals and photographs available there.

The results indicate that project 1 had higher species richness than the other two projects **(Table 4.11)** implying that the forested area has high species diversity. This gradually reduced as one moved the agricultural zones. Overall a total of 1220 invertebrates belonging to 71 different species were collected **(Table 4.12).**

Table 4.11: Overall species richness and abundance of macro invertebrates per project

Project	Total Species	Total abundance	No. Listed IUCN
P1	53	397	0
P2	44	496	0
P3	36	327	0

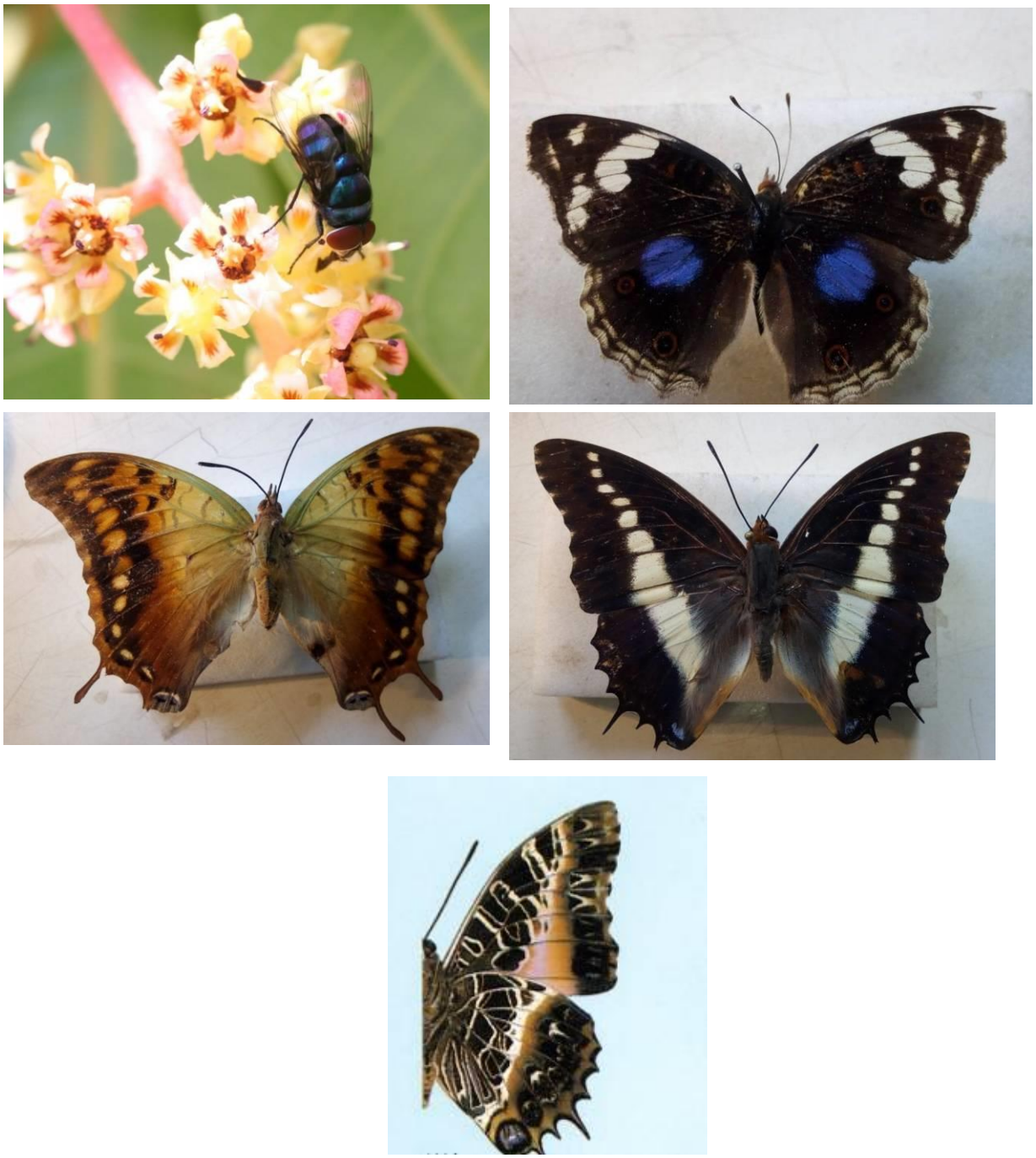


Figure 4.43: **Some invertebrate species recorded during the survey**
Top right clockwise: Chrysomya sp, Junoniaoenone, Charaxes brutus, Charaxes candiope, andCharaxes pollux

Table 4.12: **Overall species checklist per project and IUCN conservation status**
LC=Least concern while NA= Not assessed

Order	Family	Genus	Author	IUCN Status	Project 1	Project 2	Project 3
Lepidoptera	Nymphalidae	*Charaxes candiope sub sp candiope*	Godart, 1823	LC, Larsen 2011	18	7	
Lepidoptera	Nymphalidae	*Charaxes brutus*	Cramer,1779	NA	20		
Lepidoptera	Nymphalidae	*Charaxes druceanus subsp katamayu*	Plantrou, 1982	NA	23	2	5
Lepidoptera	Nymphalidae	*Vanessa dimorphica*	Howarth, 1966	NA	14	3	1
Lepidoptera	Nymphalidae	*Bicylus kenia*	Rogenhafer 1891	NA	1		3
Lepidoptera	Nymphalidae	*Charaxes fulvesnes*	Aurivillius, 1891	NA	1	2	2
Lepidoptera	Nymphalidae	*Charaxes ethalion subsp kikuyuensis*	van Someren, 1967	NA	1		
Lepidoptera	Nymphalidae	*Charaxes pollux*	Cramer,1775	NA	1	4	
Lepidoptera	Pieridae	*Eurema floricola leonis*	(Butler, 1886)	NA	3	3	8
Lepidoptera	Nymphalidae	*Melantis leda*	Linnaeus, 1758	NA	3	1	
Lepidoptera	Nymphalidae	*Neptis rogersi*	Eltringham, 1921	NA	2		2
Lepidoptera	Nymphalidae	*Junonia oenone*	(Linnaeus, 1758)	LC, Larsen 2011		2	1
Lepidoptera	Hesperiidae	*Metisella medea*	Evans, 1937	NA		2	2
Lepidoptera	Pieridae	*Belenois thysa*	(Hopffer, 1855)	NA	1	3	2
Lepidoptera	Pieridae	*Belenois zochalia*	(Boisduvai, 1836)	NA	2		
Lepidoptera	Pieridae	*Colotis antevippe*	(Boisduvai, 1836)	NA		2	3
Lepidoptera	Pieridae	*Colotis hetaera*	Gerstaecker, 1871	NA		1	2
Lepidoptera	Papilionidae	*Catopsilia florela*	(Fabricius, 1755)	NA	3	5	4
Lepidoptera	Lycaenidae	*Actizera stellata*	(Trimen, 1833)	NA			
Lepidoptera	Lycaenidae	*Leptotes pirithous*	Linnaeus, 1776	NA	2	1	4
Lepidoptera	Lycaenidae	*Zizula hylax*	Fabricius, 1755	NA	2	1	2
Lepidoptera	Lycaenidae	*Leptotes adamsoni*	Collins & Larsen 1991	NA		2	3
Lepidoptera	Lycaenidae	*Lycaena phlaeas*	Linnaeus, 1761	NA	3	4	2

Blattodea	Blattellidae	*Pseudoderopeltis sp*	Fabricius 1781	NA	13	1	13
Blattodea	Blattellidae	*Cartoblatta sp*	Shelford 1907	NA	2	3	
Blattodea	Blattellidae	*Ectobius sp*	Stephens, 1835	NA		3	5
Blattodea	Blattidae	*Perisphaeria sp*	Burmeister, 1838	NA			1
Coleoptera	Carabidae	*Agonum sp*	Bonel 1810	NA	12		
Coleoptera	Chrysomelidae	*Apthona sp*	Koch, 1803	NA	1		
Coleoptera	Nitidulidae	*Blaesodactylus sp*	Boulenger,1885	NA		25	10
Coleoptera	Nitidulidae	*Platychora sp*	Boheman, 1851	NA	1		
Coleoptera	Nitidulidae	*Axyra sp*	Erichson, 1843	NA	1		2
Coleoptera	Scarabaeidae	*Trochalus sp*	Linnaeus, 1758	NA	1	1	
Coleoptera	Staphylinidae	*Philonthus sp*	Stephens, 1829	NA	2	2	
Coleoptera	Staphylinidae	*Staphylinidae sp*		NA	1		
Coleoptera	Tenebrionidae	*Gonocephalum simplex*	Solier, 1834	NA	1	20	5
Diptera	Asilidae	*Asilidae sp*		NA	1		4
Diptera	Calliphorida	*Chrysomya sp*	Robineau Desvoidy,1830	NA	1	6	
Diptera	Culicidae	*Culex sp*	Theobald, 1907	NA	1	1	
Diptera	Muscidae	*Musca sp*	Weldemann, 1830	NA	6	9	4
Diptera	Muscidae	*Stomoxys sp*	Geofry, 1762	NA	3	2	1
Diptera	Muscidae	*Musca domestica*		NA	1	2	22
Diptera	Sarcophagidae	*Sarcophaga sp*	Parker, 1916	NA		13	
Diptera	Tephritidae	*Tephritidae sp1*		NA	1	16	2
Hemiptera	Cicadidae	*Cicadidae sp*	Linnaeus, 1758	NA	8		5
Hymenoptera	Apidae	*Apis mellifera*	Linnaeus, 1758	NA		1	
Hymenoptera	Formicidae	*Camponotus sp*	Mayr,1861	NA	2		
Hymenoptera	Formicidae	*Messor sp*	Forel, 1860	NA		1	
Hymenoptera	Formicidae	*Ocymyrmex sp*	Mayr,1866	NA	1	48	
Hymenoptera	Formicidae	*Pheidole sp*	Westwood, 1839	NA	88	26	2
Hymenoptera	Formicidae	*Tetramorium sp*	Mayr, 1855	NA	23	234	189
Hymenoptera	Halictidae	*Patellapis sp*	Walker, 1855	NA			

Hymenoptera	Halictidae	*Seladonia sp*	Robertson, 1918	NA	1		
Hymenoptera	Halictidae	*Patellapis sp*	Walker, 1855	NA	2		
Hymenoptera	Halictidae	*Lasioglossum sp*	Michener	NA	13	12	11
Hymenoptera	Iceneumonidae	*Enicospilus sp*	Stephens, 1835	NA	5	1	
Hymenoptera	Megachilidae	*Megachile sp*	Gerst	NA			1
Hymenoptera	Sphecidae	*Ammophila sp*	Kirby	NA		1	
Lepidoptera	Hesperidae	*Colotis sp*	Hubner, 1819	NA	1		
Lepidoptera	Pieridae	*Catopsilia sp*	Hubner, 1819	NA	3		
lepidoptera	Hesperidae	*Eurema sp*	(Boisduval 1833)	NA	1		
Lepidoptera	Lycaenidae	*Lycaenidae sp*		NA	1		1
Orthoptera	Acrididae	*Acrotylus sp*	Fieber, 1853	NA	1	2	1
Orthoptera	Gryllidae	*Apteroscrirtus sp*	Saussure, 1877	NA	28		
Orthoptera	Gryllidae	*Gryllulus morio*	Fabricius, 1781	NA	17		1
Orthoptera	Gryllidae	*Gryllus sp*	Linnaeus, 1758	NA	1	11	
Orthoptera	Gryllidae	*Gymnobothrus sp*	Bolivar, 1889	NA		2	
Orthoptera	Gryllidae	*Phaeophilacris sp*	Walker, 1855	NA	51	3	
Orthoptera	Gryllidae	*Scapsipedus sp*	Saussure, 1877	NA		5	1
Orthoptera	Tettigonidae	*Tettigonidae sp*		NA	1		
Total Abundance					**397**	**496**	**327**

4.7 Mammal survey

The mammal survey was conducted mostly from a desktop review because most of the project area lies on cultivated landscape, and therefore no significant mammal populations were expected.

Information held at the mammalogy section of National Museums of Kenya (NMK) was conducted prior to fieldwork by performing a thorough desktop review. This helped build a profile for mammal populations at the project site. In addition, the Global Biodiversity Information Facility (GBIF), an online database, was collated. We also collated information from field reports, expedition reports, specimen collection and grey literature.

In addition, opportunistic observations from other taxon groups, specifically birds, were used to record the mammal species encountered, including calls, scats, prints and any other signs indicative of the presence of mammals on the site.

Mount Kenya forest holds several red data Red Data Book mammal species, including Leopard *Panthera pardus*, Bongo *Tragelaphus euryceros*, Giant Forest Hog *Hylochoerus meinertzhageni*,, Black Rhino *Diceros bicornis* and African Elephant *Loxodonta africana*. The uncommon central Kenya race of Black-fronted Duiker *Cephalophus nigrifrons hooki* also occurs here. The forest also holds several endemic species of mammals, such as Mt Kenya Mole-shrew *Surdisorex polulus*, Mt. Kenya Mole-rat *Tachyoryctes rex*, Mt KenyaThicket Rat *Grammomys gigas*, Highland Musk Shrew*Crocidura allexalpina* and East African Rock Hyrax *Procavia johnstoni mackinderi* (Coe & Foster 1972, Young & Evans 1993, Davies & Vanden Berghe 1994).

The area outside the forest is dominated by agricultural land use, and therefore devoid of mammals of conservation concerns. However, the Vervet monkey *Chlorocebus pygerythrus*was recorded along riverine bush in Project (3) **(Figure 4.44).**

Figure 4.44: **Vervet Monkey Chlorocebus pygerythrus recorded during the survey**

Table 4.13: **List of Mammal Species Recorded**

Species	Habitat	Cue	No of encounters
Elephant	Forest	Scat/ tree scratch	7
Buffalo	Forest	Scat	3
Unidentified Mouse	Forest	Found dead	1
Vervet Monkey	Riverine bush	Seen	3
Unidentified small carnivore	Forest	Prints	1

4.8 Critical Habitat

Three major habitats were identified in the project: modified natural forests, riparian forest and farmlands. Of the three, forests and riparian forest were considered as critical habitats for biodiversity conservation. The upper part of the project lies within Mt. Kenya Forest, which is an Important Bird Area.

The forest is one of the most important water catchment areas in Kenya, supplying the Tana and Northern Ewaso Ng'iro systems. The project site lies within the southern slopes, which receive rainfall up to 2,500 mm per year and hold luxuriant rain forest up to 2,400m. The forest has valuable indigenous trees such as Camphorwood *Ocotea usambarensis*.

Mt Kenya is a stronghold for the threatened and little-known Abbott's Starling *Poeoptera femoralis*, even though there are few recent records. It has a rich montane bird fauna, with 53 out of Kenya's 67 African Highlands biome species, at least 35 forest-specialist species (Bennun et al), and six of the eight species that make up the Kenyan Mountains Endemic Bird Area. The African Green Ibis *Mesembrinibis cayennensis* feeds in marshy forest glades and the rare and little-known race graueri of the African Long-eared Owl *Asio abyssinicus* has been recorded from the high forest. The Scarlet-tufted Malachite Sunbird *Nectarinia johnstoni* is particularly common on the high moorland. Mt Kenya Bush Viper *Atheris desaixi* and Mt Kenya Soft-horn Chameleon *Chameleo schubotzi* are notable endemic reptiles, while the Montane Viper *Vipera hindii* is found only on Mt Kenya and the Aberdare Mountains. The butterfly *Capys meruensis* is restricted to the Mt Kenya area (Larsen 1991).

In the forest, endemics or nearendemics include the rare shrubs *Ixora schefflerikeniensis*, *Pavetta hymenophylla, Maytenus keniensis* and *Embelia keniensis* and the climber *Rubus keniensis*. The project traverses Kianyaga valleys, another Important Bird Area and the center of abundance for the threatened, restricted-range Hinde's Babbler *Turdoides hindei*, a species endemic to central part of Kenya.

Meanwhile it is worth noting that this project is only traversing very small proportion of the critical Mt Kenya Forests (200 metres along the river) and it does not extend to Kianyaga Valley IBA or the larger interior of Mt Kenya forest **(Figure 4.45).** The 200m from the forest boundary where this project will be erected is interefered by human activites such as grazing, firewood fetching which have substantially modified the area's primary ecological functions and species composition. As shown on **Figure 4.45** the riparian forests / vegetation cover aproximatley 6 m on either side of the river bank. Riparian vegetation was primarily abundant in steep and rocky areas where agricultural activities are unsuitable. Ecological connectivity of the remaining fragmented riparian vegetation was there but more need to be done to enhance its connectivity through such practices as farm forestry and conservation of remaining vegetation.

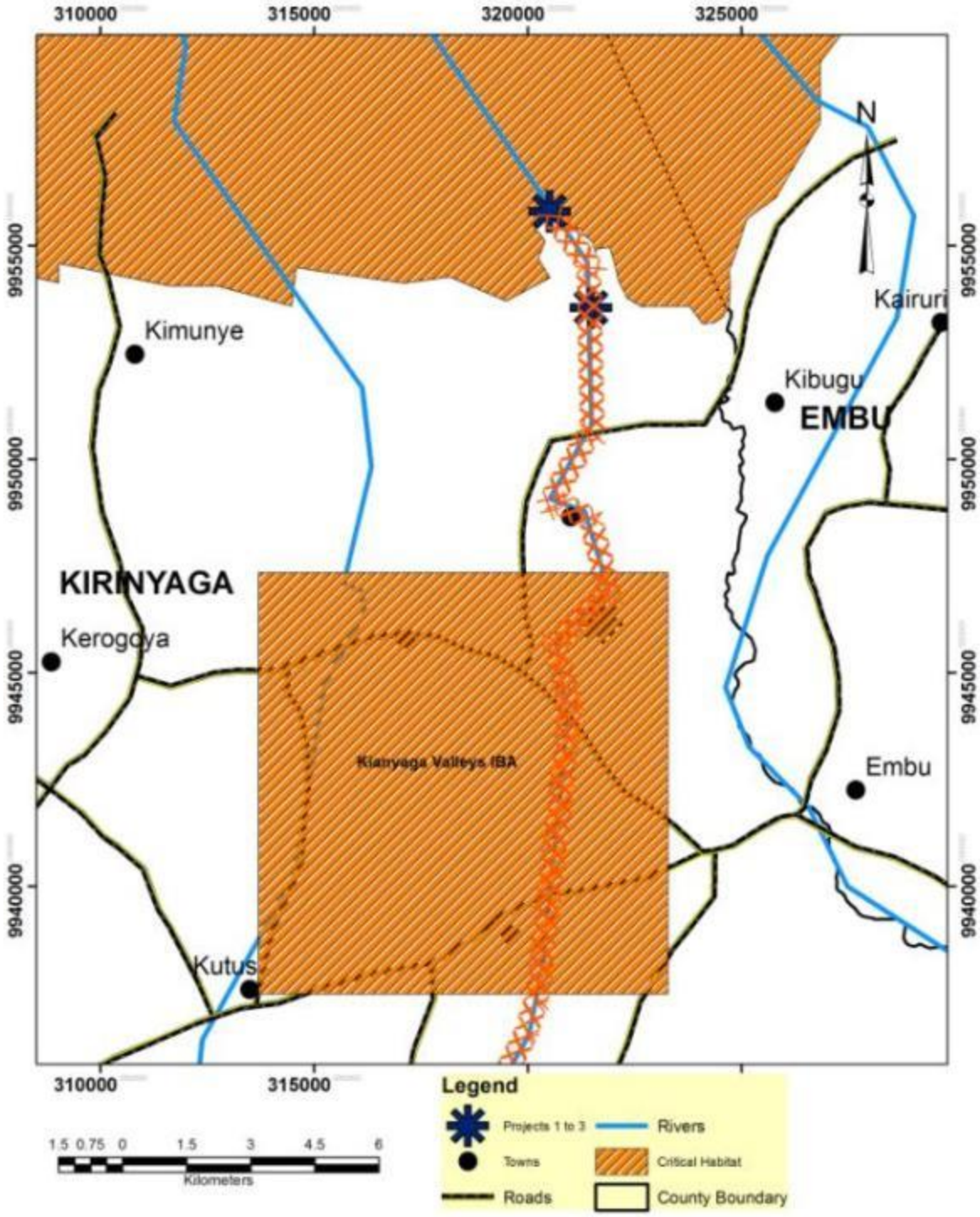


Figure 4.45: Critical Habitats that are traversed or near the project

4.9 Social economic and cultural heritage environment

The environmental and social setting that is narrated here allows for identification of the baseline social and economic status of the communities living in the neighourhood of the project areas , the particular areas that are most vulnerable to the negative impacts of the project as well as positive outcomes. These positive impacts may be in the form of skilled and unskilled laboring opportunities, improved infrastructure, compensation for land and resource use for project affected persons, and education for the workers and neighboring communities on aspects of healthcare as well as proper work and safety procedure.

In order to assess socio economic benefits or detriments arising from this R. Nyamindi cascade development project, baseline information was collected through review of secondary sources such as the statistical information available in the county; information downloaded from the internet, development plans and published literature such as State of Environment Report. The population data was collated under the sub-locations namely Kabari, Ngiriambu, Rungeto, and Ngerwe.

Several rounds of community consultations were undertaken through focus groups (FGDs) and through the small group discussions. There had been 04 FGDs where more than 50 community members took part in each of the FGD. A list of participants attended the three to four FGDs is attached **in Appendix 13.9.**

In addition, there was a household survey. Social mobilisers drawn from the area were engaged. **(Figure 4.46)** The HH survey was conducted using questionnaires administered to a sample 75 individual households representing the villages affected or potentially affected by the project construction activities. However, they were not the project affected persons, as the PAPs were not determined yet through a proper cadastral survey. The list of the HHs who responded to the HH questionnaire is also given in the attachments **(Appendix 13.9).**

Figure 4.46: Social mobilisers from the local area were trained to conduct the HH survey

In addition consultations were made with the key stakeholders such as county officials of NEMA, WRMA, Forest Officials, Officials in the private health centers, officials of School administration in selected schools in the project influence area and with officials of County sub location and location Chiefs. Consultations were conducted with the Chairman of the Water User Association.

Once a Cadastral survey will be completed a comprehensive baseline survey of the PAPs will be undertaken in order to assist the Resettlement Action Plan.

Limitation in collecting grass root level information:

Paucity of information (population, housing health etc. at the Sub Location and Village level was a key constraint)

4.9.1 Administrative Boundaries of the Project Area

The R. Nyaminmdi Cascade Development Project includes three (03) small hydro power projects along a stretch of 19 km of the Nyamindi River Cascade. They will be located in the administrative sub county of Kirinyaga East. Therefore, administrative boundary of the project area falls with the County Administration. The Kirinyaga County is divided into five administrative sub-counties, namely, Kirinyaga West, Kirinyaga Central, Kirinyaga East, Mwea East, Mwea West and the Forest Area. **Table 4.14**

These sub-counties are further divided into divisions, locations and sub-locations. Each Location is administered by a Location Chief. The county has four parliamentary constituencies, namely, Mwea, Ndia, Gichugu and Kirinyaga Central. Gichgu constituency falls within the Kirinyaga East sub county or the District.

In terms of administration, the sub county of Kirinyaga East consists of 3 Divisions, 10 locations and 27 sub locations. In terms of political administration, the Gichgu Constituency has several county assembly wards. Following sub locations have a direct influence over the projects various activities such as land acquisition (purchase), labor recruitment, vehicle movements, water abstraction etc.

- Rungeto
- Kabari
- Ngiriambu
- Ngerwe

For purpose of administration these sub locations fall within Nagariama location and Njukhni Location. In terms of political administration, the above four sub locations fall within at least two of the county assembly wards as follows.

- Rugento and Kabari sub locations in Nagariama county assembly ward (Location),
- Ngerwe and Ngiriambu sub locations in Njukhni county assembly ward (Location).

In case of Project (1) Gitie, the project infrastructure falls within part of the forest and rest of the structures will traverse along the crops lands in Kithima Village of Kabari Sub Location in Nagariama Location. The project infrastructure including the Weir and a section of the HRC will fall witin the 200 m inside the forest are.

In case of Project (2) Kiamutugu, the project infrastructure will traverse along the crops lands in Villages of Kithiga, Kebere, Kinagoro and Kabatia in Rugento Sub Location in Nagariama Location.

In case of Project (3) Mbiri, the project infrastructure will traverse along the crops lands in Villages of Muburi and Kiangoroin Ngerwe sub location in Njukhni Location. This makes the project to fall under two Locations.

Project Areas fall with the forest administration:

The Flow Diversion Weir of the Gitie Project and its HRC will be located within a 200 m stretch the Kathandenie Forest. The HRC will fall along the electric fence built on the forest border belonging to Kenya Forest Service. Forebay is located in the village called Kithima Village which is on the tea planted area, belonging to Thumaita Tea Factory Company Limited. There will be a need to obtain the formal approval to build the weir and associated facilities in the Land area falls within the Kenya Forest Service.

The project areas therefore fall under administrative purview of two Locations, three Sub Locations in one Sub County of Kirinyaga County. Part of the area also falls with Kenya Forest Service as well.

Table 4.14: Administrative Units of the County

District	Land area (km^2)	No. of Divisions	No. of Locations	No. of Sub- locations
Kirinyaga West	211.3	3	8	16
Kirinyaga Central	173.6	3	5	18
Kirinyaga East	229.7	3	10	27
Mwea East	512.8	1	5	16
Mwea West	204.0	2	2	4
Forest Area	308.2			
		12	30	81

Source: Kirinyaga County Commissioner's office

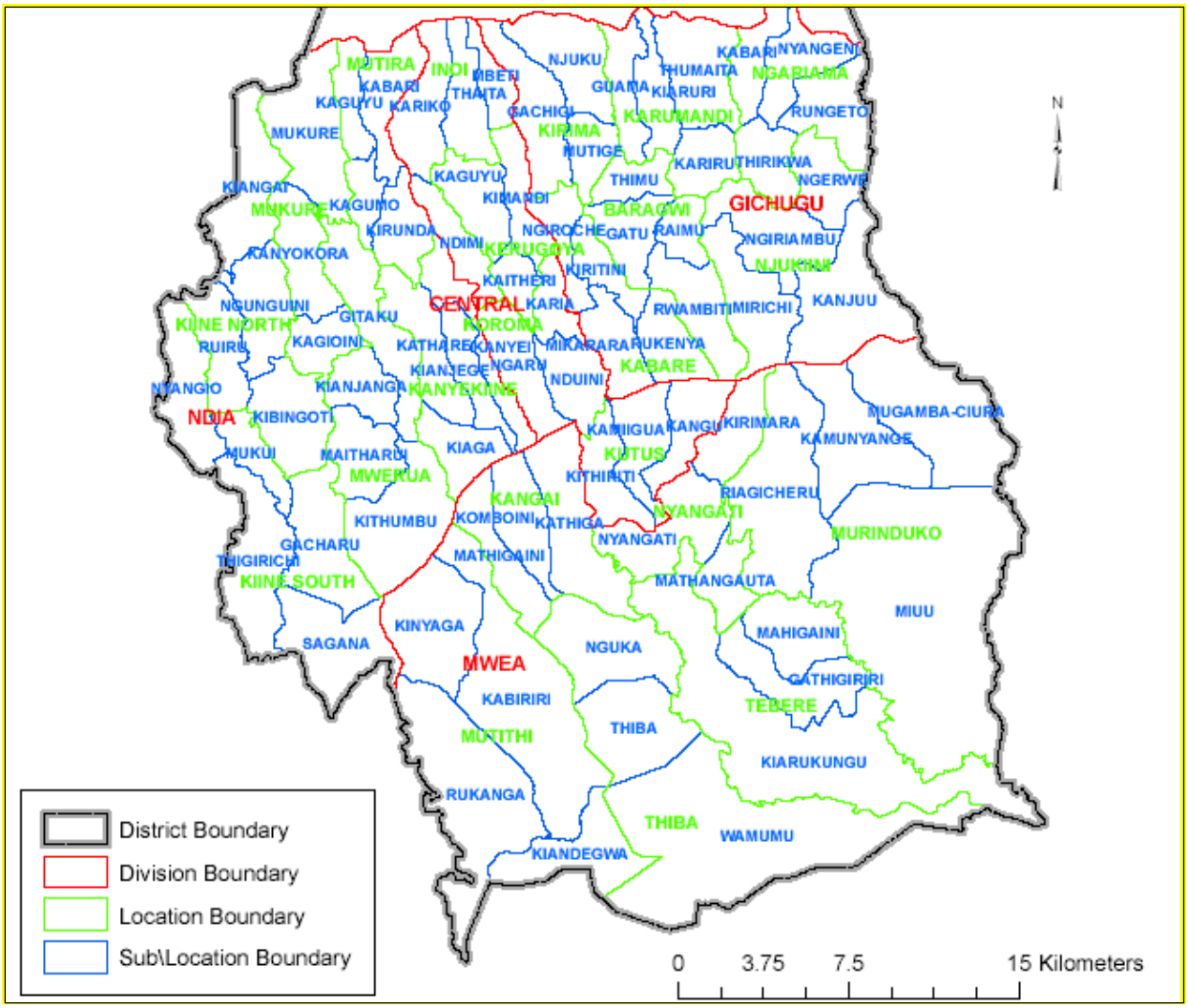


Figure 4.47: **Map indicating the project influence area. (Adopted from the County Map)**

4.10 Land use in the project influence area

The county can be divided into three ecological zones namely;

- The lowland areas that fall between 1158 m. to 2000 m. above sea level,
- The midland areas that lie between 2000 m. to 3400 m. above sea level and
- The highland comprising areas of falling between 3400 m. to 5380 m. above sea level.

The lowland area is characterized by gentle rolling plains that cover most of Mwea constituency. The midland area includes Ndia, Gichugu and Kirinyaga Central constituencies. The middle and lower parts are under cropland and urban development. In the middle parts (Gichugu, Kirinyaga

Central and Ndia Constituencies), cropland is privately owned while in the lower parts (Mwea Constituency), the National Irrigation Board (NIB) owns most of the land. There is one settlement scheme located in Mwea Constituency (the South Ngariama Ranch) where the community without land was settled in 2007.

4.10.1 Proportion of land cover under forests, woodlands and range lands

The government gazetted forests cover a total of 30867.02 ha categorized as follows;

- Natural forest 14616.4,
- Plantation 1443.22Ha,
- Bamboo forest 7500Ha,
- Bushland and grassland 7037.40Ha and Kenya forest tea zones 270.0Ha.

Of this, there are four forest blocks (stations) that form the forest administrative units which are managed by forest managers these are;

- Kangaita forest station 4737.15 Hectares (ha)
- Castle forest station 15970.70 ha.,
- Kathandeini forest station 9358.30 ha. and
- Njukiini West forest station 47 ha.

Kirinyaga County has three major land use types namely, cropland, urban areas and forests. Most of the land falls under cropland. The upper parts fall under Mount Kenya National Park and Mount Kenya Forest reserve, which are under the jurisdiction of Kenya Wildlife Service and Kenya Forest Service respectively.

The Kathandenie Forest, which consists of 9,358 ha is the second large forest area in the county. There are two isolated but gazetted hills; Kamuruana 23.87Ha and Murinduko 202.3Ha which are under the jurisdiction of Kangaita and Njukiini forest managers respectively. The county has two un-gazetted county government forests in the county and these are Kerugoya Urban forest covering 12.9Ha and Karimandu forest which covers an area of 2.8Ha making a total of 15.70Ha.

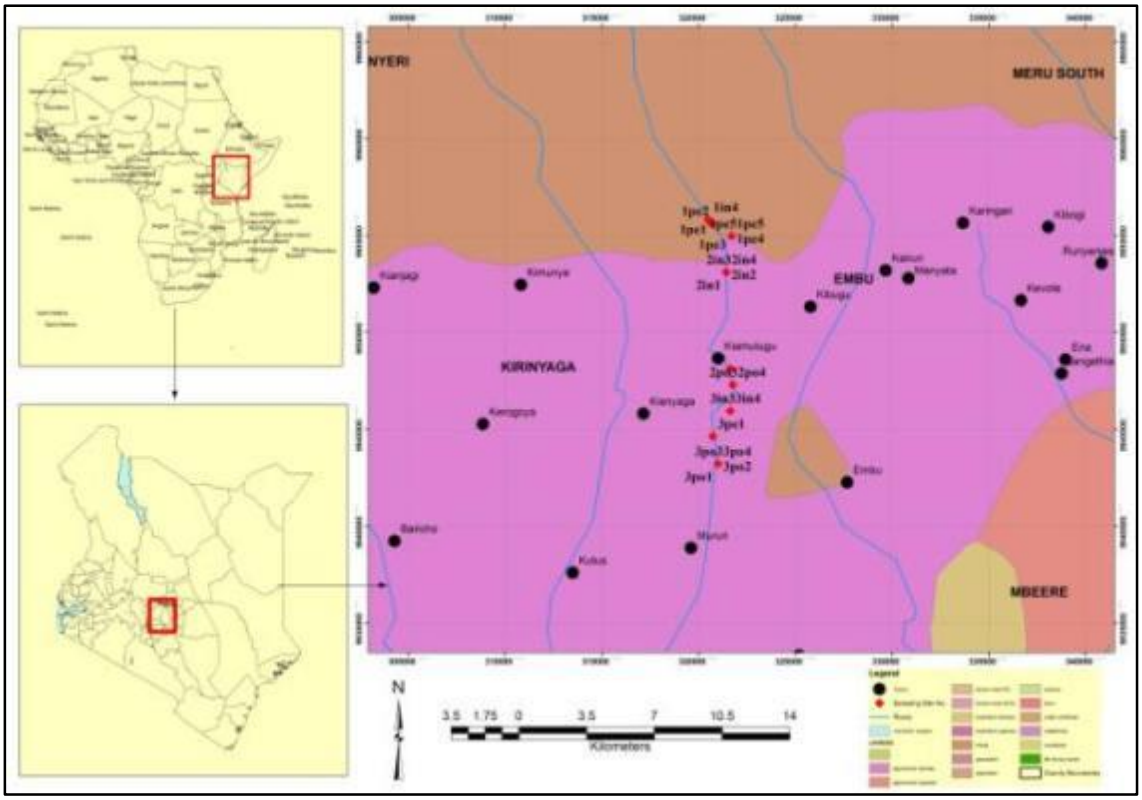


Figure 4.48: **Land use map of the study area**
modified from Survey of Kenya and World Resources Institute base maps

4.11 Demographic Characteristics:

4.11.1 Population in the County

Population of Kirinyaga County stood at 528,054 persons with an annual growth rate of 1.5 percent[5]. The total land area in the county is 1,205 sq. km. The population density of the county is 357 people for one $Km^{2.}$.The population is projected to be 595, 379 in 2017.[6] The female population is expected to increase from 279,733 to 301,520 while male population will increase from 272,626 to 293,860 from the year 2012 to 2017. 60.8 percent of the population is below the age of 30 years. The highest population falls between the age group 5-9 years followed by those between 0-4 years and 10-14 years.

The labor force in the county (people in the age group between (15- 64) is projected to be to the tune of 365,981 by 2017. This is about 61% of the county projected population of 595,637 for the year 2017.

4.11.2 Population in the Location

The District of Kirinyaga East (where the sub locations of the project influence area lies) has a population of 124,672 (2009). The total land area in the constituency is 229.6 sq.km. According to the Location Chief of the respective Locations, the population in each of the location is 25,000 in Nagariama and 22,000 in Njukhni.

Information pertaining to population at sub locations as well as at the village level is difficult to come by as the records are not available with Sub Location Chiefs. The House Hold Survey carried out as part of the socio economic assessment revealed that in the 75 HHs the total population stands at 449 with 235 females. Female population exceeds slightly which is also the same as in the case of County average. Average family size in those sub locations is in the range of 5.15 to 7.18. The working population (between 15 to 60) is 338. The respondents have mentioned the religion as Christian and belong to Kikuyu Tribe. All the respondents have lived in the area at least more than 10 years. The table indicating the population composition trends is in the T**able 4.15 below:**

[5]From the Kenya Population and Housing Census 2009 report.

[6]State of Environment Report (2016) and Kirinyaga County Development Profile (2013)

Table 4.15: The Population characteristics in the HH survey

Sub Location	Total sampled	Average family size	Total males	Total females	% of males	% of females
Kabari	121	6.37	60	61	49.59%	50.41%
Ngiriambu	103	5.15	56	47	54.37%	45.63%
Rungeto	79	7.18	33	46	41.77%	58.23%
Ngerwe	146	6.18	65	81	44.52%	55.48%
Total	**449**		**214**	**235**		

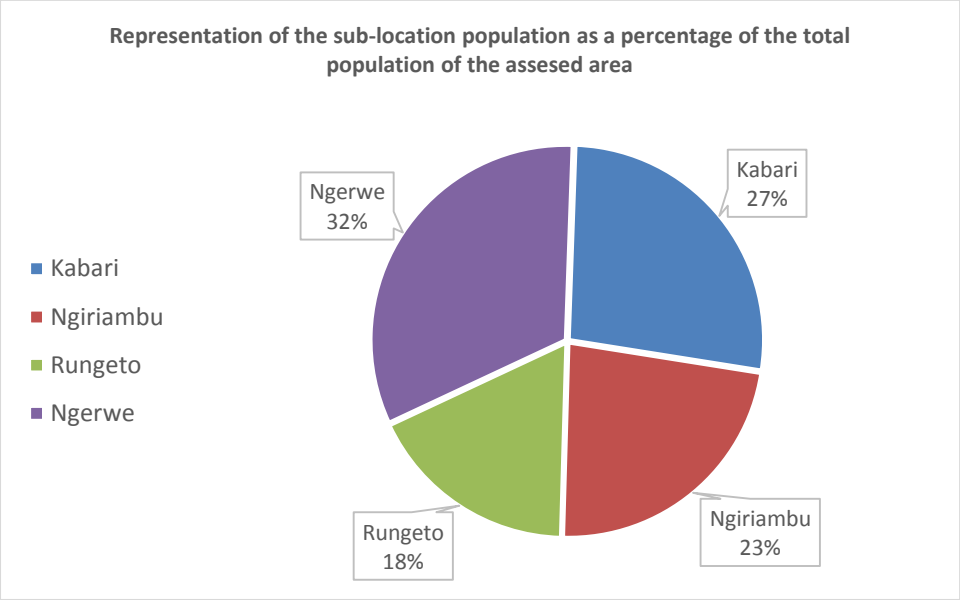


Figure 4.49: Sample of HHs included in the HH survey distributed in each of the sub location

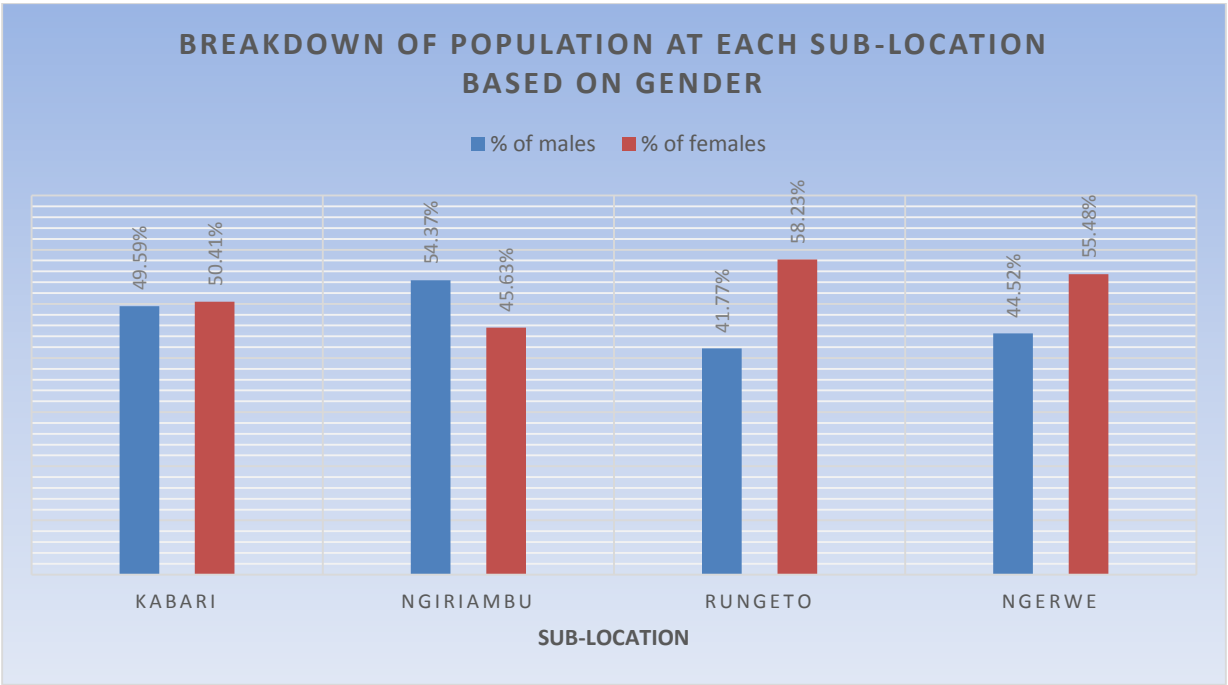


Figure 4.50: **HH population disaggregated by Gender**

4.11.3 Land ownership:

There are 154,220 households in the county and the total land mass is 1478.1 ha indicating average land holding size of 0.0958 ha/HH. Most of the land in the county is free-hold with 67% of farmers in the county having title & deeds for their lands. The land in the major towns of the county is under leasehold. Twenty-three percent of the farmers especially in the lower zones of Mwea Constituency do farming on the land owned by National Irrigation Board. There is one settlement scheme located in Mwea Constituency known as South Nagariama Ranch where the community without land was settled in 2007.

The average farm size for large scale farms is 5.2 Ha and 1 Ha for small scale farms. This is likely to change in future as the population increases and land is fragmented for inheritance.

House Type:

Generally, the houses in the project area are strong and permanent in nature. They are built with bricks, and some are plastered, roofs made up of with Iron Sheets or tiles and the floor cemented. But there remain semi-permanent houses as well which are mostly done with Timber. **(Fig 4.54)** Almost all the house have a separate cattle shed and for other facilities such as kitchen area and a pit toilet. Houses are owned by the occupants themselves in most cases.

Figure 4.51: Semi-permanent Houses made of Timber in close proximity to Project (1)

In terms of the ownership of the Houses, the HH survey revealed that except for one occupant, all others responded positively to claim that they own the house that they live.

4.11.4 Economic activities and household income:

Kirinyaga County is largely a farming county, with most farmers practicing mixed farming. "*Kirinyaga County's economy primarily depends on natural resources with 87 percent of the total population deriving their livelihoods mainly from agriculture sub sector, with the largest of the population living in rural areas of the county. Economic activities derived from the natural resources include agriculture, small-scale industry, energy, water, trade and mining. The environment and*

natural resources have in the recent years been under threat due to increased dependence on natural resources to meet basic needs".[7]

Agricultural production is dominated by cereals, grain legumes, root crops and several industrial crops like cotton, tea, macadamia and coffee. Livestock is a major economic activity in the county, pastures and water for animals last only a few months leaving the animals with virtually no grazing fields. Types of livestock include dairy cattle, dairy goats, Pig and poultry farming.

The project area especially the upstream land is widely used for tea cultivation. The land around the project area close to Kiamutugu project is used extensively for cultivation of Coffee and Tomato. Bee-keeping is an income generating activity which the communities are adopting in the project area. Since the project is in close proximity to the forests and that the river banks are a good source for collecting bee honey, during the filed surveys, it was observed that several bee cages were introduced along the river stretch where the Kiamutugu project' proposed weir will be located. During the clearing of the vegetation, care should be exercised not to disrupt the activities which will impact on the HH income of those families.

The land close to Mbiri is more used for growing trees such as Eucalyptus, Coffee other short crops such as Maize and vegetables and Banana.

Homesteads are integrated with cultivation of Macadamia trees for their nuts, which is a popular and very lucrative source of tree income. It is bearing once a year and can be harvested during February / March period of the year. A grown up tree fetches an income of 30,000 shillings (average) according to the cultivators.

Those living close to tea estates work on the tea estates which is a permanent source of income. There are several markets where the trading is taking place. Kiamutugu Trade Center, Mbiri Trade center which are more of rural trade centers help the people to sell their products.

In term of HH income, the HH survey revealed that farming is a major source of HH income. The response received from the respondents about the HH average annual income in the sub location of Kabari is higher than other sub locations **(Fig.4.55).** This may be due to the employability in the Tea estates, possibility of other income earning activities such as bee keeping, availability of gazing land in the forest area and the suitability of the area for Macadamia trees which are giving a good annual income. Other areas are very much affected during the dry spells of the year which will have a direct impact on the HH income. (However it should be noted that very often income figures are not divulged in many HH surveys)

[7] Statement drawn from County Environmental Action Plan (2014-2018)

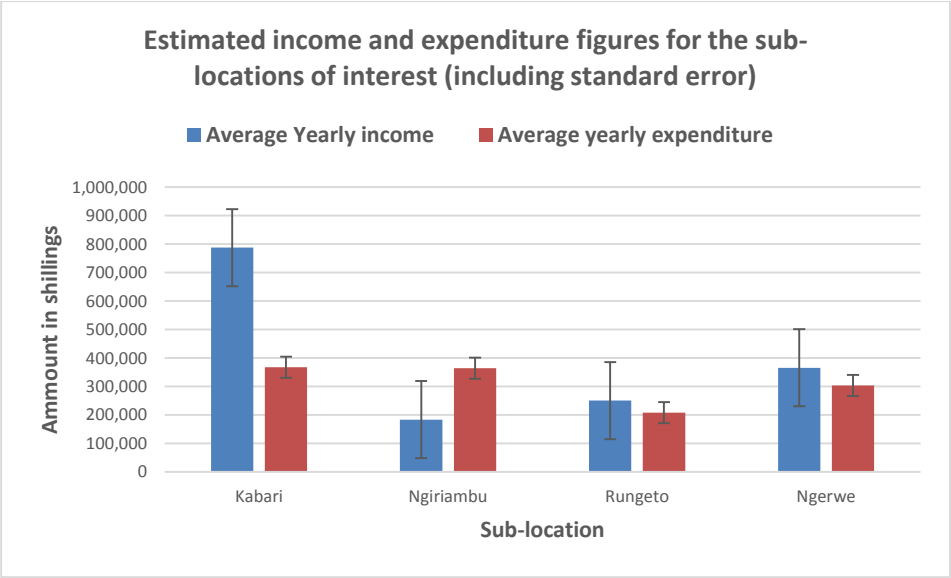


Figure 4.52: Comparison of the income among the sub locations based on the HH survey

<u>Income from Macadamia Trees / Coffee</u>

Cultivation of Macadamia trees for their nuts is a popular and very lucrative home stead cultivation practice in the project area. It is bearing once a year and can be harvested during February / March period of the year. A grown up tree fetches an income of 30,000 shillings (average) according to the cultivators.

Coffee is expected to produce at least 3 mil shillings per year for those having at least 2 acres of coffee plantation. According to the farmers, in a 2-acre land, at least 800 coffee trees can be grown. Each fully grown tree will provide at least 50 km in a harvesting period, if the coffee is well managed. Selling t 80/= Shillings per kilo, a farmer will be able to earn in excess of 3 mil shillings per annum.

4.11.5 Status of land resources in the county

There are 154,220 households and the total land mass is 1478.1 ha giving a mean land holding size of 0.0958 ha/HH. According to the State of Environment Report, individual people own most of the land in the upper parts of the county (Gichugu, Kirinyaga Central and Ndia Constituencies) while in the lower parts (Mwea Constituency); National Irrigation Board (NIB) owns most of the land. There is one settlement scheme located in Mwea Constituency known as South Nagariama Ranch where the community without land was settled in 2007. Most of the land in the upper parts of the county is ancestral land which has been passed down from one generation to the next over past years; therefore, there are no major conflicts as most of the land is inherited.

In the lower regions of the county which comprise Mwea Constituency, the average land holdings are larger while they are smaller in the central and upper regions of Gichugu, Ndia and Kirinyaga Central Constituencies. The average farm size for large scale farms is 5.2 Ha and 1 Ha for small scale farms. This is likely to change in future as the population increases and land is fragmented for inheritance.

While 67 percent (67%) of farmers in the county have title deeds, 23 percent (23%) of the farmers especially in the lower zones of Mwea Constituency are farming on the land owned by National Irrigation Board. Most of the lower parts of the county comprising Mwea Constituency most of the land is owned by NIB and farmers lease the land which is under irrigation.

4.11.6 Land ownership, availability of title and deeds as per the HH Survey

In the HH survey 75 HHs were provided with questionnaires to respond. Several of the questions were to assess the extent of land that they have, their ownership and whether the tile and deeds are available. All the respondents said that they have their own land for cultivation. The size of the land appears to be varying from 8 acres to 0.5 acres in general. However, there was one respondent living in Kiangoro village who owns about 17.5 acres of land. Based on the results of the HH survey, 1-2 acres of land is a common unit owned by an average farmer. This represents about 40% of the 75 families whose responses were analyzed. **Fig 4.54.**

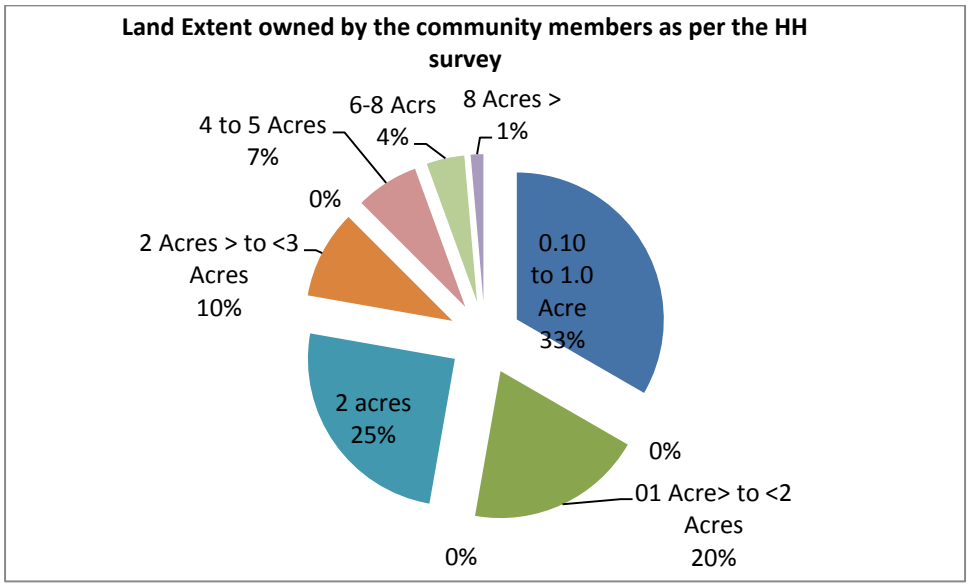


Figure 4.53: Extent of land owned by individuals in the HH Survey

4.11.7 Availability of Title and Deeds:

Based on the responses given by the HHs during the HH survey it was revealed that 46 % of the HHs (population in the sample) does not have a land title with them, another 35% have land titles whereas 19% had not responded to the question. This situation will be further analysed during the preparation of the Resettlment Action Plan.

Status of the availability of Title and Deeds for the sample of the community members in the HH survey is shown **in Fig (4.57)**

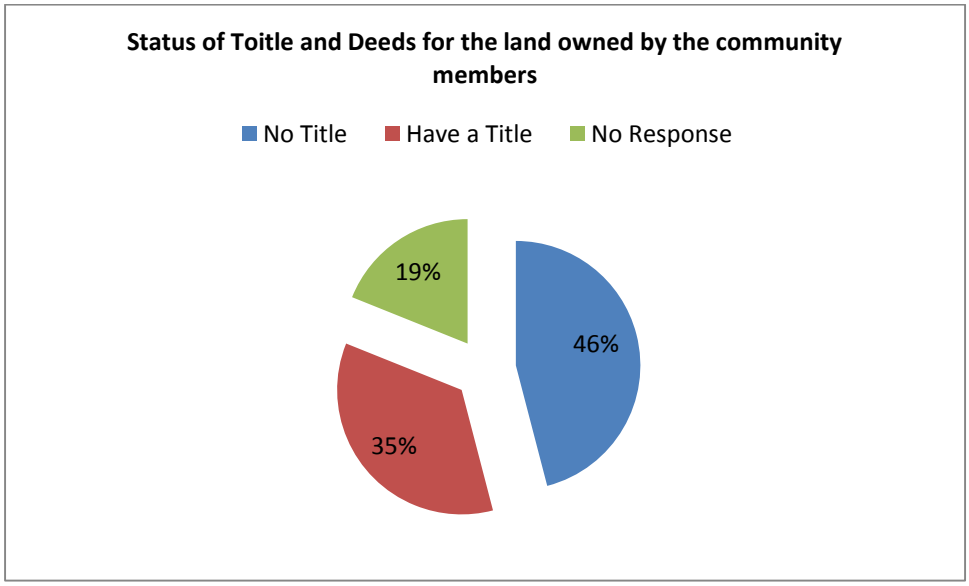


Figure 4.54: Availability of Title and Deeds for the sample HH survery of the community members

4.11.8 Water for Domestic and Public Purposes

Water resources are managed by Water Resources Management Authority (WRMA), Water resources Users Associations (WRUAs), Tana Water Service Board, water service providers and the County Water office.

The water requirements for domestic purposes in the county include provision of water for household and sanitary purposes, watering and dipping of livestock, for public purposes to municipalities, townships, villages, communities and small industries and for all reasonable demands for public undertakings but not involving the use of water for generation of power or major irrigation and industrial use. Water for domestic use forms the bulk of water use in the county at the rate of 65,198m3 /day.

Drinking water for the HHs in the project area is partly met from piped water systems when the water is available during the rainy periods. Rain water harvesting is a popular activity and most houses are seen equipped with water tanks to collect rain water. However, many community members use the irrigation water supplied from the upstream in the forest area for their irrigation purposes. During the dry spells of the year they fetch water from the River; even schools in the neighbouring areas collect river water during the dry spells, according to the school teacher of Nagariama Primary School.

According to the community members, dry seasons, water is scarce and they fetch water in jerry cans from the river. Transporting of water to their villages is either through bicycles, motor cycles, and carts or head carrying. River at Mbiri is a prominent water collection point where alomost people from distance villages converge when the dry spells begin, in order to collect water. **See the visual in fig 4.56**. Accordin to the HHS, during a day at least 8 to 10 times they walk about 800 m to the river to collect water. Daily water requirement including to feed cattle is about 200 liters. Some say that they either boil water or that they use water guard tablets to purify water before they rink the river water.

Figure 4.55: **Community member collecting water from the water point**
Just below the proposed Mbiri Project, weir location

4.11.9 Other infrastructure:

<u>Road network:</u>

The total road network of in the county is 1,109.11 Km, out of which 106.5 Km is bitumen, 462.05 Km is gravel and 540.5 Km is earth surfaced roads. The county has an established road network with 7 tarmac roads passing through it namely Makutano – Embu road, Kutus – Karatina road,

Baricho road, Kiburu road, Kutus – Sagana road, Kutus – Kianyaga road and Kabare – Kimunye road. The gravel and earth surfaced roads are however not motorable during the rainy season due to poor maintenance, poor drainage and unstable soils. This makes it difficult for farmers to transport their products to the market during rainy seasons thereby limiting the growth of the agricultural sector. During the dry season, there is dust tossing up due to vehicle movements. Project work will have more impacts on the air quality of the project area, when there is a heavy movement of construction vehicles in the area.

Health & Sanitation:

There are 202 health facilities in the county with a total bed capacity of 764 comprising of 109 public health institutions, 39 mission/NGO institutions the largest one being Mwea Mission hospital and 54 private clinics. There are 3 level four facilities located in Kirinyaga Central, Gichugu and Mwea Constituencies in addition there is one private hospital namely Mt. Kenya hospital located in Kerugoya town.

In addition to these, there are 10 level three health facilities, 45 level two facilities and 51level one facilities which are spread all over the county. The doctor population ratio is 1:36,339 and the average distance to the nearest health facility is 5 Km. Pneumonia HIV/AIDS are considered main causes of death

Findings of the health status during the socio economic assessment:

Those who are in the close vicinity of Gitie Project revealed that they would travel as far as 15 – 20 Km in order to receive treatment from a government hospital. Except those close to the Mbiri project, other are been served with private dispensariues or church managed dispenseries. For example there is a dispensary close to the villages around Project which is the Gatumbi Dispensary, operated by the Church (Fr. Mosses C Kongette – Contact 0727345945). There is one Officer in-charge of the health Center (Mrs. Gladice Gachewa- contact No. 0725940133) and there are two clinical officers, one nurse and one Lab assistant, 01 Attendant and a Watcher to run the health center on day to day basis. It is reported that at least 315 patients seek health services from the center

Figure 4.56: **Services provided by the dispensary**
Mrs. Gladice Gachewa Officer in charge explaining the services provided by the dispensary

per month. The Dispensary has a maternity unit (with limited facilities) a laboratory and HIV aid test center. At least two to three deliveries are carried out in the maternity unit every month.

Comprehensive care for HIV patients is provided through this dispensary. At least (08) HIV tests are undertaken in the laboratory. According to the records, HIV prevalence in the area is 15%. Other major illnesses treated at the center are: Amebiosis and Respiratorytract infections, asthma, Tuberculosis, skin diseases such as scabies. According to the records of the dispensary, it appears that the HIV prevalence is on the rise whereas diseases like Tuberculosis is on the declining trend. The HH survey revealed that the presence of Malaria is also high in the project area.

Those community members living close to Project (2) Kiamutugu and (3) Mbiri, have the access to health centers operated by the government (who have also access to the general hospital the main town in Giture). Within a distance of 3-5 km they can find a government hospital either in Kiamutugu or in Giture.

Electricity and pipe borne water:

The villages in the project area are adequately covered with electricity. All the HHS in the sample survey responded positively to the question pertaining to the electricity: that is whether the houses are connected to the electricity. All have responded positively. However, the access to pipe water is not found in most cases.

Schools in the project area:

A number of pre, primary and secondary schools are found in the project area as well as in the areas where the project access roads are located. Gatumbi primary school is located along the road frontage to the intake of the Gitie Project and its Power House. Mr. Daniel Kabera, the Deputy Principle of Gatumbi Primary schools said that they have 247 students enrolled in the school. They (students) go to the Nyamindi River to collect water during the pipes are dry in the dry season of the year.

The Ngariama Primary School is also located on the road frontage to the access road to Project (11) Kiamutugu. According to the Head Teacher (Ms. Perris W Irerit No. 0710982880), the school provides education to about 286 students. Of them 160 students are female. The school also has a preschool section which caters to about 75 students. Although the school has access to piped water, this becomes dry in the dry spells, requiring the students to fetch water from the Nyamindi River. Another school close to the project area is Nagariama Secondary School which has about 196 students. Although the schools has piped water, alternatively they have arranged a gravity flow water scheme through a stream in the close by source to access to water during the dry season.

During the construction phase of the projects, due consideration has to be made of the presence of these schools, owing to the possibility that there could be accidents due to speeding vehicles and other obstructions to movements by the children along the access roads. Safety of the school children from construction vehicles need to be ensured and any dust emissions activities should be minimized. Water collection points that the students use, during the dry season has to be cleared. According to the Head Teacher and the Deputy Principle with whom the discussions were made, following measures have been proposed to mitigate possible impacts to the schools:

- Dust should be prevented specially during the morning and evening hours when the students are walking to and from schools.
- Bumps /humps and road signs should be constructed to warn drivers not to speed in front of schools;
- Sound control should be exercised by the drivers when the schools are in progress:
- It is also important to ensure that protection is provided to students by way of erecting fences when the construction is very close proximity to the schools.
- When the construction is in progress, water collection points and their access roads should be protected.

4.11.10 Discussions with Stakeholders:

During the socio economic baseline assessment, discussion was held with several stakeholders including the senior state officials of the County and the community members of the project areas.

<u>Discussion with Mr. Joel Kariuki Nderitis(Contact 0702082289); Forester in charge (Kathandenie Forest)</u>

This is a state gazette forest reserve, according to the Forester in charge. He observed that the project weir will be in the location inside the forest and the head race canal will be laid adjacent to the electric fence built on the forest border. He said that the forest station is manned by 08 rangers, 01 Corporal, and the Forster. 18 Beat officers are also engaged. They all are from Kenya Forest Service. Land ownership of the tea growing area is vested with the Government of Kenya. (Department of Agriculture). According to him tea belt is helping to prevent encroachment by villagers towards the forest land.

Having a project structure close to the forest areas, the forester said that there is no problem with such structures, provided necessary negotiations are concluded and the due payments are made to the Forest Department by the Developer. He said that the project structures can be located in

the forest area but, necessary approval should be sought from the Kenya Forest Service Head Quarters. A topographic map indicating the layout from the Intake upto the Forebay, a letter explaining the intention of the project and the other relevant documents should be provided to the Director at the HQ which will negotiate the price for compensation and will allow the project to commence construction. He said that the project would help them to increase eco-tourism in the area. The structure would be an added attraction to the tourists he said.

He emphasized that the Electric fence needs to be de energized, to facilitate the civil works; therefore, he said such requirements should be notified well in advance.

The cost of constructing one km of the electric fence is about 5 ml. Kenyan Shillings according to him.

Figure 4.57: **Chief Forester explains the services rendered by the forest station**

The Forester said that the river is used by the Fishermen to catch Fish (Trout) but only for home consumption. Harvesting of firewood from the forest areas used of forest for grazing of cattle/goat is permitted for which a fee is to be paid monthly. (Fire wood collection @ shillings 100 per, grazing permit for sheep 40/= shillings per head per month and cattle 100/=

shillings per head.) At present, about 20 families have received such permits from the forest station.

Discussion with the County Environmental Officer attached to NEMA:

Discussion was held with Mr. Mark Murmi (Contact 0729205556). Mr. Joseph Kopejo (County Director) was not in the office at the time of the visit. Commenting on the NEMA procedure of approval of the EIA, he said that he will make a visit to the site before approving the EIA report, when the report will be submitted to the county for review. Thereafter once the EIA will be approved, there will be site visits made by the County Environmental Officers to ensure that the mitigation actions will be implemented according to the NEMA recommendations.

Figure 4.58: Mr. Mark Murmi Offfciala of NEMA in the county Office

Commenting on the existing programs for river catchment protection, the NEMA County Environmental Officer sad that there is no ongoing programme for catchment protection, but programs have been made and incorporated into documents such as the Sate of Environment report and County Environmental Action Plan.

He said that river bank protection will be a major requirement during the project implementation. It is necessary to restore the river banks, with indigenous trees. He made a point that the bio diversity assessment could be carried out to identify the existing vegetation and the composition of trees in the riparian areas of the river. The Environmental Officer also suggested that a further discussion could be

Figure 4.59: Mr. Bernanrd K Ngoruse - Sub Regional Manager

held with County Director and recommended that the team should visit WRMA office and get more information about the water extraction from the river for various development actives.

He shared the copies of the State of Environment Report and the Environmental Action Plan for the County and said that all environmental related activities should fall within the strategies identified in that document.

Meeting with Water Resource Management Authority - County (Thiba) Sub Regional Manager:

Discussion was held with Mr. Bernard K Ngoruse (Contact 0723153469) at his office on 06.02.2017. Mr. Bernard said that the Hydro Power projects deprive other water users the water required for various other development activities and therefore, it is necessary to use water after considering the water users for various other community activities such as small irrigation.

His concerns have been that possible contamination of river from silt and sediments due to the construction work at the river; ground water table can be affected due to the loss of or blockage of springs during construction; loss of soil and erosion of the river banks due to the construction activities; possible dumping of spoils along the river embankments which will increase incidence of erosion and sediment loads into the river.

Meeting with the Chairman, Water Resource User Association (WRUA) Upper Nyamindi, Mr. Giddion Moriithi (Contact No. 0723821917)

According to Mr. Giddion, the WRUA (Upper Nyamindi) was registered with WRMA in 2009 and have about 45 members (Water users) who represent the irrigation projects, water supply projects and farmers. According to him, the principal objectives of the association are to conserve the water catchments; and to manage the water resources properly. He said that the association also ensures that all water users are equitably received water for economic and social improvements. Although this is a registered body, he says that the association does not have statutory powers.

Figure 4.60: Mr. Giddion, the WRUA (Upper Nyamindi)

The chairman is elected by the members for a period of 04 years and the Board of management consists of a Secretary, Vice Secretary, Treasurer and a committee comprising 13 members. Mr. Giddion stated that there are a few other Water Resource User Associations operating in the area.

They are representing the different areas such as Lower Nyamindi, Thiba and the one that is around Murubara River. The committee members represent various projects and therefore issues are brought to the notice of WRUA promptly. Explaining the threats to the river water sources, he said that some of the non-members or Riparian Land Owners who use waters of the river for various non-drinking purposes do not have any regard to the environment and some of their actions allow the river waters to pollute heavily. For example, he said that certain types of leaves of trees which are considered can be used for intoxication after they are put into the water for some time, is widely practiced in the lower section of the river and is a main source of water contamination. Another challenge is to distribute water to the various irrigation projects and that some do not comply with the requirements of the Water Resource Users' Association.

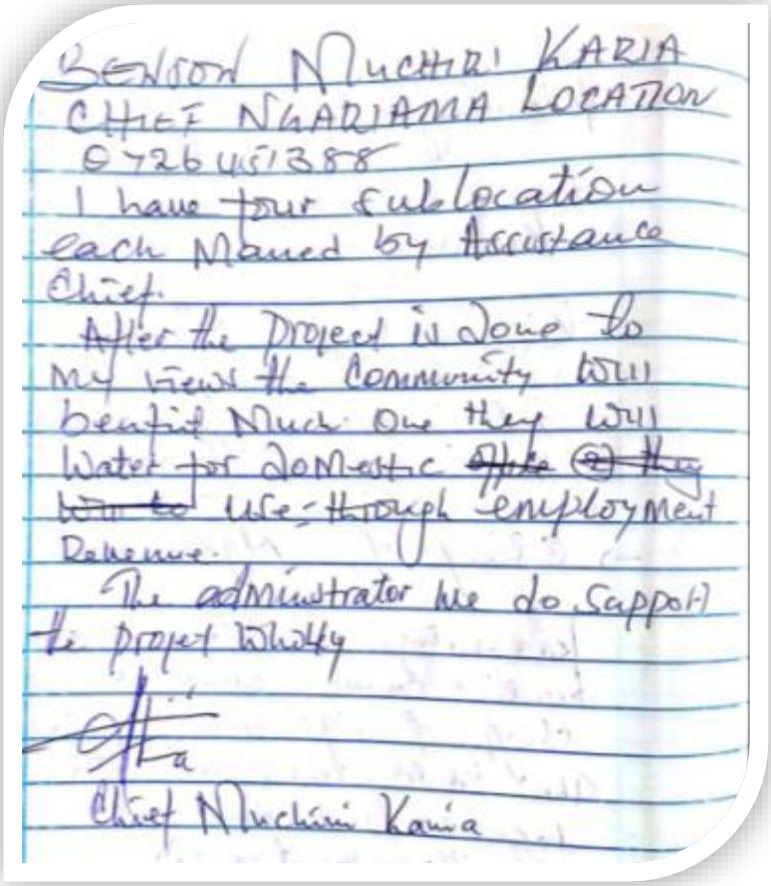
Discussions with Chief of Nagariama Location: Mr. Benson N. Karia – Contact No. 0726451388

According to him, the population in the location is about 25,000 distributed among 5000 households. He has under him 04 sub locations. 73 villages are located in the 04 Sub locations.

Spread of the villages in those sub locations is:

- Sub Location (1) Ruppeto -26 villages,
- sub location (2) Thirikwa -17 villages,
- Sub Location (3) Kabari - 14 Villages and
- Sub Location (4) Nyawgeni - 16 villages.

In the location there are 06 secondary schools and 07 primary schools, 02 public health centers01 private health center and 01 Dispensary. He said that the project is an essential development initiative to the county and that the approval of the Ngariama Location is provided to the project. A letter to this effect given by him is given below **(Fig 4.64):**



BENSON MUCHIRI KARIA
CHIEF NGARIAMA LOCATION
0726451388
I have four sublocation
each Maned by Assistance
Chief.
After the Project is Done to
My views the Community will
benfit Much One they will
Water for domestic ~~After~~ ~~(2) they~~
~~will be~~ use; through employment
Revenue.
The administrator we do Support
the project Wholly

Chief Muchiri Karia

Figure 4.61: **Letter of support provided by Location Chief**

4.11.11 Focus Group Discussions (FGDs) with the community members:

Several community meetings were held with a view to keeping them aware of the proposed project and to allow them to learn more about the proposed project. Four meetings were held in order to facilitate community members to represent their villages according to each of the project in the cascade.

The meetings provided an opportunity for them to raise concerns and them to understand the planning process. They were informed at the outset of the meetings that these are more awareness meetings rather than meetings to negotiate any compensation etc. because the project is still in the planning stage.

Questions raised by them centered on following areas of concerns:

- Where the line will be passing through?
- When will the project start?
- Will you compensate to the land if the project will go over the land?
- How much will be paid as compensation?
- Will the compensation be paid before the project or after the project?
- How do the community being benefitted?
- When will the pipes be lad and what are the sizes of those pipes?
- When the machines damage our crops and when the soils come to our lad, how do you compensate?
- Will there be work for ladies?
- Will compensation be paid to the owners of the land or those who are living in the lands (as tenants)
- During the survey of the lands, will the local people be given jobs?
- What is the composition of the Grievance Committee?
- Can we also be benefitted by having electricity connections?
- Are there any obstacles that will prevent project implementation?

Community meeting (1)

Following Participants raised questions:

1. Ephantics Mwaniki
2. James Wachira
3. Joseph Mullandis
4. John Mochiri
5. Cathline Njeri
6. Alex Njero
7. Benson Murilithi
8. Antony Munyua
9. Wallece Mungai

Photographic evidence of the community meeting (FGDs)

Figure 4.62: Community meeting No 1 of the 1st project

Figure 4.63: Community meeting No 1 of Project 2

Figure 4.64: Community Meeting No 1 of project (3)

Figure 4.65: Small group discussions

5 METHODS FOR ASSESSING IMPACTS

This ESIA anticipates environmental issues to arise as result of plans to develop this project. Potential impacts during each of the phases of the proposed development namely construction, operation and decommissioning can be categorized as impacts on biophysical environment, socio-economic and health and safety. The purposes of impact assessment is to assign relative significance to predicted impacts associated with the project, and to determine the manner in which impacts are to be avoided, mitigated or managed. The potential severance of environmental impacts will be assessed based on the nature of the receiving environment, a review of the proposed activities, and issues raised during the public consultation process.

Definition and Classification of Environmental Impacts

In the impact assessment stage of an ESIA, identified issues are analyzed and expected impacts are defined. The analysis identifies:

1. The type of impacts
2. Predicts the magnitude
3. Probability of occurrence
4. Extent of the impacts
5. Determines the overall significance of the impact based on the above 1-4.

Impact Assessment Scoring and Significance

Key aspect of this stage is identification of environmental issues and its specific manifestation and consequences in the environmental due to the proposed project. As observed above, consequences are potentially interpreted on biophysical, social economic or health and safety components of the environment. Once environmental issues are identified, their potential impacts are assessed and based on accumulated knowledge and findings of the environmental investigations. Basically, the severity of the impact and its consequences on the environment are characterized based on:

- **Extent** of impact can be limited to the project site and to specific activity at a particular period, or affect areas beyond the project site. The extent of the impact will be scaled from 1 (local) to 5 (beyond Kenya).
- **Duration** in which the project takes place is also considered in the evaluation of the impact. The period can be specific to the period of certain activities or could be related to the occupancy period of the project development. Therefore, in terms of duration, the impact can be short, medium, long term or permanent. Projects with short duration will be allocated 1 while those with long duration given 5.

- **Magnitude** of an impact is derived from the proportion of the environmental entity affected, that is, impact can be partial or complete. For example, an impact can destroy a small part of the habitat, ecological process or a small population of a species (see scaling below).
- **Probability** of an impact to happen will be estimated as a function of the four characteristics described above.

Table 5.1 Impact assessment matrix

EXTENT			MAGNITUDE	
Localized (At localized scale and a few hectares in extent)	**1**		Small and will have no effect on the environment	**0**
Study area (The proposed site and its immediate environs)	**2**		Minor and will not result in an impact on the processes	**2**
Regional (County level)	**3**		Low and will cause a slight impact on the processes	**4**
National (Country)	**4**		Moderate and will result in process continuing but in a modified way	**6**
International (Beyond Kenya)	**5**		High (processes are altered to the extent that they temporarily cease)	**8**
			Very high and results in complete destruction of patterns and permanent cessation of the processes	**10**
DURATION			**PROBABILITY**	
Very short (0 – 1 Year)	**1**		Highly improbable (<20% chance of occurring)	**1**
Short (1 – 5 Years)	**2**		Improbable (20 – 40% chance of occurring)	**2**
Medium term (5 – 15 years)	**3**		Probable (40% - 70% chance of occurring)	**3**
Long term (>15 years)	**4**		Highly probable (>70% - 90% chance of occurring)	**4**
Permanent	**5**		Definite (>90% chance of occurring)	**5**

The purpose of the evaluation is to assign relative significance to predicted impacts associated with the project in order to determine the manner in which impacts are to be avoided, mitigated

or managed. Significant impact or environmental significance rating is an attempt to evaluate the importance of particular impact, the consequence and likelihood of which has already been assessed by the relevant specialist. The sum of the first three criteria, (extent, duration and magnitude) provides collective score for the **consequences** of each impact. The last criteria determine the **probability** of the impact occurring. The product of **consequence** and **probability** leads to the assessment of the significance of the impact as shown in the table below:

Significance of the Impact = (Extent + Duration + Magnitude) x Probability

Table 5.2: Significance Assessment Matrix

		CONSEQUENCE (Extent+Duration+Magnitude)																			
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
PROBABILITY	**1**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
	3	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
	4	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
	5	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100

In order to evaluate mitigation threshold in the above Table, significance of the impacts rating provided below will be used.

Table 5.3: Significance of the impacts rating

Low	<30	Where this impact would not have a direct influence on the decision to develop in the area
Medium	30-60	Where the impact could influence the decision to develop in the area unless it is effectively mitigated
High	>60	Where the impact must have an influence on the decision process to develop in the area

[1]*Impact Assessment, Scoring and Significance adapted from (i) Biodiversity EIA Assessment for Proposed Thabametsi Coal-Fired Power Station, South Africa 2014 and (ii) ESIA Study for the Proposed 1,050MW Coal Fired Power Plant Project, Kenya 2016. This was adapted from Leopold Matrix.*

Mitigation of Potential Impacts

The IFC's PS 1-6, 8 will be used to guide the process of impact mitigation. These PSs are supported by several other conservation-based multilateral organizations, including Fauna and Flora International and Convention for Biological Diversity (CBD). To comply with the IFC's PS, and the performance standards of several other multilateral finance institutions, Project Proponent must develop and verify the implementation of a mitigation hierarchy that complies with the Standard.

This hierarchy consists of prioritized steps to alleviate environmental harm as far as possible through avoidance, minimization (or reduction) and restoration of detrimental impacts to biodiversity. Further, biodiversity offsetting is only considered to address residual impacts after appropriate avoidance, minimization and restoration measures have been applied. This mitigation hierarchy favors early awareness and action to proactively and efficiently achieve 'no net losses, or preferably 'net positive impact', to biodiversity.

1. **Avoidance:** which includes activities that change or stop actions before they take place, in order to prevent their expected negative impacts on biodiversity and decrease the overall potential impact of an operation. Specific actions may include adjusting the location, scope or timing of a development that could avoid negative impacts to a vulnerable species or sensitive ecosystem. Avoidance helps protect the integrity of valuable and threatened biodiversity and ecosystem services and also makes good business sense, e.g. by reducing later steps in the mitigation hierarchy.
2. **Minimization:** These are measures taken to reduce the duration, intensity, extent and/or likelihood of impacts that cannot be completely avoided.
3. **Restoration:** This involves deliberate measures to alter an area in a way intended to re-establish an ecosystem's composition, structure and function, usually bringing it back to its original (pre-disturbance) state or to a healthy state close to the original. This step aims at to returning an ecosystem to a former natural condition and to restore ecological function.
4. **Biodiversity offsets:** These are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development and persisting after appropriate avoidance, minimization and restoration measures have been taken. Biodiversity offsets are usually regarded as the last resort. Biodiversity offset should be designed and implemented to achieve measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity.

6 ASSESSMENT OF ENVIRONMENTAL AND SOCIAL IMPACTS

6.1 Introduction

There will be both positive and negative impacts as a result of the project during its construction phase and operational phase. Project impacts have been identified in the following order:

- Project Positive Impacts
- Project Negative Impacts:
    - Impacts on the physical Environment
    - Impacts on the bio diversity
    - Impacts on the socio economic environment
    - Impacts on the occupational safety and health of the workers
    - Impact on Public Safety

After assessing the impacts, mitigation measures have been proposed specially to mitigate all potential adverse impacts. Measure should be taken to enhance the positive impacts of the project.

6.2 Project Positive Impacts

The commissioning of the proposed SHPP along River Nyamindi cascade will add 18.5MW of electricity to the national grid. Increased power supply to the national grid, has the potential to contribute to the possibility of tariff reduction and increased reliability on sustainable energy sources. Other positive impacts are:

- Higher probability that the project area will show accelerating growth such as rural based industries and small enterprises through increased participation by the communities in value added processing of their agricultural products.
- Improved road infrastructure including access roads and renovated bridges which will facilitate community movements and reduced road accidents due to the rugged nature of the road.
- Creation of job opportunities to the local unskilled, semi-skilled as well as skilled persons in the community and transfer of technology in the medium term and.
- Provision of markets for locally available resources needed for construction work *e.g.* aggregates, sand and cement, the services such as transport, supply of dry rations etc.

Hydropower presents various environmental benefits compared to other primary energy sources: hydropower does not result in emissions of pollutants into the atmosphere nor does it emit residuals that can have a negative impact on soil, vegetation, drinking water etc. The proposed

hydro power project is carbon zero and contributes to sustainable energy generation targets of the Government of Kenya.

6.3 Project Negative Impacts and Mitigation Measures (Construction Phase):

6.3.1 Impacts of Air Quality (Noise, Vibration)

During construction there will exhaust fumes from vehicles, digging machines, concrete mixers and other fuel-operated machines. There will be heavy equipment engaged for excavating rocks, piling and excavation which cause vibration and excessive noise. This will have an impact on the local community. The existing environment is only noise emanating from the river and the sound of the vehicle movements which is of no impact to the community members. Since the project will have a fleet of vehicles moving with construction materials the vehicular noise will be significant. Relative range of noise form construction equipment is given in the table below table (6.1)

Table 6.1: Relative range of noise levels for some common types of heavy construction machinery

Machinery	Noise levels at distance of 16 m
Compactors (rollers)	71-75
Front loaders	70-83
Backhoes/excavators	70-85
Tractors	78-95
Trucks	83-93
Concrete mixers	75-88
Jack hammers and drills	82-98
Crow bar	115
Compressor	109
Pile drivers (drop hammer type)	110
Pneumatic drill	85

Machinery	Noise levels at distance of 16 m
Excavator	112
Loader	112

Table 6.2: Impact significance due to noise/vibration from construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Medium	Moderate	Definite
	1	4	6	5
	Result: Medium (45)			
Mitigation measures	• The Civil contractors should ensure that equipment which are generating excessive noise should be maintained by replacing old parts, noise should be reduced by installing insulations and using acoustic materials. • The NEMA stipulated Noise Standards need to be complied with. In this regard The National Environment (Noise Standards and Control) Regulations, 2003 issued by NEMA (Under sections 28 and 107 of the National Environment Act Cap 153) 21st March 2003 should be adhered to. • There should be construction work with excessive noise restricted only to day times • All the workers should be provided with ear plugs to prevent them were exposed to excessive vibration and noise. For vibration, the work should be rotated in small cycles.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Minor	Definite
	1	2	2	5
	Result: Low (25)			

6.3.2 Impacts of air quality (Dust)

Clearing of the vegetation along the project structures and excavations is estimated to generate spoils which needs be transported away into spoil dumping yards. There will be cut and fill areas when constructing a long path of Head Race Canal and the Penstock Line for each of the project. Several new but short access roads will be opened up. The surrounding access roads (Existing) are all gravel roads allowing dust in the dry and windy periods. All roads will be busy with a fleet of construction vehicles which will speed when transporting construction materials.

They will have a potential to generate airborne dust particles in terms of Suspended Particulate Matter (SPM), Particulate matter with aerodynamic diameter less than 10 micron (PM_{10}) and less than 2.5 micron ($PM_{2.5}$) The impact will be that the dust will be settled on the crops, home gardens in the close by areas, dust will be a problem for those walking along the roads and the school children. There is also the possibility that dust will settle on the river and that drinking water will be further degraded due to dust. Under very dry and windy weather conditions such an impact is very likely and also the magnitude of dust emission will be heavy. Workers too will be exposed to inhaling dust fumes if the sources of dust tossing are not suppressed.

6.3.3 Impacts due to Gaseous Pollutants from exhaust of vehicles

The gaseous pollutants emission from the exhaust of vehicles servicing the construction activities could be identified as SO_2, NO_x, O_3, CO, HC etc. Gaseous pollutants emission by mechanical equipment and vehicles used for site cleaning, land preparation would lead to slight increased air pollution. However, the contribution from mechanical equipment and vehicular emission are insignificant since the activities are restricted to a shorter period and adequate dispersion is generally available for such emissions.

The presence of significant fine dust particles along with other gaseous pollutant could affect nearby sensitive recipients in the area. Most of the houses are on the road frontage and that elderly persons and small children would be at risk from asthmatic and other respiratory problems that cause by particulate matter.

Furthermore, significant dust with above pollutant would lead to asthmatic and other respiratory problems to the work force too.

Table 6.3: Impact significance of dust and pollutants of exhaust vehicles during construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short	Moderate	Definite
	1	2	6	5
	Result: Medium (45)			

Mitigation measures	• The dust to emit from the explosion of the rocks in the river area will be temporary and can be minimized with the application of proper rock blasting practices. (Using low volumes of explosives & by using machinery such as Breakers)
	• The dust on the access road, excavated areas and the spoils yards can be mitigated by:
	  ○ Paving/tarring the roads
	  ○ Water sprinkling
	  ○ Imposing vehicle speeding limits and reducing speeding especially close to settlements / schools and trade centers.
	• Other measure will be to reduce air quality impacts are:
	• Ensure that all vehicles carrying aggregates etc. should be covered with sheets:
	• All vehicles should be in good condition and ensure that they do not emit black smoke.
	• Creating awareness among vehicle drivers about possible inconveniences due to dust stirring and related social problems;
	• IN addition ensure health & safety of the workers (those unloading cement should be provided with dusk masks)			

Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Minor	Less probable
	1	2	2	3
	Result: Low (15)			

6.4 Water Resources

6.4.1 Impacts of water pollution due to construction work:

River Nyamindi is a source of water (for daily consumption) and for irrigation. Large number people in the villages around the three projects in the cascade use river water for drinking purposes, cattle feeding and also for irrigation purposes. The river already provides irrigation water and also adversely impacted due to illegal water abstractors. During the dry spells of the year the community members depend on river water than any other season. Some local communities also catch fish for consumption.

During the construction it is expected that three (3) numbers of Flow Diversion Weirs will be constructed crossing the river at three locations, requiring rock blasting, deep excavation and clearing of vegetation. There will be boulder removing heavy machinery working in the middle of the river engaged in removing boulders and other activities. Construction of the weir shall require using coffer dam materials. Machinery will also be used for dewatering processes the water of which in turn can be mixed with river water. The result of these activities will be that the water will be further polluted and the down-stream water users will be impacted as a result.

Water quality report has already indicated presence of bacteriological contents. The temporary toilets if constructed close to the river can further increase the bacteriological contents. During construction phase, river water will be polluted with sediments. However, considering the rocky nature of the river channel, this sedimentation will be minimal and temporary.

Table 6.4: Impact significance of river water pollution during construction

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short	Moderate	Definite
	2	2	6	5
	Result: Medium (50)			
Mitigation measures	• During weir construction, and excessive blasting materials should not be used for blasting of rock which will result fly rocks: • During construction, sediment traps will be used.			

	• Water from all dewatering activities should be directed to settlement tanks before they are directed to the river: • All coffer dam materials should be taken out immediately after construction work: • No effluents should be directed to the river (from the wash bay and any other construction sites) • Regular water quality monitoring should be carried out to ensure whether the baseline water quality is affected due to the construction activities • Necessary amounts of water should be released for the downstream communities and for irrigation purposes during construction. • Regulation regarding the necessary distance between the siting of toilets and the water courses should be strictly followed: • Vehicle washing in the river should be stopped			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Minor	Less probable
	1	2	2	3
	Result: Low (15)			

6.5 Solid and Liquid Waste Management

6.5.1 Impacts due to waste generated from the construction site

Waste generated from construction sites is usually of non-hazardous nature. Composition of wastes will include empty plastic bottles (mostly drink/ water bottles), excess fill materials from excavation activities, scrap wood, sawdust, waste concrete, scrap metal, paper, cloths and food scraps which can be recyclable if disposed properly. Other wastes that will be generated include scrap materials from the dismantling of the associated equipment. There will be empty cement bags, oil spills which may be of hazardous nature.

There will also be liquid wastes such as the waste from sewage system (temporary toilets); waste water from the kitchen in temporary labor camps and other waters used for washing purposes. If received by surface water bodies, the water will be polluted. There is a possibility that the vehicle

lubricants, oil and wash bay effluents can contaminate the adjacent water sources during the construction period.

Chemicals, paints, used oil, empty cement bags and empty cans (contained chemicals) can be hazardous wastes needing proper disposal. Management of all hazardous wastes will be crucial to the health and safety of the workers or visitors and to the public. For example poorly disposed wastes could attract vermin to the area and cause pollution of the river water.

Table 6.5: Impact significance of waste generation during construction

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short	Moderate	Definite
	2	2	6	5
	Result: Medium (50)			
Mitigation measures	***Mitigation Measures:*** • Appropriate waste management practices that include: Separation of wastes according to their hazardous and non-hazardous nature and their proper treatment and disposal shall be considered with special attention paid to any hazardous wastes; and • Pollution prevention and waste minimization shall be made key aspects of a wider construction waste management plan. • These shall be supplemented by having waste management facilities e.g. waste containers on site during construction that takes waste segregation into account. • All spoils should be dumped into a designated spoil yard and they should be graded and compacted if they are not used for filling purposes. • The Local authority of the sub location should inform the collection of sewage and other hazardous waste appropriately as per the NEMA stipulated regulations. • Vendors should be registered with the contractor to receive the cement bags and other hazardous waste and their final destination should be closely monitored.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**

With mitigation	Localized	Short	Minor	Less probable
	1	2	2	3
	Result: Low (15)			

6.6 Soil and geology

6.6.1 Impacts due to land preparation activities and impacts on natural drainage pattern

The geological study has revealed that the topography of the area is undulated and is characterized with low hills and ridges to plateau like areas. Valleys affected when the project structures will be built. For example, there will be several aqueducts constructed for the conveyance of water to respective power houses. Existing situation is also that river valley has eroded through fresh basalts and incised valley sections have formed in some sections with rock bluffs on both banks.

Excavation along the river along several places will cause temporary obstruction to the natural surface water relief. Minor pooling of water or ponding can occur due to storm events if proper drainage measures are not implemented. More sediment can be flown into river as the vegetation cover is removed. The tipping of spoils on the river banks can cause also erosion of same into the river.

The newly excavated areas with steep embankments will be prone to mud slides, erosion, during the rainy seasons. The roads in the area are gravel laid but will not be suitable for heavy vehicles during the rainy seasons. These construction activities could adversely affect surrounding drainage system which will impede storm water relief.

Table 6.6: Impact significance of land preparation during construction

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short	Moderate	Definite
	1	2	6	5
	Result: Medium (45)			
Mitigation measures	• The excess spoils generated from the vegetation clearance at the access road, excavated areas and the spoils yards can be mitigated by:			

	• Proper implementation of soil conservation and erosion control strategies such as constructing retain walls and structures; • The natural relief during rains can be restored by opening up of the natural drainage in the construction area; • Immediately after excavation all spoils should be removed from the locations to designated spoil yards; • Drivers / operators should be instructed not to tip spoils along the river embankment; • All excavation at steep embankments should be monitored for soil erosion;			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Minor	Less probable
	1	2	2	3
	Result: Low (15)			

6.7 Project Negative Impacts and Mitigation Measures (Operational Phase)

6.7.1 Impacts to downstream water users due to operations

With construction of the three flow diversion weirs, the sediments that are flowing from the upstream of the river (which is very critical in relation to this river) can impact on the inundation area in the long run. Since sediment loading of the river will be obstructed the downstream will not receive nutrients.

If there will be periodical flushing takes place of the sediments collected at the inundation (impounded areas) downstream water users will be temporarily affected. In addition, river water quality may be changed (Temperature/turbidity).

Tail race water can have a scouring effect on the river bank as the banks are susceptible to erosion. Sudden plant shut downs can cause spillage of water and can endanger the people using the water collection points immediate downstream of the tail race points.

Table 6.7: Significance of impact of river water quantity and quality

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Long Term	Moderate	Definite
	2	4	6	5
	Result: Medium (60)			
Mitigation measures	***Mitigation Measures:*** • Flushing of all the gates of the three projects in regular intervals is necessary to ensure that it will carry sediments to the lower areas; and that inundation area will not be impacted due to sediment collection; • A water quality monitoring programme should be implemented at least every six months to ensure that operational activities of the project will not interfere with the water quality. • To prevent scouring effect the river banks at tail race water releasing pints should be protected with gabion walls. • Water resources related community conflicts should be taken up with the Water Resources Users Association and the Project Grievance Committees. • There should be warning signs at location where people will be collecting water enabling them to be cautious at the time of sudden water releases from spill ways. • All flushing activities should be informed to the community well in advance:			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Long Term	Minor	Less probable
	1	4	2	3
	Result: Low (21)			

6.7.2 Social impacts in the diverted reach of the river due to water abstraction

River Nyamindi is a source of water (for daily consumption) and for irrigation purposes. A large number people in the villages around the cascade (running to around 19 km.) use the water for both drinking purposes, cattle feeding and also for irrigation.

The baseline study revealed that the schools also fetch water from the river and that school children come to the water points. A number of water collecting points is already available in addition to the points at which irrigation waters is abstracted along the diverted reach of the river. The proposed weir location for Mbiri SHPP is a prominent place for water abstraction for both irrigation and for individual purposes.

The river is already used by illegal water abstractors as well. During the dry spells of the year they depend on river water more than any other season. The waters diverted into the project though are reverted back to the river; a cumulative stretch of more than 5 km of the river will be affected due to the diversion of water to these three projects.

The hydrology report has recommended an environmental flow release for each of the projects which take into account the community needs and the riparian vegetation. Nevertheless during the operational phase the community members will have less amount of water for drinking and other recreational purposes especially during the dry spells of the year; Incidences of illegal water abstraction could also be high during the drought. Therefore, there could be social conflicts due to low volumes of water.

Table 6.8: Impact significance of river water abstraction during operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short	Moderate	Probable
	2	2	6	4
	Result: Medium (40)			
Mitigation measures	***Mitigation Measures:*** • It is necessary to provide watering points for the people to abstract sufficient water for their daily use. • Access routes to water collection points should not be blocked by the developer/contractor • Ensure that the environmental flow release is allowed specially the dry spells of the year. Refer recommended flows in the Hydrology Report which is not less tha 90% of mean annual flow. • Work very closely with WRMA and the Water Resources User Association to implement joint programs to improve catchments of the individual hydro power projects by planting trees. • Implement measures introduced by WRMA to monitor abstraction of water to the power generation and submit relevant reports to ARMA as required			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Minor	Less probable
	1	2	2	3
	Result: Low (12)			

6.8 Biodiversity

6.8.1 Impact on Aquatic Biodiversity

6.8.1.1 Construction phase

There are no likely impacts to higher plants in the riparian habitats. However, lower plants may be adversely affected by increased levels of sedimentation that are likely to moderately affect photosynthesis of water submerged liverworts. This will also affect fish as a result of decreased water quality and reduction in the food base. Mosses and hornworts are not likely to be affected.

Table 6.9: Impact significance for aquatic biodiversity loss (lower plants and fish)

due to increased sedimentation - construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short	Moderate	Definite
	1	2	6	5
	Result: Medium (45)			
Mitigation measures	• Retain forest cover in the forested area; (minimize the footprint for vegetation clearence) • Retain existing riparian forests in the agricultural areas; • Establish more riparian forests of indigenous trees or environmental friendly ones in agricultural areas through community assited tree plantong programmes and awareness creation programme. • Monitoring of biological and chemical parameters in the water and in aquatic biota to alert the proponent, relevant Government Agencies and local communities on potential hazards to aquatic habitat. • Rehabilitate all degraded land during and following completion of construction activities			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Minor	Definite
	1	2	2	5
	Result: Low (25)			

6.8.1.2 Operation phase

Decreased water levels will likely affect liverworts because they are water dependent. However, they are capable of adapting to reduced amount of water by migrating and occupying areas with enough water. Similarly most of higher plants are likely to adapt by shifting toward river channel so that they are closer to water. Just like in construction phase, mosses and hornworts are less likely to be affected.

Reduced water levels are also likely to affect fish through reduction in dissolved oxygen, increased sedimentation, and downstream water temperature effects. Water level reduction may also alter the structure and function of riverbanks through reduction of the vegetation, which forms the basis for fish forage. These are also likely to significantly affect fish behavior and habitation. There is also the risk of fish being entrained into the turbines, causing injury and mortality and leading to reduction in the fish population.

Table 6.10: Impact significance for aquatic biodiversity loss (lower plants and fish) due to reduced water levels and fish mortality - operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Medium	Moderate	Definite
	1	3	6	5
	Result: Medium (50)			
Mitigation measures	• Construction of Fish passes to reduce the entrainment and also allow way for migratory fish • Installing systems to discourage fish from entering abstraction equipment, including acoustic barriers, lighting barriers and bubble curtains. • Installation of river gauging system to monitor water flows • Retain forest cover in the forested area • Retain existing riparian forests in the agricultural areas • Establish more riparian forests of indigenous trees or environmental friendly ones in agricultural areas. • Monitoring of biological and chemical parameters in the water and in aquatic biota to alert the proponent, relevant Government Agencies and local communities' on potential hazards to aquatic habitat.			

	• Rehabilitate all degraded land during and following completion of construction activities			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Minor	Definite
	1	2	2	5
	Result: Low (25)			

6.8.2 Impact on Terrestrial Biodiversity

6.8.2.1 Construction Phase

<u>Habitat Loss and modification</u>

During the construction phaseit is expected to clear vegetation which may have a impact on the important biodiversity habitat. The uppermost part of the project where the weir and part of the channel that directs water to the penstock is within the forest reserve. Approximately 200m of the head race canal will go through the forest boundary. Forest trees are expected to be cleared to pave way for construction of the HRC. Some forest birds may be affected by this modification. Herpetofauna microhabitats on the ground such as trees, dead tree trunks and grasses that are home to amphibians and reptiles may be removed. It will also remove the source of food, which are insects eaten by lizards who in turn are eaten by snakes thereby interfering with the food chain. The weir construction is also expected to re-channel water from the natural water channel, leading to modification of the habitat along the river. Species such as the Giant Kingfisher (which forages on the river channel) and African Black Duck (which was observed nesting on the Rocky River banks) may be displaced or their numbers reduced.

Landscaping activities including excavation, compacting flattening of some areas will result in loss of vegetation cover, covering and removal of loose top soils and burrows. This will result in loss of breeding sites for amphibians which congregate on areas where the actual powerhouse building location will be. Vegetation clearance will result in exposure of birds, mammals, macro invertebrates and herpetofauna to predation and road deaths: Cleared vegetation will expose these taxa to their predators as they move across the access roads and in open spaces for the transmission line. The animals maybe crushed on the road by vehicles. This can be higher especially during the wet season when the animals have more movement in search of mates for breeding.

Table 6.11: Impact significance on Habitat loss and modification-construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Long Term	Moderate	Definite
	1	3	6	5
	Result: Medium (50)			
Mitigation measures	• Areas that will not be put to immediate use to be left intact. • Excavation should not be carried out during the rainy(wet) season when animals are breeding • Top soil to be kept aside for use in replanting and landscaping • Together with experts relocate animals that move slowly and found in the site during excavation and clearing • Reestablish original habitat patterns to improve surface water runoffs before commencing operations • Establish erosion prevention measures on sloping areas to prevent soil erosion on loose soils after from excavation. • Avoid using heavy machinery especially in the protected forest areas to prevent extensive damage to the forest • Where possible use already established tracks and roads • Use of human labour (non-mechanized) during construction inside the forest to minimize damage to the forest habitat. • The project proponent should compensate by rehabilitating/ restoring the modified habitat elsewhere			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Low	Less probable
	1	2	4	3
	Result: Low (27)			

6.8.3 Impact on modified forest habitats

The part of the forest reserve where the uppermost part of the project will be constructed (approximately 200m into the forest) consists of tropical montane forest which has been modified through livestock grazing, firewood collection and selective logging. Forest trees will be cleared during construction of the weir and part of the channel that directs water to the penstock along the 200m strip.

Table 6.12: Impact significance on Modified Forest Habitat-construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short Term	Low	High
	1	2	4	4
	Result: Low (28)			
Mitigation measures	• Where possible, avoid use of heavy machinery in the modified forest (use labourers instead) for weir and channel construction • Together with experts relocate animals that move slowly and found in the site during excavation and clearing • Excavated top soil should be kept aside to rehabilitate degraded areas. • Reestablish original habitat patterns to improve surface water runoffs before commencing operations • Establish erosion prevention measures on sloping areas to prevent soil erosion on loose soils after from excavation. • Where possible use already established tracks and roads • The project proponent should compensate by rehabilitating/ restoring the modified habitat elsewhere			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short Term	Low	Improbable
	1	2	4	2
	Result: Low (14)			

Table 6.13: Impact significance on Modified Forest Habitat-operation phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short Term	Low	Improbable
	1	2	4	4
	Result: Low (14)			
Mitigation measures	• Where possible, avoid use of heavy machinery in the modified forest (use labourers instead) for maintenance and other repair works. • Re-plant native trees where possible to re-establish original habitat • Top soil to be kept aside for use in replanting and landscaping • Establish erosion prevention measures on sloping areas to prevent soil erosion on loose soils during operations. • Use already established tracks and roads for inspection and maintenance. • Establish mechanisms for rehabilitating the forest habitat elsewhere.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Very Short	Minor	Improbable
	1	1	2	2
	Result: Low (8)			

6.8.4 Impacts on Population of Threatened Bird Species

The Abbot's Starling (Vulnerable) and Hinde's Babbler (endangered) occur in habitats traversed by the project. The Abbot's Starling is a little-known highland forest dwelling species that occurs between of 1800 to 2500m above sea level (Zimmerman et al., 2000). Some trees may be felled inside the forest during construction of the weir & intake and the HRC which may lead to a small change in forest habitat structure. This species is unlikely to be significantly affected by the project since only c200m of the forest, largely at its edge, will be cleared. The Hinde's Babbler is a Kenyan endemic that forages among *Lantana camara* bushes (and exotic species sometimes considered as invasive). Construction activities of intake, penstock and powerhouse could result in clearance of some Lantana bushes.

Table 6.14: Impacts significance on Abbot's Starling (Vulnerable) and Hinde's Babbler (endangered)

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short Term	Moderate	Probable
	1	2	6	5
	Result: Medium (45)			
Mitigation measures	• Where possible, avoid felling of trees forest while constructing the intake and the channel • Minimize destruction of Lantana camara bushes in the framlands and river valleys during construction • Rehabilitate Hinde's Babbler habitat after construction. • Areas that will not be put to immediate use to be left intact. • Excavation should not be carried out during the rainy (wet) season when animals are breeding. • Top soil to be kept aside for use in replanting and landscaping • Together with experts relocate animals that move slowly and found in the site during excavation and clearing • Reestablish original habitat patterns to improve surface water runoffs before commencing operations • Establish erosion prevention measures on sloping areas to prevent soil erosion on loose soils after from excavation. • Avoid using heavy machinery especially in the protected forest areas to prevent extensive damage to the forest • Where possible use already established tracks and roads			

	• Use of human labour (non-mechanized) during construction inside the forest to minimize damage to the forest habitat. • The project proponent should compensate by rehabilitating/ restoring the modified habitat elsewhere			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Low	Less probable
	1	2	4	3
	Result: Low (27)			

6.8.5 Invasive Species Impacts

The increase in human population, establishment of worker camps and associated activities such as waste generation and disposal is likely to attract and increase populations of scavenging and invasive bird species e.g. Marabou Storks. This will have direct effect on populations of indigenous species of birds through mainly predation as well as risk to public health. During the clearing phase, animals like snakes and lizards will easily move to other areas. However, due to the sudden change of environment there is likely aggression from agitated snakes trying to escape. In addition, the snakes will move to other sites that are near the area. The population of snakes will rise this may lead to competition for available resources leading to hunting near homes and feeding on domesticated animals. Increased snake encounters are likely to workers and the surrounding general population. Reptiles generate a lot of phobia and kills when exposed by these activities can occur.

A construction camp is going to be established holding a number of workers. Waste and new habitats formed will attract lizards and rodents that in turn attract snakes this might cause human life conflict owing to people's phobia for snakes.

During construction a workers camp maybe established which involving feeding facilities that attracts rodents who establish a new home. These animals are prey to other animals like snakes that may visit the campsite. Reptiles being ectothermic and establish their homes in human habitations especially during the rainy and colder seasons as human homes are shielded from these elements.

Table 6.15: Impact significance for invasive species- construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Short Term	Low	Probable
	2	2	4	4
	Result: Low (40)			
Mitigation measures	**Comments/Mitigation:** • Implement habitat monitoring to detect and manage invasive species during the construction phase before habitats are irreversibly modified. • Put in place invasive species control and management program (Manual removal and burning of plants (invasive) • Trap and rid-off the site of any rodents which attract snakes • Educate workers on the harmless nature of reptiles like chameleons and other lizards to remove phobia • Equip with the4 site health venter or the nearby local hospital with anti-venom readily available in Bio-ken Malindi. • All workers be equipped with protective gear like heavy duty shoes and tough pants • Educate local people of dangers from snake bites and how to prevent them • Put in place a proper waste management programme • Dispose all solid waste according to NEMA waste management regulations 2006 and EMCA act 1999			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study Area	Medium term	Moderate	Less Probable
	2	3	3	3
	Result: Low (24)			

6.8.6 Impact of Spillages of chemicals and Oils on the animals

Oils and fuels from machines, generators and vehicles plus other chemicals used during construction and in the operation may accidentally spill on the site. This spillage if collected by rainwater will eventually accumulate and if not well disposed will end up in the river or in other habitats. This will contaminate water and soils and affect especially amphibians that depend on their skin for respiration. This leads to death and low reproduction due to the eggs and larval stages not getting enough air thus population changes (Mahaney, 1994, Akani et al. 2004). Lubricating the turbines and other moveable parts requires use of oils.

Table 6.16: Impact significance of spillage of chemicals and oils on animals -Construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Medium Term	Moderate	Definite
	1	3	6	5
	Result: Medium (50)			
Mitigation measures	**Comments/Mitigation:** Preventive measures as follows should be adopted not to pollute river water which will harm the animals: • A log of all dangerous chemicals be kept, how to be used, transported stored and disposed • Keep all dangerous chemicals, oils, greases, solvents, and residues in a strong room. • Have a containment and disposal plan for all hazardous material (where to dispose) • All oils and hazardous materials disposed of according to NEMA waste management regulations 2006 and EMCA act 1999			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Long Term	Low	Probable

	1	4	3	3
	Result: Low (24)			

6.8.7 Dust and exhaust particles pollution and their impact on herpetofauna

During construction there will exhaust fumes from vehicles, digging machines, concrete mixers and other fuel-operated machines. Another source of dust is from vehicles transporting construction material to the construction site. Other processes like excavation, mixing of mortar and blasting of rocks produce a lot of dust. All these forms of pollution may affect herpetofauna breathing systems. It may also affect by impeding sight and so slowing down movement and escape from danger of predation. Amphibians, which breathe through their skin and need to keep their skins moist for this purpose, are likely to be affected. Chameleons that rely on clean vegetation for dew and attraction of insects as food will suffer due to dust accumulating on plants.

Table 6.17: Impact significance for dust and exhaust particles pollution - Construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Medium Term	Moderate	Highly probable
	2	3	6	5
	Result: Medium (55)			
Mitigation measures	**Comments/Mitigation:** • Sprinklers to be used to reduce dust when work involving dust is to be carried out • Vehicle speed set at limits of 30 to 40 KPH • Set units like generators in areas where winds will blow most of the smoke away • Type of fuels to be used should be low Sulphur and unleaded fuels avoid heavy industrial oils			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**

With mitigation	Study Area	Medium Term	Low	Highly probable
	1	3	4	4
	Result: Medium (32)			

6.8.7.1 Operational Phase

<u>Reduction of riparian diversity</u>

A number of species depend on riparian habitat for their survival, including various species of birds (e.g. African Black duck-also observed nesting in the river banks- and Giant King Fisher) some animals such as the grass frogs and the river frogs depend on flooding for their survival. When the river overflow then recedes, it forms pools of water in areas along the river. These frogs use these pools to hide during the day and lay eggs which, then hatch into tadpoles. However, when water is abstracted from the river and channeled to the turbines the volumes of water below the weir (intake) will not experience the normal flows during the rainy season when there is flooding. The reduction of water resultant from the removing water from the river to the canal will lead to this pools not forming normally therefore, the natural lifecycle of the river life below the intake will be broken.

Table 6.18: Impact significance for reduction of riparian biodiversity -operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability	
Without mitigation	Study Area	Long Term	Moderate	Probable	
	1	4	6	3	
	Result: Medium (33)				
Mitigation measures	**Comments/Mitigation:**				

	• All oils, hazardous materials and water disposed of according to NEMA Waste Management Regulations of 2006 and EMCA Act 1999 • Ensure a environmental flow with sufficient quantity allowed to flow back into the river as per agreed uptake quantities • Restriction of abstraction of water from river in the areas between the uptake and the powerhouses. • Have a standard operating procedure manual on how to deal with spills and how to prevent them • Have a spills response team? • Train worker on spills and how to deal with them				
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**	
With mitigation	Study Area	Long Term	Minor	Probable	
	1	4	2	3	
	Result: Low (21)				

6.9 Social-economic and cultural heritage environment

6.9.1 Social Impacts due to land acquisition and resultant economic displacement:

The proposed development projects will require at least 60 acres of land for purpose of constructing its structures and access roads. Another 0.9 acres of land will be used to construct poles for the power evacuation line. Land belongs to the individuals, the Coffee and Tea Factories and / or the Kenya Forest Services. Household income of almost of the people in the project area depends on the income received from agricultural products and working on the Tea plantation areas. The land acquisition will deprive the people's total HH income even if they will be paid

compensation. When the tea cultivated areas will be reduced, it will have an impact on the income of the people.

Table 6.19: Impact significance due to land acquisition

Mitigation Status	Extent	Duration	Magnitude	Probability	
Without mitigation	Study Area	Long Term	Moderate	Definite	
	2	4	6	5	
	Result: High (60>)				
Mitigation measures	**Comments/Mitigation.** • A RAP need to be developed. Mutual agreement with the affected land owners for payment of compensation will be considered. • All affected persons should be adequately compensated for the land, taking into consideration IFC PS 5 which calls for provision of land for land. All PAPs will be paid compensation at full replacement cost after a proper valuation of the land to be affected. Land areas used for poles will be compensated separately. • Provide employment opportunities during the construction phase to more people from the local area and pay suitable remuneration; • Assist the vulnerable / poor HHs in the ways possible to restore their previous incomes (through implementation of the livelihood improvement plan)				
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**	
With mitigation	Study Area	Long Term	Minor	Less probable	
	1	4	2	3	

	Result: Low (27)	

6.9.2 Social Impacts on people's subsistence livelihoods: Construction phase

There will be indirect project affected persons who will be affected by the excavation work, blasting work through which their crops / animals can sustain losses/damages. The fisherman can lose subsistence income from the fishing activities during the construction as well as operational phases. Land required for the temporary structures will be obtained by the Developer on long leaseholds. The owners will deprive their seasonal income although they will be paid for the leasehold. The work environment while the construction of three projects run parallel will have adverse impacts on the crops on other lands due to accidents, falling of debris etc.

The subsistence livelihood sources of income such as from bee keeping practices can be impacted due to construction activities along the river. There will be loss of livelihood income as a result of diversion of water. Baseline information indicated that a majority of families in the sub location are peasant farmers, and that a significant proportion of the land.

Table 6.20: Impact significance due to construction activities interfering people's livelihoods

Mitigation Status	Extent	Duration	Magnitude	Probability	
Without mitigation	Study Area	Long Term	Moderate	Definite	
	1	4	6	5	
	Result: Medium (55>)				
Mitigation measures	**Comments/Mitigation:** • All leased lands should be paid proper compensation and help those people as to use productive the money received by them; • A grievance procedure should be put in place enabling the affected people to register their concerns and to seek redress. • All crop damages during construction should be promptly compensated;				

	• Those who are earning from activities such as bee keeping should be provided with sustainable options / training and linking them to other income generating activities. • After introducing alternative IGAs there should be a proper monitoring programme				
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**	
With mitigation	Study Area	Long Term	Minor	Probable	
	1	4	2	2	
	Result: Low (14)				

6.9.3 Social Impacts arising from influx of people to the project area:

The project during the construction phase will engage a large work force. While some of them will be from the local areas other will be migrating to the local areas from other locations and sub locations. In addition, there will be in migrating labor for various support services. The suppliers of construction materials send drivers/assistants to the site areas that may spend at least one or two days in the local arrears until they are released after unloading of the materials that they transport. Their presence will help increasing the incidence of HIV Aids due to social relationships that can happen. Already the area has recorded a growth of the prevalence of AIDS by 15% according to the health officials. Lack of awareness and not having any strict measures will lead to this situation. The impact will be that the children and the population in general in the project area can have more HIV affected persons. The area has very limited facilities for HIV tests and one needs to travel at least 10-15 km for a suitable hospital.

Table 6.21: Impact significance due to influx of workers

Mitigation Status	Extent	Duration	Magnitude	Probability	
Without mitigation	Study Area	Long Term	Moderate	Definite	

	1	4	6	5	
	Result: Medium (55>)				
Mitigation measures	**Comments/Mitigation:** • Either a health center at the site or in the sub location should be opened / improved to provide necessary health care to the workers and those affected by the project. • Workers should be provided with continuous awareness on HIV AIDS. • Workers should be tested for HIV on a regular basis: • There should be community awareness programs conducted by the project (Environmental Officers) on HIV AIDS • All possible actions should be taken to prevent other diseases that may arise due to the project activities.				
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**	
With mitigation	Study Area	Long Term	Minor	Probable	
	1	4	2	2	
	Result: Low (14)				

6.9.4 Occupational Health and Safety Impacts on the workers:

There will be a workforce of 400-500 working on all three projects during the construction phase at its peak (if the three projects overlap their construction activities). They will be involved in construction activities which may be injurious and accident prone. Especially working in an environment in the forest area makes them exposed to threats from wild life. Working on high-rise platforms when constructing the weirs, power houses, can have the risks of falls unless they

are provided with required training and safety equipment. Rock blasting, chipping of rocks, etc. will cause unexpected injuries and accidents. In summary, the workers may be exposed to:

- Burns (Welding/hot works, etc.)
- Falls from working at heights or wet surfaces
- Electrocution
- Injury from fly rock e.g. at quarry sites or debris
- Noise and body vibration from equipment;
- Inhale of obnoxious gases
- Exposure to wild life threats

Table 6.22: Impact significance due to lack of safety in the work environment

Mitigation Status	Extent	Duration	Magnitude	Probability	
Without mitigation	Study Area	Long Term	Moderate	Definite	
	1	4	6	5	
	Result: Medium (55>)				
Mitigation measures	**Comments/Mitigation:** The Civil contractors need to ensure safe working environment to the workers with the following: • Safety for workers from wild life when working in the forest area: (Provide Guards) • Safe constructional equipment and work methods • Safe handling, storage, transport and disposal of materials in a way that avoids risk to workers • Provision of protective gear (PPE) • Conducting safety awareness among all workers (Introducing Tool Box Meetings) • Control harmful insects/ vectors (including mosquitoes and houseflies) • Introduce incident / accident reporting procedure				

	• Control contagious diseases (e.g. Cholera) through proper sanitation and awareness • Provide workers drinking water; flush type toilets and running water and suitable place • Ensure that the work site displays safety messages and maintain good housekeeping practices • Ensure that fire extinguishers are placed in areas where there will be fire possible. • Provide site clinic for health care of the workers				
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**	
With mitigation	Study Area	Long Term	Minor	Probable	
	1	4	2	2	
	Result: Low (14)				

6.9.4.1 Impacts on Occupational Health and Safety & Security (Operational Phase)

The project will have only a limited number of work-force during the operation phase. They will work in the three Weirs (Operating Trash Tracts), Forebay and in the Power House (Operating the Plant & Machinery) There will be emergencies, work related accidents and health issues for which immediate responses will not be possible in view of poor health services and poor road conditions in the area. In terms of noise, the only significant noise will be the noise emanating from the turbines of the power house. The operators engaged in the PH will be exposed to noise. The weir of the first project will be in the forest area. The operators at the tracsh trcat will be exposed to wild life attacks.

Table 6.23: Impact significance due to lack of safety in the work environment

Mitigation Status	Extent	Duration	Magnitude	Probability	
Without mitigation	Study Area	Long Term	Moderate	Definite	
	1	4	6	5	
	Result: Medium (55>)				
Mitigation measures	**Comments/Mitigation:** The Developer should ensure that: • Implement emergency preparedness plan to be executed at a time of floods and impromptu plant shut downs: a fully stocked and easily accessible first aid kit/ contact list / communication equipment etc. • Carry out regular noise monitoring and provide workers with medical examinations / health advise regularly • Mock drills for the staff will be conducted regularly. • Safety signage to communicate health and safety instructions which include; mandatory use of PPE and restricting unauthorized access to the power house will be installed. • Adequate security measures will be readily availed at the areas where there will be wild life attack.				
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**	
With mitigation	Study Area	Long Term	Minor	Probable	
	1	4	2	2	
	Result: Low (14)				

6.9.5 Public Safety due to vehicular traffic and other construction activities:

During the construction phase, the local roads will be very busy with vehicular traffic. It will have safety risks particularly to those children who walk to schools. Most of the houses too are sited on road frontage and sudden appearance of speeding vehicles can cause accidents and injuries. Increased vehicular traffic, construction work that will impact on the public receptors (such as schools, trade centres, health centres) and the obstruction which are temporary for vehicular traffic are impacts that need to be addressed.

Construction activities such as use of explosives can impact on public safety as most farmers are worlkimng on the vegetable plots during day time. Rock blasting can cause noise pollution as well as injuries to the community working in the nearby crop lands. During the construction of three weirs, there will be inundation areas created at least under Project No. (2) and (3). The river at which weir will be constructed in project (2) is a gorge. The weir in the project No (3) is in the immediate surroundings of those who come to the watering points.

Further, construction of the respective HRCs and penstock paths which cut across several of the motorable roads can impact on the community access roads and areas which are used by the community members who are engaged in cultivation.

Table 6.24: Impact significance due to lack of public safety

Mitigation Status	Extent	Duration	Magnitude	Probability	
Without mitigation	Study Area	Long Term	Moderate	Definite	
	1	4	6	5	
	Result: Medium (55>)				
Mitigation measures	**Comments/Mitigation:** The Developer should ensure that: • During construction of the canal and penstock path along or across the roads should be provided with diversions in consultation with the areas traffic police, well in advance				

	• Approval should be obtained from the local authorities when the excavations are carried out along the roads; • Driver awareness will be essential enabling them to be cautious when driving through trade centers, public receptors and areas cultivated by the community members: • Any damage caused to private or community property whether accidentally or with intent shall be swiftly compensated at a rate agreed on between the property owner and the contractor in accordance with the law. In case of failure to come to an agreement the affected person(s) will be free to appeal for assistance through the courts of law; • Community should be pre warned on the times of using explosives for rock blasting purposes; • Construction close to the watering points should be enclosed with protective fences for public to be kept away from areas under excavation. • Alternative sources of water should be made available, if the community members are unable to access to water during construction times.				
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**	
With mitigation	Study Area	Short Term	Minor	Probable	
	1	2	2	2	
	Result: Low (14)				

6.10 Impact on archeological artifacts

There was no evidence of either paleontological or archaeological sites found around the proposed project area. Experience elsewhere proves that the communities bury their dead along the home yards and that tombs are revered. However, in this area, the communities were unable

to provide any information on such issues. Therefore, although no archaeological sites were found; its advised that if found during the excavations and construction, the contractor will take responsibility to notify the local council and the relevant government department (department of antiquities) who will advise on the next steps to be followed.

7 ALTERATIVES TO DEVELOPMENT

7.1 Alternative for the development

The following alternative aspects are considered in the initial feasibility assessment for the proposed developments.

- Technology: relates to improved efficiencies in an operation
- Location: what is the best site for the proposed development and any infrastructure associated with it.
- Project Impacts to peoples' assets and sources of livelihoods
- No-go option: implications of not preceding with the project.

7.1.1 Project Technology

Electricity production from hydropower has been, and still is today, is a widely recognized practice. However, the proposed development project consists of the development of the cascade of River Nyamindi with three run –of-the-river projects. The projects will not have Dams that facilitate large reservoirs. In the case of the large hydro power projects, there are conventional dams with its consequential environmental and social issues which are much complex than that of the issues face by the small hydro power projects of run of the river nature.

The flow diversions weirs are small concrete gravity structures with a height generally not more than two to three meters from the bottom of the river (river bed). They are well equipped with environmental flow pipes to release the environmental flow and spillage of water is allowed during rainy season. The waters after generating power will be flowing into the same river meaning no or relatively small quantity of water is stored. Therefore dseveloping a single project with a large dam as against the construction of the small ydro power projects along the cascade was evaluated in the initial fasibility and was the latter was confirmed more environmentally sustainable.

7.1.2 Project Location

The hydro power generating installations will be situated close to water cascades and falls. These areas are normally steep and rarely visited by people. Along the cascade there are several locations which have potential for small hydro power projects. But the options were weighed and most suitable locations have been identified for the proposed projects based on optimum hydrology, minimum environmental and social impacts. Three projects have been decided upon after assessing six (6) options. Optimum generation capacity that could be harnessed for each of the project, minimum environmental and social impacts are key considerations when alternatives sites were identified.

In respect of Project Gitie , alternatives for the site locations were assessed after reviewing a layout combining two small hydro power projects (as option 1) and to have two small projects in the same stretch as option 2. Option (1) was selected based on the geology, geotechnical consideration of the locality as well as minimal impact on forest biodiversity. As demonstrated above, the 200m stretch of forest that will be affected is already modified by human-forestry activities of grazing and firewood collection.

The location for the weir of this project is in the forest area. An alternative could have been that the weir could have been located outside the forest land. Having carried out a detailed hydrological studies, the weir location was decided at the current location (with 200 m interir to the forest from its boundary), which will give the necessary elevation to have sufficient head to generate the optimum capacity of energy. Had the weir been shifted to a lower location avoiding the forest, it would have resulted a lower head and the resultant capacity of enengy produced with a reduced head could have been much less and would not have been vialble considering the construction cost and other variables.

In respect of Project No (2) the penstock path could have been taken two alternative routes one of which was to construct the penstock path along the community road sandwiched between the main road and the houses. The second option was to construct the path well beyond the community road. In option (2) there is no physical displacement whereas in option (1) the public would be inconvenienced due to number of houses to be affected. Option (2) was decided upon.

In respect of project (3) the project location was assessed for two options. Option 1 was to construct one project with the Power House located just upstream of the weir of the proposed Rianjue Hydro Power Project, which is currently in an abandoned state. In this context, following the run-of–the-river principle, the Rianjue Project could be operated if re-activated. However, since the river drops rapidly after this Weir, there is an opportunity to make use of this drop to increase the head (if the Power House is located downstream of the Weir). Therefore, if Option 2 is decided upon, the Rianjue Project would have to be abandoned as the water would be released back into the river only downstream of that Weir. As far as the penstock pipes line was concerned, in Option 1, the final 60m of the Penstock would need to be traversed along a steep terrain, and the water is discharged back into the river upstream of the Rianjue Project Weir. In Option 2, the Penstock would be extended further, to discharge the water back into the river, downstream of the Rianjue Project Weir. The location options were assessed in respect of project (3) is to ensure a higher head which will increase the capacity for electricity generation.

7.1.3 Project Impacts to Peoples' Assets and Sources of Livelihoods

Acquisition of land for development of infrastructures will follow the laid down legal frameworks that are nationally and internationally accepted. During the Resettlement Action Plan IFC PS 5 will

be triggered. Neighboring environs that will be influenced by this project fall within private lands where owners practice agriculture (coffee, tea, food crops, fruit trees and livestock rearing).

7.1.4 No-go Option

The No-project or No Action scenario will mean the status quo of the area remains and no occurrence of adverse impacts as well as positive impacts posed by the project implementation. "No-action" would mean the proposed activity would not take place, and the resulting environmental effects from taking no action would be compared with the effects of permitting the proposed activity or an alternative activity to go forward. The “no-action” alternative is developed for two reasons. It is almost always a viable choice in the range of reasonable alternatives, and it sets a baseline of existing impact continued into the future against which to compare impacts of action alternatives.

Basically, the Government of Kenya is engaged in building its energy generation capacities with increased reliance on renewable energy as very attractive to accomplish sustainable development objectives. In this context, it is essential private sector participation in harnessing existing hydro sources for the small scale hydro power development projects possible to go hand in hand with proposed large scale energy generation projects. In the absence of the Project, equivalent amount of energy has to be fulfilled by other means – most likely by the thermal power options which not only absorb foreign currency but also adversely impact on the environment. Both thermal alternatives – oil fired and coal fired – would result emissions of CO_2, SO_x, NO_x and particulates. With the project that generates 18.6 MW of electricity using hydro resources, it can be firmly argued that an equivalent emission would be saved. Further, under the No action alternative, the disparity between the minimum and maximum daily power demand will continue to increase. The continued increase in the base-load demand for the grid will increase the frequency and duration of power outages and load shedding. This will impact economic development of the area and hinder poverty reduction efforts.

At the local level No Action option would mean, the communities will have no socio economic impacts due to loss of land. However, there will be no generation of employment opportunities which can facilitate expansion of business activities that would have been spurred by availability of electric power. In summary, any decision of not proceeding with the proposed projects would mean no environmental and social impacts on the environment. On the other hand this means that the country will be unable to harness its existing hydropower poterntial and sources to its full capacity denying the Government of Kenya to generate and meet demand for electricity. Also likely to be missed are conservation initiatives to be associated with this project in the near future. They could be the promotion of farm forestry, enhanced conservation of biodiversity influencing Mt. Kenya and the riparian forests along River Nyamindi.

8 OVERVIEW OF THE SEP, GM AND RAP

8.1 Stakeholder engagement activities undertaken

Table 8.1: Record of past stakeholders engagements

Stakeholder Group	Stakeholder meeting and engagement purposes
NEMA (Kirinyaga County Office)	Meetings held on the 7th February 2017: Main stakeholders as far as approval for the EIA are concerned. They are consulted to appraise the status of the EIA report and to receive advice on the policy direction.
WRMA (Kirinyaga County Office)	Meeting held on 7th February 2017: Main stakeholder as far as river water use for hydro power purposes is concerned. They are consulted on the matters concerning the water abstraction and the measures to be adopted for any impact mitigation.
Kenya Forest Service	Meeting held on 6th February 2017: Main stakeholder regarding the ownership of land of the forest impacted areas. Need to consult them on land lease from forest areas; security for the construction crew (from wild life); acquisition of access road to weir and intake area of the project (1)
Chief of Location	Meeting held on 8th February 2017; The authority for the development works in the location. To obtain location based information to assess the existing environment. Need to keep him informed and the approvals and support is essential.
Health Officials in the Sub Location	Meeting held on 9th February 2017: To understand the baseline health status of the area; to assess the level of communicable diseases or other diseases such as HIV Aids for taking precautionary action.
Educational Officials in the Sub Location	Meeting held on 9th February 2017: To understand the baseline educational status of the area; to assess the level of impacts to the educational centers in the sub location to make mitigation action.

Community members of the sub Location	Meeting held on 7th 8th and 9th February 2017: To keep them aware of the project; to solicit their support and to keep informed of the procedure related to land acquisition. Future engagement is necessary for land acquisition and for Grievance Management
Water Users Association of the Sub Location	Meeting held on 9th February 2017: To ensure that water members of the association arte well aware of the project and the project will work in close harmony and that no party will interfere with the other
Officials running coffee/tea factories in project locations	Meeting held on 7th& 9th February 2017: Where the land is owned by the coffee or tea factories, it is essential to negotiate with them when acquiring land.

8.2 Stakeholder Engagement Plan (SEP)

It is evident that different stakeholders having stakes to the project at several stages need to be properly engaged during the construction and operation of the small hydropower project. The engagement will range from keeping them informed to the level of engaging them in making decisions where consultation and dialogue will be essential.

Table 8.2: Key stakholders and their relative importnace

Key Stakeholder (SH)	Level of relative Importance
Key Officials in the relevant Government Ministries & Departments: (Kenya Power, NEMA WRMA)	Primary : On policy and regulatory matters regarding the approvals, land transfers and tariff payments etc.
Donors / Financiers of the project	Primary: On matters regarding the Investment Capital ; project sustainability

Communities (Land Owners who will be affected) in the project area	High Priority / Primary SH due to land acquisition, disclosure and compensation payment; issue arising from the payment of compensation
Users of the community access roads; water users; fishing community; close by school children	Priority Primary (SH) due to being affected by construction of project's associated structures, access roads , Safety concerns;
County representative of government agencies such as NEMA, WRMA,	Priority (Primary SH) due to being statutory agencies involved in approving permits, licenses and all policy decisions; River water monitoring and compliance monitoring
Location / Sub Location Officials	Primary SH; they being in charge of location level policy decisions LC (5) institution is important in view of its capability to harness political will for the project.
General public including School Children and motorists, (affected by dust, noise and other project related construction impacts)	Secondary SH, they being(potential workers, those who seek employment & job opportunities, other benefits such as electricity to provide HIV Awareness; Safety Measures
NGOs ; Community based originations such as SACO	Secondary SH; Awareness creation , pressure Groups

Whilst, it is the duty of the project management to attend promptly to various statutory requirements which need close communication with the key officers of the institutions based in Nairobi (NEMA Head Office, Kenya Power; and related Department and Ministries, at the project site, there should be a proper stakeholder engagement plan. The plan should enable the above key stakeholders:

1. To have reports on a regular basis informing them of the level of compliance to environmental mitigation actions as underlined in the EIA report; Monitoring of the actions in the EMP

2. To have information regarding the project disbursement and expenses as stipulated by project donors / financiers.
3. To share information and to keep the parties aware of the project status through regular visits as required by the County officials;
4. To inform the community members about the payment of compensation etc. through regular meetings;
5. To involve the community members (through participation in the Grievance Committee)

8.3 Grievance Redress Mechanisms

In practice, grievances and disputes that are most likely during construction of the small hydro power projects are:

- Grievances pertaining to payment of compensation namely:
- Misidentification of assets or mistakes in valuing them;
- Disputes over plot limits, either between the affected person and the Project, or between two neighbors;
- Dispute over the ownership of a given asset (two individuals claim to be the owner of this asset);
- Disagreement over the valuation (either the unit rate applied or the count) of a plot or other asset;

Other unplanned situations such as:

- Crop damages:
- Worker disputes with the community members
- Impacts on livelihoods of the people due to construction
- Accidents and Incidents

<u>Functions of the Grievance Redress Committee:</u>

The main function of the GC will be to conduct arbitration and negotiation based on transparent and fair hearing of the cases of the parties in dispute between PAPs and the Project contractor/developer. The committee gives solution to grievances related to compensation amount, delays in compensation payment or provision of different type of resettlement assistance. Dissatisfactions may arise through the process of compensation for a variety of reasons, including disagreement on the compensation value during valuation for assets, and controversial issue on property ownership etc.

The GRC will be convened at least once in three months (depending on the urgency of the issues to be redressed) during the construction phase of the project. All committee proceedings of the GRC will be recorded and files will be maintained for future reference. The Developer will arrange

paying suitable seating allowance for the committee members in order to sustain their interest in the committee meetings.

8.3.1 Grievance Redressing Committee (GRCs)

A Grievance Redress Committees to be formed under each of the project to address the above issues. The wider consensus of all the project affected persons is required to form the Grievance Committee members. Two females may be appointed in order to ensure that the committee is well represented. The commitees will be formed after the cadesrtral map is drawn in which project affected persons will be best identified.

Procedure for investigating grievances:

The appointment of a GRC can be best done when the PAPs are identified. Grievance redress committee can work hand in hand with the site Contractor / developer's staff in resolving any grievance. The grievance can be verbally informed or can be registered in the Grievance Register which is kept at the Project office or with a member of the GC. The committee needs to examines the particular grievance or compliant and responds within a period of 15 days from the time the grievance was registered. If the PAPs are not satisfied with the decision of the Grievance Redress Committee (GRC) PAPs can seek justice from the Mediation Committee to be established at the sub location.

8.4 Resettlement Action Plan (RAP)

RAP will be preperaed only after the cadestral (Strip) map of the project will be completed. The total land area that will be affected permenantly by the project's land acquisition will be around 60 Acres (24 ha). All the land owners affected will be paid compensation at full replacement cost as per the IFC PS (5)

8.5 Guidelines for the RAP

During the preparation of the RAP, necessary guidelines will be drawn from the statutory instruments of the Government of Kenya and the IFC performance Standards.

9 CUMMULATIVE IMPACT ASSESSMENT

9.1 Approach taken to assess cumulative impacts

Cumulative impacts are those that result from the incremental impact of a project when added to other existing, planned, and/or reasonably predictable future projects and developments. Cumulative impacts are limited to those impacts generally recognized as important on the basis of scientific concerns and/or concerns from Affected Communities. In the cascade cumulative impacts can be discussed under two different scenarios.

One is that by taking each small hydro power project in the cascade as an individual project, incremental impacts are discussed taking into consideration the impacts which may occur from each of the individual hydro power projects in the cascade, when the three will be overlapping of the construction schedules.

Second method is to consider the impacts of the three projects as producing overall impact of the development activity and discuss any other incremental impacts arising from an additional project or projects that will be planned in the future. Any project that will necessitate either water abstraction from the same river or any resource utilization in the same locality, if occurs during the operational stage of the SHPPs can fall into this category. But considering the time needed to implement impact mitigation actions of the impacts to arise from the prosed Nyamindi River Cascade development and the time taken to initiate new projects in the area, occurrence of this scenario will be most unlikely.

In assessing the cumulative impacts, the findings of special studies carried out by team members were analyzed, the discussions with the key stakeholders too were considered. They were considered in relation to the spatial boundaries of the proposed cascade development. Mainly the analysis is based on expert judgment.

9.2 Spatial and temporal boundaries

Spatially the three projects stretch from the weir location of the project (1) Gitie to the tail race of Project (3) Mbiri. Longitudinally the river stretch between these two locations is around 19 km. The construction plan shall span over a three-year period in which construction stages of all three projects may overlap during certain period of time. The cumulative local impacts of the project will be significant during such periods. In terms of temporal boundaries, the projects' operations during the rainy spells of the year will also need to be considered as having significant impacts on areas of high floods, s and motorability along the access roads, whereas in the dry spell the cumulative impacts will be more on river water abstractions. During the construction phase climatic variation can have impacts on soils, surface relief when rain fall is heavy and exposure to

areas which are cleared of vegetation will be extensive. Specific assessment of potential cumulative impacts is described below:

9.2.1 Geology and soils

9.2.1.1 Weir locations

The geology and soils related cumulative impacts of the project may be triggered due to disturbances of soil structures along the river at several weir locations which will show signs of breach during a high flood seasons. Cumulative impact nevertheless is not significant in view of the fact that the weirs will be small concrete gravity structures which accommodate the adequate spillage of water with their run of the river nature of individual projects. Weir inundation areas will not have a major impact as the weirs are located at least within a distance of 1 km or more from the tail race of the other project's inundation area.

9.2.1.2 Powerhouse locations

Some of the powerhouse locations fall on river flood plain terraces where thick deposits of alluvial material can be expected. No significant cumulative impacts are expected as they will be located far apart. During operations a plant shutdown of one project will not have a cumulative impact on the other as spill ways will allows water to flow into the other project in the cascade.

9.2.2 Water resources

There can be a combined reduction of flow volumes and flow velocity of the river within the cascade especially in the diverted reach. This could further be aggravated due to diversion of water to the existing irrigation purposes. The stretch will be fed through several feeder streams and the environmental flow release which may to some extent mitigate the cumulative impacts. However, had there been any further irrigation schemes or piped water schemes approved in the same catchments, cumulative impact may be high.

9.2.3 Waste

Cumulative impact arising from construction waste will include sewage and spoils mainly from individual projects when the projects are constructed simultaneously. Waste streams will be numerous, for example there can be several temporary toilets which can be sited along the areas where construction sites are spatially distributed. They need to be sited away from the water courses. Tipping of spoils close to the river banks can impact on the surface water quality. Cumulative impacts will be significant if the construction contractors adopt different construction practices when managing construction wastes. During the construction stage dewatering activities can have impacts on the river water quality if construction activities can run parallel to each other. Since there are no other sources of wastes envisaged from large scale projects in the

same locality, the cumulative impacts can be minimized by proper application of the mitigations actions proposed in the EIA Report.

9.2.4 Biodiversity

Biodiversity-related cumulative impacts for this project include those related to construction of the transmission line to Kenya Power owned Kutus sub-station, water abstraction for domestic use and waste management as a result of an increased human population during construction and operation activities. Depending on whether these activities will take place at the same time, the cumulative impact on biodiversity will be in form of loss of vegetation cover, habitat loss and declining species populations. Meanwhile activities associated construction of transmission lines to Kutus sub-station will be through private owned farmlands and minimal vegetation and habitats will be affected.

9.2.5 Involuntary resettlement

Any cumulative impacts due to involuntary resettlements will be explored at the time when the RAP will be prepared and when baseline information will be collected. If the very same PAPS will be affected during the land acquisition, it will be necessary to evaluate the cumulative impacts in terms of income loss.

The use of land for the construction of poles along private lands will be compensated and the way leave will be maintained. Cumulative impacts may occur during the way leave maintenance as the community members will not be able to use the land within way leave for permenant crops and structures.

9.2.6 Population increase

The population increase will be an indirect impact due to the increased development activities in the area. With development of the area with three hydropower projects, there will be a conducive situation that will allow more industries to come to the area, price escalation of the land and property and immigration of the population. Cumulative impact on land price will be favorable for the land owners in the area. While such positive impacts could be seen as cumulative impacts there could also be adverse cumulative impacts will be in the form of more pressure the existing infrastructure such as roads and service delivery systems such as electricity, health, education and piped water services in local areas.

9.2.7 Cultural heritage

Exploitation or more pressure on cultural heritage is not considered important in view of the absence of important cultural site in the area. However, during the excavation work of the areas

under all the three projects, it will result in exhuming burials; the cumulative impacts on the same will be high. A chance find procedure needs to be introduced before construction.

9.2.8 Economy and employment

Cumulative impacts on the economy and employment will be positive, which has both short term and long term results. Attraction to the employment by the labor force in various employment opportunities in this project may have an impact on the economic activities such as the labor requirement needs for tea plantation. Cumulative impact will be negative if the tea sector will run short of adequate labor which will have an impact on the regional economy. However given the fact that people are in need of employment opportunities, it is expected that labor requirements to tea plantation activities will not be affected. The cumulative impact on the Coffee industry can be marginally expected as land is mostly under Coffee cultivation.

9.2.9 Pollution:

Pollution of river water will be high during the dry spells of the year when the water will be added with chemicals that are used for cultivation purposes (vegetable cultivation) by the surrounding farmers. Since the water is passing through three hydro power generation points some possibility of adding pollutants is expected (oil and grease). The level of pollution can be high if the toxic chemical properties of fertilizer will be mixed up when the same is eroded into the river.

9.2.10 Occupational Health and Safety

Cumulative impacts of health and impacts on the workers will be high if the three projects will be constructed parallel and that workers are spread thinly in all projects. For the public too, the safety will be an issue as construction vehicles will travel very close intervals along roads which are not used to have such traffic. High level of cumulative impacts can be expected when the construction of the power evacuation line will be commenced.

10 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

10.1 Introduction

The preparation of the ESMP is guided by the environmental regulations laws and policies and social safe guard policies and strategies, the county environmental sector strategies and action plans of the Government of Kenya.

In addition, the IFC Performance Standards on Social and Environmental Sustainability, 2012, adopted by the International Finance Corporation (IFC) mandates the need for compliance monitoring and reporting of environmental and social impact mitigation of the development projects which are categorized as causing environmental and social impacts.

The ESMP is intended to be used during the full project life cycle to ensure that the project is compliant with all the regulatory and monitoring procedures and standards. It is also intended to ensure that any positive project impacts can be further harnessed to ensuring long term sustainability of the project. ResponsAbility Africa being the developer, through the civil contractor/s, will have the overall responsibility in implementing the management plan ensuring adequate compliance.

The ESMP will also serve as a ready reference to the developer, the key stakeholders namely contractors, sub-contractors, external consultants and other statutory agencies in the county and in the ventral agencies, in order to ensure that the project adopts a strategic approach to mitigate environmental, health and safety impacts of the project according to accepted guidelines and best practices.

Implementation of the ESMP is therefore essential as a measure to be accountable to the requirements identified by those lead agencies. Success of the implementation of the ESMP lies in the willingness to take action by the contractor/s and the sub-contractor/s as well as the staff engaged in all the phases of the project's life cycle. The ESMP can be revised, amended after reviewing the periodical progress, in case any further improvements will be required.

Regular monitoring and reporting is also essential enabling the lead agencies to be aware that action to arrest the likely adverse impacts has been taken by the project contractors and the developer.

10.2 Objectives of the ESMP

The ESMP reflects the environmental impact mitigation actions as explained in the Environmental Impact Assessment Report. Following areas of concerns will receive special attention:

- Minimizing social and economic impacts on arising from the land acquisition and any other similar impacts arising from the construction phase an operational phase;
- Minimize, if avoidance is not possible to, all the bio diversity related impacts during the construction and operational phases including
    - Conservation / protection of bio diversity including riparian forest and river ecology
- Minimizing all impacts arising from the construction phase of the project to physical environment;
    - Prevention of contamination of natural water courses and groundwater contamination due to project activities;
    - Prevention atmospheric pollution including dust/noise pollution control
- Prevention of haphazard waste disposal and hazardous substances, fuel etc. and spillage prevention including:
    - Management of construction spoils and solid and liquid waste collection& prevention of hazardous waste (oil spills)
- Minimizing disturbance to the public from activities such as construction traffic and irrigation/ river water supply
- Ensuring worker occupational health & safety.

In addition, there will be an environmental monitoring plan is provided with a view to regularly monitor the progress of the monitoring of E&S indicators

10.3 Project responsibilities

Management structure proposed here is intended for the construction phase. A slightly different management structure will be evolved during the operational and monitoring (O&M) phase to ensure that compliance pertaining to environmental, health and safety mitigation actions as part of the O & M work.

During the construction phase the Developer has the following responsibilities:

1. Overall implementation of the ESMP and establish a functional environmental/social unit within the site to carry out the functions stipulated in the ESMP
2. Obtain / renew on time necessary statutory permits and approvals and to comply with the same during the subsequent phases. Display them as per the disclosure procedure.
3. Engage required experts & site specific management and supervisory personnel including Environmental Liaison Officer (ELO) to provide necessary guidelines for the contractors' environmental, health and safety staff to comply with risk mitigation actions and reporting on the same

4. Provide them with all the necessary resources, training and orientation to ensure proper implementation of the EMP.
5. Incorporate necessary contractual obligations into the contracts of the main Construction Contractor/s as well as the sub-contractors during the construction stage with mandate to comply with the same.

10.3.1 The Civil Contractor

1. Ensure that the civil contractors through their construction schedules incorporate all required measure (both engineering and otherwise) to
2. Ensure incorporating the risk mitigation measures into project engineering design documents and construction contracts;
3. The contractor will also design site specific method statements to include environmental management measures for all activities during the Construction and Demobilization phase; obtain all necessary approvals in consultation with Environmental Liaison Officer; advise all the technical staff to follow measures to ado

10.3.2 Contractor's Project Manager

The Project Manager (PM) will provide overall guidance and supervision for works required for the implementation of the Environmental Management Plan (EMP) at the site level and reports to the Developers' Project Environmental Liaison Officer. The PM shall monitor the implementation of the EMP to ensure that all the engineering measures will be taken by the contractor during the construction phase to minimize any likely ecological, geological physical impacts arising from the project's construction. The PM will play a key role side by side the Developer (and the staff engaged by the Developer), to identify in advance the relevant impacts and plan mitigation actions according to the construction best practices / and or according to stipulated practices and regulations. He will provide monitoring reports on implementing all the environmental and social compliances which will be integrated into the construction design.

10.3.3 Contractor's Environmental Control Officer

Contractor's Environmental Control Officer will be particularly responsible for carrying out environmental and health, safety awareness during toolbox meetings. He/She will be responsible for ensuring that workers wear appropriate personal protective equipment (PPE). He is responsible for preparing suitable method statements in consultation with the PM to incorporate the E&S mitigations actions into the construction designs. Monitoring of the site slope protection measures, bio diversity related actions, occupational health and safety related measure are other responsibilities. He/She will also be responsible to assist the Environmental Liaison Officer to collect monthly data at the site for preparing progress reports

10.3.4 Environmental Liaison Officer

The Developer will receive the services of an Environmental Liaison Officer during the construction phase of the project to obtain technical backstop on environmental and social risk and impact mitigation. His/her overall responsibility will be to coordinate with NEMA and the County line officers to effect necessary mitigation actions in keeping with the EIA and other NEMA stipulated conditions. The position holder will undertake regular monitoring, advice the contractor's environmental control officer of the appropriate actions.

Specific roles will be:

1. Liaise with all the county environmental and other development agencies who need information about the project:
2. Liaise with Contractor's staff on the carrying out of specific mitigation actions;
3. Collect necessary baseline information (specially Water Quality reports) and regular conduct of audits and monitoring programme
4. Ensure implementation of the stakeholder engagement plan;
5. Coordinate with the project Grievance Management Committees.
6. Attend to all the community grievances in regard to payment of compensation and proper implementation of the Recommendations of Resettlement Action Plan

10.3.5 Independent Auditor

The Developer will appoint an Independent Auditor who will conduct regular environmental audits as required by NEMA and submit reports for perusal. He will advise the Developer on matters which need to be complied with

10.4 ESMP Matrix

The site specific E&S risk and impact mitigation actions as shown in the previous chapter of the EIA report is summarized in the following matrix. It defines the specific issues and the impact, overall strategies and specific actions, responsible agency and the time frame for their implementation.

10.5 Environmental Management and Monitoring Plan (Biodiversity)

10.5.1 Management Plan for Biodiversity Conservation:

Potential Impact	Mitigation	Responsibility	Frequency/ Monitoring Requirement
Loss of aquatic Biodiversity	• Fell only the trees marked for felling; all other trees should be protected to save the forest cover in the forested area • Conserve riparian forests in the agricultural areas: reduce the vegetation clearance footprint • Establish more riparian forests of indigenous trees or environmental friendly ones in agricultural areas. This could be undertaken in keeping with the mitigation measures as recommended in the impact • Rehabilitate all degraded land during and following completion of construction activities • Install systems to discourage fish from entering abstraction equipment, including acoustic barriers, lighting barriers and bubble curtains. • Retain forest cover in the forested area • Establish more riparian forests of indigenous trees or environmental friendly ones in agricultural areas. • Rehabilitate all degraded land during and following completion of construction activities • Monitoring of biological and chemical parameters in the water and in aquatic biota to alert the proponent,	Project Proponent or its Service Contractors	Weekly

Potential Impact	Mitigation	Responsibility	Frequency/ Monitoring Requirement
	relevant Government Agencies and local communities on potential hazards to aquatic habitat.		
Habitat loss and modification	• Areas that will not be put to immediate use to be left intact. • Excavation should not be carried out during the rainy(wet) season when animals are breeding • Top soil to be kept aside for use in replanting and landscaping • Together with experts relocate animals that move slowly and found in the site during excavation and clearing • Reestablish original habitat patterns to improve surface water runoffs before commencing operations • Establish erosion prevention measures on sloping areas to prevent soil erosion on loose soils after from excavation. • Ensure that extensive damage to the forest should not be made by engaging heavy machinery for clearing and excavation work • Where possible use already established tracks and roads • Use of human labour (non-mechanized) during construction inside the forest to minimize damage to the forest habitat.	Project Proponent or its Service Contractors	Weekly

Potential Impact	Mitigation	Responsibility	Frequency/ Monitoring Requirement
	• The project proponent should compensate by rehabilitating/ restoring the modified habitat elsewhere.		
Invasive Species	• Habitat monitoring to detect and manage invasive species early before habitats is irreversibly modified. • Project proponent to put in place invasive species control and management program • Trap and rid-off the site of any rodents which attract snakes • All workers be equipped with protective gear like heavy duty shoes and tough pants • Educate local people of dangers from snake bites and how to prevent them • Educate workers on the harmless nature of reptiles like chameleons and other lizards to remove phobia • Ensure that local hospitals to obtain anti-venom which is readily available in Bio-ken Malindi. • Put in place a proper waste management programme • Dispose all solid waste according to NEMA waste management regulations 2006 and EMCA act 1999	Project Proponent or its Service Contractors	Weekly
Impacts on fauna and flora due to oil and chemical Spillage	Ensure that excessive oil or chemicals spill into the environment where there are a large number of species living on the natural environment: Where possible keep all machinery away from the river and water sources. This can be achieved by:	Project Proponent or its Service Contractors	Daily

Potential Impact	Mitigation	Responsibility	Frequency/ Monitoring Requirement
	• A log of all dangerous chemicals be kept, how to be used, transported stored and disposed • Keep all dangerous chemicals, oils, greases, solvents, and residues in a store room. • Have a standard operating procedure manual on how to deal with spills and how to prevent them • Have a spills response team? • Train worker on spills and how to deal with them • Have a containment and disposal plan for all hazardous material (where to dispose) • All oils and hazardous materials disposed of according to NEMA waste management regulations 2006 and EMCA act 1999		
Impacts on the aquatic fauna and herportafauna due to Dust and Exhaust Particles	Prevent all sources of dust and exhaust particles receive by the natural environment where there are a large number of species living whose survival will be endangered due to dust and gases. This can be achieved by: • Wetting the areas where there will be strong winds carrying dust particles on the habitat of the species. • Using Sprinklers to reduce dust when work involving dust is to be carried out • Allow not to toss up dust when vehicles speed set at limits of 60 to 700 KMP • Set units like generators in areas where winds will blow most of the smoke away	Project Proponent or its Service Contractors	Daily

Potential Impact	Mitigation	Responsibility	Frequency/ Monitoring Requirement
	• Type of fuels to be used should be low Sulphur and unleaded fuels avoid heavy industrial oils		

10.5.2 Management Plan (Physical Environment and Social Environment)

Impact Area	Mitigation Actions	Responsibility	Time frame
Location of the project	• Ensure minimum interruption to the agricultural lands; Allow uninterupted accessibility through existing access roads with minimum requirements to open up new access roads • Avoid using heavy machinery especially in the protected forest areas to prevent extensive damage to the forest	EPC Contractor/Surveyor	Before the commencement of the cadastral Map
Design of the project	• Design the project structures to withstand high flood occurrences; • Calculate an environmental flow sufficient to support water abstractions	Specialists / Developer	Before the commencement of the final designs
Prevent excessive Dust /Noise during construction	• Newly excavated areas should be wetted using construction best practices; and/or water sprinkling will be necessary during the dry seasons	Contractor	During construction

	• All new roads when opened up should be compacted and graded and if possible Paving/tarring the roads is suggested: • Sheeting of construction material spoil stockpiles is necessary • Noise from construction activities should be not in excess of the standards stipulated for construction sites.		
Protection of water sources from possible contamination	• Vehicle wash bay should be away from the river or other streams: • All sediments from the construction concrete mixers and batching plants etc. should be equipped with settlement tanks and filtration system • Ensure that the receiving body of effluent waters should be treated to the standards stipulated by NEMA; • Construct settlement tanks along the wash bay and other chemical storage areas (including fuel storage areas) • Manage dewatered effluents properly when they are sent back into the river. Equip them with silt traps and settlement tanks • A water quality monitoring programme should be implemented at least every six months to ensure that construction and operational activities of the project will not interfere with the water quality	Contractor	During construction

Water abstraction	• Install river gauging system to monitor water flows	Developer	During operational phase
Prevent soil erosion	• All spoils should be dumped into a designated spoil yard and they should be graded and compacted if they are not used for filling purposes. • Top soil to be kept aside for use in replanting and landscaping • Establish erosion prevention measures on steep embankments (Retention structures and natural barriers such as turfs and stone pitching to prevent erosion.) • Identify area with slopes to prevent soil erosion on loose soils after excavation. • Use of human labor (non-mechanized) during construction inside the forest to minimize damage to the forest habitat.	Civil Contractor	During Construction
Surface water relief and obstruction to natural gullies:	• Ensure that all the obstructions made to the natural gullies are opened up early to facilitate surface water relief during the rainy period: • All construction sites should have line drains; culverts to the accepted standards;	Civil Contractor	During the construction Phase
Waste management	• There should be an appropriate waste management practices that include: Separation of wastes according to their hazardous and non-hazardous nature and their proper treatment and	Civil Contractor	During the construction Phase

	disposal with special attention paid to any hazardous wastes; • Wastes from construction work should be minimized by reusing most of the recyclable materials. • Pollution prevention and waste minimization shall be made key aspects of a wider construction waste management policy. • These shall be supplemented by having waste management facilities e.g. waste containers on site during construction that takes waste segregation into account. • The contractor should work hand in hand with the Local authority of the sub location for the collection of sewage and other hazardous waste appropriately as per the NEMA stipulated regulations. • Vendors should be registered with the contractor to receive the cement bags and other hazardous waste and their final destination should be closely monitored. • All the temporary toilets need to be sited according to the local regulations that require minimum distance from water courses.		
Crop damages and livelihood losses due to construction activities	• Any damage caused to private or community property whether accidentally or with intent shall be swiftly compensated at a rate agreed on	Civil Contractor	During the construction Phase

	between the property owner and the contractor in accordance with the law. • In case of failure to come to an agreement the affected person(s) will be free to appeal for assistance through the location chief or the GC; • Ensure that no damage is occurred to any land, structure or crop due to vehicular , machinery movement and blasting activities; • Ensure payment of compensation to landowners whose lands will have poles constructed for power evacuation lines; • Provide alternative water sources when the construction at the weir points can increase turbidity of the water. • Provide public safety by way of road humps, sign boards and no access limits for the public. • Appointment of a Grievance Committee and implement grievance handling mechanism. • Where possible use already established tracks and roads • Prepare and implement full Resettlement Action Plan taking into consideration the number of PAPs, their extent of land loss and the corresponding income loss. Use IFC PS (5) guidelines in addition to requirements in the Land Act.		
Restoration of Livelihoods affected by the project	• A livelihood restoration programme should be implemented for those whose small income generating activities will be affected;	Developer	During the construction Phase

	• One measure would be to provide employment opportunities to work in the project on priority basis for the members of those affected by the construction activities. • A grievance procedure should be put in place enabling the affected people to register their concerns and to seek redress. • Those who are earning from activities such as bee keeping should be provided with alternatives which can be sustainable • After introducing alternative IGAs there should be a proper monitoring programme		
Influx of Workers	• Workers should be provided with continuous awareness on HIV AIDS. • Workers should be tested for HIV AIDS on a regular basis and facilitate continuous health care if found positive: • There should be community awareness programs arranged by the project (Environmental Officer) using external experts on HIV AIDS • All possible actions should be taken to prevent other diseases that may arise due to the project activities.	Civil Contractor	During the construction Phase
Occupational safety and health of the workers	• Ensure appropriate safety arrangements for workers from wild life attacks when working in the forest area: (Provide Guards / Boots and prompt medical care for snake bites) • Provide good quality and relevant personal protective gear (PPE) to all the workers	Civil Contractor and all sub-contractors	During the Construction Phase

	according to the contractor's health and safety policy; • Ensure that the workers always adopt safe constructional equipment and work methods when working at high rise platforms, river areas and vulnerable areas such as steep locations: • Introduce safe handling, storage, transport and disposal of materials in a way that avoids risk to workers; • Conduct safety awareness among all workers (Introducing Tool Box Meetings) • Control harmful insects/ vectors (including mosquitoes and houseflies) • Introduce incident / accident reporting procedure • Control contagious diseases (e.g. Cholera) through proper sanitation and awareness • Provide workers drinking water; flush type toilets and running water and suitable place • Ensure that all work sites display safety messages; • Workers when engaged, pay them all statutory allowances and entitlements (IFC PS 2) • No child labor should be engaged as per the relevant laws:		
Public safety and health risks	• Route diversions should be introduced during construction of the canal and penstock path along or across the roads. This should be done	Civil Contractor	During the construction Phase

	in consultation with the area traffic police. The public should be made known well in advance • Approval should be obtained from the local authorities when the excavations are carried out along the roads; • Implementation of a proper traffic management plan when the construction of the structures impact on the motorable roads; • Driver awareness will be essential enabling them to be cautious when driving through trade centers, public receptors and areas cultivated by the community members: • Community should be pre warned on the times of using explosives for rock blasting purposes; • Construction close to the watering points should be enclosed with protective fences • Alternative sources of water should be made available, if the community members are unable to access to water during construction times.		
Implementation of the EMP and Monitoring Plan	Following requirements should be complied with: • Regular collection of water quality report and submit results to the County Environmental Officer (EO) of NEMA • Bio Diversity Monitoring Reports should be submitted regularly to NEMA EO • Waste management reports to be submitted to the Local Authority of the sub location	Civil Contractor / Developer's representative at the site	Both construction and pre construction phases.

	• Progress Reports should be submitted to NEMA as per the conditions of approval • There should be a site Environmental Liaison Officer and the relevant staff as per the EMP located during the construction phase as well as in the operational phase; • Convene the Grievance Management Committee regularly in order to resolve all the grievances as registered by the public and the workers:		

10.5.3 Environmental Monitoring Plan

Sector /Issue	Impact Mitigation	Monitoring Indicator	Means of Verification	Period & by Whom
Physical Environment				
Air Pollution from construction activities (Dust)	Sprinkling of water during dry season; Good practices of materials stockpiling to prevent resultant fugitive dust in the immediate vicinity of the site excavation work causing dust emission	Level of dust tossing during the vehicle movements Visual levels of dust settled in the local areas	Methods statements and physical observations; By referring to the Complaints made by the general public Availability of resources for dust control	Regularly during the construction phase , especially during the dry season – By the Site Civil Contractors,

Vehicle emissions	Resultant exhaust emissions from Vehicles, Generators and other machinery & Equipment and atmospheric pollution	Level of exhaust emissions emission of fumes to air by the vehicle and equipment	By referring to the Complaints made by the general public: Vehicle condition Reports	Regularly during the construction phase at all times, - By the Site Civil Contractors,
Noise	Due to construction machinery; Rock Blasting, construction piling at the weir)	Relevant Noise standards as stipulated by NEMA/IFC PS (Provided)	Using random noise measurements;	Regularly during the construction phase at all times, - By the Site Civil Contractors,
Water quality (Pollution of river water)	Prevent all sources that pollute river water as per the EMP	Water quality parameters for Drinking water	Water quality tested at predetermined points (weir, powerhouse)	During construction and excavation of the areas of the river; By the Site Civil Contractors
	Measure adopted to prevent contamination of water from wash bay, effluents released from oil storage areas and the waste disposal methods	Water quality and construction practices	Physical Observations	Regularly during the construction phase at all times - By the Site Civil Contractors, DEO
Soil protection measures	Soil protection and erosion control measures in areas where erosion is possible during construction (Proper Design of Culverts, Drainage paths along the improved access roads)	Presence of Soil Protection and Erosion Control measures	Physical Observations of implementing all the properly designed access roads, culverts and surface drainage systems.	To be monitored at all times

	Methods to prevent Contamination of surface water due to sewage spillage of temporary toilets	Regulation for sitting of hygienic toilets according to the accepted guidelines (away from the water bodies)	Physical observation during site inspections	To be monitored at all times
Occupational Health & Safety and Public Safety				
Poor working environment (Hygiene and sanitation at work sites)	Measures adopted to prevent Increased incidence of injuries / illnesses among workers due to wild life attacks, lack of PPE and inadequate drinking water facilities at the specific sites	Level of safety provided in terms of PPE, Drinking water; Guards;	Site Medical records	At all times, l
Public Safety	Measures taken to prevent increased traffic along the access roads leading to possible accidents	Demonstrated levels of Worker awareness on traffic management	Incident Reports; public complaints	Regular at all times
	Safety of the public on construction along the roads; newly created structures (spill way, Inundation at the upstream of the weir and Forebay)	Level of community awareness: Availability of Sign Boards; Road Humps; Traffic Plans	Physical observation	Regular at all times
	Inconvenience caused to general public due to excessive noise and dust emissions from the construction activities	Number of Community Complaints received and resolved by the	Grievance Register	At all times, contractor

		Grievance Committee and the Civil Contractor		
Land acquisition and loss of income	Possible economic and physical displacement of the project affected persons prior to construction and due to way leave maintenance in case of power evacuation line.	Measure adopted by the Developer to implement the recommendations made in the Resettlement Action Plan and the Grid Study	Documents available regarding payment of compensation – computation method adopted for compensation – Market Rates and Replacement costs (as per NEMA Guidelines and IFC PS)	To be monitored at all times by the Site EHS Manager and the civil contractors
	Possible damages to the crops/crop lands due to construction activities (blasting, spoils dumping)	Measure adopted by the contractor to implement the recommendations made in the Resettlement Action Plan	Grievance Register, compensation records	To be monitored at all times by the DEO, Site EHS manager and the civil contractors
		Measures adopted by the Civil Contractor to dispose spoils without being disturbed to community agricultural lands	Presence of designated spoil yards	To be monitored at all times by the DEO, Site EHS manager and the civil contractors

	PAPs whose land is acquired in large parcels will lose livelihood income and will need some assistance from the project to restore their incomes	Availability of a Livelihood assistance programme (LIF)	Selection of the PAPs eligible for LIF and the programme in effect to assist them by the Developer	Local leaders, contractor
Community Conflicts arising from project construction activities	Resolve community conflicts by complying with required practices such as formation of a Grievance Committee ; empowering the GC to resolve conflicts	Presence of a functional Grievance Committee	Minutes of the Grievance Committee Meetings;	Local leaders, contractor
	Conflicts with Water resources users associations over irrigation water	GC to have WRUA members	Minutes of the Grievance Committee Meetings;	Local leaders, contractor
Biodiversity	Ensure minimum clearing of forest vegetation and prper cathchment protection programme implemented	Availability of a catchment protection plan	Agreements with the County NEMA Officer	During the operational phase / Developer
	Ensure maintaining environmental flow as per the Hydroloy report for the sustenance of the excosystems functions	Environmental Flow pipes fitted to the respective FDW and they have free flow durin the dry season.		Developer / WRMA

10.5.4 Tentative Budget for the Implementation of the EMP

Tentative Budget for the implementation of E&S Mitigation Actions				
	Activity	**Nos./Rate**	**Months**	**Amount US $**
	Supervision and Reporting			
1.1	E&S Supervision- Visits to the project site by Environmental Consultant (Kenyan) on a quarterly basis	01 visit @ 05 days every 06 months	Minimum 04 visits during construction period	10,000.00
1.2	Remuneration to the to the site E&S staff engaged for environmental and social impact mitigation activities	$ 750 per month for 03 site based staff	12 months – To be incorporated into the contractor's budget	12,000.00
1.3	Incidental expenses to be incurred when visits to be made by the County Environmental Officer.	As and when visits are made	Fuel reimbursement	2,000.00

1.4	Transport and other administrative facilities and compliance audit	As per the NEMA conditions	At least one audit per year	5,000.00
2	**Implementing worker safety & health services**			
2.1	OHS - Providing of Safety helmets and other safety gear such as Gloves, Boots, Goggles, Ear Plugs, Ropes etc.	Required based on the # of workers engaged	Construction Phase	40,000.00
2.2	OHS-Emergency health care for the workers. Medical centre with basic facilities and a qualified nurse. First Aid/ OPD treatment and/or any other medical care to injured/sick persons.		Construction phase	15,000.00
2.3	Public safety : Implementing recommendations pertaining HIV awareness/Grievnace Redress and impromptu compensation	Based on the recommendations of the GRC	Construction phase	50,000.00
2.4	Bio Physical environment: Implementing the recommendations of soil conservation, slope protection and, terracing, retaining structures, culverts, drains, waste collection bins etc..	Based on the NEMA conditions	Construction phase (To be included in the contractors budget)	50,000.00
3.	**Environmental Pollution Prevention and catchment protection**			
3.1	Regular Water Quality monitoring	4 times a year @ 100$ per time	During construction	800.00

3.2	Ambient Air/Noise and dust control & Monitoring	Througoput construction phase (per year)	During construction (Contrcators budget)	2,000.00
3.3	Community assisted tree planting program and to assist the County catchment protection management plan (To protect the riparian egetation and other forested areas)	Along the river catchment areas and the forest areas	During Operational Phase	20,000.00
3.4	Pritection measures for acquatic species such as contrcting Fish Passes	As per the NEMA conditions of approval	During the operational Phase	25,0000.00
4.	**Implement RAP and LIF**			
4.1	Implement RAP (Provided in the RAP Report) and implement the grid study (Grid Study Report)	As per the compensation valuation report and grid study report	Prior to Construction	To be decided after the valuation of land (In case of compensation of way leave, it is $ 8925/-)
4.2	Implement LIF (Livelihood improvement Framework) including support for alternative livelihoods for fishermen and CDAP (Health center, community hall)	As per the Detailed LIF	During construction	TO be decided after identification of the PAPs

4.3	Corporate social responsibility projects (water/ schools etc)		Diuring operational Phase	To be decided after agreeing on the CSR portfolio
4.4	Other expenses			3,200.00
	Total Budget (all three projects)			**355,000.00**

11 CONCLUSIONS

11.1 Overall Conclusions

The key findings of the EIA study are as follows: -

1) During the construction phase, majority of the impacts are negative and of high rating before mitigation except a few positive impacts such as enhancement of grid connected electricity, creation of employment opportunities, creation of markets and increased revenue;
2) Nonetheless, the significance of all these negative impacts are reversible to low (Negligible) with the adoption of appropriate mitigation measures.
3) Also, due to the minimal activities and short-term duration of the construction phase, most of the impacts are short term.
4) It is worth noting that some negative impacts in this phase are substantial in rating and these include: Impacts on the forest vegetation, bio diversity, surface water quantity and quality; occupational health and safety, Noise and risk of meeting with accidents within the project sites but with the application of the prescribe mitigation measures, the impact rating reduce to Minor (Negligible).
5) Significant economic benefits attributed to the project will occur in both short term and long term during the operational phase.

11.2 Overall Recommendations:

The project is recommended for environmental clearance subject to the Developer implementing the required mitigation measures.

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13 APPENDICES

13.1 NEMA letter of Approval of the TOR for the EIA

nema

NEMA/TOR/5/2/..... Date: 20/1/2017

PROPONENT: LASANTHA S. JAYASINGHE.

.....

RE: ACKNOWLEDGEMENT AND APPROVAL OF TERMS OF REFERENCE (TOR) FOR THE ENVIRONMENTAL IMPACT ASSESSMENT STUDY

We acknowledge receipt of the TOR for the above subject.

Pursuant to the Environmental Management and Coordination Act, 1999 the Second schedule and the Environmental (Impact Assessment and Audit Regulations 31 and 25, your terms of reference for the Environmental Impact Assessment (EIA) study for the proposed Nyamindi Hydropower Project ..... has been approved.

You shall submit ten (10) copies and one electronic copy of your report prepared by a registered expert to the Authority.

BONFACE MAMBOLEO
EIA SECTION HEAD

13.2 Project Geological Report (As a separate Document)

13.3 Project Hydrology Report (As a separate Document)

13.4 List of plant species recorded during the survey

			Project I			Project II			Project III			
Family	**Genus**	**species**	**Iin**	**1pe**	**1po**	**2in**	**2pe**	**2po**	**3in**	**3pe**	**3po**	**IUCN Status**
Leguminosae	*Acacia*	*mearnsii*	0	0	0	1	0	0	0	0	0	Not assesed
Acanthaceae	*Acanthus*	*eminens*	1	0	0	1	0	0	0	0	0	Not assesed
Amaranthaceae	*Achyranthes*	*aspera*	1	0	0	1	0	1	0	0	1	Not assesed
Compositae	*Acmella*	*calirrhiza*	1	0	0	0	0	0	1	0	0	Not assesed
Zingiberaceae	*Aframomum*	*zambesiacum*	0	0	0	1	0	1	0	1	1	Not assesed
Connaraceae	*Agelaea*	*pentagyna*	1	0	0	0	0	0	0	0	0	Not assesed
Leguminosae	*Albizia*	*gummifera*	1	0	0	1	0	0	1	1	0	Not assesed
Rosaceae	*Alchemila*	*sp.*	1	0	0	0	0	0	0	0	0	Not assesed
Sapindaceae	*Allophylus*	*abyssinica*	1	0	0	0	0	0	0	0	0	Not assesed
Sapindaceae	*Allophylus*	*ferruginus*	1	0	0	0	0	0	0	0	0	Not assesed
Asphodelaceae	*Aloe*	*sp.*	0	0	0	0	0	0	0	1	0	Not assesed
Sapotaceae	*Aningeria*	*adolfi-friedericii*	1	0	0	0	0	0	0	0	0	Not assesed
Loganiaceae	*Anthocleista*	*grandiflora*	1	0	0	1	0	0	0	0	0	Not assesed
Icacinaceae	*Apodytes*	*dimidiata*	1	0	0	0	0	0	0	0	0	Not assesed
Primulaceae	*Ardisiandra*	*wettsteinii*	1	0	0	0	0	0	0	0	0	Not assesed
Gramineae	*Arundinaria*	*alpina*	1	0	0	0	0	0	0	0	0	Not assesed
Compositae	*Aspilia*	*mossambicensis*	0	0	0	0	0	0	0	0	1	Not assesed
Passifloraceae	*Basananthe*	*hanningtoniana*	1	0	0	0	0	0	0	0	0	Not assesed
Basellaceae	*Basella*	*alba*	1	0	0	0	0	1	0	0	0	Not assesed
Melianthaceae	*Bersama*	*abyssinica*	1	0	0	0	0	0	1	0	1	Not assesed

Compositae	*Bidens*	*pilosa*	0	0	0	1	1	0	0	0	1	Not assesed
Euphorbiaceae	*Bridelia*	*micrantha*	0	0	1	1	1	1	1	1	0	Not assesed
Simaroubaceae	*Brucea*	*antidysenterica*	0	0	0	1	0	0	0	0	0	Not assesed
Leguminosae	*Caesalpinia*	*decapetala*	1	0	1	0	0	0	0	0	0	Not assesed
Roccellaceae	*Camellia*	*sinensis*	1	0	0	0	0	0	0	0	0	Not assesed
Theaceae	*Camellia (Tea)*	*sinensis*	0	1	9	0	0	0	0	0	0	Not assesed
Rubiaceae	*Canthium*	*sp.*	1	0	0	0	0	0	0	0	0	Not assesed
Flacourtiaceae	*Casearia*	*battiscombei*	1	0	0	0	0	0	0	0	0	Not assesed
Rhizophoraceae	*Cassipourea*	*malosana*	1	0	0	0	0	0	0	0	0	Not assesed
Menispermaceae	*Cissampelos*	*mucronata*	1	0	0	0	0	0	0	0	0	Not assesed
Vitaceae	*Cissus*	*sp.*	1	0	1	0	0	1	0	0	0	Not assesed
Rutaceae	*Clausena*	*anisata*	0	0	0	1	0	0	1	0	1	Not assesed
Verbenaceae	*Clerodendrum*	*johnstonii*	1	0	0	0	0	1	0	0	0	Not assesed
Rubiaceae	*Coffea (Coffee)*	*arabica*	0	1	0	1	1	0	1	1	0	Not assesed
Combretaceae	*Combretum*	*paniculatum*	1	0	0	0	0	0	0	0	0	Not assesed
Commelinaceae	*Commelina*	*sp.*	0	0	0	0	0	0	0	1	0	Not assesed
Compositae	*Conyza*	*bonariensis*	1	0	0	1	1	0	1	0	0	Not assesed
Boraginacaeae	*Cordia*	*africana*	0	0	0	0	0	1	1	1	1	Not assesed
Compositae	*Crassocephalum*	*montuosum*	1	0	0	0	0	0	0	0	0	Not assesed
Euphorbiaceae	*Croton*	*macrostachyus*	1	0	1	1	1	1	1	1	0	Not assesed
Euphorbiaceae	*Croton*	*megalocarpus*	1	0	0	0	0	0	0	0	0	Not assesed
Araliaceae	*Cussonia*	*spicata*	1	0	0	1	0	1	1	0	0	Not assesed
Cyperaceae	*Cyperus*	*alternifolius*	0	0	0	1	0	0	0	1	1	Not assesed
Vitaceae	*Cyphostemma (reddish hairy)*	*sp.*	0	0	1	0	0	0	0	0	0	Not assesed
Leguminosae	*Dalbergia*	*lactea*	1	0	0	0	0	0	0	0	0	Not assesed

Leguminosae	*Desmodium*	*repandum*	1	0	0	0	0	0	0	0	0	Not assesed
Leguminosae	*Desmodium*	*sp. A of UKWF*	0	0	0	0	0	1	1	0	0	Not assesed
Dioscoreaceae	*Dioscorea*	*schimperana*	0	0	0	0	0	0	0	1	0	Not assesed
Flacourtiaceae	*Dovyalis*	*macrocalyx*	1	0	0	0	0	0	0	0	0	Not assesed
Dracaenaceae	*Dracaena*	*afromontana*	1	0	0	0	0	0	0	0	0	Not assesed
Dracaenaceae	*Dracaena*	*laxissima*	1	0	0	0	0	0	0	0	0	Not assesed
Dracaenaceae	*Dracaena*	*steudneri*	0	0	0	1	0	1	0	0	0	Not assesed
Caryophyllaceae	*Drymaria*	*cordata*	1	0	0	0	0	0	0	0	1	Not assesed
Euphorbiaceae	*Drypetes*	*gerrardii*	1	0	0	0	0	0	0	0	0	Not assesed
Meliaceae	*Ekebergia*	*capensis*	1	0	0	1	0	0	0	0	0	Not assesed
Gramineae	*Eleusine*	*indica*	0	0	0	0	0	0	0	0	1	Not assesed
Myrsinaceae	*Embelia*	*schimperi*	1	0	0	0	0	0	0	0	0	Not assesed
Compositae	*Emilia*	*discifolia*	0	0	0	0	1	0	0	0	0	Not assesed
Musaceae	*Ensete*	*edule*	1	0	0	1	0	0	0	0	0	Not assesed
Rosaceae	*Eriobotrya*	*japonica*	1	0	0	0	0	0	0	1	0	Not assesed
Leguminosae	*Eriosema*	sp.	0	0	0	0	0	0	0	1	0	Not assesed
Leguminosae	*Erythrina*	*abyssinica*	0	0	0	1	0	0	1	0	0	Not assesed
Orchidaceae	*Eulophia*	*horsfallii*	0	0	0	0	0	0	0	0	1	Not assesed
Moraceae	*Ficus*	*sur*	1	0	0	0	0	1	1	1	0	Not assesed
Moraceae	*Ficus*	*sycomorus*	0	0	0	1	0	0	0	1	1	Not assesed
Moraceae	*Ficus*	*thonningii*	1	0	0	1	0	0	1	1	0	Not assesed
Rubiaceae	*Galiniera*	*saxifraga*	1	0	0	0	0	0	0	0	0	Not assesed
Guttiferae	*Garcinia*	*volkensii*	1	0	0	0	0	0	1	0	0	Not assesed
Leguminosae	*Glycine*	*wightii*	0	0	0	0	0	0	0	0	0	Not assesed
Rhamnaceae	*Gouania*	*longispicata*	1	0	0	0	0	1	0	0	0	Not assesed

Proteaceae	*Grevilea*	*robusta*	0	1	1	1	1	1	1	1	0	Not assesed
Compositae	*Gutenbergia*	*cordifolia*	0	0	1	0	0	0	0	0	0	Not assesed
Guttiferae	*Hypericum*	*roeperanum*	1	0	1	1	0	0	1	1	0	Not assesed
Acanthaceae	*Hypoestes*	*forskahlii*	0	0	0	0	0	0	0	0	0	Not assesed
Balsaminaceae	*Impatiens*	*meruensis*	0	0	0	1	0	0	0	0	0	Least Concern
Balsaminaceae	*Impatiens*	*tinctoria*	1	0	0	0	0	0	0	0	0	Not assesed
Leguminosae	*Indigofera*	*arrecta*	0	0	1	0	0	0	0	0	0	Not assesed
Oleaceae	*Jasminum*	*fluminense*	0	0	0	1	0	0	0	0	0	Not assesed
Crassulaceae	*Kalanchoe*	*densiflora*	1	0	0	0	0	0	0	0	0	Not assesed
Rubiaceae	*Keetia*	*gueinzii*	1	0	0	0	0	0	0	0	1	Not assesed
Bignoniaceae	*Kigelia*	*africana*	0	0	0	1	0	0	0	0	0	Not assesed
Cucurbitaceae	*Lagenaria*	*abyssinica*	0	0	0	1	0	0	0	0	0	Not assesed
Apocynaceae	*Landolphia*	*buchananii*	1	0	0	0	0	0	0	0	0	Not assesed
Verbenaceae	*Lantana*	*camara*	1	0	1	1	1	0	1	1	1	Not assesed
Verbenaceae	*Lantana*	*trifolia*	1	0	0	0	0	0	0	0	0	Not assesed
Urticaceae	*Laportea*	*alatipes*	1	0	0	0	0	0	0	0	0	Not assesed
Labiatae	*Leonotis*	*nepetifolia*	1	0	0	0	0	0	0	0	0	Not assesed
Meliaceae	*Lepidotrichilia*	*volkensii*	1	0	0	0	0	0	0	0	0	Not assesed
Labiatae	*Leucas*	*grandis*	1	0	0	1	0	0	0	0	0	Not assesed
Lobeliaceae	*Lobelia*	*gibbberoa*	1	0	0	0	0	0	0	0	0	Not assesed
Onagraceae	*Ludwigia*	*abyssinica*	0	0	0	0	0	0	1	0	0	Not assesed
Proteaceae	*Macadamia*		0	0	1	0	0	1	0	1	0	Not assesed
Euphorbiaceae	*Macaranga*	*kilimandscharica*	1	0	0	0	0	0	0	0	0	Not assesed
Myrsinaceae	*Maesa*	*lanceolata*	0	0	0	1	0	0	1	0	0	Not assesed
Celastraceae	*Maytenus*	*heterophylla*	1	0	0	0	0	0	0	0	0	Not assesed

Compositae	*Melanthera*	*scandens*	0	0	0	0	0	1	1	0	0	Not assesed
Compositae	*Microglossa*	*pyrifolia*	1	0	0	0	0	0	0	0	0	Not assesed
Leguminosae	*Millettia*	*dura*	0	0	0	0	0	0	1	0	1	Not assesed
Cucurbitaceae	*Momordica*	*foetida*	0	0	0	0	0	0	0	0	1	Not assesed
Musaceae	*Musa (Bananas)*		0	1	0	0	0	1	0	0	0	Not assesed
Cecropiaceae	*Myrianthus*	*holstii*	1	0	0	0	0	0	0	0	0	Not assesed
Euphorbiaceae	*Neoboutonia*	*macrocalyx*	1	0	0	0	0	0	0	0	0	Not assesed
Leguminosae	*Newtonia*	*buchananii*	0	0	0	0	0	0	0	0	1	Not assesed
Loganiaceae	*Nuxia*	*congesta*	1	0	0	0	0	0	0	0	0	Not assesed
Ochnaceae	*Ochna*	*holstii*	1	0	0	0	0	0	0	0	0	Not assesed
Labiatae	*Ocimum*	*gratissimum*	1	0	1	1	0	1	1	0	0	Not assesed
Oleaceae	*Olea*	*welwitschii*	1	0	0	0	0	0	0	0	0	Not assesed
Oliniaceae	*Olinia*	*rochetiana*	1	0	0	0	0	0	0	0	0	Not assesed
Flacourtiaceae	*Oncoba*	*spinosa*	1	0	0	0	0	0	0	0	0	Not assesed
Oxalidaceae	*Oxalis*	*corniculata*	0	0	1	0	0	0	0	0	0	Not assesed
Rubiaceae	*Oxyanthus*	*speciosus*	1	0	0	0	0	0	0	0	0	Not assesed
Polygonaceae	*Oxygonum*	*sinuatum*	0	0	0	0	0	1	1	1	0	Not assesed
Rubiaceae	*Pauridiantha*	*paucinervis*	1	0	0	0	0	0	0	0	0	Not assesed
Compositae	*Pennisetum*	*macrourum*	0	0	1	0	1	1	0	1	0	Not assesed
Gramineae	*Pennisetum*	*trachyphyllum*	0	0	0	1	0	0	0	0	0	Not assesed
Rubiaceae	*Pentas*	*lanceolata*	0	0	0	1	0	1	0	0	0	Not assesed
Asclepiadaceae	*Periploca*	*linearifolia*	1	0	1	0	0	0	0	0	0	Not assesed
Lauraceae	*Persea*	*americana*	0	0	0	0	1	0	0	1	0	Not assesed
Acanthaceae	*Phaulopsis*	*imbricata*	1	0	0	0	0	0	0	0	0	Not assesed
Euphorbiaceae	*Phyllanthus*	*sepialis*	0	0	0	0	0	0	1	1	1	Not assesed

Euphorbiaceae	*Phyllanthus*	*sp.*	1	0	1	0	0	0	0	0	0	Not assesed
Solanaceae	*Physalis*	*peruviana*	0	0	0	0	0	0	0	1	0	Not assesed
Phytolaccaceae	*Phytolacca*	*dodecandra*	1	0	0	1	0	0	0	0	0	Not assesed
Piperaceae	*Piper*	*capense*	1	0	1	0	0	0	0	0	0	Not assesed
Plantaginaceae	*Plantago*	*palmata*	1	0	0	0	0	0	0	0	0	Not assesed
Plumbaginaceae	*Plumbago*	*zeylanica*	0	0	0	0	0	0	0	0	1	Not assesed
Polygonaceae	*Polygonum*	*salicifolium*	0	0	0	1	0	0	0	0	0	Not assesed
Rosaceae	*Prunus*	*africana*	1	0	1	1	0	0	0	0	0	Vulnerable
Leguminosae	*Pseudarthria*	*hookeri*	0	0	0	0	0	0	0	0	1	Not assesed
Myrtaceae	*Psidium*	*guajava*	1	0	1	0	1	0	1	1	0	Not assesed
Rubiaceae	*Psychotria*	*mahonii*	1	0	0	0	0	0	0	0	0	Not assesed
Dennstaedtiaceae	*Pteridium*	*aquilinum*	1	1	0	1	1	1	1	0	1	Not assesed
Leguminosae	*Pterolobium*	*stellatum*	0	0	0	1	0	0	0	0	1	Not assesed
Apocynaceae	*Rauvolfia*	*caffra*	0	0	0	1	0	1	1	0	0	Not assesed
Rhamnaceae	*Rhamnus*	*prinoides*	1	0	0	1	0	0	0	0	0	Not assesed
Gramineae	*Rhynchelytrum*	*repens*	0	0	0	0	1	0	0	0	0	Not assesed
Verbenaceae	*Rotheca*	*myricoides*	0	0	0	0	0	0	1	0	0	Not assesed
Connaraceae	*Rourea*	*thomsonii*	1	0	0	0	0	0	0	0	0	Not assesed
Rosaceae	*Rubus*	*pinnatus*	1	0	0	0	0	0	0	0	0	Not assesed
Rosaceae	*Rubus*	*scheffleri*	0	0	1	0	0	0	0	0	0	Not assesed
Polygonaceae	*Rumex*	*abyssinicus*	1	0	0	1	0	0	0	0	0	Not assesed
Polygonaceae	*Rumex*	*steudelii*	1	0	0	0	0	0	0	0	0	Not assesed
Rubiaceae	*Rytigynia*	*uhligii*	1	0	0	0	0	0	0	0	0	Not assesed
Umbelliferae	*Sanicula*	*elata*	1	0	0	0	0	0	0	0	0	Not assesed
Amaryllidaceae	*Scadoxus*	*multiflorus*	1	0	0	0	0	0	0	0	0	Not assesed

Rhamnaceae	*Scutia*	*myrtina*	1	0	0	0	0	0	0	0	0	Not assesed
Leguminosae	*Senna*	*didymobotrya*	1	0	0	0	0	0	0	0	0	Not assesed
Gramineae	*Setaria*	*plicatilis*	0	0	0	1	0	0	0	0	0	Not assesed
Smilacaceae	*Smilax*	*anceps*	1	0	0	0	0	0	0	0	0	Not assesed
Compositae	*Solanecio*	*mannii*	1	0	0	0	0	0	0	0	0	Not assesed
Solanaceae	*Solanum*	*aculeatissimum*	1	0	0	0	0	0	0	0	0	Not assesed
Solanaceae	*Solanum*	*campyracanthum*	0	0	0	0	0	0	1	1	1	Not assesed
Solanaceae	*Solanum*	*mauritianum*	1	0	0	0	0	0	0	0	0	Not assesed
Anacardiaceae	*Sorindeia*	*madagascariensis*	1	0	0	0	0	0	0	0	0	Not assesed
Gramineae	*Sporobolus*	*pyramidalis*	0	0	0	1	0	0	0	0	0	Not assesed
Gesneriaceae	*Streptocarpus*	*glandulosissimus*	1	0	0	0	0	0	0	0	0	Not assesed
Olacaceae	*Strombosia*	*scheffleri*	1	0	0	0	0	0	0	0	0	Not assesed
Myrtaceae	*Syzygium*	*cordatum*	0	0	0	0	0	0	1	0	0	Least Concern
Myrtaceae	*Syzygium*	*cuminii*	0	0	0	0	0	0	0	0	1	Not assesed
Myrtaceae	*Syzygium*	*guineense*	1	0	0	1	0	1	0	0	0	Not assesed
Apocynaceae	*Tabernaemontana*	*stapfiana*	1	0	0	0	0	0	0	0	0	Not assesed
Compositae	*Tagetes*	*minuta*	0	0	1	0	0	0	0	1	0	Not assesed
Rutaceae	*Teclea*	*nobilis*	0	0	0	0	0	0	0	0	0	Not assesed
Acanthaceae	*Thunbergia*	*alata*	0	0	0	1	0	0	0	0	0	Not assesed
Compositae	*Tithonia*	*diversifolia*	0	0	0	0	0	0	0	1	1	Not assesed
Rutaceae	*Toddalia*	*asiatica*	1	0	1	1	0	0	0	0	0	Not assesed
Solanaceae	*Tomatoes*		0	0	1	0	0	1	0	0	0	Not assesed
Euphorbiaceae	*Tragia*	*brevipes*	1	0	0	1	0	0	0	0	0	Not assesed
Ulmaceae	*Trema*	*orientalis*	0	0	1	0	0	0	1	0	1	Not assesed
Meliaceae	*Trichilia*	*emetica*	1	0	0	0	0	0	0	0	0	Not assesed

Tiliaceae	*Triumfetta*	*rhomboidea*	0	0	0	0	1	0	0	0	0	Not assesed
Tiliaceae	*Triumfetta*	*tomentosa*	1	0	0	1	0	0	1	1	0	Not assesed
Malvaceae	*Urena*	*lobata*	1	0	0	0	0	0	0	0	0	Not assesed
Rubiaceae	*Vangueria*	*apiculata*	1	0	0	1	0	0	0	0	0	Not assesed
Verbenaceae	*Verbena*	*bonariensis*	0	0	0	0	0	0	0	0	0	Not assesed
Compositae	*Vernonia*	*auriculifera*	1	0	1	0	0	0	0	0	0	Not assesed
Compositae	*Vernonia*	*galamensis*	0	0	0	0	0	0	0	0	0	Not assesed
Compositae	*Vernonia*	*lasiopus*	0	0	0	1	0	0	1	0	1	Not assesed
Monimiaceae	*Xymalos*	*monospora*	1	0	0	0	0	0	0	0	0	Not assesed
Cucurbitaceae	*Zehneria*	*scabra*	0	0	1	0	0	0	0	0	0	Not assesed
			108	5	35	50	14	25	34	29	27	
Key												
in: Intake												
pe: Penstock												
po: Powerhouse												
1: Present												
0: Absent												
IUCN: International Union of Conservation for Nature												

13.5 List of aquatic macroinvertebrates recorded during the survey.

The letter following the site number signifies microhabitat, a: water pool, b: river run, c: boulders and d: wood

Site	River point	Order	Family	Genus/species	No. of individuals
1a	water pool	Plecoptera	Perlidae	*Neoparla sp.*	2
1a	water pool	Odonata	Aeshinidae		2
1a	water pool	Diptera	Tipulidae		1
1a	water pool	Diptera	Ceratopogonidae		41
1a	water pool	Ephemeroptera	Leptophlebiidae		1
1a	water pool	Ephemeroptera	Baetidae	*Baetis harrisonii*	2
1b	River run	Turbellaria	Planariidae	*Planaria*	7
1b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	10
1b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	4

Site	River point	Order	Family	Genus/species	No. of individuals
1b	River run	Plecoptera	Perlidae		1
1c	Boulders	Ephemeroptera	Baetidae	*Baetis harrisonii*	3
1c	Boulders	Ephemeroptera	Trichorythidae		1
1c	Boulders	Ephemeroptera	Baetidae	*Baetis sp2*	1
1c	Boulders	Coleoptera	Elmidae		1
1c	Boulders	Coleoptera	Helodidae		2
1c	Boulders	Trichoptera	Philopotamidae		3
1c	Boulders	Diptera	Simulidae	*Simulium sp*	4
1c	Boulders	Diptera	Chironomidae	*Chironomus sp.*	1
1c	Boulders	Diptera	Psychodidae		1
1d	Wood	Ephemeroptera	Baetidae	*Baetis harrisonii*	8
1d	Wood	Ephemeroptera	Baetidae	*Baetis sp2*	4
1d	Wood	Plecoptera	Perlidae		1
1d	Wood	Diptera	Simulidae	*Simulium sp*	2
1d	Wood	Diptera	Chironomidae	*Chironomus sp.*	2
1d	Wood	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	2
2a	water pool	Ephemeroptera	Caenidae	*Caenis sp*	3
2a	water pool	Ephemeroptera	Baetidae	*Baetis harrisonii*	11
2a	water pool	Diptera	Chironomidae	*Chironomus sp.*	13
2a	water pool	Odonata	Gomphidae		6
2a	water pool	Heteroptera	Gerridae	*Laccocoris limigenus*	2
2a	water pool	Heteroptera	Mesoveliidae	*Mesovelia sp*	1
2b	River run	Trichoptera	Hydropsychidae	*Hydropsyche sp*	1
2b	River run	Trichoptera	Leptoceridae		1
2b	River run	Diptera	Simulidae	*Simulium sp*	5
2b	River run	Diptera	Ephydridae		3
2b	River run	Diptera	Psychodidae		1
2b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	1
2b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	19
2b	River run	Ephemeroptera	Leptophlebiidae		1
2b	River run	Ephemeroptera	Polymitarcyidae		1
2c	Boulders	Ephemeroptera	Heptageniidae	*Heptagenia sp*	1
2c	Boulders	Ephemeroptera	Baetidae	*Baetis harrisonii*	7
2c	Boulders	Ephemeroptera	Leptophlebiidae		2
2c	Boulders	Diptera	Simulidae	*Simulium sp*	8
2c	Boulders	Turbellaria	Planariidae	*Planaria*	2
2c	Boulders	Heteroptera	Mesoveliidae	*Mesovelia sp*	2
2c	Boulders	Coleoptera	Helodidae		1
2d	Wood	Ephemeroptera	Caenidae	*Caenis sp*	1
2d	Wood	Diptera	Chironomidae	*Chironomus sp.*	7
2d	Wood	Turbellaria	Planariidae	*Planaria*	1
2d	Wood	Odonata	Aeshinidae		1
2d	Wood	Decapoda	Potamonautidae	*Potamonautes sp.*	1

Site	River point	Order	Family	Genus/species	No. of individuals
3b	River run	Turbellaria	Planariidae	*Planaria*	4
3b	River run	Ephemeroptera	Prosopistomatidae	*Prosopistoma sp*	2
3b	River run	Odonata	Gomphidae		1
3b	River run	Coleoptera	Hydrophilidae	*sp1*	1
3b	River run	Odonata	Gomphidae		1
3b	River run	Trichoptera	Leptoceridae		1
3b	River run	Trichoptera	Hydropsychidae	*Hydropsyche sp*	3
3b	River run	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	2
3b	River run	Trichoptera	Ecnomidae	*Paracnomina sp.*	2
3b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	19
3b	River run	Ephemeroptera	Baetidae	*Baetis sp*	2
4a	water pool	Diptera	Chironomidae	*Chironomus sp.*	2
4a	water pool	Diptera	Simulidae	*Simulium sp*	1
4a	water pool	Coleoptera	Elmidae		1
4a	water pool	Decapoda	Potamonautidae	*Potamonautes sp.*	1
4a	water pool	Odonata	Libellulidae		1
4a	water pool	Ephemeroptera	Heptageniidae	*Heptagenia sp*	1
4a	water pool	Ephemeroptera	Caenidae	*Caenis sp*	1
4a	water pool	Ephemeroptera	Leptophlebiidae		10
4a	water pool	Ephemeroptera	Baetidae	*Baetis harrisonii*	2
4b	River run	Ephemeroptera	Leptophlebiidae		5
4b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	2
4b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	5
4c	Boulders	Trichoptera	Hydropsychidae	*Hydropsyche sp*	2
4c	Boulders	Trichoptera	Leptoceridae		1
4c	Boulders	Ephemeroptera	Baetidae	*Baetis harrisonii*	10
4c	Boulders	Ephemeroptera	Leptophlebiidae		1
4c	Boulders	Ephemeroptera	Heptageniidae	*Heptagenia sp*	5
4c	Boulders	Diptera	Simulidae	*Simulium sp*	7
5a	water pool	Decapoda	Potamonautidae	*Potamonautes sp.*	1
5a	water pool	Odonata	Gomphidae		1
5a	water pool	Ephemeroptera	Baetidae	*Baetis harrisonii*	9
5a	water pool	Ephemeroptera	Caenidae	*Caenis sp*	1
5a	water pool	Diptera	Ceratopogonidae		13
5a	water pool	Diptera	Chironomidae	*Chironomus sp.*	2
5a	water pool	Diptera	Simulidae	*Simulium sp*	12
5b	River run	Diptera	Tipulidae		1
5b	River run	Diptera	Ceratopogonidae		1
5b	River run	Diptera	Chironomidae	*Chironomus sp.*	2
5b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	6
5b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	33
5b	River run	Ephemeroptera	Leptophlebiidae		4
5c	Boulders	Coleoptera	Elmidae		11

Site	River point	Order	Family	Genus/species	No. of individuals
5c	Boulders	Coleoptera	Helodidae		1
5c	Boulders	Ephemeroptera	Baetidae	*Baetis harrisonii*	12
5c	Boulders	Ephemeroptera	Caenidae	*Caenis sp*	10
5d	Wood	Decapoda	Potamonautidae	*Potamonautes alluaudi*	1
5d	Wood	Ephemeroptera	Heptageniidae	*Heptagenia sp*	4
5d	Wood	Ephemeroptera	Baetidae	*Baetis harrisonii*	1
5d	Wood	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	1
5d	Wood	Diptera	Simulidae	*Simulium sp*	1
6a	water pool	Odonata	Libellulidae		1
6a	water pool	Coleoptera	Elmidae		1
6a	water pool	Diptera	Chironomidae	*Chironomus sp.*	19
6a	water pool	Ephemeroptera	Heptageniidae	*Heptagenia sp*	1
6a	water pool	Ephemeroptera	Baetidae	*Baetis harrisonii*	10
6a	water pool	Heteroptera	Notonectidae	*Micronecta sp*	3
6a	water pool	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	2
6d	Wood	Ephemeroptera	Heptageniidae	*Heptagenia sp*	10
6d	Wood	Ephemeroptera	Baetidae	*Baetis sp*	3
6d	Wood	Turbellaria	Planariidae	*Planaria*	2
7a	water pool	Odonata	Libellulidae		9
7a	water pool	Diptera	Chironomidae	*Chironomus sp.*	5
7a	water pool	Trichoptera	Ecnomidae	*Paracnomina sp.*	1
7a	water pool	Ephemeroptera	Baetidae	*Baetis harrisonii*	7
7a	water pool	Heteroptera	Corixiidae	*Sigara pectoralis*	1
7a	water pool	Heteroptera	Corixiidae	*Micronecta sp*	1
7a	water pool	Heteroptera	Notonectidae	*Enithares chinai*	1
7b	River run	Odonata	Libellulidae		1
7b	River run	Trichoptera	Hydropsychidae	*Hydropsyche sp*	4
7b	River run	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	2
7b	River run	Diptera	Simulidae	*Simulium sp*	10
7b	River run	Diptera	Muscidae		1
7b	River run	Coleoptera	Elmidae		2
7b	River run	Turbellaria	Planariidae	*Planaria*	6
7b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	16
7b	River run	Ephemeroptera	Baetidae	*Baetis sp*	1
7b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	3
7c	Boulders	Turbellaria	Planariidae	*Planaria*	8
7c	Boulders	Ephemeroptera	Baetidae	*Baetis harrisonii*	1
8a	water pool	Decapoda	Potamonautidae	*Potamonautes alluaudi*	2
8a	water pool	Coleoptera	Elmidae		1
8a	water pool	Ephemeroptera	Heptageniidae	*Heptagenia sp*	18
8a	water pool	Ephemeroptera	Heptageniidae	*Heptagenia sp*	27
8a	water pool	Ephemeroptera	Caenidae	*Caenis sp*	2
8b	River run	Coleoptera	Elmidae		1

Site	River point	Order	Family	Genus/species	No. of individuals
8b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	21
8b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	26
8b	River run	Ephemeroptera	Leptophlebiidae		4
8b	River run	Diptera	Simulidae	*Simulium sp*	1
8b	River run	Coleoptera	Helodidae		1
8b	River run	Odonata	Aeshinidae		1
8c	Boulders	Decapoda	Potamonautidae	*Potamonautes alluaudi*	1
8c	Boulders	Araneae			1
8c	Boulders	Ephemeroptera	Heptageniidae	*Heptagenia sp*	2
8c	Boulders	Trichoptera	Hydropsychidae	*Hydropsyche sp*	2
8c	Boulders	Turbellaria	Planariidae	*Planaria*	2
8d	Wood	Coleoptera	Elmidae		7
8d	Wood	Ephemeroptera	Heptageniidae	*Heptagenia sp*	6
8d	Wood	Ephemeroptera	Baetidae	*Baetis harrisonii*	11
8d	Wood	Plecoptera	Perlidae		1
8d	Wood	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	2
8d	Wood	Diptera	Ceratopogonidae		2
9a	Water pool	Heteroptera	Belastomatidae	*Lethacerus niloticus*	1
9a	Water pool	Heteroptera	Gerridae	*Eurymetra natalensis*	1
9a	Water pool	Heteroptera	Naucoridae	*Laccocoris limigenus*	1
9a	Water pool	Odonata	Chlorolestidae	*sp1*	5
9a	Water pool	Odonata	Platycnemidae	*sp1*	5
9a	Water pool	Ephemeroptera	Heptageniidae	*Heptagenia sp*	1
9a	Water pool	Ephemeroptera	Baetidae	*Baetis harrisonii*	19
9a	Water pool	Ephemeroptera	Leptophlebiidae		1
9a	Water pool	Decapoda	Potamonautidae	*Potamonautes sp.*	1
9b	River run	Ephemeroptera	Baetidae	*Baetis sp*	10
9b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	18
9b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	5
9b	River run	Ephemeroptera	Leptophlebiidae		2
9b	River run	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	13
9b	River run	Diptera	Tipulidae		1
9b	River run	Decapoda	Potamonautidae	*Potamonautes sp.*	2
9c	Boulders	Turbellaria	Planariidae	*Planaria*	10
9c	Boulders	Ephemeroptera	Heptageniidae	*Heptagenia sp*	4
9c	Boulders	Ephemeroptera	Baetidae	*Baetis sp*	2
9c	Boulders	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	4
9c	Boulders	Diptera	Chironomidae	*Chironomus sp.*	3
9c	Boulders	Coleoptera	Psephenidae	*Psephenus sp.*	1
9d	Wood	Ephemeroptera	Baetidae	*Baetis harrisonii*	5
9d	Wood	Ephemeroptera	Baetidae	*Baetis sp*	3
9d	Wood	Coleoptera	Elmidae	*sp1*	3
10b	River run	Decapoda	Potamonautidae	*potamonautes odneri*	1

Site	River point	Order	Family	Genus/species	No. of individuals
10b	River run	Odonata	Gomphidae		1
10b	River run	Odonata	Libellulidae		1
10b	River run	Diptera	Simulidae	*Simulium sp*	1
10b	River run	Diptera	Chironomidae	*Chironomus sp.*	2
10b	River run	Diptera	Tipulidae		2
10b	River run	Turbellaria	Planariidae	*Planaria*	3
10b	River run	Trichoptera	Hydropsychidae	*Hydropsyche sp*	12
10b	River run	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	18
10b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	6
10b	River run	Ephemeroptera	Baetidae	*Baetis sp*	4
10b	River run	Coleoptera	Dryopidae		1
10b	River run	Fish			1
11a	Water pool	Decapoda	Potamonautidae	*Potamonautes sp.*	2
11a	Water pool	Odonata	Libellulidae		3
11a	Water pool	Coleoptera	Elmidae		1
11a	Water pool	Ephemeroptera	Baetidae	*Baetis harrisonii*	12
11a	Water pool	Ephemeroptera	Leptophlebiidae		5
11a	Water pool	Trichoptera	Hydropsychidae	*Cheumatopsyche sp*	1
11b	River run	Trichoptera	Hydropsychidae	*Hydropsyche sp*	6
11b	River run	Ephemeroptera	Heptageniidae	*Heptagenia sp*	1
11b	River run	Ephemeroptera	Leptophlebiidae		2
11b	River run	Ephemeroptera	Baetidae	*Baetis harrisonii*	3
11c	Boulders	Coleoptera	Psephenidae	*Psephenus sp.*	6
11c	Boulders	Trichoptera	Hydropsychidae	*Hydropsyche sp*	1
11c	Boulders	Ephemeroptera	Baetidae	*Baetis harrisonii*	1
11c	Boulders	Ephemeroptera	Heptageniidae	*Heptagenia sp*	3
11c	Boulders	Ephemeroptera	Prosopistomatidae		1
11d	Wood	Diptera	Ceratopogonidae		1
11d	Wood	Coleoptera	Elmidae		2
11d	Wood	Ephemeroptera	Baetidae	*Baetis harrisonii*	3
11d	Wood	Ephemeroptera	Baetidae	*Baetis sp.*	3

13.6 Checklist of birds encountered during the survey

Order	Family	Species Common Name	***Scientific Name***
Accipitriformes	Accipitridae	African Harrier Hawk	*Polyboroidestypus*
Anseriformes	Anatidae	African Black Duck	*AnasSparsa*
Bucerotiformes	Bucerotidae	Silvery-Cheeked Hornbill	*Bycanistesbrevis*
Bucerotiformes	Bucerotidae	Silvery-Cheeked Hornbill	*Bycanistesbrevis*
Coliiformes	Coliidae	Speckled Mousebird	*Coliusstriatus*
Columbiformes	Columbidae	Olive Pigeon	*Columba arquatrix*

Columbiformes	Columbidae	Red-Eyed Dove	*Streptopeliasemitorquata*
Columbiformes	Columbidae	Tambourine Dove	*Turturtympanistria*
Coraciiformes	Meropidae	Cinnamon-Chested Bee-eater	*Meropsoreobates*
Cuculiformes	Cuculidae	Red-chested Cuckoo	*Cuculussolitarius*
Galliformes	Numididae	Crested Guineafowl	*Gutterapucherani*
Musophagiformes	Musophagidae	Hartlaub'sTuraco	*Tauracohartlaubi*
Passeriformes	Cercotrichas	Rufous Bush Chat	*Cercotrichasgalactotes*
Passeriformes	Cisticolidae	Black-throated Apalis	*Apalisjacksoni*
Passeriformes	Cisticolidae	Chestnut-throated Apalis	*Apalisporphyrolaema*
Passeriformes	Cisticolidae	Grey Apalis	*Apaliscinerea*
Passeriformes	Cisticolidae	Grey-backed Camaroptera	*Camaropterabrachyura*
Passeriformes	Cisticolidae	Hunters Cistolica	*Cistolicahunteri*
Passeriformes	Cisticolidae	Red-faced Cisticola	*Cisticolaerythropssylvius*
Passeriformes	Cisticolidae	Red-faced Cistolica	*Cisticolaerythrops*
Passeriformes	Cisticolidae	Singing Cistolica	*Cistolicacantans*
Passeriformes	Cisticolidae	Tawny-Flanked Prinia	*Priniasubflavamelanoryncha*
Passeriformes	Corvidae	Pied Crow	*Corvusalbus*
Passeriformes	Cyanomitra	Green-Headed Sunbird	*Nectariniaverticaliviridisplendens*
Passeriformes	Dicruridae	Common Drongo	*Dicrurusadsimilis*
Passeriformes	Emberizidae	Golden-Breasted Bunting	*Emberizaflaviventriskalaharica*
Passeriformes	Estrildidae	Black-and-White Mannikin	*Lonchura bicolor*
Passeriformes	Estrildidae	Bronze Mannikin	*Lonchuracucullata*
Passeriformes	Estrildidae	Common Waxbill	*Estrildaastrild*
Passeriformes	Fringillidae	African Citril	*Serinuscitrinelloides*
Passeriformes	Fringillidae	Streaky Seedeater	*Serinusstriolatus*
Passeriformes	Hirundinidae	Barn Swallow	*Hirundorustica*
Passeriformes	Hirundinidae	Black Saw-wing	*Psalidroprocneholomelas*
Passeriformes	Hirundinidae	Common House Martin	*Delichonurbica*
Passeriformes	Hirundinidae	Common House Martin	*Delichonurbica*
Passeriformes	Hirundinidae	Mosque Swallow	*Hirundosenegalensis*
Passeriformes	Hirundinidae	Red-Rumped Swallow	*Hirundodauricaemini*
Passeriformes	Hirundinidae	Wire-Tailed Swallow	*Hirundosmithii*
Passeriformes	Laniidae	Common Fiscal	*Laniuscollarishumeralis*
Passeriformes	Leiothrichidae	Hinde's Babbler	*Turdoideshindei*
Passeriformes	Locustellidae	Cinnamon Bracken Warbler	*Bradypteruscinnamomeus*
Passeriformes	Malaconotidae	Black-backed Puffback	*Dryoscopuscubla*
Passeriformes	Malaconotidae	Brown-Crowned Tchagra	*Tchagraaustralis*
Passeriformes	Malaconotidae	Tropical Boubou	*Laniariusaethipicus*
Passeriformes	Monarchidae	African Paradise Flycatcher	*Terpsiphoneviridis*
Passeriformes	Monarchidae	African Paradise Flycatcher	*Terpsiphoneviridis*
Passeriformes	Motacillidae	African Pied Wagtail	*Motacillaaguimpvidua*
Passeriformes	Motacillidae	Mountain Wagtail	*Motacillaclaratorrentium*
Passeriformes	Muscicapidae	African dusky Flycatcher	*Muscicapaadusta*
Passeriformes	Muscicapidae	Brown-chested Alethe	*Alethepoliocephala*

Passeriformes	Muscicapidae	Cape Robin-Chat	*Cossyphacaffraiolaema*
Passeriformes	Muscicapidae	Ruppell's Robin Chat	*Cossyphasemirufa*
Passeriformes	Muscicapidae	White-Eyed Slaty Flycatcher	*Melaenornisfischeri*
Passeriformes	Muscicapidae	White-Starred Robin	*Pogonocichlastellata*
Passeriformes	Nectariniidae	Amethyst Sunbird	*Nectariniaamethystina*
Passeriformes	Nectariniidae	Beautiful Sunbird	*Nectariniapulchella*
Passeriformes	Nectariniidae	Bronze Sunbird	*Nectariniakilimensis*
Passeriformes	Nectariniidae	Collared Sunbird	*Hedydipnacollaris*
Passeriformes	Nectariniidae	Eastern Double-Collared Sunbird	*Nectariniamediocris*
Passeriformes	Nectariniidae	Golden-Winged Sunbird	*Nectariniareichenowi*
Passeriformes	Nectariniidae	Nothern Double-Collared Sunbird	*Nectariniapreussikikuyuensis*
Passeriformes	Nectariniidae	Olive Sunbird	*Nectariniaolivacea*
Passeriformes	Oriolidae	Black-headed Oriole	*Orioluslarvatus*
Passeriformes	Passeridae	Grey-Headed Sparrow	*Passer griseus*
Passeriformes	Platysteiridae	Chin-spot Batis	*Batismolitor*
Passeriformes	Ploceidae	Baglafecht Weaver	*Ploceusbaglafecht*
Passeriformes	Ploceidae	Grosbeak-Weaver	*Amblyospizaalbifrons*
Passeriformes	Ploceidae	Holub's Golden Weaver	*Ploceusxanthops*
Passeriformes	Ploceidae	Spectacled Weaver	*Ploceusocularis*
Passeriformes	Ploceidae	Village Weaver	*Ploceuscucullatus*
Passeriformes	Pycnonotidae	Cabanis'sGreenbul	*Phyllastrephuscabanisi*
Passeriformes	Pycnonotidae	Common Bulbul	*Pycnonotusbarbatus*
Passeriformes	Pycnonotidae	Grey-Olive Greenbull	*Phyllastrephuscerviniventris*
Passeriformes	Pycnonotidae	Yellow-whiskered Greenbul	*Andropadusgracilirostris*
Passeriformes	Pycnonotidae	Yellow-whiskered Greenbul	*Andropaduslatirostris*
Passeriformes	Stenostiridae	White-tailed Crested Flycatcher	*Trochocerusalbonotatus*
Passeriformes	Sylviidae	Blackcap	*Sylvia atricapilla*
Passeriformes	Sylviidae	Common Whitethroat	*Sylvia communis*
Passeriformes	Sylviidae	Garden Warbler	*Sylvia borin*
Passeriformes	Turdidae	Olive Thrush	*Turdusolivaceus*
Passeriformes	Zosteropidae	Montane White-eye	*Zosteropspoliogaster*
Pelecaniformes	Scopidae	Hamerkop	*Scopus umbretta*
Piciformes	Indicatoridae	Eastern Honeybird	*Prodotiscuszambesiaeellenbecki*
Piciformes	Lybiidae	Yellow-rumpedTinkerbird	*Pogoniulusbilineatus*

13.7 List of Participants attended the FGDs.

Attendance List – Community Meeting # 1- 04.02.2017

04. 02 . 2017.

Community Meeting.

Nyaminili Cascade

Project on

	Name	Village	M/F	Signature
1	ERIC MUNE NGARI	GITHIMA	M	
2	STEPHEN MAIGA	GITHIMA	M	
3	JOHN MUCHIRA	GITHIMA	M	
4	ALBERT GACHOKI	GITHIMA	M	
5	DAVID MUTEMA	GITHIMA	M	
6	WALTER NJAGI	GITHIMA	M	
7	LINUS KINYUA	GITHIMA	M	
8	JOSEPH MURITHI	GITHIMA	M	
9	PATRICK KAMAU	GITHIMA	M	
10	EMMANUEL MWANIKI	GITHIMA	M	
11	JOSEPH N NYAGA	GITHIMA	M	
12	JAMES WACHIRA	GITHIMA	M	
13	WALLACE MUNGAI	GITHIMA	M	
14	JOHN GACHENA	GITHIMA	M	
15	ANTHONY MUNYUA	GITHIMA	M	
16	MATHEW GACHOKI	GITHIMA	M	
17	CATHRINE NJERI	GITHIMA	F	

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Date :.....

	Name	Village	M/F	Signature
18	CYRUS NJERU	GITHUNGA	M	
19	ALEX NJERU	GITHUNGA	M	
20	JAMES MWANGI	GITHUNGA	M	
21	JOSEPH GACHAGO	GITHUNGA	M	
22	BENSON MURIITHI	GITHUNGA	M	
23	JOHN GITHAU	GITHUNGA	M	
24	GERALD CHOMBA	GITHUNGA	M	CHOMBA
25	STEPHEN MURIMI	GITHUNGA	M	
26	KENETH GITONGA	GITHUNGA	M	
27	DAVID MWITA	GITHUNGA	M	
28	JOYCE MUTHONI	GITHUNGA	F	
29	JOHN MUCHIRI	GITHUNGA	M	
30	EPLAN MUKONO	GITHUNGA	M	
31	SAMUEL NJERU	GITHUNGA	M	
32	PAULINE NJERI	GITHUNGA	F	
33	SEPHANIA NJAGI	GITHUNGA	M	
34	DAVID NYAGA	GITHUNGA	M	
35	NJOGU KAGAI	GITHUNGA	M	
36	JOSEPH MURIITHI R	GITHUNGA	M	
37	MOSES NJERU	GITHUNGA	M	

Page (3)

No :.....

Date :.....

NAME	VILLAGE	M/F	SIGN
38 JOSEPH MUTUA	GITHIMA	M	Mutua
39 KIUGA KIUGANDU	GITHIMA	M	[illegible]
40 PETER MURAKARI	GITHIMA	M	[illegible]
41 KELVIN GATUMBI	GITHIMA	M	[illegible]
42 NYAGA MURAKARI	GITHIMA	M	NYAGA
43 SAMUEL MGAI	GITHIMA	M	[illegible]

Attendance Sheet Meeting of Project # 2 (08.02.2017)

No. ..... Meeting 2nd No. 2. - 08.02.2017. No. .....

Date: ..... Date: .....

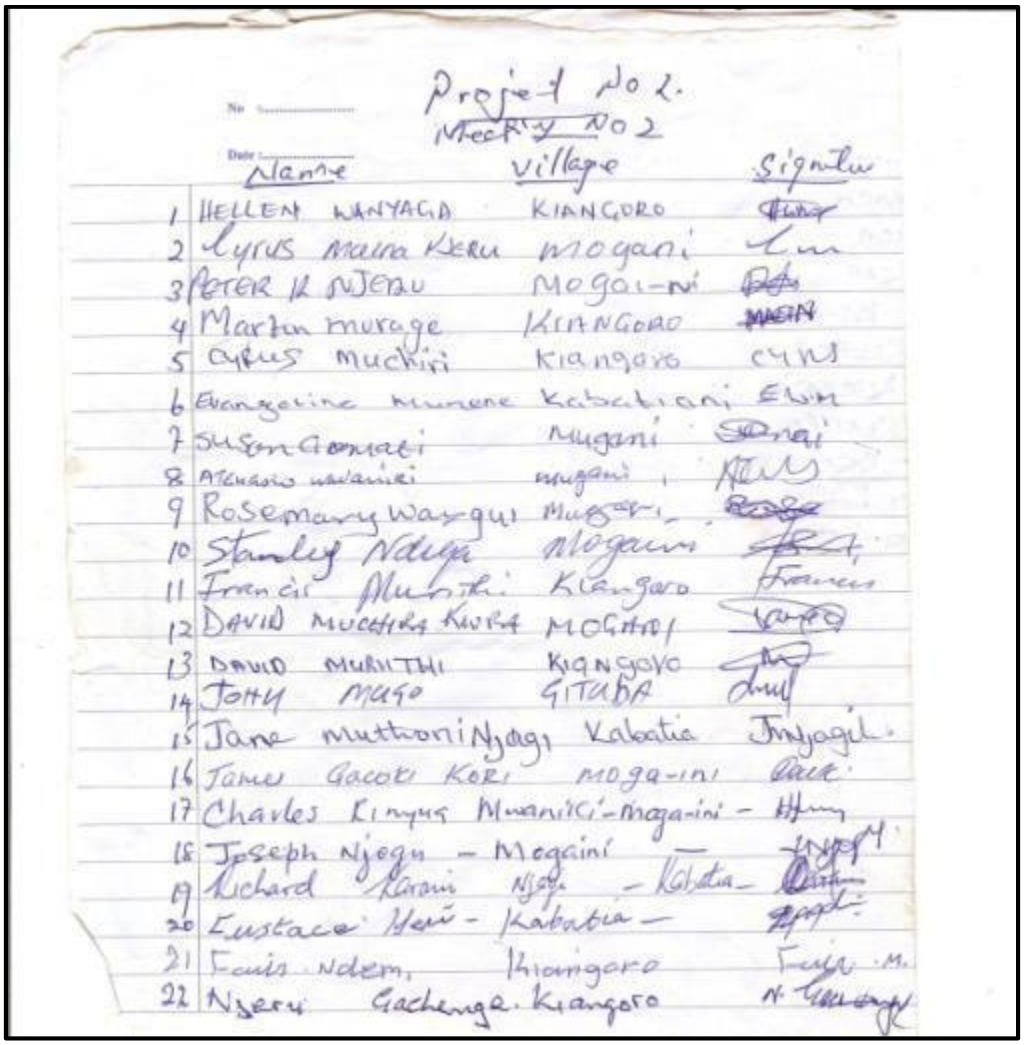
	Name	village.	signature.
1	Douglas Ngari Njoka	Kiangoro	
2	Christopher Kibugus	Kiangoro	
3	Hellen Gathera	Kiangoro	
4	Daniel Muiruki	Kiangoro	
5	Rechael Njahiva	Muburi	
6	Joseph Muniko Njogi	Muburi	
7	Veronica Nawira	Muburi	
8	Joseph Muriithi	muburi	
9	Albert Gicobi Njeru	Muburi	
10	Jennifer Muthoni Gicobi	Muburi	
11	David Ngari	Muburi	
12	Peter Mburia	Muburi	
13	Francis Njogi Njoka	Kiangoro	
14	Francis Njeru Gacoki	Kiangoro	
15	Patrick Gachoki	muburi	
16	Ndunga Mbego	muburi	
17	Agnes Wairimu	Muraura	Kiangoro
18	Matheu		kiangoro
19	Jane Murunga		kiangoro
20	Ann Wairimu		muburi
21	Lucy Wambui		muburi
22	Millicent Muthoni		muburi

			Village
23	Lucy	Kamau	Muburi
24	Joseph	Imbi	Muburi
25	Michael	Gichobi	Kachoki Muburi
26	Bernie	Mburu	Muburi
27	Nancy	Wangeria	Muburi
28	Agnes	Kachungu	Muburi
29	Laurence	Gaturi	Mberu Kiangoro
30	Kalua	Muthi	Kiangoro
31	Peter	Mbaathi	Kiangoro
32	Ann	Mbaki	Wachira Kiangoro
33	Jumus	Kirana	Muburi
34	Gabriel	Mburu	Kiangoro
35	John	Mgosi	Mgai Kiangoro
36	Kamau	Mbui	Muburi
37	Catalice	Wanjiru	Muburi
38	Mary	Wanjiru	~~Mugo~~ Muburi
39	Margaret	Mugo	Mugo Muburi
40	Mary	Nyambura	Muburi
41	Margaret	Mbaki	Kiangoro
42	Rose	Kiangui	Kiangoro
43	Catherine	Kiongani	Kiangoro
44	Nelly	Mbaki	Kachelke Muburi

45	Stephen	muriuki	kiangoro
46	Joseph	muchiri	kiangoro
47	Kibunja	Mwaji	kiangoro
48	Joseph	muthuri	muburi
49	Charles	Ianria	kiangoro
50	James	Kubuni	muburi
51	Moses	kamau	muburi
52	Ann	muthoni	muburi
53	Cecily	kubuni	muburi
54	Mercy	Mberi	muburi
55	Martin	kingara	muburi
56	Pauline	wanjiku	muburi
57	Faith	muthoni	muburi
58	Rosia	wanjiru	kiangoro
59	Samuel	muthuri	muburi
60	Albert	muriyi	kiangoro
61	Beatrice	wanjiru	muburi
62	Benson	wanjiru	muburi
63	Charity	wanjiru	muburi
64	Susan	muthoni	muburi
65	John	wanderi	muburi
66	John	muriuki	muburi

Susan	kamuri	muburi
Simon	kamuri	muburi
Catherine	wakuthie	muburi
Ann	Mberi	muburi
Jane	wajibi	kiangoro
Sarah	kamuri	kiangoro
Alice	wambui	muburi
Catherine	wanjiku	kiangoro
James	Mbera	kiangoro

Attendance Sheet Meeting of Project # 2



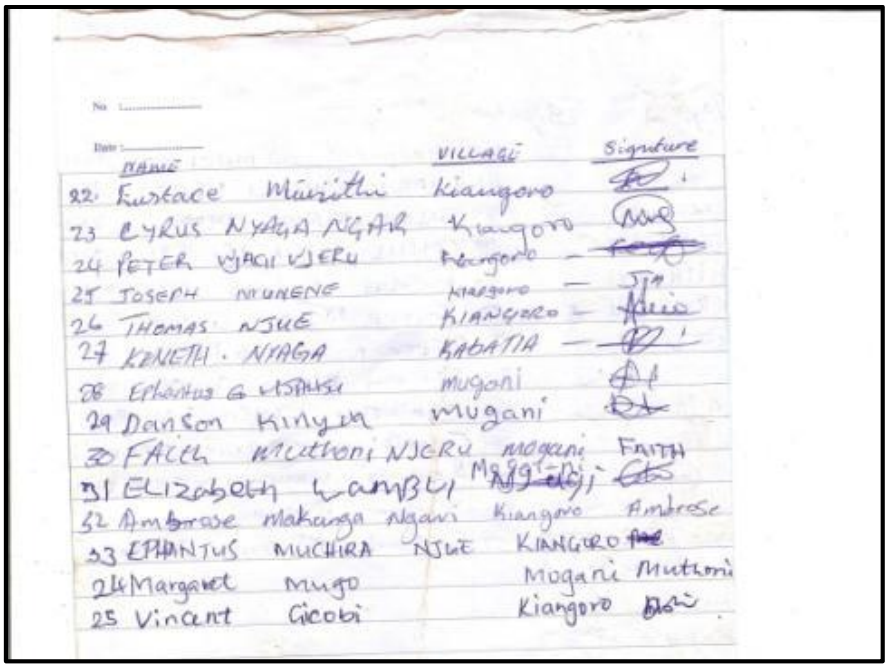
No .....

Date .....

Project No 2.

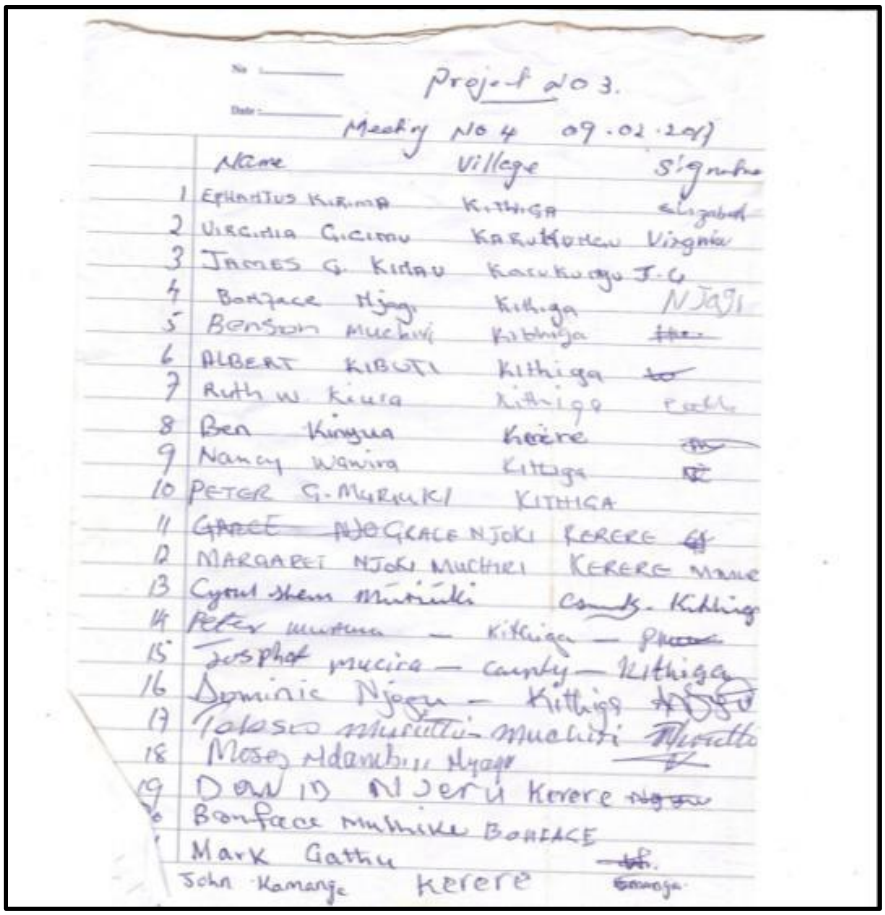
Meeting No 2

	Name	Village	Signature
1	HELLEN WANYAGIA	KIANGORO	
2	Cyrus Maina Kieru	Mogani	
3	PETER K NJERU	Mogaini	
4	Martin murage	KIANGORO	
5	Cyrus Muchiri	Kiangoro	
6	Evangeline Munene	Kabatiani	
7	SUSAN Gomaki	Mugani	
8	Mekario wawanki	mugani	
9	Rosemary Wangui	Mugani	
10	Stanley Ndegwa	Mogaini	
11	Francis Muriithi	Kiangoro	
12	DAVID MUCHIRA KIURA	MOGAINI	
13	DAVID MURIITHI	KIANGORO	
14	JOHN MUGO	GITURA	
15	Jane Muthoni Njagi	Kabatia	
16	James Gacoki Keri	Mogaini	
17	Charles Kinyua Muaniki	Mogaini	
18	Joseph Njogu	Mogaini	
19	Richard Karani Njogu	Kabatia	
20	Eustace Heri	Kabatia	
21	Louis Ndem	Kiangoro	
22	Njeru Gachenge	Kiangoro	



NAME	VILLAGE	Signature
22. Eustace Muriithi	Kiangoro	
23 CYRUS NYAGA NGAR	Kiangoro	
24 PETER NJAGI NJERU	Kiangoro	
25 JOSEPH MUNENE	Kiangoro	
26 THOMAS NJUE	KIANGORO	
27 KENETH . NYAGA	KABATIA	
28 Ephantus G Mshaki	mugani	
29 Danson Kinyua	mugani	
30 FAITH Muthoni NJERU	Mogani	FAITH
31 ELIZABETH WAMBU	Mogani	
32 Ambrose Makanga Ngari	Kiangoro	Ambrose
33 EPHANTUS MUCHIRA NJUE	KIANGORO	
34 Margaret Mugo	Mogani	Muthoni
35 Vincent Gicobi	Kiangoro	

Attendance Sheet Meeting of Project # 3



Project No 3.

Meeting No 4 09.02.2017

	Name	Village	Signature
1	EPHANTUS KIRIMA	KITHIGA	
2	VIRGINIA GICIMU	KARUKOKEU	Virginia
3	JAMES G. KIRAU	Karukuogu	J.G
4	Boniface Njagi	Kithiga	NJAGI
5	Benson Muchiri	Kithiga	
6	ALBERT KIBUTI	Kithiga	
7	Ruth W. Kiura	Kithiga	
8	Ben Kingua	Kerere	
9	Nancy Wanira	Kithiga	
10	PETER G. MURUKI	KITHIGA	
11	~~GRACE~~ NJOGRACE NJOKI	KERERE	
12	MARGARET NJOKI MUCHIRI	KERERE	
13	Cyrus Shem Muriuki	County - Kithiga	
14	Peter Muriuki	Kithiga	
15	Josphat Mucira	County	Kithiga
16	Dominic Njogu	Kithiga	
17	Tobias Muriithi	Muchiri	
18	Moses Mdambuni Nyaga		
19	DAVID NJERU	Kerere	
20	Boniface Muthike	BONIFACE	
	Mark Gathu		
	John Kamanga	Kerere	

Date: .....

	Name	Village	Sign
22	Kennedy muriuki		
23	Nancy wakuthi		
24	benjamin Mugunyamaku	KARUNGO	
25	ISAAC GACHOKI NJOKA	KITHIGA	
26	Boniface NJOGU	KITHIGA	
27	EDWARD MUNYITHI NGARI	KERERE	
28	HENRY NYAGATHATIA	Kerere	
29	Samuel Bundi	Kayeve	
30	ANTHONY MWANGI NJOKA	KITHIGA	
31	Peter N. Ndambiri	Kerere	
32	stephen Karani	kerere	
33	Joseph Njoroge	Kerere	
34	David Njeru M.	Kerere	
35	JUSTIN KIMOTHO KIBUTI	KITHIGA	
36	Peline Wairuri	Kerere	
37	Cicily Wangeci	Kabore	
38	Pauline Wanjiru	Kithiga	
39	Simon Mgiri	Kithiga	
40	HIRAM MBOGO NJAMBIRI	KERERE	
41	JOHN NDERI GICHOBI	KERERE	
42	MARY MUTHONI GICHOBI	KERERE	
43	Eunice wanjiru	Kithiga	
44	Elija muriuki Nyaga	Kithiga	

No :.....

Date :.....

45 margaret W. MUCHIRA KITHIGA
46 MARY WANGECI NJAGI KABORO
47 SALOME MUTHONI NYAGA KITHIGA
48 CYRUS NYAGA NDAMBIRI KERERE
49 NICOLUS MURITHI MUTHIRE KITHIGA
50 JOSEPH NGIAO GICHOBI KERERE
51 ESTHER MURINGO KANYUA KERERE
52 SAMMY NJOGU GICHOBI KERERE
53 MATHEW NJAGI GICHOBI KERERE
54 FELISTA WANGERWE NDAMBIRI KITHIGA
55 REGINA WANGEWAMOKU NJUE-KITHIGA
56 Muriuki Antony
57 Benard Muchiri Njuki BMK

13.8 List of Respondents for the HH Survey under social Assessment

No.	Date and time	Village	Sub location	Location	Name of respondent	Sex	Interviewer
1	06/02/2017 - 1.00pm	Kithima	Kabari	Ngariama	Cyprian Njogu	Male	Joyce Njogu
2	6/2/2017 - 4.00pm	Kithima	Kabari	Ngariama	Francis Nyaga Kagai	Male	Joyce Njogu
3	06/02/2017 - 5.00pm	Kithima	Kabari	Ngariama	Jamuel Njeru	Male	Joyce Njogu
4	06/02/2017 - 5.30pm	Kithima	Kabari	Ngariama	Margaret Wambura	Female	Joyce Njogu
5	06/02/2017 - 6.00pm	Kithima	Kabari	Ngariama	Jamuel Ngari	Female	Joyce Njogu
6	06/02/2017 - 5.44Pm	Kithima	Kabari	Ngariama	James Wachira	Male	Joyce Njogu
7	6/2/2017 - 18.40pm	Kithima	Kabari	Ngariama	Millicent Wanjiru	Female	Joyce Njogu
8	6/2/2017 - 18.50pm	Kithima	Kabari	Ngariama	Newton Kariuki	Male	Joyce Njogu
9.	08/02/2017 - 1.00pm	Kithima	Kabari	Ngariama	Henery Nyaga Kathii	Male	Joyce Njogu
10	07/02/2017 - 9.00am	Kithima	Kabari	Ngariama	Eric Njine	Male	Joyce Njogu
11	07/02/17 - 10.00am	Kithima	Kabari	Ngariama	Kiura Kigundu	Male	Joyce Njogu
12	07/2/2017 - 10.30am	Kithima	Kabari	Ngariama	Moses Njui Wambeu	Male	Joyce Njogu
13	07/02/2017 - 11.00am	Kithima	Kabari	Ngariama	James Kirigo Murithi	Male	Joyce Njogu
14	07/02/2017 - 12.00pm	Kithima	Kabari	Ngariama	Cyacoki Nyaga	Male	Joyce Njogu
15	08/02/2017 - 8.30am	Kithima	Kabari	Ngariama	Simon Gakono	Male	Joyce Njogu
16	08/02/2017 - 8.00am	Kithima	Kabari	Ngariama	Lorna Wanjirli Mugo	Female	Joyce Njogu

17	08/02/2017 - 9.00am	Kithima	Kabari	Ngariama	Florence Wawira Nyaga	Female	Joyce Njogu
18	08/02/2017 - 12.00pm	Kithima	Kabari	Ngariama	Ernest Kiura Ireri	Male	Joyce Njogu
19	08/02/2017 - 10.30am	Kithima	Kabari	Ngariama	Wawira Peter Njogu	Female	Joyce Njogu
1	8/2/2017	Kebere	Ngiriambu	Njuki-ini	David Njeru	Male	Nancy Wakuthii
2	9/2/2017	Kithiga	Ngiriambu	Njuki-ini	Margaret W. Muchira	Female	Nancy Wakuthii
3	9/2/2017	Kithiga	Ngiriambu	Njuki-ini	Isaac Gachoki	Male	Nancy Wakuthii
4	9/2/2017	Kebere	Ngiriambu	Njuki-ini	Mark Gathu	Male	Nancy Wakuthii
5	9/2/2017	Karungu/Kiratina	Ngiriambu	Njuki-ini	Ephantus Kirima	Male	Nancy Wakuthii
6	9/2/2017	Kithiga	Ngiriambu	Njuki-ini	Margaret Gatakaa	Female	Nancy Wakuthii
7	9/2/2017	Kithiga	Ngiriambu	Njuki-ini	Felister Wangerwe	Female	Kennedy Muriuki
8	9/2/2017	Kerere	Ngiriambu	Njuki-ini	Christopher Mugo	Male	Nancy Wakuthii
9	9/2/2017	Kithiga	Ngiriambu	Njuki-ini	Peter Mwavra	Male	Kennedy Muriuki
10	9/2/2017	Mbiri	Ngiriambu	Njuki-ini	Betrace Wanjira Njiru	Female	Kennedy Muriuki
11	9/2/2017	Kerere	Ngiriambu	Njuki-ini	Mangrate Njoki Muchiri	Female	Kennedy Muriuki
12	9/2/2017	Mbiri	Ngiriambu	Njuki-ini	Antony Mwngi Njoka	Male	Kennedy Muriuki
13	10/2/2017	Kerere	Ngiriambu	Njuki-ini	Ruth Wangithi Kiura	Female	Nancy Wakuthii
14	10/2/2017	Kithiga	Ngiriambu	Njuki-ini	Jeras Njagi	Male	Nancy Wakuthii
15	10/2/2017	Kithiga	Ngiriambu	Njuki-ini	Salome Muttioni Nyaga	Female	Nancy Wakuthii
16	10/2/2017	Kerere	Ngiriambu	Njuki-ini	Hillman Mwangi	Male	Nancy Wakuthii
17	10/2/2017	Kerere	Ngiriambu	Njuki-ini	Hilan Mbogo	Male	Nancy Wakuthii

18	10/2/2017	Kerere	Ngiriambu	Njuki-ini	Peter Njoroge Nyaga	Mlae	Nancy Wakuthii
19	10/2/2017	Kerere	Ngiriambu	Njuki-ini	James Kamanga Nyaga	Male	Nancy Wakuthii
20	9/2/2017	Kerere	Ngiriambu	Njuki-ini	Zakaria Leonard Njeru	Male	Kennedy Muriuki
1	9/2/2017	Kiangoo	Rungeto	Ngariama	Hellen Wanyaga	Female	Daya
2	9/2/2017	Kabatia	Rungeto	Ngariama	Richard Karani	Male	Hellen Wanyaga
3	9/2/2017	Mogani	Rungeto	Ngariama	Keneth Nuaga	Male	Hellen Wanyaga
4	9/2/2017		Rungeto	Ngariama	Ephantus Muchira Njue	Male	Hellen Wanyaga
5	9/2/2017	Mogani	Rungeto	Ngariama	Rosemary Wangi Ireri	Female	Hellen Wanyaga
6	10/2/2017	Kiangoro	Rungeto	Ngariama	Vincent Gkobi	Male	Hellen Wanyaga
7	11/2/2017	Kiangoro	Rungeto	Ngariama	Martin Mrage Njuki	Male	Hellen Wanyaga
8	11/2/2017	Wangoro	Rungeto	Ngariama	Francis Mureithi	Male	Hellen Wanyaga
9	11/2/2017	Kiangoro	Rungeto	Ngariama	Njeru Gachenge	Male	Hellen Wanyaga
1	7/2/2017	Muburi	Ngerwe	Njukhni	Peter Mburia	Male	James Mburia
2	9/2/2017	Muburi	Ngerwe	Njukhni	Janet Kabari Njeru	Female	James Mburia
3	9/2/2017	Muburi	Ngerwe	Njukhni	Joseph Ikeri Mbogo	Male	James Mburia
4	9/2/2017	Muburi	Ngerwe	Njukhni	Nancy Wangenule Munyi	Female	James Mburia
5	9/2/2017	Muburi	Ngerwe	Njukhni	Ann Wawira	Female	James Mburia
6	9/2/2017	Muburi	Ngerwe	Njukhni	Murithi Njagi	Male	James Mburia

7	9/2/2017	Muburi	Ngerwe	Njukhni	Joseph Mugo Murici	Male	James Mburia
8	9/2/2017	Kiangoro	Rungeto	Ngariama	Nyaga Hoseth	Male	James Mburia
9	9/2/2017	Kiangoro	Rungeto	Ngariama	Hesbom Gathera Joram	Male	James Mburia
10	9/2/2017	Kiangoro	Ngerwe	Njukhni	Daniel Mwaniki Niambiri	Male	James Mburia
11	9/2/2017	Kiangoro	Ngerwe	Njukhni	Dario Joseph Kamuri	Male	James Mburia
12	9/2/2017	Kiangoro	Ngerwe	Njukhni	Catherine Wangithi Risuru	Female	James Mburia
13	9/2/2017	Kiangoro	Ngerwe	Njukhni	Nyaga Njagi	Male	James Mburia
14	9/2/2017	Kiangoro	Ngerwe	Njukhni	Christopher Kibugua	Male	James Mburia
15	9/2/2017	Muburi	Ngerwe	Njukhni	Joseph Muchira	Male	James Mburia
16	9/2/2017	Muburi	Ngerwe	Njukhni	Kamuu Mbui	Male	James Mburia
17	9/2/2017	Muburi	Ngerwe	Njukhni	Elizabeth Idanduma	Female	James Mburia
18	9/2/2017	Muburi	Ngerwe	Njukhni	Lucy Njoki	Female	James Mburia
19	9/2/2017	Muburi	Ngerwe	Njukhni	Rachael Njahira	Female	James Mburia
20	9/2/2017	Muburi	Ngerwe	Njukhni	Martin Karahi	Male	James Mburia
21	9/2/2017	Muburi	Ngerwe	Njukhni	Lalambugu Kanyangarika	Male	James Mburia
22	10/2/2017	Muburi	Ngerwe	Njukhni	Nduriga Mbogo	Male	James Mburia
23	10/2/2017	Muburi	Ngerwe	Njukhni	Agnes Wanjiru Mwaura	Male	James Mburia
24	10/2/2017	Muburi	Ngerwe	Njukhni	Erick Mumene Mbui	Male	James Mburia
26	10/2/2017	Muburi	Ngerwe	Njukhni	Margrate Muthoni Njagi	Female	James Mburia
27	10/2/2017	Muburi	Ngerwe	Njukhni	Alice Wambui	Female	James Mburia

13.9 Copy of the HH Survey (social assessment) Questionaire

Socio-Economic Assessment of the communities living within the project Influence Area. Nyamindi Cascade Development for SHPP

1. **General Information**

Questionnaire No.		**Name of the Respondent**	
Date & time		**Sex**	
Village		**HH No**	
Sub Location		**Interviewer**	
Location		**Checked by**	

2. **Household Composition (Number of family members)**

Total Number of family members	
(0) – (05) age	
05 to 18 age	
18 to 60 age	
60 and above	

2.1 Number of males in the family
2.2 Number of females in the family

2.3 Religion

2.4 Tribe / language

3. How long have you been living in this village/location?

(1) Less than 1 year (2) 1-5 years (3)5-10years (4)10years or more

4. Details of House

7.1 Nature	7.2 Floor Area (Sq.f)	7.3 No. of Rooms		7.4 Floor	7..5 Walls	7.6 Roof	7.7 Structure
		Bed Rooms	Storage				

Nature (1) Traditional circular house (2) Non- traditional rectangular shape house

Walls **(**1) Timber/poles 2) Brick 3) Mud 4) Iron 5) Plastic Sheeting

Door/Window Frame **(1**) Timber (2) Poles 2) Others

Floor **(**1) Mud (2) Cement (3) Dung

Roof **(**1) Grass Thatch 2) Tiles 3) Iron Sheets 4) Plastic Sheeting

4.2 **Are you the owner the house? Yes/No**

4.3 **Do you have a toilet (Pit Type /Flush Type?)**

5. **Type of Livelihoods and Household Income**

Type of income earning activity	Growing Tea	Growing other crops	Livestock rearing			Other income sources (Boutique/ higher labor/ permanent job
			Poultry	Cattle	Any other	

5.1 How do you earn money?

(1) Sell tea to the factory

(2) Excess crops to the trading center,

(3) Sell animals

(4) Work on the tea gardens as labor

5.2 Average household income:

Source of income	Average income (Shillings)	Total Annual income (Shillings)
Farming - Income from Tea		
Casual labor in tea gardens		
Other cash crops		
Other Unskilled work		
Livestock products (cattle, Poultry, Pigs)		
Trading (Boutique, charcoal, Fire wood, any other)		
Others		

5.3 Number of unemployed members in the family:

6. **Land ownership Do you own a piece of land? Yes/No. If Yes**

6.1 Landholdings

	Land size (acres)	**Ownership type**	**Use**	**Value**
This village				
Elsewhere				

Codes for land tenure system **(1)** *Free hold (Have title) (2) Only occupant (no title)*

Land use – *(1) Tea (2) Woodlot, 3) Others*

7. **House Hold Assets (Do you or your family members own following?)**

(1) Bicycle (2) Motor Cycle (3) Radio (4) Digging implements

(5) Others specify (Motor Car, Tractor, and Water Pump Etc.)

8. Savings - Are you a member of SACCO (Yes/No) Have you got any Savings? (Yes/No)

9. Accessibility to Water (How do you get water?)

Source of water: Tick off what is relevant in (1) in table below:

Rain water	**River Stream**	**Shallow wells**	**Bore Holes**	**Piped water**

9.2 How far you walk to get water from nearest water source?:

10. **Availability of Electricity**: Do you have electricity at home?

10.1 If No, how do you find energy for cooking and lighting?

(1) Firewood, (2) Charcoal, (3) Kerosene (4) Any other Specify …….

11. Health Services: Has any one of your family members suffered from any illness during the past 3 months?

(Please insert your response in the table below☺

Type of Disease	**You/Member**	**No. of times**	**Whether treated in village hospital or native doctor**	**If hospital, where is it located**	**Distance to hospital**
Typhoid					
Cholera					
Dysentery					
Hepatitis					
Diarrhea					
Encephalitis					
Malaria					
HIV/Aids					
Others:					

12. Access to Educational Facilities;

12.1 Are your children studying (Yes/No) If yes where?

	In the Village	***In Sub Location***	***In the County***
Preschool			
Junior School			
Secondary School			

13. Family Expenses:

How much you spend monthly for following

	Monthly	Yearly
1. For food		
2. For Medicine		
3. For Cloths		
4. For Farming(seeds)		
5. For children's education		
6. For any other		

14. Community perception about the proposed project;

Answer following:

STATEMENT	Agree	Partly Agree	Disagree	No comment
I and my family will not object the project				
We are well aware of the project				

If not agree please state why?

15. Community Perception about the Environmental Resources

STATEMENT	Agree	Partly Agree	Disagree	No comment
We use Nyamindi river to feed cattle with water				
We use Nyamindi river water to catch fish.				
We use Nyamindi river for bathing and washing				
We feel that Nyamindi river water enhances the beauty of this area				
We use the Nyamindi river water to water our agriculture				
We make use of the trees and bushes along the river for traditional food and medicine and for our House building				
We feel that drying the Nyamindi river will affect aesthetic beauty				

15. Any Other comments by the respondent:……

13.10 National Noise Standards (Construction Sites)

Maximum Permissible Noise Levels for Construction Site

Column 1	Column 2	
Noise Control Zone	**Sound Level dB (A) (Leq)**	**Sound Level dB (A) Leq**
	Day	Night
Residential	60	40
Commercial	75	50
Industrial	85	65

Time Frame:

Day : 6.00 a.m - 10.00p.m.

Night : 10.00p.m - 6.00a.m

The time frame takes into consideration human activity.