REPUBLIC OF RWANDA

Ministry of Agriculture and Animal Resources (MINAGRI)
Land Husbandry and Water Harvesting (LWH) Project

Final Report

For:

The Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) of works related to the dam construction and development of Hillside irrigation infrastructures of Muyanza (Rulindo District) Site

Prepared by:
Eco-excellence consultancy Ltd

February 2015

EXECUTIVE SUMMARY

Background

The Government of Rwanda is pursuing a comprehensive Poverty reduction program which includes development and implementation of different sustainable development projects. The Land husbandry, Water harvesting and Hillside irrigation (LWH) Project is one of the development initiatives designed under the Ministry of Agriculture and Animal Resources (MINAGRI) and partly funded by the World Bank in order to tackle the issues related to food insecurity and rural communities livelihoods income.

The Project uses a modified watershed approach to introduce comprehensive and improved land-husbandry measures for hillside agriculture intensification. It also involves developing hillside irrigation for sub-sections of each site. The Project envisions the production of high-value horticultural crops with the strongest marketing potential on irrigated portions of hillsides of the watershed as well as the production of food crops and tree/shrub products on rained parts of the catchments.

It is in this regard that the Project intends to invest in water harvesting infrastructure, including water reservoirs construction and water conveyance at Muyanza (Rulindo district) site to enhance irrigated agriculture.

A feasibility study has just been completed with a proposal of a 26m height dam capable of irrigating approximately 950ha in Muyanza valley and parts of the hillsides.

In order for LWH to guide this development and operation in an environmentally friendly manner, it was necessary to carry out an Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) of the proposed Irrigation scheme for food self-sufficiency as directed by the Rwandan Organic Law on Environment Protection, World Bank safeguard policies and related International policies, hence this study.

Objectives of the study

The objective of the assignment is to assist MINAGRI/LWH to develop an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP) to ensure that the Muyanza sub-project is implemented in an environmentally and socially sustainable manner and in full compliance with Rwanda's and the World Bank's environmental and social policies and regulations.

Environmental compliance

An Environment Impact Assessment (EIA) is required by article 67 of the Organic law 04/2005 determining the modalities of protection, conservation and promotion of the environment in Rwanda and World Bank safeguard policies such as; Environmental Assessment- OP/BP 4.01, Involuntary resettlement- OP/B.P 4.12, Pest management- OP/B.P 4.09, Natural habitat- OP/B.P 4.04, Forests – OP/B.P 4.36, Safety of dams- OP/B.P 4.37, for implementation of this kind of infrastructure. The study was done in compliance to the laws and safeguards.

Approach and methodology of the study

The methodology of the study involved a preliminary assessment of the project, known as the scoping study; where project literature, preliminary technical studies were reviewed and field visits were done to understand the project, identify its boundaries and relevant stakeholders.

Literature review of Institutional, legislative and policy framework was done with a number of laws, policies, protocols and conventions such as; Organic law determining the modalities of environmental management in Rwanda, Organic law on land management, Resettlement Policy Framework (RPF), Environmental and Social management Framework (ESMF), SPAT II, Irrigation master plan (IMP), Integrated Water Resources Master Plan (IWRMP), LWH PAD, EAC protocol on environment and natural resources and World Bank Safeguard policies.

Public consultation- From the scoping exercise, stakeholders were identified in three categories. (1) First category of Government officials, (2) Second category of local government officials and (3) Third category of locals likely to benefit or be affected the project. Public consultation was carried with people from these stakeholder categories.

During the Public consultation, the study applied different participatory methods, namely; interviews, one-to-one discussions, focused group discussions (FGD) and official meetings with stakeholders. Discussions were guided key questionnaires in *appendix 3* and stakeholders were asked to raise their concerns on the proposed Muyanza project. Issue raised by one individual or a group of people was cross-checked by discussing it over with other individuals or groups. It is from these concerns that the likely impacts were determined and summarized in chapter 5.

Baseline data collection- Information was collected on the existing physical, biological, socio-economic environment Muyanza project area.

Hydrological analysis- involved determining the areas climate, water yield in the catchment, Derivation of flow data at Muyanza dam site, Water Use and Demand Assessment, Water Quality Assessment, Soil erosion risk, Sediment Yield Estimation, Flood assessment and Environmental/ecological Flows analysis.

Soil analysis- an independent soil and compost investigation was done for terraced and un-terraced soils of the project area. Laboratory tests were done on the soil and compost samples and results used in determining the soil profiles, soil and compost analysis. From this soil analysis, impacts were predicted likely to be caused by compost, fertilizer use and terracing practice.

Ecological analysis- Assessment was done of flora and fauna for selected areas at the water catchment area, dam and reservoir area and the command area. Tools such as field observation combined with GIS mapping were used to determine land cover of this area of project intervention. e.g. land cover comprising of forest area, cultivated area, surface water. Literature review was used to predict likely fauna commonly observed with corresponding flora determined by the GIS land cover. Expert observation was also applied to understand the existing ecosystem within these areas, to determine likely eco-sensitive areas and predict flora and fauna that could emerge with the introduction of this project.

Social environment analysis- It involved collecting primary data from field and matching it with secondary data obtained from desk reviews. Methods of obtaining field data were mainly through public consultation and expert observation.

Impact assessment applied number of tools and techniques to determine the nature (positive or negative), extent (spatial), occurrence (one-off, intermitted or constant), magnitude, whether reversible or irreversible, direct or indirect, probability of occurrence and significance with and without mitigation. The tools used were; Geographical Information System (GIS), Checklist, Cost benefit analysis (CBA) and Impact Matrix. For each adverse impact identified, its level of significance was indicated, mitigation measures for the predicted impacts were proposed and an Environmental Management Plan (EMP) developed.

Project Description

Site: Muyanza site is located in Rulindo District, covering five sectors, namely; Buyoga, Burega, Cyinzuzi, Tumba and Mbogo sectors. It is located approximately 40km from Kigali.

The Muyanza site involves; a dam with reservoir construction, land husbandry techniques at the water catchment area of the Muyanza River, and development of hillside irrigation infrastructure downstream of the dam on Muyanza River.

Project Activities

The project shall involve three phases that comprise of;

- *Phase I of Land husbandry*- which involves bench and radical terracing in the water and command catchment area, in total covering a 950ha,
- *Phase II of water harvesting*- comprising of construction of 26m earth dam and reservoir of 2.2million m^3.
- *Phase III of hillside irrigation*- 26km pipeline irrigation system.

A tabular representation of main characteristics of the dam and irrigable area is shown below.

Dam Description	**Dimensions**
Dam	
Design flood	1000yr return period
Water catchment area	25.04 km ^{2}
Dam height from river bed	26m
Dam height from excavation level	31m
Crest elevation of dam	1658m.a.s.l
Crest width	8m
Crest length	124m
Reservoir capacity	2.2 million m^3
Free board at 1000yr design flood	0.8m
Spillway at right side of dam	
Crest elevation of spillway	1655m.a.s.l
Crest length	20m
Maximum outflow	100m^3/s
Coffer dam for river diversion	
Crest elevation for coffer dam	1641m.a.s.l
Crest width	5m
Command area	950ha in Muyanza valley
Hillside irrigation infrastructure	
1st alternative of canal system	42km
2nd Alternative of pipe system	26km

Environmental and social impact assessment

Chapter 5, in form of a table, gives a summary of issues raised during the public consultation likely to be caused by Muyanza development that were anticipated by the locals during stakeholders' and public consultation. Details of the public consultation are addressed in the Issues report in *appendix 1.*

Positive environmental impacts expected from Muyanza subproject include: (i) Soil conservation through land husbandry, (ii) increased land productivity, (iii) Flood control, (iv) Habitat for fish and birds nesting, and (v) reforestation. Social benefits include: (i) Increased production from farming all year round, (ii) productive use of hillsides by terracing and irrigation, (iii) market access for agricultural products, (iv) collective harvest creating large quantities and sustaining markets, (v) increased crop yield, (vi) Temporary employment creation from terraces and construction works, (vii) Transfer of skills from construction activity, (viii) Affordability of medical insurance and education, (ix) Increased livestock fodder, (x) land appreciation, and (xi) Empowerment of farmers.

The Muyanza subproject is expected to also have adverse impacts during its different phases particularly construction and operational phases. Expected adverse impacts range from physical environment impacts, biological impacts and social Impacts.

Physical environment: Reduction of soil fertility parameters due to terracing, gradual soil acidification from unregulated fertilizer application, soil and water contamination from oil spillage of construction equipment, air and noise pollution, soil erosion and landslides from terracing and construction works, fire outbreaks. water contamination at compost sites, modification of flows downstream of the dam, water pollution from fertilizer and pesticide application water logging and salinization, high sedimentation levels, clogging and damage of irrigation infrastructure due to nature and quality of water in the reservoir, water losses from evaporation and leakage.

Biological Impacts: Loss of biodiversity on hillsides and valleys to project activity. e.g. forest area in command area mostly. Reduction of aquatic life due to reservoir eutrophication, loss of existing river biodiversity due to changes in water temperature.

Social impacts: Loss of property in form of houses, land and crops, farmer's income lost by missing cultivation season due to delay in commencing terraces, injuries by workers on site, diseases contracted from interactions during construction, loss of existing infrastructure (roads, portable water points, power lines), loss of an income source for people dependent on the non-aligned project activities in the command area boundaries.i.e. brick makers and sand miners, health hazards from poor fertilizer and pesticide application, water conflict by introduction of irrigation scheme, vandalism, floods from dam collapse, increased spread of water related diseases,) destruction of reservoir boundaries and pipes from plantation encroachment, drowning of children and livestock.

Mitigation measures were proposed for each of the adverse impacts anticipated, to an extent that they can be avoided, reduced, limited or eliminated hence manageable.

Environmental Management Plan (EMP) and monitoring plan

In *chapter 7 and 8*, presented in tabular form, an environmental and social management plan (EMP) and an Environmental Monitoring Plan indicating the mitigation measures, procedure to be followed, monitoring indicators, the responsible institutions to implement these measures and likely cost of implementing each of these mitigation measures have all been included in this comprehensive Environmental Impact Assessment (EIA) report.

An estimated EMP implementation cost of 404,872US$ was reached, which included; costs of property compensation, road compensation, lime and compost manure application, reforestation of slopes above 60%, the proposed green belt or at times called the silt trap zone and vegetation of terrace embankments, among many other mitigation measures.

In conclusion, given the nature and location of the development, the potential impacts associated with the proposed development are of a nature and extent that can be reduced, limited and eliminated by the application of appropriate mitigation measures. As a matter of fact, compliance with the proposed mitigation measures and regular monitoring done as per the Environmental

management and monitoring plans issued in the report, the Muyanza land husbandry and irrigation scheme is bound to be executed in a sustainably efficient manner.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

EA	Environmental Assessment
EAC	East African Community
EDPRS	Economic Development and Poverty Reduction strategy
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESIA	Environmental Social Impact Assessment
EWSA	Energy Water and Sanitation Authority
IMCE	Integrated Management of Critical Ecosystems
LWH	Land husbandry Water harvesting and Hillside Irrigation
MCM	Million cubic metres
MINAGRI	Ministry of Agriculture and Animal Resources
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
MINISANTE	Ministry of Health
MOU	Memorandum of Understanding
NISR	National Institute of Statistics of Rwanda
NLC	National Land Centre
PAD	Project Appraisal Document
PIT	Project Implementation Team
RAB	Rwanda Agricultural Board
REMA	Rwanda Environment Management Authority
RNRA	Rwanda Natural Resources Authority
SPAT II	Strategic Program for Agricultural Transformation II
SWAP	Sector Wide Approach Program
ToRs	Terms of Reference
WUA	Water Users' Association

CHAPTER 1: GENERAL BACKGROUND

1.1 BACKGROUND TO THE PROJECT

The Government of Rwanda is pursuing a comprehensive poverty reduction program which includes development and implementation of different sustainable development projects. The Land husbandry, Water harvesting and Hillside irrigation (LWH) Project is one of the development initiatives designed under the Ministry of Agriculture and Animal Resources (MINAGRI) and partly funded by the World Bank in order to tackle the issues related to food insecurity and rural communities livelihoods income.

The Project uses a modified watershed approach to introduce comprehensive and improved land-husbandry measures for hillside agriculture intensification. It also involves developing hillside irrigation for sub-sections of each site. The Project envisions the production of high-value horticultural crops with the strongest marketing potential on irrigated portions of hillsides of the watershed as well as the production of food crops and tree/shrub products on rained parts of the catchments.

It is in this regard that the Project intends to invest in water harvesting infrastructure, including water reservoirs construction and water conveyance at Muyanza (Rulindo district) site to enhance irrigated agriculture. A feasibility study has just been completed with a proposal of a 26m height dam capable of irrigating approximately 950ha in Muyanza valley and parts of the hillsides. Such an activity requires the preparation of an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP).

We understand that a portion of the project available budget has been allocated to the study of an Environmental Impact Assessment (EIA) for the works mentioned above, with Eco-Excellence consultancy and its team of qualified and experienced personnel recruited to perform this study.

The EIA was prepared in accordance with the requirements of (i) Article 67 of the Organic Law N° 04/2005 of 08/04/2005 determining the modalities of protection, conservation and promotion of environment in Rwanda; and (ii) applicable World Bank safeguard policies, especially OP 4.01 Environmental Assessment, OP 4.04 Natural Habitats, OP 4.09 Pest Management, OP 4.36 Forests, OP 4.37 Safety of Dams, and OP 4.12 Involuntary Resettlement. Its objective was to ensure environmental and social due diligence according to Rwandan Law and the Safeguard policies of the World Bank.

1.2 OBJECTIVES OF THE EIA STUDY

The objective of the assignment is to assist MINAGRI/LWH to develop an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP) to ensure that the Muyanza sub-project is implemented in an environmentally and socially sustainable manner and in full

compliance with Rwanda's and the World Bank's environmental and social policies and regulations.

The specific objectives are: (i) to assess the potential environmental and social impacts of the LWH Project's proposed irrigation and land husbandry infrastructure development in Muyanza site, whether positive or negative, and propose mitigation measures which will effectively address the impacts; and (ii) to inform the project preparation process of the potential impacts of different alternatives, and relevant mitigation measures (including implementation requirements).

1.3 SCOPING OF THE STUDY

Scoping study was undertaken by the consultant's team with an intention of collecting enough and relevant information so as to ensure a focused EIA/EMP. Scoping was restricted to the following boundaries.

By Project components- The study covered the impacts of three sectors of the project; (i) Land husbandry at the water catchment and command catchment area hillsides, (ii) water harvesting and irrigation which included; the dam, reservoir and irrigation infrastructure and (iii) activities involved in the cultivation of the valuable crops and food crops in the rain fed parts of the sub-project area of intervention.

Scope of work was to -

- Identify which legislation, policies (both local and international) are likely to influence impacts caused by this project.
- Develop an overview of the baseline environment of the project intervention area. i.e. physical, biological and social environment.
- Develop an overview of likely impacts (positive or negative) that could be caused by Muyanza project. i.e. terracing of the water catchment area and command catchment area, application of fertilizers to the soils, dam and reservoir construction and irrigation infrastructure.
- Propose mitigation measures against of the predicted adverse impacts identified.
- Propose an Environmental Management Plan (EMP) on how these mitigation measures can be implemented.
- Propose an Environmental Monitoring Plan with measurable indicators and parameters for these mitigation measures to ensure sustainability of the project.

This study was restricted to the sectors of Burega, Buyoga, Cyinzuzi, Tumba and Mbogo in Rulindo district.

1.4 APPROACH AND METHODOLOGY OF THE STUDY

This study followed procedures stipulated in the World Bank Safeguard policies, General Guidelines and Procedures for Environment Impact Assessment. The study adopted the

following approach: (i) scoping study/ preliminary assessment, (ii) review of secondary data on baseline information (iii) review of policies and regulations, (iv) review of previous meetings and consultations with stakeholders, (v) interviews with key stakeholders, and (vi) field surveys at the project site of water catchment, dam area and command area of Muyanza River.i.e.Areas in Rulindo district, covering the sectors of Burega, Buyoga, Cyunzuzi, Tumba and Mbogo. This was done to gather information and data on various aspects of the project site. Site locations, land cover, proposed infrastructure were described fully with clear maps for a comprehensive understanding of the area and project activities and to make the task of planning and monitoring easier during the implementation of the mitigation measures for the identified impacts. The methodology is detailed hereafter.

1.4.1 Preliminary Assessment/ Scoping study

A scoping study involved consultation with LWH headquarter staff and a field visit to familiarize the study team with existing features and proposed project infrastructure.

Scoping continued by visiting the site area again to consult with LWH site coordination team on activities proposed for Muyanza site, understand the sectors the project covers, what areas of the catchment area already have been terraced, where the dam axis lies, reservoir areas and likely limits of the command area. The study also established local authorities in the five sectors of project intervention. i.e. Cyunzuzi, Burega, Buyoga, Tumba and Mbogo.

The scoping exercise further entailed the following:

- Identification of the likely stakeholders who eventually were involved in the public consultation;
- Preliminary findings of the existing environment; (primary, biological and socio-cultural environment);
- Preliminary predictions of likely positive and adverse impacts;
- And finally establishing clear boundaries of the study and focus on the relevant issues concerning the study.

The scoping study also involved a preliminary desk review of: feasibility study of the Muyanza site, LWH project documentation, Strategic Programme for Agriculture Transformation II (SPAT II), other agriculture sector policies and regulations, Government Economic Development for Poverty Reduction Strategy (EDPRS), World Bank safeguard policies and the organic law on the environment.

1.4.2 Review of Institutional, legislative and Policy framework

An intense deskwork was done of existing institutional legislation, policies, plans and programs, which are likely to influence different parts of the implementation of Muyanza project, its sustainability and ensure enhancement of the environmental resources.

The literature review involved but was not restricted to the following;

- Feasibility study of the Multiple land husbandry, Dam and Hillside irrigation sites for Muyanza site;
- Organic Law no. 04.2005 establishing the modalities of protection, conservation and promotion of the environment on,
- Expropriation in the Public Interest (Expropriation Law – Law No. 18/2007 of 19/04/2007).
- EDPRS II,
- LWH Project Appraisal Document;
- Strategic Programme for Agriculture Transformation II (SPAT II),
- National Water Resources Management Policy
- Water and Sanitation Policy
- Land Policy
- Rulindo District Development Plan.

Other than national policies and regulations influencing this project, this review paid considerable attention to regional protocols, World Bank safe guard policies and International conventions.

Regional protocols include:

- The Nile Treaty,
- EAC Protocol on Environment.

Relevant World Bank Safeguard Operational Policies (OP) include;

- Environmental Assessment (OP4.01),
- Natural Habitats (OP 4.04),
- Forest (OP 4.36),
- Safety of Dams (OP 4.37),
- Pest Management (OP 4.09),
- Involuntary Resettlement (OP 4.12), and
- Physical Cultural Resources (OP 4.11).

An institutional framework was also presented, indicating roles and responsibilities of National and international Institutions that will have a stake in implementing this project, approving the EIA and monitoring mitigation measures proposed against anticipated adverse impacts. e.g. LWH, MINAGRI, REMA, MINIRENA, MININFRA, District and sector authorities and World Bank.

1.4.3 Public Consultation with Stakeholders

Identification and Involvement of stakeholders

Information collected from the preliminary desk review, preliminary consultation with LWH staff at headquarters and after having an initial field visit guided the study in identifying the Muyanza project stakeholders. Without chronological priority, these stakeholders were identified in three categories. (1) First category of Government officials, (2) Second category of

local government officials and (3) Third category of locals likely to benefit or be affected the project.

During the Public consultation, the study applied different participatory methods, namely; interviews, one-to-one discussions, focused group discussions (FGD) and official meetings with stakeholders. Stakeholders consulted were informed on the proposed project and by using the key guiding questionnaires in *appendix 3*, the study was able to guide discussions and obtain relevant information on the likely impacts of the project activities. Stakeholders were asked to raise their concerns on the proposed Muyanza project. An issue raised by one individual or a group of people was cross-checked by discussing it over with other individuals or groups. It is from these concerns that the likely impacts were determined and summarized in chapter 5. *(A Public consultation Issues report of the field visit may be referred in appendix 1).*

1.4.4 Baseline Data and Information

Information on the physical, biological, socio-economic environment, institutional and legal regimes was collected from a variety of sources, namely project documents and general literature review, visual and inspection, expert opinion, consultations with selected stakeholders and discussions with LWH representatives.

Field data / information collection
This involved visits to the site earmarked for the project components and activities. The Consultant was accompanied to the sites for the scoping visit, by the LWH field staff, who included; LWH Engineer, Environmental and safeguard officer, Community Development officer responsible for Muyanza site.

Subsequent field surveys were done with support from LWH coordination team on site. The consultant's team was split into three; (i) the sociologist carried out public consultation with local authorities, local farmers and residents in the area, (ii) the Ecologist and environmentalist embarked on field analysis to understand the previous, existing and likely ecosystem of the project area. i.e. Areas terraced in the water catchment area, the Dam and reservoir area and the command area, (iii) The soil scientist organised a team to support him in the field to dig, collection of soil samples for laboratory analysis and soil profile description on site.

All these activities were done to capture a broad picture of the prevailing situation at the site and in physical, biological and social assessment of Muyanza.

1.4.4.1 Methods used for baseline data collection and analysis

Hydrological analysis
The data required for the hydrological assessment includes; daily rainfall records, daily stream flow, monthly evaporation and temperature, sediment concentrations, borehole yield and depth.

This information is used to verify the potential capacity that will be contained in the reservoir for irrigation.

Available historical hydrometric data on the Muyanza stream, as well as meteorological data recorded at stations within the drainage basin and the surrounding area was gathered from the relevant national institutions and analysed for any inconsistencies. Other data included water quality data, sediment load, water census data (i.e. principal water users downstream and upstream of the proposed dam), ground water resources and surface water bodies. Topographic data including maps (both paper and digital form), land-use areas, soil types and geology, vegetation cover aided in characterisation of the watershed under study.

A field visit to the project area was carried out to crosscheck information obtained during the desk study and obtain any additional field information where necessary.

Climate- With climatic data not available in the feasibility study, this EIA study went ahead to characterize the climate of Muyanza catchment by analyzing climatic data (rainfall) obtained from Rulindo Meteorological station and Byumba Meteorological stations which are approximately 7km and 16km from the centre of the Muyanza catchment respectively. Temperature data was obtained from the Kigali Aero Meteorological Station approximately 30km from the catchment.

Water yield in catchment- A study of existing surface and ground water resources within the catchment including; geological formations, monitoring networks, and water sources was carried out.

Since the data on borehole, shallow wells and springs monitoring network was missing for the area, ground water data from Integrated Watershed Management Program for Kagera Basin (LTS, 2012) was able to direct us to determining ground water depth of Muyanza area.

This guided us as to determine whether any existing surface water sources or the ground water depth would be affected or would affect the existence of the project.

Derivation of flow data at Muyanza dam site- Information about inflows into a proposed dam is important for determining the sufficient storage capacity of a reservoir to meet the water demands. The proposed Muyanza site is located on Muyanza stream, a tributary of River Nyabarongo in the Lower Nyabarongo catchment of the Kagera River basin in Rwanda. River Nyabarongo is gauged downstream of the proposed dam site. Considering that data from the gauge at a bridge on Muyanza stream was insufficient, the flows at the dam site were determined by applying the drainage –area ratio method, given that the Muyanza catchment is a sub-basin of the Nyabugogo basin and can therefore be considered to have similar hydrological characteristics.

Once the flow at the dam axis was estimated and the water demand obtained, then an estimate of the period required for the reservoir to yield would be determined.

Water Use and Demand Assessment- The principal water users upstream and downstream of the proposed dam site were identified, and their current water demands determined together with their seasonality, levels of service and priority of use. It was observed that water from Muyanza River was used mainly for irrigation purposes and hardly for domestic purposes since they had cleaner alternative portable or stream water. The EIA study considered the water demand to be that derived from the calculations by the feasibility study based on crop water requirements estimated from crop patterns proposed for the command area.

Water Quality Assessment- Water quality determination is crucial for understanding the health of the stream where the proposed dam site is located. To establish the status of the water quality of the streams of interest to the study, water quality data for the Muyanza stream was obtained from the Feasibility Study Report.

The water quality parameters analysed included pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Chloride, Sulphates, Carbonates and Magnesium. The observed results of the laboratory analysis were then compared for suitability with the existing international standards for irrigation water.

Soil erosion risk- Soil erosion risk data was extracted from the SLEMSA (Soil Loss Estimation Model for Southern Africa) model that was developed for the Kagera basin during the watershed feasibility study (LTS, 2012).

Sediment Yield Estimation- The determination of sediment yield into any dam is important as it has bearing on the life period of the dam. Sediment yield generated from the catchments upstream of the dam site is computed to ascertain the amount of sediments that will be deposited into the dam. In the case of this study, the gross soil erosion data from the feasibility study was considered as the sediment yield.

Flood assessment- Frequency analysis method was used independently estimate peak flows at the dam site using historical flow records generated from the gauging station on River Nyabarongo. Annual maximum discharges were extracted to constitute the Annual Maximum (AM) discharge series from daily flow data. The AM series were modeled using the Gumbel/Extreme value type I distribution. The model was then used to estimate peak flows for return periods, T =20, 50, 100, 1000 and 10,000. These independently derived peak flows were then compared to the outflows designed for the spillway to handle specific flood return periods in order to establish that the dam could not collapse once these floods returned.

Environmental/ecological Flows analysis- The construction of the dam embankment across the stream will block the flow of water downstream which will impact on the livelihood of the ecosystem on the area downstream side of the embankment. As such, some water of specified quantity must be allowed to continue to flow on a continuous basis for purposes of maintaining the health of the ecosystem downstream of the dam, which is referred as the environmental or ecological flow. To establish this environmental flow, a simple methodology referred to as 'Montana Method' proposed by Tennant (1976), where by an environmental flow regimes are prescribed on the basis of the mean annual flow (MAF) was applied. This method provides guidelines for flow management based on the percentage of average flow, daily and monthly stream flow records, that would maintain biological attributes of a river as optimum conditions (>60%), outstanding (40%), excellent (30%), good (20%), fair, poor, minimum, or degrading (10%). In this study, 10% of MAF has been quantified as it is the least for the survival of the existing ecosystem before it is considered degraded.

Soil analysis

The study carried out an independent soil and compost investigation from that done by the pre-feasibility study for Muyanza site, soil assessment report. This investigation was based on; (i) *preparation of soil profiles and description and (ii) soil and compost analysis*.

During the soil profiles analysis**,** two (2) soil profiles were selected; one in a radically terraced area and another in a non- terraced one. The two soil profiles were prepared and described following the guidelines for soil profile study (FAO World Reference Base 2006). The selection of sites took into account the soil formation factors including; origin of parent materials, slope and moisture content. This soil profile description was complemented by soil sampling for laboratory analysis.

As for the soil and compost analysis**,** top soil samples collected from two profiles underwent laboratory analysis at the University of Rwanda (UR) referential soil laboratory in Huye Campus. Laboratory analysis concerned the following parameters: Soil Organic Carbon, Soil pH, soil texture classes determination, exchangeable acidity, available Phosphorus, Ammonium concentration and Nitrates concentration. Un-disturbed soil samples were also collected from the top horizon of soil profiles and investigated for bulk-density.

Compost samples were collected from composting sites and underwent laboratory investigations for pH, total Nitrogen and Mineral Nitrogen. Soil samples collected on composting sites were also investigated for potential Nitrates and ammonia leaching.

Results both in-situ at site and from laboratory analysis were presented and interpreted and a soil profile description presented in Chapter 4 of baseline data. From this soil analysis, impacts were predicted likely to be caused by compost, fertilizer use and terracing practice. Mitigation

measures and best practices were proposed against each impact assessment, these were included in the chapter 7 EMP.

Ecological analysis

Assessment was done of flora and fauna for selected areas at the water catchment area, dam and reservoir area and the command area. Tools such as field observation combined with GIS mapping were used to determine land cover of this area of project intervention. e.g. land cover comprising of forest area, cultivated area, surface water. Literature review was used to predict likely fauna commonly observed with corresponding flora determined by the GIS land cover.

Expert observation was applied to understand the existing ecosystem within these areas, to determine likely eco-sensitive areas and predict flora and fauna that could emerge with the introduction of this project.

Reference was made to already established projects to determine likely ecosystems to emerge once land husbandry was done on the hillsides, the dam and irrigation infrastructure was set up, such as those in Rwamagana and Nyanza LWH sites.

Social environment analysis

It involved collecting primary data from field and matching it with secondary data obtained from desk reviews. Methods of obtaining field data were mainly through public consultation and expert observation. Social data collected from field public consultation with local government and locals were on; population project awareness, local impression of the project, identification of likely areas of expropriation, population and demography, land use, infrastructure (roads, water, electricity), health and sanitation, education, cultural heritage. This data was interpreted from which positive and adverse impacts were anticipated to be addressed in proceeding chapters.

Compensation estimations-during the field visit areas demarcated for expropriation for post-harvest facilities were determined. Valuation data of local price rates for houses was referred from similar completed LWH sites, prices for land were from the Ministerial order no.002/16.01 for land prices outside Kigali city which corresponded with market prices of land transfer contracts observed at the local sectors and prices for crops used for post-harvest areas was obtained from locals, local authorities and LWH coordination staff.

These price rates were used in determining cost estimates for property likely to be expropriated at the dam, reservoir and command area from irrigation infrastructure.

By referring to the feasibility study irrigation piping layout of the command area, number of houses in the path of irrigation infrastructure was estimated, while for the dam and reservoir area a diameter of 224m construction influence along the dam axis(124m crest length + 50m of

green belt either sides) was proposed and by using GIS as a tool (i.e. 6th June 2013 google earth) and actual field visit to the community settlements to the left of the dam, estimates of houses and land for expropriation were determined. A more detailed assessment of how compensation of land, crops and houses lost to project activity will be determined in the Resettlement Action Plan (RAP).

1.4.5 Impacts Assessment

Impacts prediction and analysis involved assessment of the entire project cycle i.e. project mobilization, construction, operation and decommissioning phases. Impact assessment applied number of tools and techniques to determine the nature (positive or negative), extent (spatial), occurrence (one-off, intermitted or constant), magnitude, whether reversible or irreversible, direct or indirect, probability of occurrence and significance with and without mitigation. These tools were:

- *Geographical Information System (GIS)* - used to show the extent of a particular project activity's influence on an area by mapping it out.
- *Checklist*- Under this section, project activities that might affect or enhance the livelihood in the project areas were listed and drawn against environment and occurrence.
- *Cost benefit analysis (CBA)*- Which involved analysis of project activities in terms of their financial and economic effects to establish the cost implications of the impacts and the mitigation measures. Impacts will be analysed according to market costs, foregone costs or opportunity cost. The CBA was used to assign economic values where feasible to impacts both adverse and beneficial.
- *Impact Matrix*- Under the Impact matrix, the analysis by these tools of GIS, checklist, CBA, were also tested against their significant effect on recipients in the project area of intervention. Impact matrix in tabular format will be drawn, in which impacts from project activities will be tested against their significant effect on the areas of intervention. These significant impacts were presented in an Impact matrix in tabular form in *appendix 4*, in categories of direct or indirect impact, reversible or irreversible and of cumulative effect.

For each adverse impact identified, its level of significance was indicated, mitigation measures for the predicted impacts were proposed and an Environmental Management Plan (EMP) developed.

1.5 REPORT STRUCTURE

This report is organised in ten chapters. Chapter 1 gives a general background of the project; Chapter 2 deals with the project description, Chapter 3 gives a description of pertinent policy, legal and institutional framework within which the project will operate; and Chapter 4 presents the baseline data, environmental, socio-economic and cultural setting of the project site. Chapter 5 presents the findings of the Stakeholders' consultation and public participation. Impacts identification, evaluation for significance and proposed mitigation measures are elaborated in Chapter 6, while Chapter 7 presents the Environmental management Plan.

An Environmental Monitoring is presented in Chapter 8, while a preliminary decommissioning plan is discussed in chapter 9. Chapter 10 provides conclusions and recommendations of the project.

CHAPTER 2: PROJECT DESCRIPTION

2.1. PROJECT AREA

2.1.1. Location

The Muyanza project covers five (5) sectors in Rulindo District, which are; Burega, Buyoga, Cyinzuzi, Tumba and Mbogo. The reason this project covers such a large area since it involves land husbandry of the water catchment area of the Muyanza river, the dam and reservoir area and the command area downstream of the dam and its catchment area.

Access to the site is by the Kigali- Kagitumba national road, branching off at a place called Nyancyonga on to an earth feeder road leading to project area, approximately 40km North of Kigali.

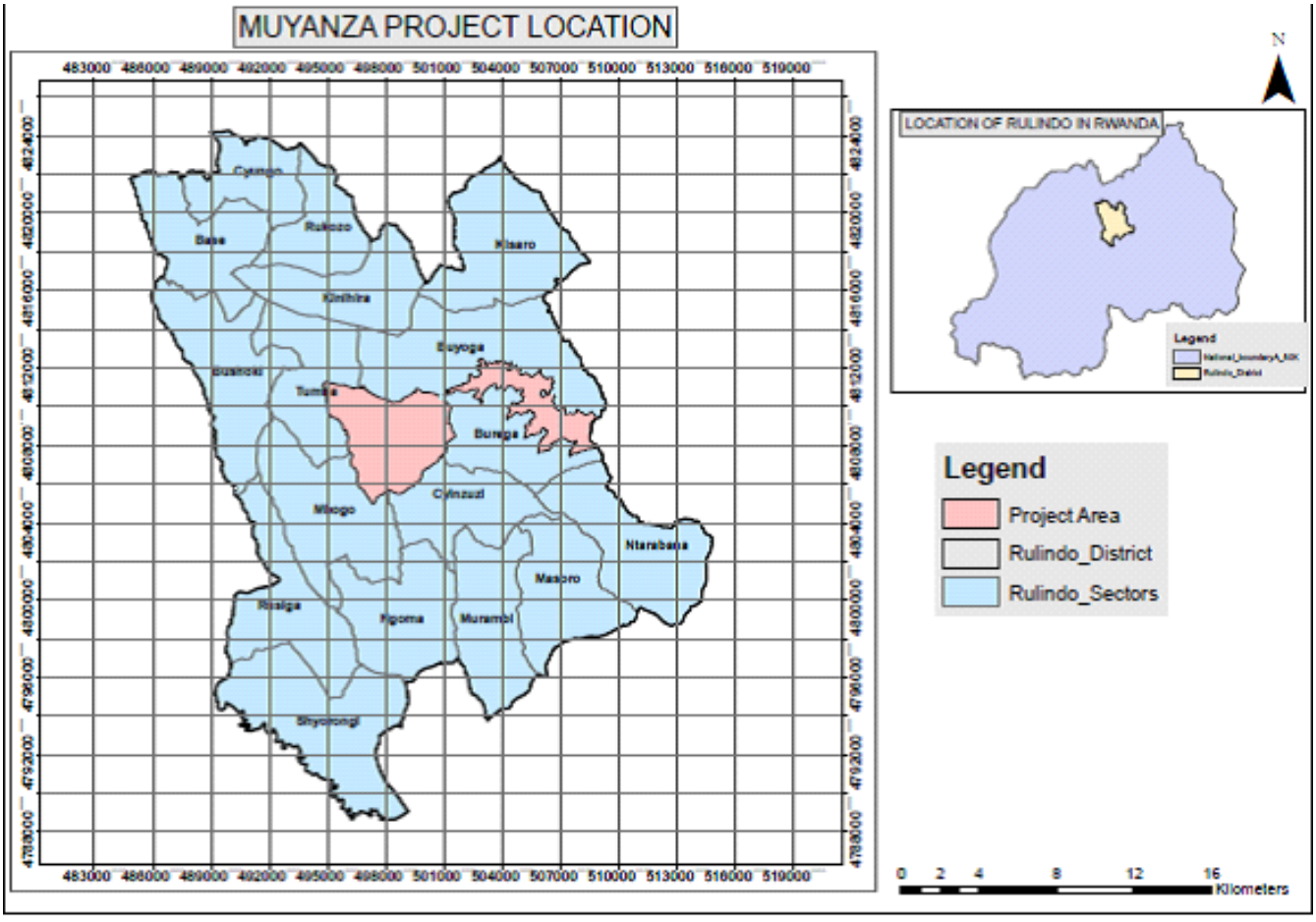


Figure 1: Muyanza project site location.

2.2. DESCRIPTION OF THE PROJECT ACTIVITIES

Muyanza project implementation will be structured in two components: one component focusing on how the farmers shall be organised, and the infrastructure component that includes terracing, dam and reservoir construction and laying irrigation infrastructure.

2.2.1. Component A.

Farmers' organization- with the help of the District and sectors, LWH will be able to organize farmers in the following manner.

- ***Group formation***- With consideration of land proximity, 15-20 households come together to form a Small Help Group (SHG). Each group then elects its executive committee comprising 3 persons. i.e. the president, secretary and adviser. It also elects five (5) committee leaders for positions of; Lead farmer in charge of extension (LFE), Lead farmer in charge of harvesting and Marketing (LFHM), Lead farmer in charge of Savings and Credits (LFSC), Lead farmer in charge of Land husbandry and infrastructures maintenance (LFIM) and Lead farmer in charge of Social welfare and Conflicts management (LFSW).
- ***Zone formation***- 10-15 groups then form a Zone. These groups elect a zone committee comprising of 7 persons; The President, Change Agent in charge of extension (CAE), Change Agent in charge of Data collection and marketing (CACM), Change Agent in charge of Infrastructure Maintenance (CAIM).
- ***Cooperative formation***- With all groups and zones functioning then a cooperative is formed at the site level. In the course of forming a cooperative, the zonal committees will then elect provisional site committee composed of; a President, secretary, 1 person in charge of extension, 1 person in charge of harvesting and marketing, 1 sector agronomist from the area of the project operation, 1 representative from the private sector and 1 representative from the Civil society organizations (e.g. religious affiliations, NGOs, etc.).

Agronomy related Activities. The project supports related activities such as:

- *Compost manure*- Developing of compost manure heaps per group of $18m^3$ and family of $1m^3$. Compost shall comprise of; decomposable weeds, twigs, leaves, ash or poultry droppings, livestock manure, livestock dung, and local soil either in heaps or compost pits. Water and cow urine is added to the fresh biomass to speed up decomposition. Group compost heap are of 4x3x1.5m in dimension while family heaps comprise of 1x1x1m.
- *Kitchen gardens*- These are gardens of vegetables set up with residential compounds in order to increase balance diet and household revenues.
- *Site Development Fund (SDF)* - Savings of 500Rwf per cultivation season per farmer is proposed as a sustainable source of funds for acquisition of fertilizer such as urea or seeds.
- *Operation with SACCOs*- As opposed to direct cash, payments are done through Savings and Credit Cooperatives (SACCOs) to encourage farmers to embrace the savings concept for future investments. This also acts as collateral for farmers interested in taking loans for investment.

Project Infrastructure for Hillside intensification

The objective of Component B is to provide the essential 'hardware' for hillside intensification to accompany the capacity development and institutional strengthening activities of Component A. Its three sub-components are organized around the L, the W and the H of LWH: (i) *L*- Land husbandry infrastructure which supports the development of participatory and comprehensive land husbandry practices throughout the sub-watershed to improve productivity for rain-fed and irrigated areas. This sub-component shall involve; terracing, liming of soils, application of compost and inorganic fertilizer; (ii) *W*- Water harvesting infrastructure, including dam and reservoirs construction; and (iii) *H*- Hillside irrigation infrastructure, including the development of the water conveyance structures for hillside irrigation. A project layout for a LWH site is shown below.

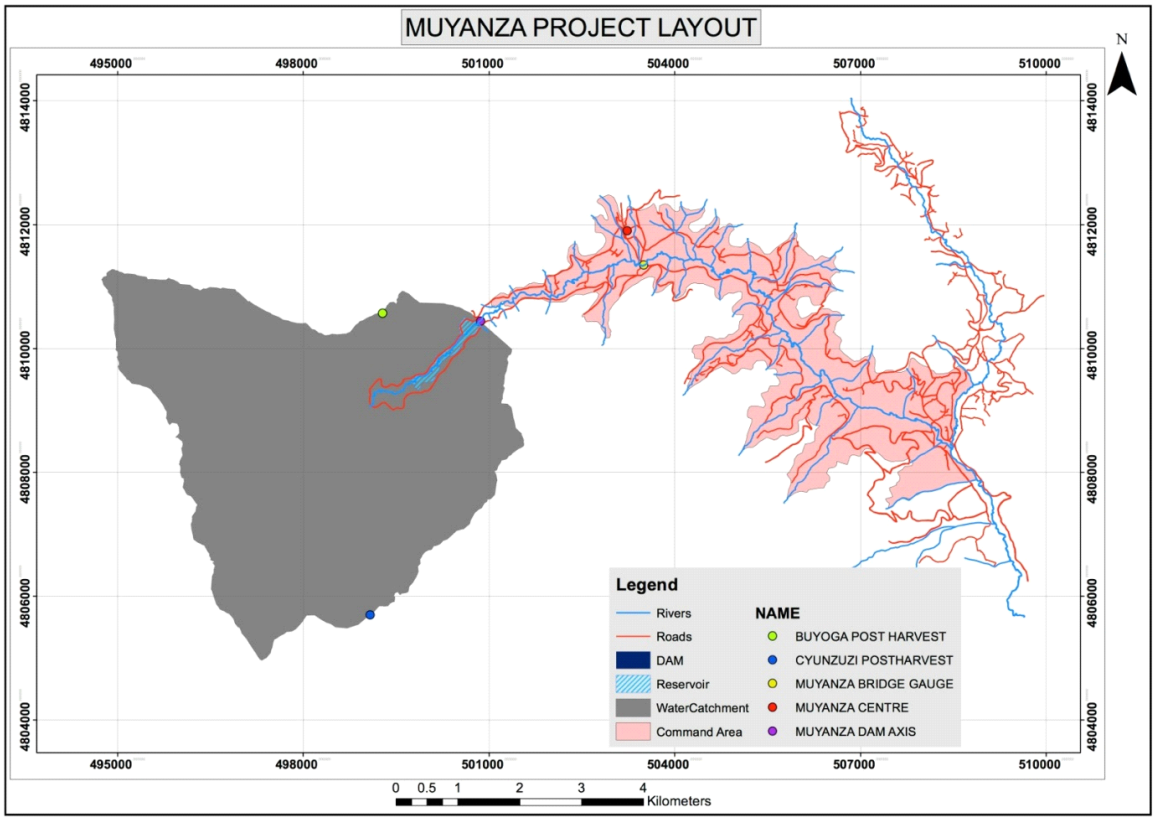


Figure 2: Muyanza project layout.

2.2.2. Component B

As indicated in the project layout map above, the site comprises of three components; (i) the water catchment area, (ii) the dam and reservoir area, (iii) the command area along with its command area.

In reference to data obtained from LWH site coordination team, each component of the Project will cover an area of size comprising of:

- The water catchment area will cover an area of 2604.8ha.

- The Reservoir area will cover up to 30ha.
- Command area with the irrigation system proposed will cover an area of ±950ha.
- The Catchment of the command area will cover 2610ha including the command area.

Muyanza project generally will have three phases; Phase I for land husbandry of catchment areas, Phase II dam construction and Phase III- laying irrigation infrastructure.

2.2.2.1 Land husbandry in catchment areas

Activities on water and command area catchments

Depending on slope category, activities on the catchment areas are proposed to have the following activities;

- < 40% slope category- Soil bund terraces are established where all selected crops are grown.
- >40-60% slope category- Fruit trees are proposed.
- > 60% slope category- coffee and forestry trees.

2.2.2.2 Terracing and farm preparation phase

Employment- For a terrace to be constructed, a single task comprises an area of 13x2m (26m^2) assigned to a local worker per day and paid 1,000Rwf (an equivalent of 1.4US$). An average of 2000 workers are employed per day for terrace works.

Duration- According to LWH site staff, terraces for the catchment area have been given a year for completion, while a duration of three (3) years was given for the dam, reservoir, irrigation infrastructure and terraces at the command area catchment to be completed.

Equipment- For terracing, traditional equipment is used for digging involving; hoes, spades, machetes.

Trend of events in preparation of terraces for cultivation- Once terraces have been prepared by casual labours, then napier grass "Urubingo" is grown at the terrace embankments to support them from sliding. Lime provided by LWH is then delivered at farms that have been terraced and landowners spread it. A quantity of 50kg/acres is applied with the guidance of the project agronomist.

Organic compost is then applied to the soil in quantities of 100kg/acre or 10tons/ha. Planting of selected crops agreed on by the farmer, local government and opinion leaders, then proceeds.

The type of fertilizers applied is DAP and Urea, applied in quantities of 1kg/acre of DAP and 0.5kg/acre of Urea.

Compost preparation- A compost heap is normally of dimension of 3x4m. Preparation shall involve the followings stages: First layer of grass, cow dung, cattle urine, ash and water sprinkled on this layer. Next layer of 12cm height shall comprise grass only and shall be watered by 2 jerrycans of 20l. This is followed by a layer of 3cm height of cow dung with 2 jerrycans of cow urine applied to it. Then a layer of ash of 2cm height and finally a 6cm layer of topsoil. Bamboo sticks are installed in this heap in the opposite direction of wind to facilitate aeration of the

compost. The heap is watered 3 times a week during the dry season, while in the wet season, there is no need.
Compost is prepared for month and such a heap can provide 10 tonnes that can be used for a period of 3-6months.

2.2.2.3 Dam construction

Dam and reservoir associated activities

The irrigation system comprises of a number of components such as;

- **The Dam-** which consists of the dyke and reservoir.
- **The command area-** Which is downstream of the dam and the area irrigated mainly on the hillsides of the Muyanza valley. It covers parts of Buyoga and Burega sector.

Dam- In our case, this is an earth embankment used to impound water from a river for irrigation purposes. Only one dam will be constructed impounding the Muyanza River and served by a watershed of 25.04km^2.

Dam construction activity

Construction Material- The proposed embankment is the modern zoned construction which is built in three sections: (i) upstream and relatively impermeable section. i.e. riprap and filter (of sand and gravel); (ii) central core or hearting of highly impermeable material e.g. clay (which with a below ground cutoff, will effectively seal the dam against seepage) and; (iii) downstream section of poorer, coarser material that allows frees drainage of the structure and which by its weight anchors the complete embankment to its foundation and prevents slip and other movement. *(FAO, 2010)*

Construction procedure- shall involve; setting out of the dam site, mobilization of plant and equipment that shall be used in the construction, site clearing and preparation, river diversion, settlement, construction of a spillway and the constructing the dam embankment.

Equipment applied for these works shall comprise of; bulldozers, excavators, compactors, sheep foot compactors, graders, wheel loaders, dumpers, trucks, pick-ups, topographical equipment (total stations, damp levels), wheel barrows, hoes, spades, trolleys and a generator incase of no power or power cuts at the site.

The Feasibility study of the Muyanza site development by Z&A P. Antonaropoulos & Associates L.P and Gk – G. Karavokyris & Partners Consulting Engineers S.A (Z&A and GK) in 2014, proposes construction of one dam for adequate irrigation of a command area of about 950ha.

Table 1: Summary of Dam geometry

Dam Description	**Dimensions**
Dam	
Design flood	1000yr return period
Water catchment area	25.04 km ^{2}
Dam height from river bed	26m

Dam height from excavation level	31m
Crest elevation of dam	1658m.a.s.l
Crest width	8m
Crest length	124m
Reservoir capacity	2.2 million m^3
Free board at 1000yr design flood	0.8m
Spillway at right side of dam	
Crest elevation of spillway	1655m.a.s.l
Crest length	20m
Maximum outflow	$100m^3/s$
Coffer dam for river diversion	
Crest elevation for coffer dam	1641m.a.s.l
Crest width	5m
Command area	950ha in Muyanza valley
Hillside irrigation infrastructure	
1st alternative of canal system	42km
2nd Alternative of pipe system	26km

2.2.2.4 Irrigation system

The total irrigable command area is 865ha. There are two main pipes starting from the dam outlet which cover the south and the north command area. The total area of the north part is 370ha when the total area of the south part is 495ha. Both the south and the north area have been separated following the same concept as with the canal alternative.

The north area supplied from the night storage reservoirs is 195ha and directly from the main pipe 175ha. The south area supplied from the night storage reservoirs is 235ha and directly from the main pipe 260ha.

The irrigation water is released from the dam through an outlet structure. The main pipes are of different diameters ranging from 110mm-630mm. The main pipes are proposed to be laid on the existing roads for easy access and reduced cost. The total length of the pipe in the north is 11974m and in the south 13516m. The difference in elevation between the dam and the lower part of the command area, which is in the south part, is 160m and the pressure in the system during operation is not less than 120m. For this reason it was decided that a tank is needed to control the pressure which must not exceed 7atmospheres during operation. The tank is proposed on the main pipe 9.8km from the dam.

The inlets of the secondary pipes are on the main pipe system and the secondary pipes are laid vertically to the terraces. The distance between the secondary pipes is variable and is highly dependent on the main pipe alignment and the morphology of the ground. Wherever possible, a

distance of 100m between two secondary pipe lines is maintained. The total length of all the secondary pipes is 115,181m and the secondary pipe diameter will range from 32-225mm.

CHAPTER 3: RELEVANT POLICY, LEGAL AND INSTITUTIONAL ARRANGEMENTS

This chapter describes policies, laws, regulations and institutional framework that will be relevant, to the Muyanza sub-project. Both international and national regulations are presented in the sections below.

3.1. NATIONAL LEGAL AND POLICY FRAMEWORKS

3.1.1. Organic law determining the modalities of environmental management

This organic law 04/2005 of 08/04/2005 determines the modalities of protecting, conserving and promoting the environment in Rwanda. In the framework of implementation of this organic law, the Rwanda Environment Management Authority (REMA) is the public establishment with legal personality and authority to implement the articles of this law.

Under article 67 of the organic law 04/05, every project shall be subjected to environmental impact assessment (EIA), before obtaining authorization for its implementation. This applies to programmes and policies that may affect the environment.

The ministerial order *N° 004/2008 of 15/08/2008* establishes the list of activities or projects that have to undergo environmental impact assessment before commencement.

This Land husbandry and irrigation scheme fits the description of projects that require EIAs mentioned in annex 2 of this ministerial order.

EIA is a tool for prevention and control of environmental impacts caused by socio-economic development. The "General Guidelines and Procedures for Environmental Impact Assessment, 2006" were prepared to improve EIA practice in Rwanda and they aim to serve agencies and individuals taking part in the EIA process.

The guidelines are designed to ensure that participants in the EIA process understand their roles and that laws and regulations are interpreted correctly and consistently. Two main principles underlie these general guidelines: first, they comply with the legal and institutional frameworks on environmental protection in Rwanda and, second, they contribute to improvement of quality and efficiency of EIA process in the country, and as such merge, step by step, with general global trends and practice of conducting EIA.

LWH understands these regulations and the need for an EIA for such a project, hence the recruitment of an Environmental firm to perform the EIA/ EMP of the Muyanza project, with an eventual approval of this EIA/EMP report from REMA.

3.1.2. Law governing land in Rwanda

Articles of the organic law *no. 43/2013* governing land in Rwanda relevant to the Muyanza site are article 30 and 34, which respectively indicate that for purposes of optimization of productivity, an Order of the Minister in charge of Agriculture and Animal Resources shall set up procedures and modalities of land use consolidation for agricultural and livestock purposes. It also prohibits sub-division of plots of land reserved for agriculture and animal resources, if the result of such subdivision leads to parcels of land of less than a hectare in size for each of them. Owners of lands prohibited to be subdivided shall co-own and use the land in accordance with the laws.

Regarding land rights, article 34, states that the State recognizes the right to freely own land and shall protect the land owner from being dispossessed of the land whether totally or partially, except in case of expropriation due to public interest.

Muyanza project shall involve land consolidation of small plots of land to allow for terracing and irrigation to succeed. It shall also involve expropriation of land, crops and houses, hence the reference to this law.

3.1.3. Law relating to expropriation in the Public interest

Based on the *law no. 18/2007* article 3, Only Government shall carry out expropriation only in the public interest and with prior and just compensation. No person shall hinder the implementation of the program of expropriation on pretext of self- centered justifications.
It also informs us that a person to be expropriated shall be informed of the beginning of the process of the land survey and the inventory of the properties thereon.

A just compensation shall be reached through agreement between the person to expropriate and the one to be expropriated, the just compensation may be monetary or an alternative land and a building equivalent to the determination of just monetary compensation.

A ministerial order no. 002/16.01, determining reference land prices for all areas outside Kigali city was approved in 2010 and can be guidance to pricing of land for expropriation in Muyanza.

Considering that areas around the dam, reservoir and irrigation infrastructure shall require expropriation, this law and ministerial order shall be applied in reaching a just compensation of property within the limitations of these project activities.

3.1.4. Strategic Plan for Agricultural Transformation II (SPAT II)

Referring to the Strategic Plan for Agricultural Transformation II, 2008, the performance of the Rwandan economy depends mainly on the production of the primary sector, in which agricultural production, particularly of food crops, is essential. Four Programmes lie at the heart of the SPAT II but programme 1 is the most relevant to Muyanza project.

Programme 1: Physical resources and food production involves intensification and development of sustainable production systems. Muyanza project involved in atleast three (3) sub-programmes under it. For example; (i) *sub-programme 1.1*- Sustainable management of natural resources and water and soil conservation which is the land husbandry on the catchment areas, (ii) *Sub-programme 1.4*- irrigation development and (iii) *Sub-programme 1.5*- supply and use of inputs such as; fertilizers and certified seeds.

3.1.5. Irrigation master plan (IMP)

The IMP of 2010 has provided Rwanda with a planning tool for rational exploitation of its soil and water resources, with an intension to increase crop production of both staple foods for local consumption and high-value products for export. It supports decision making by giving guidance on; (i) identifying the most favourable areas to establish irrigation water infrastructure;(ii) estimating the water stock that can be used for irrigation; (iii) prioritising distribution of irrigation water; (iv) identifying means of transporting water to selected sites; (v) recommending means of abstraction for the chosen type of water source; (vi) establishing irrigated agriculture in small-, medium- and large-scale projects on hillsides, marshlands and other topographically suitable areas; (vii) identifying options for upgrading the agricultural value chain through appropriate training and extension (especially promoting the use of inputs, introducing mechanisation, training in postharvest management and marketing and sales); (viii) recommending options for water harvesting and storage; (ix) proposing solutions for drainage and flood mitigation; (x) recommending locations and management for water storage and hydroelectric purposes; (xi) producing a plan map for the potential irrigation areas (PIAs) that could be irrigated by the different kinds of water resources by agroclimatic zone (ACZ) or even province level; and (xii) articulating the national policy options concerning the distribution of irrigation water.

With part of the Muyanza project involving irrigation, the feasibility and detailed designs of the Muyanza irrigation scheme shall need to follow guidance and reference tools recommended in the IMP in preparing an accurate project that fits in the nation's holistic irrigation master plan.

3.1.6. Integrated water resources master plan (IWRMP)

The IWRMP policy focuses on conserving and protecting Rwanda's water, restoring its water reservoirs, ensuring efficiency and equity in allocation and use of water.

As one of the Integrated Water Resource Management (IWRM) strategy expected outcomes is the rehabilitation of all critical watersheds and catchments and restoration of ecological functions. Part of the Muyanza project is to protect the catchment areas of the watershed of Muyanza River and the proposed command area downstream. This might be considered a contribution towards achieving one of the IWRM strategy outcomes.

3.2. REGIONAL POLICIES AND REGULATIONS

3.2.1. EAC protocol on environment and natural resources

This Protocol applies to the East Africa Partner States' cooperation in the management of the environment and natural resources within their jurisdiction including trans boundary ecosystems and natural resources.

In regard to article 3 of this Protocol, it is a protocol of general application and shall apply to all activities, matters and areas of management of the environment and natural resources of the Partner States, including the following: (i) sustainable environment and natural resources management; (ii) management of trans boundary resources; (vi) management of water resources;

Considering that Muyanza River has a confluence with Nyabarongo River, one of the River Nile tributaries, LWH activity on this river shall need to involve hydrological investigations in the technical study to determine whether it triggers activity on shared trans-boundary resources and as such might have to follow the protocol of approval to use the river for irrigation purposes.

3.3. World Bank Safeguard policies

3.3.1. Environmental Assessment- OP/BP 4.01

In reference to the LWH Project Appraisal Document (PAD), the LWH project was classified under Category B project of the World Bank classification.

Muyanza project classified as a Category B project involves interruption of existing areas of the Muyanza narrow wetland, modification of flows of this river at dam axis; it will involve involuntary resettlement of people and restriction of access to resources, and might involve destruction of small forests later on planting new forests above the >30% slopes in this area. This would imply that study will require examination of its environmental impacts and propose mitigation measures.

3.3.2. Involuntary resettlement OP/BP- 4.12

International experience indicates that involuntary resettlement under development projects, if unmitigated, often gives rise to severe economic, social, and environmental risks: production systems are dismantled; people face impoverishment when their productive assets or income sources are lost; people are relocated to environments where their productive skills may be less applicable and the competition for resources greater; community institutions and social networks are weakened; kin groups are dispersed; and cultural identity, traditional authority, and the potential for mutual help are diminished or lost. This policy includes safeguards to address and mitigate these impoverishment risks.

To address the impacts of this policy, it is necessary that proponent prepares a resettlement plan or a resettlement policy framework that covers the following: (a) measures to ensure that the displaced persons are: (i) informed about their options and rights pertaining to resettlement; (ii) consulted on, offered choices among, and provided with technically and economically feasible resettlement alternatives; and (iii) provided prompt and effective compensation at full replacement cost for losses of assets attributable directly to the project.

(b) If the impacts include physical relocation, the resettlement plan or resettlement policy framework includes measures to ensure that the displaced persons are: (i) provided assistance (such as moving allowances) during relocation; and (ii) provided with residential housing, or housing sites, or, as required, agricultural sites for which a combination of productive potential, locational advantages, and other factors is at least equivalent to the advantages of the old site.

Certain areas within the project size shall be affected such as; communities on the hills close to the dam area, roads and plantations that shall be inundated by the reservoir area, homes and plantations that are in the aligned path of the pipe/canal irrigation infrastructure.

A RAP guided by the LWH RFP is required to settle any likely impacts that might arise from involuntary resettlement with in Muyanza project scope of works.

3.3.3. Pest Management- OP/BP-4.09

In assisting the proponent to manage pests that affect either agriculture or public health, a strategy that promotes the use of biological or environmental control methods and reduces reliance on synthetic chemical pesticides is required under this safeguard policy.

The proponent is required to use various means to assess pest management in the project area, support integrated pest management (IPM) and the safe use of agricultural pesticides.

For agriculture projects, pest populations are normally controlled through IPM approaches, such as biological control, cultural practices, and the development and use of crop varieties that are resistant or tolerant to the pest.

Observations from field survey identified local farmers applying pesticides to some of their vegetable plantations. If pesticides have to be applied in the Muyanza site project, then they will have to follow recommendations from an IPM study.

3.3.4. Natural habitat- OP/BP- 4.04

The conservation of natural habitats, like other measures that protect and enhance the environment, is essential for long-term sustainable development. The proponent is required to support the protection, maintenance, and rehabilitation of natural habitats and their functions in its economic and sector work, project financing, and policy dialogue. The proponent is expected to apply, a precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development.

In the areas of project intervention, the proponent should identify; (a) natural habitat issues and special needs for natural habitat conservation, including the degree of threat to identified natural habitats (particularly critical natural habitats), and (b) measures for protecting such areas in the context of the country's development strategy.

Considering the study field observation, most of the project area with indigenous flora and fauna has been replaced by cultivated plantations and community settlement. From an ecological point of view, the project might have minimal impact on indigenous natural habitat of this area. Instead most natural habitat influence could be on changes in existing crops and scattered deforestation.

3.3.5. Physical Cultural resources- OP/BP- 4.11

This policy addresses management of physical cultural resources, which are defined as movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance. Physical cultural resources are important as sources of valuable scientific and historical information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices.

3.3.6. Forests- OP/BP- 4.36

This policy applies to: (i) Projects that could have impacts on the existing forests; (ii) Projects that affect the rights and welfare of people and their level of dependence upon or interaction with forests; (iii) projects that aim to bring about changes in the management, protection or utilization of natural forests or plantations, whether they are publicly, privately or communally owned.

In line with this policy, World Bank shall not support projects which involve significant degradation or conversion of critical forest areas.

Whereas not so many forests exist within the Muyanza project area of influence, even those scattered existing forests area shall be the responsibility of LWH to protect and regenerate. It appears to have been considered in the Muyanza project activities, where areas >40% shall be proposed for forest planting and coffee plantations.

3.3.7. Safety of Dams- OP/BP- 4.37

For the life of any dam, the owner is responsible for ensuring that appropriate measures are taken and sufficient resources provided for the safety of the dam, irrespective of its funding sources or construction status. Because there are serious consequences if a dam does not function properly or fails, the World Bank is concerned about the safety of new dams it finances and existing dams on

The Bank distinguishes between small and large dams.
(a) Small dams are normally less than 15 meters in height. This category includes, for example, farm ponds, local silt retention dams, and low embankment tanks.

(b) Large dams are 15 meters or more in height. Dams that are between 10 and 15 meters in height are treated as large dams if they present special design complexities.

Muyanza dam is of height of 26m above the river bed surface, which implies that it is classified under large dams and will be required to follow Bank requirements for large dams.

In reference to the different safeguard policies discussed above, the following table indicates that are triggered by the Muyanza site project.

Table: 3.2. Safeguard policies triggered by the project

Safeguard Policies Triggered by the Project	Yes	No
Environmental Assessment (OP 4.01) The Muyanza project has been classified under category B as per the World Bank categorisation. The project will involve investments in dam and reservoir construction, irrigation infrastructure, terraces, preparation of composite manure, application of fertilizers. Each of these bares impacts on the physical, biological and social environment existing hence triggering this policy.	[X]	[ ]
Natural Habitats (OP 4.04) Though the area of project intervention has been occupied with human community habitat, land use activities such as; predominant agricultural farming and cattle keeping, from field visits and analysis of the project components, there were small pockets of indigenous trees that still existed, bird nesting close to the sorghum fields and aquatic life in the flowing river.	[X]	[ ]
Pest Management (OP 4.09) With field observations of local farmers applying pesticides to their vegetables, the LWH Pest Management Plan will be used to address the requirements of this policy.	[X]	[ ]
Physical Cultural Resources (OP 4.11) Whereas field studies, consultation with cultural institutions did not indicate cultural heritage, this policy might possibly discover unexpected findings of cultural heritage during the implementation of works such as; graveyards.	[X]	[ ]
Involuntary resettlement – (OP - 4.12) This being an Irrigation project involving construction of a dam, reservoir, irrigation infrastructure, there is a possibility of displacement of communities and land, which give rise to economic, social and environmental risks, impoverishment, social network weakening, kin groups dispersed, cultural identity dissolved. It is very likely that this policy is triggered by the project	[X]	[ ]
Forest (OP 4.36) Project activities involving dam and reservoir construction, installation of irrigation infrastructure and terracing could involve levels of deforestation hence likelihood of triggering this policy.	[X]	[ ]

Dam safety (OP4.37) The project involves construction of a new dam, with the height of 26m above river bed. This implies that this irrigation dam is categorized under the large dam and shall require to follow Bank requirements of large dam safety.	[X]	[ ]

3.4. INSTITUTIONAL FRAMEWORK

For the Muyanza Irrigation development scheme to succeed, a number of key implementers shall be involved that include; MINAGRI, LWH, REMA, MINIRENA, RNRA, RDB, Local government and the World Bank. The roles and responsibilities of each of these implementers is elaborated hereafter.

MINAGRI/ LWH

In order for the proposed mitigation measures to be implemented in an environmentally friendly way, a number of institutions are required to actively participate in this regard. MINAGRI, acting on behalf of the Government of Rwanda as the borrower and project implementer shall oversee operations of the LWH. LWH considered as the project unit on the ground and coordinating the project activities on behalf of MINAGRI, has the required staff at the head office and district level to directly implement all proposed mitigation measures and proceed with procuring contractors for required construction works.

LWH has been involved in procuring and coordinating services towards, preparation of the feasibility study of Muyanza project, sensitization of locals of the project intervention in preparation of the launch of this project, supervised preparation of terraces as soil conservation techniques along the upstream catchment area and will coordinate and monitor the entire dam, reservoir and irrigation infrastructure. The ministry is also responsible for engagement of the dam safety panel to ensure the technical review of the dam designs and preparation of the reports: (1) plan for construction supervision and quality assurance; (2) instrumentation plan; (3) operation and maintenance plan; and (4) emergency preparedness plan.

World Bank

The World Bank, as the lender, shall support the project team to ensure that the Muyanza project follows all World Bank safeguard policies that the project is found to trigger before funds are realised for this project.

MINIRENA

The Ministry of Natural Resources (MINIRENA) is considered as the Government's arm responsible for establishing norms and practices for rational exploitation and efficient land management, Environment protection, Water Resources and evaluating their implementation. This implies that it shall oversee all aspects regarding environmental monitoring and appropriate natural resources exploited through project activities. MINIRENA delegates some of these responsibilities to REMA, RNRA and RDB.

REMA

REMA, as the authorized Government institution to determine modalities of protection, conservation and promotion of the environment in Rwanda, shall review the EIA report, authorize the project to proceed by issuing an EIA certificate and periodically monitor the Muyanza project activities to ensure mitigation measures are implemented and that it has no adverse impacts on the environment.

RNRA

It is the authority that oversees the management of promotion of natural resources i.e. land, water, forests, mines and geology. It has been entrusted with supervision, monitoring and to ensure the implementation of issues relating to the promotion and protection of natural resources in programs and activities of all national institutions. RNRA will ensure that the project does not exploit resources to levels of depletion especially in this case that the project is an irrigation scheme collecting its water from Muyanza River. An ecological flow for the downstream should still be maintained even after the dam is operation. Working independently like REMA, RNRA will periodically visit and assess the extent of project influence on natural resources in the area.

Local Governments

Local government shall be considered under the jurisdiction of Rulindo district and the five (5) sectors of project influence; Burega, Buyoga, Cyunzuzi, Tumba and Mbogo sectors. Local authorities that include; the District Mayor and Executive secretaries for the sectors, sector Agronomists, local opinion leaders shall be at the forefront of; organizing local farmers into group committees, zonal committees and eventual one or two cooperatives, Water Users Associations (WUAs), participating in demarcation of plots in the small strip of marshland, compensation of affected property, conflict resolutions amongst farmers, market access for farmers among others. All these activities shall be done in conjunction with LWH site coordination.

3.3.8 Safeguards Instruments

3.3.8.1 Resettlement Policy Framework (RPF)

The purpose of the RPF is to ensure that the World Bank safeguard OP 4.12 for involuntary resettlement and national requirements for land acquisition and resettlement are adequately addressed. It presents the objectives, principles, organizational arrangements and funding mechanisms for any displacement and resettlements that may be necessary during implementation of LWH.

The RPF highlights the difference between Rwandan legislation and the World Bank policy OP 4.12. It gives guidance on the steps taken in the preparation and implementation of a Resettlement Action Plan (RAP), such as; consultation, screening and RAP development process, notification to affected parties, agreement on compensation, contract payment, compensation payment and assistance in resettlement. It also elaborates how the grievance and redress mechanism will be done once the RAP is complete and how monitoring and evaluation of RAP recommendations shall proceed. In coming up with estimates of land and houses likely to be expropriated in our social environment data collection for Muyanza site, a number of these steps mentioned above were applied. A standalone RAP report is required to determine level of involuntary resettlement and the amount of compensation required.

3.3.8.2 Environmental and Social Management Framework (ESMF)

The LWH ESMF is currently used by the MINAGRI to ensure that the World Bank safeguard OP 4.01 for environmental assessment and other relevant policies (e.g. Natural Habitats, Forests, Pest Management, and Dam Safety) are adequately addressed. The ESMF is an instrument used to guide LWH sub-project's in the identification, assessment, evaluation of environmental and social impacts and in the proposal of appropriate mitigation, management and monitoring measures, designed and incorporated within the sub-project itself.

The ESMF was prepared for the overall projects, as the project activities were not known at the time of project preparation. It sets out guidelines of how the screening, mitigation, monitoring and institutional measures are to be taken during design, implementation and operation of sub-project activities to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels. The LWH ESMF has already identified likely impacts to be caused by LWH sub-projects and categorized them under the adverse and positive impacts. The ESMF is used by the project to guide the preparation of the site-specific ESIAs.

These impacts listed in the ESMF were used for screening of the activities of Muyanza project to determine which of them are relevant in this case before mitigation measures would be proposed.

CHAPTER 4: BASELINE ENVIRONMENTAL CONDITION

4.1. PHYSICAL ENVIRONMENT

Physical environmental survey involves understanding the actual status of the area, in regard to; Climate (temperature, rainfall), relief, hydrology, vegetation, soil, water and air quality. Physical parameters of the Muyanza site are discussed hereafter.

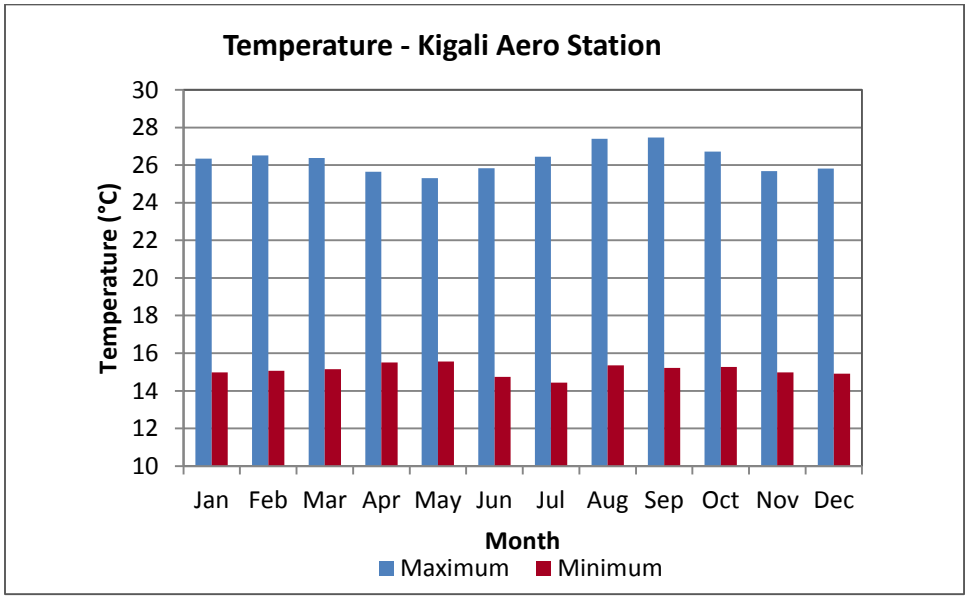
4.1.1. Climate

The climate of Muyanza catchment was characterized by analyzing climatic data (rainfall) obtained from Rulindo Meteorological station and Byumba Meteorological stations which are approximately 7km and 16km from the centre of the Muyanza catchment respectively. Temperature data was obtained from the Kigali Aero Meteorological Station approximately 30km from the catchment.

4.1.1.1. Temperature

Being near the equator, temperatures at Muyanza are relatively constant. From the Kigali Aero station, the mean minimum temperature is 15°C and a mean maximum reaches 26°C as shown in *Figure 3.*

Figure 3: Seasonal temperature variation in Muyanza Catchment



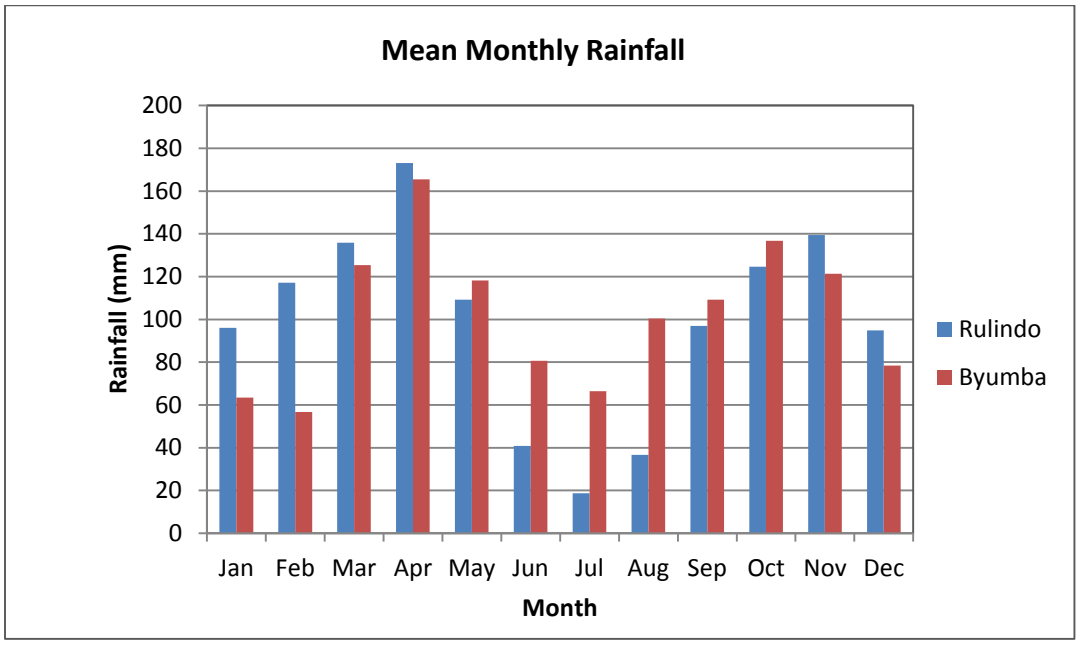
No evaporation data was obtained but as temperature directly affects evaporation, the pattern of evaporation variation at Muyanza is expected to be similar to the pattern of temperature variation. From the feasibility report, average evaporative demand is 1576mm/year.

4.1.1.2. Rainfall

The seasonal pattern of the rainfall regime at Muyanza site is such that there are two (2) rainy seasons extending from February to May and late September to November with generally high spatial and temporal rainfall variability (*Figure 4).* The seasonal variation indicate the relatively

dry period between June and August with monthly rainfall amounts predominantly below 40 mm. July is the driest month in the catchment while the wettest month is April with the average rainfall amounts recorded as high as 173 mm. The average annual rainfall recorded for Muyanza catchment is estimated at about 1,183 mm (Source: Rulindo station).

Figure 4: Seasonal rainfall pattern in Muyanza Catchment



4.1.2. Hydrology

4.1.2.1. Water yield in catchment

The water yield of any catchment depends on the existing surface and ground water resources. It was important to study these existing water resources as they would affect and be affected by the water flow into the proposed dam.

4.1.2.1.1. Ground water resources

Geology-The geological formations around the Muyanza dam are shown in Figure 5 indicating that the catchment area is underlain by metamorphic rocks.

According to the Lower Nyabarongo catchment report, the lithology of the Muyanza catchment is defined by the predominance of schist (rich in quartz) and alluvial in the valley bottoms. In terms of groundwater productivity, quarzite and alluvial material is generally good for groundwater exploitation. The alluvial aquifer is an important storage for infiltrating river water and has potential for drinking water supply, good storage and high flow rates.

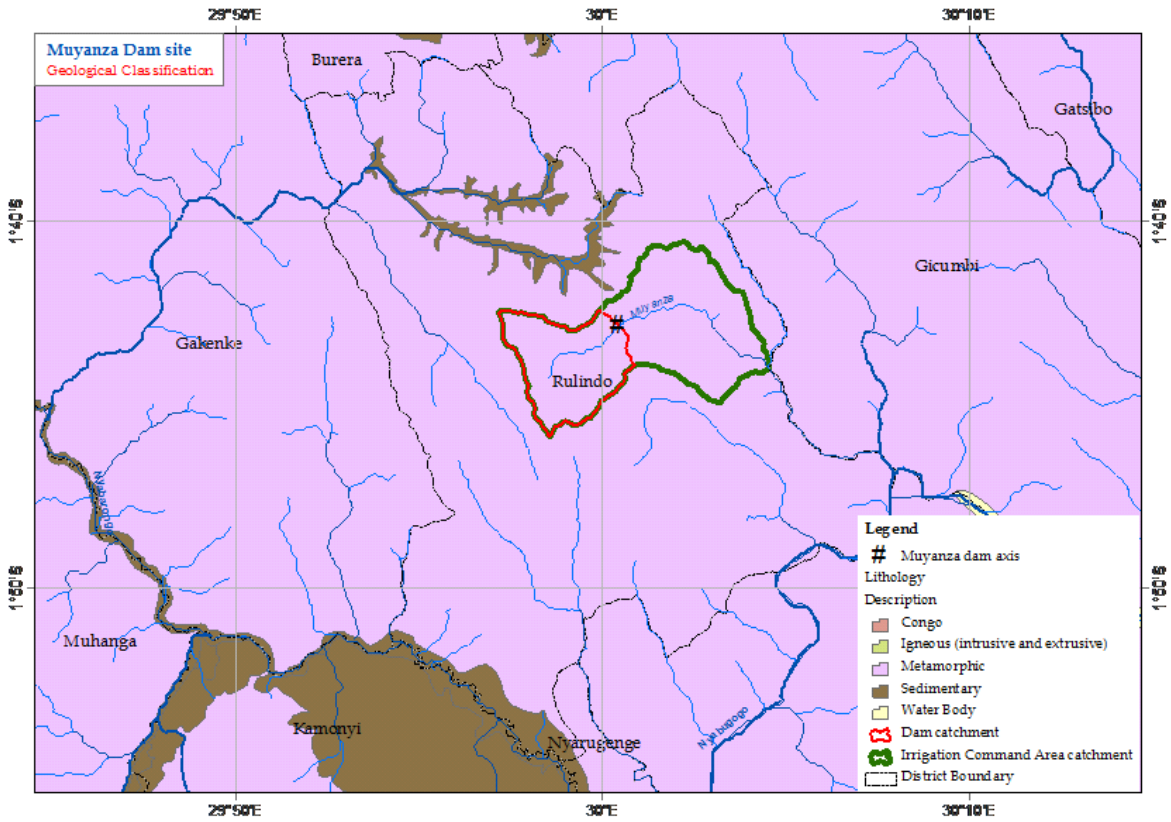


Figure 5: Geological formation in Muyanza Catchment

Groundwater Monitoring- No information could be obtained on a borehole monitoring network for monitoring changes in groundwater level and quality, however, according to the Integrated Watershed Management Program for Kagera Basin (*LTS, 2012*), depth to the ground water table in the Muyanza area ranges from 7 – 25m below ground.

Existing Ground water resources- Ground water sources include boreholes, shallow wells and springs. Actual location of these resources could not be obtained. These water sources are mainly for domestic water supply.

4.1.2.1.2. Surface water resources

Surface water resources in the Muyanza catchment include; the Muyanza stream and its small tributaries from the hills. There are no major wetlands and swamps located within the Muyanza catchment, except for the small narrow wetland area along the Muyanza River.

Surface to ground water interaction- Investigation of the interactions between groundwater and surface water runoff were done by observing presence of springs discharging flow to the rivers/streams. There are a number of springs in and around the catchment indicating obvious interaction groundwater and surface runoff. The importance of springs is that they can contribute firm flow to streams during the dry season when surface runoff ceases. This

contribution is of crucial importance to water supply. Flow records for Muyanza stream show that it is perennial.

In order to determine the contribution of the surface to ground water interaction, inflows at the proposed Muyanza dam axis were independently determined.

4.1.2.2. Derivation of flow data at Muyanza dam site

The lower Nyabarongo catchment starts at the confluence of the Upper Nyabarongo River with the Mukungwa River. It comprises numerous smaller catchments as well as three significant tributaries in the form of the Base (in the North West), the Mambu (in the West), and the Nyabarongo River (in the East). The Nyabarongo catchment covers almost half of the entire catchment area (*Lower Nyabarongo Catchment Report, 2013*).

The Muyanza sub-catchment, formed from Muyanza stream a tributary of Nyabarongo River, is located in the west of the Lower Nyabarongo catchment, ending at the confluence with the Rubona (also referred as Mwange stream) flowing from the north.

Given that the Muyanza catchment is a sub-catchment of the general Nyabarongo catchment and is as such deemed to have similar climatic and basin characteristics, the drainage-area ratio method was used to transfer data from the main Nyabarongo River to the Muyanza catchment. This method assumes that the stream flow at an ungauged site for the same stream is the same per unit area or at least responds in the same fashion as that of the nearby, hydrologically similar stream gauging station used as an index, in this case Nyabarongo 3 gauge downstream of Muyanza stream.

The data from the Nyabarongo 3 gauge had been collected for a period of 1968-2001. Based on the Nyabugogo river analysis results in Table 2, the mean monthly river flow of the Nyabugogo at Nyabugogo 3 gauge is 1.77m^3/s, ranging between 1.27 in August and 3.27m^3/s in April. The monthly maximum flow is 8.4m^3/s in April, and 2.17m^3/s in August and September.

Table 2: Monthly summary at Nyabarongo 3 gauge

Month	Mean flow (m^3/s)	Maximum flow (m^3/s)	Minimum flow (m^3/s)
January	1.42	2.45	0.45
February	1.50	2.49	0.43
March	1.68	3.06	0.53
April	3.27	8.40	0.81
May	2.67	4.91	0.74
June	1.60	3.13	0.61
July	1.36	2.36	0.51
August	1.27	2.17	0.35
September	1.33	2.17	0.44

October	1.44	2.39	0.45
November	1.98	4.05	0.64
December	1.68	3.09	0.50
Average			
Daily	**1.77**	**21.39**	**0.22**
Monthly	**1.77**	**3.39**	**0.54**

The total catchment area of River Nyabarongo as measured at the Nyabarongo 3 station is 1,162km^2 while the Muyanza dam catchment is approximately 25.8km^2. Using the drainage area ratio, flows at Muyanza dam axis are therefore 2% of the flows at Nyabarongo 3 gauge.
This would imply that the mean monthly inflows into the Muyanza dam site is 0.04m^3/s as presented in Table 3 and would also show two peaks corresponding to the long rainy seasons from February to May and the short rains from September to November. The seasonal pattern indicates dry periods from December to January and June to August.

Table 3: Generated Monthly Flows at Muyanza

Month	Mean flow (m^3/s)	Maximum flow (m^3/s)	Minimum flow (m^3/s)
January	0.03	0.05	0.01
February	0.03	0.05	0.01
March	0.03	0.06	0.01
April	0.07	0.17	0.02
May	0.05	0.10	0.01
June	0.03	0.06	0.01
July	0.03	0.05	0.01
August	0.03	0.04	0.01
September	0.03	0.04	0.01
October	0.03	0.05	0.01
November	0.04	0.08	0.01
December	0.03	0.06	0.01
Average			
Daily	**0.04**	**0.43**	**0.004**
Monthly	**0.04**	**0.07**	**0.01**

Table 4: Flow measurements at proposed dam axis from LWH collected data

Dates	Water level (cm)	Flow	
		l/s	m^3/s
31/01/2012	11	124.1	0.124
24/02/2012	9	91.2	0.091
3/4/2012	15.5	185.2	0.185

From Table 4, the actual flow measurements for three separate days by LWH staff at the proposed dam axis indicate values much higher than the computed mean daily flow value of $0.04m^3/s$ in Table 3, but fall between the minimum-maximum range of $0.004 - 0.43m^3/s$.
Due to absence of consistent measured flow data for Muyanza stream for the same period as the period of available data for the Nyabarongo 3 gauge, the values in Table 4 cannot be used to confirm the accuracy of the generated Muyanza flows from the Nyabarongo flows and hence the EIA study maintained the generated flows in table 3.

4.1.2.3. Water use and demand

Principal Water Users

It was important to identify the principal water users upstream and downstream of the proposed dam site as this facility is bound to impact the current and future uses of the water resource. Consultations with the local authorities in the area revealed that irrigation is the major use of the Muyanza resource. Other minor uses included domestic, livestock and mining.

Water for irrigation

Existing Irrigation schemes-The existing irrigation going on the Muyanza valley is done by subsistence farmers for crops which include maize, sorghum, cassava, beans, sugarcane, sweet potatoes, bananas, grass for fodder (grown in the uplands), and carrots, tomatoes, garden peas (grown in the alluvial lains).

Proposed Irrigation schemes- Based on the feasibility Study as calculated on crop water requirements estimated from crop patterns, the water demand for irrigation from the dam was 2.5MCM/year for an irrigable area of 950ha by pipe irrigation. With reference to the estimated inflow at the dam axis ($0.04m^3/s$) and water demand for crop irrigation, it could take up to 24months for the capacity to meet maximum crop water demand mentioned above.

4.1.2.4. Water Quality assessment

The water quality in the Muyanza catchment is affected by intense cultivation (with increasing removal of vegetation cover and soil loss), cultivation of riverbanks and hills, poor solid waste management, wetland degradation, exploitation of biomass, poor sanitation, water pollution (surface water and groundwater), flooding, widespread extraction of sand and clay for construction and pollution from fertilizers.

From the above pollution sources, the common water quality problems with the Muyanza stream are poor colour, high turbidity and silt load, and nutrient loading. The groundwater sources are expected to generally have better physical and bacteriological quality than the surface water sources.

Sources of pollution in the Muyanza catchment

The magnitude of water pollution of the river is mainly from non-point sources. The major pollutants include; fertilizers, pesticides as well as soil erosion arising from confined agricultural practices and soil cover destruction. Point sources of pollution are from the existing households in the catchment.

Water Quality Analysis

Given that the primary use for water from the proposed Muyanza dam is irrigation, water quality parameters of interest are; pH, Electrical Conductivity (EC), Phosphates, Nitatres, Colour, Turbidity, Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Magnesium, Calcium, Chloride, Carbonates, Hydro carbonates and Sulphates.

During the Muyanza project feasibility study, water samples were obtained from the Muyanza stream. The water samples were analysed and tested for nutrients, chemicals and physical variables. The observed results of the laboratory analysis were then compared descriptively with the existing international standards. Results of the analysis are shown in Table 4.2.

The pH in water which describes its alkalinity or acidity affects plant growth, irrigation equipment, pesticide efficiency and drinking water. The pH tested was 6.82 which is well within the acceptable range for irrigation of 5.5 and 8.5 and is in line with that of natural waters.

High alkalinity (pH > 8), an indication of presence of high concentrations of bicarbonate and carbonates, can result in precipitation of calcium from the soil which reduces the soil's exchangeable calcium content and increases soil sodicity and loss of magnesium, and decrease in copper and zinc. These conditions would affect plant growth.

High levels of carbonates and bicarbonates can also cause blockages in irrigation equipment or precipitation of calcium and magnesium ions, thereby increasing adsorption ratio (SAR) SAR.

The SAR is a measure of the potential sodium hazard for crops and soil. When sodium (Na+) occupies cation exchange sites at the expense of more stabilizing ions (Ca2+, Mg2+, CO3-2, and HCO3-), soil stability can be compromised resulting in dispersion of clay and breakdown of aggregates. These processes can result in soil expansion and surface crusting, which reduce infiltration and therefore, can reduce crop growth due to moisture stress. Carbonates in the water sample were within acceptable limits, while hydro carbonates were on the low side as shown in table 5.

Electrical conductivity measures the ability of a solution to conduct an electrical current, which is directly related to the concentration of dissolved salts. High concentration of salts in the plant root zone causes moisture stress. The parameter EC indicates the extent of dissolved solids in the water and hence the intensity of non-point sources of pollution. The observed value of EC of

56µS/cm is relatively on the lower side indicating that the impact of human activities on water quality within the catchment is still low. The results for EC can be related to the determined values of Total Dissolved Solids (TDS). These are a measure of the sum of all the ions present in a sample of water and represent the total salt content of the water which in this case as 28mg/l. Chloride (Cl^-) have the ability to accumulate in plant leaves through transpiration and direct absorption. Given the type of irrigation proposed in this project, this will not be an issue and the tested values are within the acceptable guidelines. Sulphate can contribute to salinity problems, but also can benefit crops by increasing fertility.

Total hardness which is the measure of the amount of calcium and magnesium in water can useful for irrigation by countering the effects of sodium in the soil. Higher magnesium and sodium levels than calcium can induce deficiencies of potassium and calcium.

Based on the feasibility study, results of tests done on water samples collected from Muyanza River are summarized in the Table 5. All parameters were within acceptable limits for irrigation water.

Key parameters to watch out for during the operation phase of Muyanza project is exceeding carbonate levels that could affect plant growth due to moisture stress, cause blockages in irrigation equipment through precipitation.

Table 5: Water Quality Results

S/No	Parameters	Units	Average	Guideline Standards for Irrigation Water
1	E. Conductivity	ds/cm	0.056	9.0-3.0
2	Total Dissolved Solids (TDS)	mg/l	28	0-2000
3	pH		6.82	6.5-8.4
4	Total Hardness	mg$CaCO_3$/l	32	
5	Chloride	mgCl/l	11.5	0-30
6	Calcium	mg/l	6.8	0-20
7	Magnesium	mg/l	3.6	0-5
8	Sulphates	mg/l	1	0-20
9	Hydro Carbonate	mg/l	0.38	1.5-7.5
10	Carbonates	mg/l	0	0-0.1

Source: Feasibility Study

4.1.2.5. Soil erosion risk

Soil erosion risk data was extracted from the SLEMSA (Soil Loss Estimation Model for Southern Africa) model that was developed for the Kagera basin during the watershed feasibility study

(LTS, 2012). Areas with the highest risk are located along the western ridge coinciding with the areas with high slope gradient and high cultivation intensity. Muyanza lies in the Nyabugogo sub-watershed which is classified as having a severe (278 – 742 tonnes/ha/year) to very severe (742 – 6,274 tonnes/ha/year) erosion risk. This attributed to high population density and infertile soils resulting in high pressures on the land. This is further exacerbated by the steep slopes (1500 -2200m.a.s.l) and shallow soils.

Erosion types observed in the catchment include rill erosion, stream bank erosion and minimal cases of gully erosion in recently excavated and exposed areas for temporary activities like access roads for equipment. Due to high erosion rates experienced, soil and silt in large quantities are carried in both bed load and suspended load by the Muyanza stream.

4.1.2.6. Sediment Yield Assessment

Due to high erosion rates experienced in the basin, soil and silt in large quantities are carried in both bed load and suspended load by the Muyanza stream.

A rapid assessment of the sediment yield into the proposed dam was done by visual observation of the siltation in the stream and the general watershed practices. The Muyanza stream is heavily silted as shown in *figure 6*. This is attributed to the poor farming practices in the watershed including cultivation on steep slopes and cultivation right up to the river banks. The determination of sediment yield into the proposed was therefore extremely important as it has bearing on the life period of the dam.
Gross soil erosion data as computed in the feasibility study is 25,000Tonnes/year.

Figure 6: Siltation in Muyanza Stream River

4.1.2.7 Flood Assessment

Existing flood condition in catchment

Given the direct relationship between rainfall and runoff in the catchment, the torrential rains experienced undoubtedly lead to floods. Flood events experienced include the flood of April 2012 which destroyed the flow gauge installed on a small measuring weir at the proposed dam site. Consultations with local residents by the feasibility study team also revealed three other flood events (overtopping the main road bridge in the Muyanza area) in the last 15 years in 2013, 2004 and 1998/1999. This translated to an empirical probability of appearance of 20% in the last 15 years.

Estimation of peak floods

The annual maximum (AM) flood series for Muyanza were used to estimate Annual maximum flood series for the dam catchment. This was achieved by transposing the Nyabarongo annual maximum flood series to Annual maximum series by use of the catchment area ratio method. The AM series were modelled using the Gumbel/ Extreme value type I distribution. The model was then used to estimate peak flows in table 7 for return periods, T =5, 10, 20, 25, 50, 100, 1000 and 10,000. Table 6 presents the AM data that was used in the analysis. Data was available from the Nyabarongo 3 gauge for the years 1968 – 2001. However due to presence of huge gaps in the data (some with complete years), a total of the 14 years between (1970-1986) with consist data recorded were used.

Table 6: Annual Max Series for Nyabarongo and the Estimated Annual Max series for Muyanza

Annual Maximum Discharge		
Year	**Nyabarongo Flow (m^3/s)**	**Estimated Muyanza Flow (m^3/s)**
1970	20.22	0.40
1971	10.68	0.21
1973	8.25	0.17
1974	4.01	0.08
1975	7.62	0.15
1976	5.40	0.11
1977	15.45	0.31
1978	13.73	0.27
1979	5.94	0.12
1982	16.13	0.32
1983	21.39	0.43
1984	11.05	0.22
1985	17.05	0.34
1986	10.31	0.21
Mean	**11.95**	**0.24**
Standard Deviation	**5.52**	**0.11**

Using the Gumbel modelling, peak floods of return periods of 5, 10, 25, 50, 100, 1000 and 10,000 years were estimated for the Muyanza catchment as in Table 7 below.

Table 7: Estimated Peak floods for Muyanza at the specified return periods

Return periods $T\ (Years)$	Frequency factor of return period (K_T)	$\bar{X}\ (m^3/s)$	Standard Deviation. S	Flood flows$X_T\ (m^3/s)$
5	0.72	0.24	0.11	0.32
10	1.30	0.24	0.11	0.38
25	2.04	0.24	0.11	0.46
50	2.59	0.24	0.11	0.52
100	3.14	0.24	0.11	0.59
1,000	4.93	0.24	0.11	0.78
10,000	6.73	0.24	0.11	0.98

Where: X_T = Flood of return period T, K_T = Frequency factor for Return period T, S= Standard deviation for the sample data (Annual Maximum series). For the equation:

With the a side spillway designed to accumulate a design outflow of 100 m^3/s for a return period 1:1000 and also checked for the 1:10,000year flood of 155 m^3/s, this is more than sufficient to handle the estimated peak floods above.

4.1.3. Ecological flow analysis for Muyanza River

Methods for estimation of environmental flows can be grouped into methods based on (i) hydrologic or statistic value, (ii) physiographic principles, (iii) velocity and depth of water, and (iv)multi-objective planning taking into consideration ecological parameters. Hydrologic methods, based on statistical analysis of hydrological data available at a given site, are commonly used because they are the simplest and least expensive. These methods are based on the premise that the aquatic ecosystem of a river depends on its historical hydrological regime.

The hydrological method was adopted to establish the minimum ecological flow requirements. The total environmental flow was obtained as the total of human and ecological flow requirements as detailed in the sections below.

- ***Human settlement in affected area-*** The affected area includes the sectors of Burega and Buyoga with a population of 13,253 and 22,264 persons respectively.

- ***Water demand-*** Based on the socioeconomic survey of the Muyanza area (Z& AP et al, 2013), the major water use of the Muyanza stream downstream of the proposed dam location is irrigation. This irrigation demand has been catered for in the design of the irrigation system in the Feasibility study and will therefore be met by the dam supply.
  Regarding the domestic water demand, consultations with the locals revealed that very few people if any, draw their water for domestic use from the Muyanza stream as there are various cleaner water sources in the area which include natural springs, small streams feeding into Muyanza and gravity flow schemes. Domestic water demand downstream of the demand is therefore negligible.

Irrigation and domestic water use demand were hence not factored in the calculations for determining the Ecological flows.

For purposes of establishing the level of water to be released to flow downstream of the dams to maintain the environment a simple methodology referred to as 'Montana Method' proposed by Tennant (1976), where by environmental flow regimes are prescribed on the basis of the average daily discharge or the mean annual flow (MAF). This method provides guidelines for flow management based on the percentage of average flow, daily and monthly stream flow records, that would maintain biological attributes of a river as; optimum (when MAF is >60%), outstanding (at a MAF of 40%), excellent (at a MAF of 30%), good (at a MAF of 20%), fair, poor, minimum, or degrading (at a MAF of 10%).

In absence of more reliable data and due to time limitations hindering rainfall-runoff modelling, the mean annual flow (MAF) computed by the Feasibility study of 3.81Million m^3/year which translates to approximately 0.12m^3/s flow, was used in this study.

10% of MAF is proposed to be the minimum level of flow required to be released downstream of the dams for purposes of maintaining the ecosystem. Computed 10% of the MAF values is presented in Table 8.

Table 8: Environmental flow values

Dam site	**Mean Flow (m^3/sec)**	**Minimum Ecological flow 10% of the mean flow (m^3/sec)**	**Minimum Muyanza daily flow (computed) (m^3/sec)**
Muyanza	0.12	0.012	0.004

From our computation, the determined environmental flow of 0.012m^3/s is greater than the minimum daily flow computed in Muyanza of 0.004m^3/s and is therefore sufficient for maintenance of the ecosystem downstream of the dam that comprises of mostly crops such as; carrots, cabbages, onions, tomatoes, sorghum, climbing beans and bananas. Fauna commonly known to exist downstream and in areas with such crops are; carrot root flies, onion flies, flea beetles and nematodes

Given that the human water demand is not considered and is going to be met by the dam supply, the recommended environmental flow for the dam is that of the ecological flow computed above for maintenance of the ecosystem and is therefore set as **0.012m^3/s.**

4.1.4. Relief

***Slope classification*-**Based on slope classification map (*refer to appendix 5*) of the Muyanza site, the water catchment area has a slope range of 30-40% and for most hills >40%, while command

area is mostly in the slope range of 10-30% ending in a valley through which the Muyanza river traverses.

4.1.5. Soils

A soil map has been presented in *Appendix 6* for reference of the general soil taxonomy of the site layout.

In addition to information in the soil assessment report presented in the feasibility study of Muyanza site, we were able to perform an independent soil analysis by collecting soil samples from three (3) points of the Muyanza site area during our field study.

From the field study we were also able to select to two (2) soil profiles in a radically terraced site and an un-terraced one. The two soil profiles were prepared and described. Soil profile descriptions following the guidelines for soil profile study (FAO World Reference Base 2006) were carried out. A soil profile at about 1.5 to 2 m depth was prepared by casual labour under supervision of the soil scientist. The depth depended on the profile development and level of the water table.

4.1.5.1. Soil profile description

From field observations, the following soil profile was developed for both the terraced and un-terraced soils investigated of Muyanza site area. The table below elaborates the two soil profiles.

Table 9: Description of two soil profile analysed

1	**Profile number:**	**RWANDA- RULINDO-BUREGA-TABA PI**	**RWANDA-RULINDO-BUREGA-TABA PII**
	Date:	08-07-2014 or 140708	09-07-2014 or 140709
	Location:	Northern Province, Rulindo District, Burega Sector, Taba Cell, Mwenene Village.	Northern Province, Rulindo District, Burega Sector, Taba Cell, Mwenene Village.
	Elevation: **Coordinates**:	2042 m Latitude E: 9808911 m; Longitude S: 5501688 m	2047 m Latitude E : 9808966 m; Longitude S:5501447 m
2	**Soil Formation factor**		
	Atmospheric Climate and Weather Conditions:	Present Weather condition: sunny/ clear (SU). Former weather conditions: no rain in the last week (WC2)	Present Weather condition: sunny/ clear (SU). Former weather conditions: no rain in the last week (WC2)
	Land form &Topography		

	Level/Landform: Slope position: Slope forms and surface pathways: Slope gradient	 Sloping land (S)-Terraced (TE) Middle slope (MS) Terrace (T) Nearly level (0.5–1.0%)	 Sloping land (S)- medium-gradient escarpment zone (SE) Upper slop (UP)  Straight Convex Strongly sloping (10–15%)
	Land use and vegetation: **Crops/Vegetation:**	Crop Agriculture-Annual field cropping- AA2 Maize (CeMa); Beans (PuBe)	 Shrub and trees Short grasses (FoGr) and eucalyptus
	Human influence:	Terracing (TE)	Shrub and trees
	Parent material:	Sedimentary rock/ shale (SC4)	Dolorite
	Effective soil depth	The soil is very deep (> 2m)	The soil is very deep (> 2m)
3	**Soil Description**		
	Surface characteristics		
	Rock outcrops:	None (0%)	None (0%)
	Coarse surface fragment:	None (0%)	None (0%)
	Erosion:	(No evidence of erosion)	(No evidence of erosion)
	Surface sealing:	None (N)	None (N)
	Surface Cracks:	Fine (F)- very closely spaced (C) – surface (S)	Fine (F)- very closely spaced (C) – surface (S)
4	**Horizon Boundary and Depth**		
	1. 2. 3.	M : (0-80 cm) Ab/E: (80-106 cm) Bt: (> 106 cm)	Oa (0-40 cm) Bt: Nitic horizon (>40 cm)
5	**Distinctness and topography**		
		Diffuse(D),Smooth(S) Nearly plane surface	Diffuse (D), Wavy (V) Pockets less deep than wide
	Primary constituents	Quartz	Silicate clays
	Texture of the fine earth fraction		
	1. 2.	M: loamy Sandy Ab/E: loamy	Oa : Loam clay Bt: Clay
	3.	Bt: Clay	

6	**Rock fragment and artifacts:** **Degree of decomposition and Humification of Peat:** **Soil colour matrix**	None (0%) None	None (0%) None
	1. 2.	M : 2.5 YR 3/4 Ab/E: 2.5YR 2/4	Oa: 2.5 YR 2/4 Bt: 5YR 3/6
	3.	Bt: 5YR 3/6	
7.	**Mottling**		
	Abundance of mottles: **Redoximorphic characteristics** **Carbonate:**	None (0%) None (strongly aerated) Non-calcareous (N) 0%	Oa: Very few(V), very fine (V) and Faint (F) None (strongly aerated) Non-calcareous (N) 0%
	Gypsum: **Readily soluble salt:** **Soil structure**	Non-gypsiric (N) 0% (nearly)Not salty M: Granular, Ab/E: Blocky sub angular, Bt: Blocky sub angular	Non-gypsiric (N) 0% (nearly)Not salty Oa: Granular, Blocky Sub angular to massive
8	**Soil-water Relationship** **Consistence**	-Drainage class: Well Drained (WD) -Flooding: None(NO) -Ground Water: Deep water table **-when dry**: M: loose (LO), Ab/E: soft (SO), Bt: Slightly hard(SHA) **- When moist**: M: Very friable (VFR), Ab/E: Friable(FR), Bt: Firm (FI) **Stickiness:** M**:** Slightly sticky (SST), Ab/E: Slightly sticky (SST), Bt: Sticky (ST) **Plasticity:** M: Slightly plastic (SPL), Ab/E: Slightly plastic (SPL), Bt: Plastic (PL) **Soil water status:** M: Dry ; Ab/E: Slightly moist; Bt: Moist	-Drainage class: Moderately Well Drained (MW) - Flooding: None (NO) -Ground water: Deep water table **-when dry**: Oa: Soft (SO), Bt: hard (HA) **-When moist**: Oa: Friable (FR), Bt: Firm (FI) **Stickiness:** Oa**:** Slightly sticky (SST), B: Sticky (ST) **Plasticity:** Oa: Slightly plastic ((SPL), Bt: Plastic (PL) **Soil water status**: Oa: Dry ; Bt: Moist
	Bulk density:	M: Medium ,	Oa: Medium and

9.	**Porosity:** **Size and abundance of pores**:	Ab/E: Medium Bt: Low M: High (15-40%), Ab/E: medium (5-15%), Bt: low (2-5%) M: common/ fine, Ab/E: Common/fine, Bt: common/ very fine	Bt: Low Oa: High (15-40%), Bt: low (2-5%) Oa: common/ fine; Bt: common/ very fine
	Coatings and Mineral concentration: **Roots** Roots diameter Root Abundance	- Clay and sesquioxides , -Abundance: few (in Bt) 2-5% Very fine Very Few especially in M	- Clay and sesquioxides , - Abundance: common (in Bt) 5-15% Medium Few in Oa
	Other biological features: **Hum-made Material:** **Soil type:**	Ants and Termites Not applied If the clay content is increasing, the proposed Bt horizon is deeper than expected. The clay content of this horizon increases toward parent material. **1. Classification of the original soil:** given the progressive increase in clay content with depth of the B horizon, this soil is proposed to be an "**Nitisols**" **2. Classification of the present soil:** the presence of a deep M horizon, resulted from Radical Terracing practices indicates a type of soil affected by Human being Activities. **Conclusion:** the proposed soil is "**Anthrosol**" **3. Combination of the** original type of soil and the present one will give us a new type of soil which is called "**Nitic-Anthrosol**"	Ants and Termites Not applied Given the presence of a mollic horizon at the top of the profile and subsurface Nitic horizon, the soil is proposed to be a "**Mollic-Nitisol**"

4.1.5.2. Soil lab results presentation and interpretation

Following the sample site selection criteria, top soil samples were collected following the "Y" sampling method to form a composite sample. The soil samples collected from the profiles and top soil samples underwent laboratory analysis at the University of Rwanda referential soil laboratory in Huye campus. Laboratory analysis concerned the following parameters: Soil Organic Carbon, Soil pH, soil texture classes determination, exchangeable acidity, available Phosphorus, Ammonium concentration and Nitrates concentration and bulk density.

Soil lab results presentation

The results presented in this section include:

- Compost investigation results for pH, ammonium concentration, Nitrates concentration and total Nitrogen.
- Findings for soil samples collected from composting sites, investigated for Ammonium concentration, Nitrates concentration are also presented in this section.
- In addition, results for the top soil samples collected from the two profiles of terraced and un-terraced soils studied are shown in this section.

Table 10: pH, Total Nitrogen and Mineral Nitrogen measured in compost samples

Samples	pH	Total N (%)	NH4+-N (mg/kg)
1	9.32	0.8	5.1
2	8.7	0.9	4.38

Table 11: Mineral Nitrogen content of soils underlying the composting sites

Samples	NH4+-N (mg/kg)	NO3-N (mg/kg)
1	5.1	36.4
2	4.38	29.2

Table 12: Physico-chemical properties of top soils collected from the two profiles

	Terraced	Un-terraced
Item	*Quantity*	*Quantity*
Texture determination	Loam-Sandy	Loam-Clay
pH (H2O)	5.5	6.1
pH(KCl)	4.9	5.8
Mineral N (Nitrates) (mg/kg)	21	29
Mineral N(ammonia)(mg/Kg)	7.4	8.3
Organic carbon (%)	2.1	3.5
Available phosphorous (ppm)	5	17
Exchangeable acidity (Cmolc/Kg)	0.4	0
Bulk density (Kg/L)	1,020	0.956

Results interpretation

This section intends to assess and interpret the laboratory results obtained with regards to compost quality, soil fertility status and environmental concerns connected with compost use in the entire project zone.

Compost quality and connected environmental risks

The relatively few parameters investigated for compost samples cannot allow a comprehensive discussion on the compost quality and its potential positive and/or negative impact on plant growth and environment. Nevertheless, one of the most important chemical elements (Nitrogen) was investigated and could provide some insights on compost quality and its risks on environment pollution.

It was found that, the total Nitrogen rates measured in compost samples were relatively low compared to international standard for mature compost, which ranges from 1% - 4.2% (*Universite chouaib doukkali, 2008*).

The likely reasons behind this relatively low total nitrogen ratio could be the method used for compost preparation. There is also a possibility that high amounts of nitrogen might have been lost through both volatilization and leaching.

Indeed, the first phase of nitrogen transformation/mineralization (ammonification) produces a high amount of ammonium which is susceptible to volatilization as ammonia gas.

The second reason may be the Nitrates leaching. Nitrates leaching are common when the composting heap exposed to rainfall. Nitrate anions are very soluble in water and can quickly leach in underlying soil horizons or get lost through rain water run-off. Measurement of mineral nitrogen content from underlying soil samples of the compost heaps showed relatively high mineral nitrogen content compared to other soils of the area. As pointed out in the Environmental Impact assessment section, Leached Nitrates may constitute a threat for ground water pollution.

Top soil fertility status of the two studied soil profiles

As shown in the tables above, the soil fertility status of the Mollic Nitisol top soil is considered as good for agriculture production. The soil pH measured in water and KCl is considered as neutral, since no exchangeable acidity was detected. This is a very important aspect for soil fertility because, they will be no availability limitation for other important soil nutrients such as Phosphorus. Indeed, the available phosphorus content was in the range favourable for plant growth.

The soil texture (loam clay) was considered as a positive characteristic because, the relatively good clay content of the soil allows to increase the capacity of the soil retain water and can resist against short range droughts. The profile study has shown that the clay content was increasing

with depth. This is another positive characteristic for this soil because the relatively high clay content in the root zone enhances the capacity of the soil to keep nutrient around for a relatively long period. This will decrease the risks of nitrates and other nutrients leaching. Although potential toxic heavy metals were not investigated here, the high clay content is expected to significantly limit the heavy metals leaching.

Soil parameters measured in the topsoil of the profile from the terraced land have shown relatively low fertility compared to the profile from undisturbed land. The soil pH tended to be acidic and this was confirmed by the exchangeable acidity values. All other parameters including: mineral Nitrogen, available Phosphorus were lower than those measured in the non-disturbed land.

This type of soil had a thick M horizon which was made up of mixed material from previous horizons. Its characteristic is therefore a combination of the different characteristics from previous horizons. This disturbance has conferred a soil of the type "Anthrosol" because it is made up soil from terracing manipulations.

4.2. BIOLOGICAL ENVIRONMENT

4.2.1. Existing flora and fauna of the project area

Existing flora and fauna of the project area consists mainly of cultivated crops and small scattered forests and no sensitive or endangered flora or fauna observed in the project areas.

Fauna commonly observed in forests of eucalyptus comprise of birds, reptile living under fallen logs, rodents, invertebrates such as; millipedes, centipedes, bugs, earthworms, spiders and many related invertebrates.

Aquatic fauna observed in Muyanza River and mostly in stagnant waters of its tributaries were tadpoles a sign of presence of frogs, a water snake was also seen in the rushing waters of Muyanza River.

Terrestrial fauna is dominated by granivorous birds possibly because of the sorghum. While the most common fauna is domestic livestock, either cattle zero grazed in domestic kraals or goats and sheep allowed to graze out in the fields.

For forests coverage: It was observed that the project area has no natural forests but instead comprises of forest plantations. Eucalyptus trees dominate the area with very few interruptions of grevillea and pine trees.

By applying GIS mapping, it was established that combined forest plantation coverage is about 46.6ha mostly in the command area downstream, with upstream catchment area barely having any forest plantation. This would imply that terracing, dam and reservoir establishment is

unlikely to affect existing forest plantations. However, with these forest plantations mostly in the lower command area, there is a possibility that activities in this area could result in a reduction of the forest area.

On the other hand, considering one of the project activities set to grow forests on slopes above 60%, which shall cover an area of 366.8ha, this poses as a suitable offset of the deforestation impact caused by activity in the command area by increasing forest areas by over 300ha.

For Crops coverage- patterns of crop distribution were observed as below:

- *Hillsides with land husbandry upstream, reservoir area and in the proposed irrigation area*: Currently the farmers grow maize, beans, potatoes, *Pennisetum purpureum* "urubingo" on the embankments of the radical terraces. Fauna commonly known to exist in areas with such crops are; worms, beetles, stem borers, spider mites.
- *Valley irrigated area along the Muyanza river stream*: Currently the crops grown here include; along the stream are carrots, cabbages, onions and Tomatoes. While in the other parts of the valley were observed to sorghum, climbing beans and bananas. Fauna commonly known to exist in areas with such crops are; carrot root flies, onion flies, flea beetles and nematodes.
- *Catchment of the command area with minimal land husbandry and no irrigation*: In these areas crops grown are maize, beans, bananas. Fauna commonly known to exist in areas with such crops are; worms, beetles, stem borers, spider mites, weevils, moths, aphids and Thrips. Here the communities may decide the types of crops to be grown. However, food crops such as maize, bean, fruit trees and banana along terraces are recommended.

From the assessment of the project area, interviews with the locals and consultation with University of Rwanda ecologist, there was no sensitive/ protected flora or fauna species observed especially since it is an area that has for long been under human settlement and cultivation.

4.2.2. Predicted flora and fauna after project implementation

Flora and fauna emerging from the proposed project crops and forest area were observed to be:

- *Hillsides with land husbandry upstream and in the proposed irrigation area*: Recommended crops for slopes less than 30% are: passion fruits, tree tomatoes, water melons, strawberries, snow peas, sugar snap and summer flowers. Emerging fauna associated with these new crops are: nematodes, beetles, whiteflies, spider mites and fruit birds.
- *Valley irrigated area*: For project implementation high value crops are recommended such as; cauliflower, broccoli, brussel Sprouts, leeks and baby carrots. Emerging fauna associated with these new crops are; cabbage loopers, worms, thrips, caterpillars, aphids, maggots and Flea beetles, rats and squirrels.

- *Catchment of the command area with minimal land husbandry and no irrigation*: In these areas, since the communities are allowed to decide the types of crops to be grown, existing food crops will be maintained such as maize, bean, bananas with just a few additions like fruit trees and banana along terraces.
- *Reservoir Catchment area with some land husbandry*: Project implementation proposes forestry/Agro-forestry to dominate this area. Fruit trees such as; avocado, citrus, banana, papaya, mangoes are suggested. Suitable fodder crops are already being planted to control soil erosion. e.g. napier grass "Urubingo" at the terrace embankments. New fauna emerging associated with these new trees and crops shall include: caterpillars, avocado brown mites, six-spotted mites, fruit flies, rats and squirrels.

With the introduction of the dam and reservoir, the ecosystem will be remodeled, both the aquatic as well as terrestrial area in the upper reservoir area and in the downstream of the dam.

- *The river water course*: During the construction phase of the Dam and reservoir, the distribution of oxygen in water is likely to reduce. Aerobic animals will migrate toward the downstream, others will die due to the fact that the plankton on which they feed will have decayed due to lack of oxygen.
- It was noted that the reservoir and dam construction will flood the reservoir area hence replacing with existing crops with algae, emergent aquatic plants such as; reed, bulrush, papyrus.
- The biodiversity in the reservoir area will change rapidly because of the introduction of an aquatic environment rich in phytoplankton, zooplankton and aquatic animals making trophic chains.
- In the upper stream, the speed of the water will be slow or reservoir stagnant, thus favorable to be habited by arthropod's larva as well as gastropods, vehicles of protozoa responsible of malaria and bilharzia.

4.3. SOCIO-ECONOMIC ENVIRONMENT

This section attempts to understand the current social status of the area of project influence versus the likely effects of the proposed project. It involved collecting primary data from field investigations, group meetings, public consultations and expert field observations. It therefore describes the baseline of the socio-economic parameters of the area before project implementation. Social data collected from field public consultation are; population and demography, land use, infrastructure (roads, water, electricity), health and sanitation, education, cultural heritage.

4.3.1. Social environment of Muyanza project area

With Muyanza project covering five (5) sectors of Rulindo District, social data collected from the field public consultation with local authorities and locals was summarised in the table 13 below.

Table 13: Summary of specific social environment of Muyanza site

Social parameter	Sectors				
	Cyinzuzi	**Burega**	**Buyoga**	**Tumba**	**Mbogo**
Muyanza Project awareness	Good	Very Good	Good	Good	Good
Project local impression	Good	Good	Good	Good	Good
Project Activity	Terraces	Terraces + dam & irrigation infrastructure	Terraces + dam & irrigation infrastructure	Terraces	Terraces
Area of coverage (Km^2)	-	33	54	43	41.5
No. of Cells	-	3	7	5	4
No. of villages	-	40	37	30	32
Population	14,364	13,253	22,000	Approx. 20,000	17,130
Households (HH)	3,759	3,116	5,094	4,393	3850
Vulnerable HH	224	418	-	-	941
Extent of community settlement "Imidugudu" (%)	-	90.1	-	55	56
Schools	3 schools of level 9 and 12 YBEs. 1 Private primary school.	2 schools of level 9 and 12 YBEs.	8 schools of level 9 and 12 YBEs. 1 secondary school	1 school of level 9 and 12 YBEs. 5 primary schools 2 secondary schools.	3 schools of level 9 and 1 school of 12 YBEs. 1 primary school.
Health centres	None. Closest is in Ngoma sector	1	2	1	1
Extent of Medical insurance "Mituelle de santé" (%)	73%	81.6%	86%	85%	86%
Resilient diseases like; Malaria	None	None	None except worms in children	None	None
Extent of family planning compliance (%)	-	-	65	40	-

Markets	None. Use Ngoma sector market.	None. Use Ntarabana sector market.	1 big one and 5 small ones	1	None
Roads	All season Earth road.	All season Earth road except poor road to dam site.	All season Earth road except poor road to dam site.	All season Earth road.	All season Earth road.
Housing	Generally, Earth houses with iron sheet roofing	Generally, Earth houses with iron sheet roofing	Generally, Earth houses with iron sheet roofing	Generally, Earth houses with iron sheet roofing	Generally, Earth houses with iron sheet roofing
Electricity	Only in commercial centres	Only in commercial centres	Only in commercial centres	Only in commercial centres	Only in commercial centres
Cultural heritage points in the site area	None in site area	1: Abami bibisare "Burial site of Kings"	None in site area	None in site area	None in site area
Maginalised people.	None	None	10 HH of 30 people that also have benefited from terrace scheme.	None	-
No. of cooperatives	2 legally registered	31 but only 5 legally registered	7 legally registered	14 legally registered	8 legally registered of 33.
Main income source	Agric & livestock farming	Agric & livestock farming	Agric & livestock farming	Agric & livestock farming	Agric & livestock farming
Crops commonly grown	Climbing Beans, maize, Irish potatoes	Climbing Beans, maize, cassava, sorghum, onions, peas	Climbing Beans, maize, sorghum, onions, carrots, cabbage.	Climbing Beans, maize, irish potatoes, wheat, sorghum, peas, sweet potatoes.	Maize, Climbing Beans, irish, wheat vegetables, coffee
Other sources of income	Mining cassiterite	Brick making and sand mining	Brick making and sand mining	Basket knitting	Tailing, basket knitting, trading.

Other projects in site area or proposed on Muyanza River.	None in site area other than VUP	None in site area other than VUP	None in site area other than VUP	None in site area	None in site area
Extent of Land registration	All land complete	All land complete	All land complete	All land complete	All land complete
Areas of expropriation due to project	4 homes for Post-harvest facility.	Not yet known but a number of community settlements, catholic buildings, nursery schools could fall in the path of irrigation infrastructure in the command area	Except for 2 plantations demarcated for the post-harvest facility, dam area not yet known.	None	None

Source: Sector records for Cyinzuzi, Burera, Buyoga, Tumba and Mbogo end of 2013-2014 financial year.

In general, other socio-economic baseline data indicate that:

- *Land Use:* 75.4% of these sectors in Rulindo is under food crops, 2.5% is under cash crops, 1.2% is under forage crops, 7.9% is fallow, 0.4% is uncultivated fields and pastures, 12% forests and 0.6% under other uses. 97.8% of the crops are rain-fed.
- *Electricity*-Access to electricity in these sectors is very low at 11.4%. This has an implication on the capacity of the sectors to undertake such productive, any likely processing and other forms of value addition, many of which require electricity. It also affects other services such as health and education amongst others.

4.3.1.1. Social data interpretation:

- *Project interpretation and local impression*- Both locals and authorities appeared to have a clear understanding of what the project was about. Locals had been adequately sensitized on the activities of the project and they understand benefits that will arise from its implementation. e.g. soil conservation from erosivity, increased crop production from terracing, application of composite, urea and fertilizer, job opportunities during the establishment of terraces, dam and reservoir construction, higher income from high value crops and collective bargains for their produce.

  However, like all communities delays in implementation of project activities in some areas have not been appreciated. Issues were raised by farmers that missed on cultivating one of the seasons because their land was next in line of program to be terraced and the project had delayed to execute.

- *Education levels*- With the highest level of education being 12year Basic Education and a few secondary schools, this area is likely not have skilled labour to support technicalities involved in the construction of the complex irrigation scheme. This could imply that mostly expatriates from other areas shall be involved in implementing this scheme.

- *Resilient diseases*- Records from the sectors indicate that common diseases such as; malaria, diarrhoea, dysentery, are not common in this area. This could be because it is a hilly area, with mostly cold weather and hardly any stagnant waters except for some areas in the valley.

  However, there were indications that children commonly develop stomach worms, which is mainly a result of insufficient water for good hygiene and consumption of unboiled water.

- *Medical insurance*- As per the previous financial year, all sectors indicate a very good coverage of medical insurance (above 70%, most above 80%) by its locals. This could imply that they understand the importance of having medical insurance and probably explains why some of the resilient diseases are not common in this area.

- *Market infrastructure*- Of the 5 sectors in the project area, only 2 have markets. This possibly implies that farmers have to walk long distances to markets to sell their produce hence inadequate access to market infrastructure.

- *Access roads to dam area*- Whereas most roads in these sectors are all season earth roads, access roads to the dam are narrow, slippery in certain spots and with weak timber bridges laid across small streams at the bottom of the hills in this area. Such roads shall not be able to sustain heavy equipment and automobiles during the construction of the dam and irrigation infrastructure.

- *Cultural heritage*- Cultural heritage was investigated on site, such as; Genocide memorial sites, cultural monuments, religious set-ups, grave yards or cemeteries, traditional heritage. Information from public consultation with locals and their authorities indicated that there

were no such things except in Burega sector where Catholic Church structures might fall in the path of irrigation infrastructure in the command area.

Absence of such heritage with in the project site could be due to most of this area being either under cultivation or human habitation.

- *Other projects operation in site area*- Consultation with MINAGRI, at all sectors, EWSA indicated no projects planned in the site area other that of LWH and VUP.

  Vision Umurenge Project (VUP), a government funded project, is currently operation in all sectors with most of its activities involving locals in road maintenance and terrace establishment. VUP was observed to have a financial impact on implementation of LWH terrace activities; where for a VUP day's task ending at 11:00a.m is paid 1000Rwf, the LWH day's task for a whole day will cost the same amount. This drives many locals to go for the VUP tasks and only resort to LWH tasks as an alternative.

  Projects such as; Lake Victoria Environmental Management Project (LVEMP) in Mbogo sector involved in hillside soil protection activities operate in other sites out of the Muyanza project site demarcation and shall not affect it.

  Likewise, the Kinihira tea plantation operating in valleys of different water sheds and streams, again out of the Muyanza site demarcation.

- *Areas of expropriation*- whereas it appeared that from public consultation, sector authorities were not aware of the delimitations of the dam, reservoir and irrigation infrastructure in the command area, valuations had been done in the catchment area upstream of houses and land that would require expropriation for post-harvest facilities.

  Also with the assistance of LWH site coordination team, we were able to identify areas with community settlements and land that are within preliminary delimitation of the project activities and that might require expropriation as elaborated hereafter.

- *Main source of income and other sources*- Agriculture and livestock farming is the main source of income. There are however, other smaller off-farm activities that are income sources to locals in these areas such as; basket knitting, brick making, sand mining and commercial activities in small trading centres.

- *Cooperatives*- Whereas there a number of cooperatives in these sectors, a small percentage have legal status and lack management abilities of these cooperatives. Most of these are involved in agricultural activity. Sector officials have opted to apply the LWH down- to- top approach of forming groups, zonal committees and eventually cooperatives for the Muyanza project.

Further to this, information was collected on unit prices estimations for items likely to be compensated in the event of expropriation. This would give guidance on estimations applied to proposed mitigation measures towards expropriation.

4.3.1.2. Estimate costs of expropriation

In coming up with these estimations, reference was made to valuations agreed upon amongst LWH, property owner and District, for compensation of land, crops and houses with areas demarcated for post-harvest facilities in Cyunzuzi and Buyoga sector. *For land prices, unit rates stipulated by the Ministerial order No. 002/16.01 determining the reference land price outside the Kigali city*.

The table 14 below gives a summary of the unit rates for some of the common items that are found with project site areas of influence.

Table 14: Cost estimates for expropriation

Post-harvest infrastructure	Description	Unit	Unit prices (Rwf)
House	Levelled foundation with earth and timber elevated walls plastered in cement screed and iron sheet roofing.	piece	2,500,000 Rwf equivalent to 387USD (1USD=3,576Rwf)
Crops and land			
	Land	m^2	107- 122Rwf
	Napier grass "urubingo"	acre	10,000Rwf
	Umuravumba	acre	2,800Rwf
	Climbing beans	acre	2,250Rwf
	Maize	acre	4,200Rwf
	Cassava	acre	40,500Rwf
	Sweet potatoes	acre	20,000Rwf
	Sorghum	acre	3,500Rwf
	Eucalyptus	tree	2,145 Rwf
	Coffee	tree	3000 Rwf
	Egg plant	tree	150 Rwf
	Red pepper	tree	300 Rwf

4.3.1.3. Estimate property likely to be expropriated

By using GIS as a tool (i.e. 6th June 2013 google earth), irrigation piping layout of the command area and borrowing from the cost estimates used for compensation of post- harvest facilities, estimations of land and built-up areas in the dam area and command area that could be lost by project activities were obtained and summarized herein.

These combined with the estimate costs indicated in the table above would give an estimate of cost of compensation indicated in the table 15 below. Of course more accurate costs will be determined once the detailed design is complete and a Resettlement Action Plan (RAP) is done.

Table 15: Estimate of land and houses for compensation

Item description	*Unit*	*Unit price (Rwf)*	*Quantity*	*Total estimate (Rwf)*
Dam built up area				
Houses	Pieces	2,500,00	14	35,000,000
Private Land	m^2	122	39,388	4,411,474
Restoration of Access earth roads affected on left and right bank	m	290	30,000	8,700,000
Reservoir area				
Government land	m^2	300,000	-	-
Restoration of Access earth roads affected on left and right bank	m	1,540	30,000	46,200,000
Command Area built-up				
Houses	Pieces	2,500,000	-	-
Land	m^2	122	-	-
Total estimate				***94,311,474 Rwf***

- More accurate amount of land and homes affected in command area will be determined based on the path of pipe layout of the irrigation infrastructure. However, to avoid expropriation, pipe layout can be adjusted to reduce on any likely expropriation of homes.
- From field investigations, the lack of valid ownership of crops on pieces of land, whether they owned the land or hired it was not supported with valid documentation of contracts. This we thought could not be put to record in this study and required more time and detail to determine valid ownership of crops. Loss of crops in the dam and reservoir area could not be accurately determined. Since this was not the core of this study and some of the estimated expropriation estimates had been determined for land and house, the crops and more accurate property expropriation shall require a Resettlement Action Plan (RAP) once final technical designs are complete. They could however refer to the unit cost indicated in this part of report.
- Terraced areas were not significantly affected by the project since 10m were left from a home to the terrace plus once the land was terraced it is returned to land owner.

CHAPTER 5: STAKEHOLDERS CONSULTATION AND PUBLIC PARTICIPATION

Reference made to methodology applied in identification of stakeholders and their concerns, the study was able to conduct public consultation of the three (3) categories of stakeholders.

- *First category* of Government officials were met, which included; LWH, MINAGRI, RSSP, EWSA and REMA. A letter of introduction issued by LWH was used by the consultant to approach focal people in these institutions. By using the key guiding questionnaires in *appendix 3*, we were able to guide discussions and obtained relevant information on project activities.
- The *Second category* met was of Local government officials, which included; Executive secretaries and agronomists for the District sectors of project intervention. i.e. Cyunzuzi, Burega, Buyoga, Tumba and Mbogo. With the assistance of LWH coordination team we were able to approach these officials. Our discussions with them were again guided by the social interview questions *in appendix 3,* from which information on project benefits, constraints in implementing the project and impacts likely to be caused by the project were reflected.
- The *Third category* was of locals (i.e. residents, farmers) who are either benefiting from the project or affected by it. These too were guided by the social interview questions *in appendix 3,* from which information on project benefits and adverse impacts were aired out.

Meetings and group gatherings with stakeholders were scheduled as such:

- *2nd June 2014*- In Kigali, meetings were held with LWH social safeguards specialist and project engineer.
- *5th June 2014*- A field acquaintance visit of the Muyanza project area. Buyoga and Burega sectors of Rulindo District were visited guided by LWH social safeguards specialist and project engineer.
- *17th – 20th June 2014*- In the project area (Sectors of Cyinzuzi, Tumba, Burega, Buyoga and Mbogo sectors), meetings were held with the LWH site coordination team and gathering meetings with local residents and farmers whose land was being terraced. Hydrological, ecological and environmental assessments of the water catchment, dam reservoir and command areas were done.
- *8th- 10th July 2014*- In the project area (Sectors of Cyinzuzi, Tumba, Burega, Buyoga and Mbogo sectors), meetings with Executive secretaries and agronomists of each of these sectors, meeting gatherings with locals and farmers affected at the dam axis and reservoir area were held. Site investigations of likely areas to be expropriated by the dam, reservoir, post-harvest and parts of the command area that could be affected by pipe layout of the irrigation infrastructure.
- *8th- 10th July 2014*- In the project area (Sectors of Cyinzuzi, Tumba, Burega, Buyoga and Mbogo sectors), soil sampling and profiling were done for portions of the terraced and un-terraced areas.

From these meetings issues raised were first cross referenced by what had been obtained in one meeting with one group against issues from another group to determine their authenticity. These issues were also tested against secondary data obtained during desk review and also against baseline data collected for the project area.

Issues from Government officials- (i) Pollution of Muyanza River water during construction and from non-point sources during project implementation, (ii) Soil erosion, mudslides during preparation of terraces and dam construction, (iii) High level of sedimentation of reservoir resulting in dead load and poor performance of the dam, (iv) encroachment of reservoir increasing level of sedimentation and possibility of drowning for livestock and people using these waters for domestic purposes (v) Possibility of loss of property and lives from dam failure, (vi) water logging and salinization from introduction of irrigation, (vii) Injuries during construction works, (viii) Emergence of water borne diseases from the created reservoir.

Issues from local government officials- (i) Delays incurred in starting or progress of terracing of land which affects cultivation in prescribed seasons. This affects their crop production seasonal targets upon which their performance is rated. (ii) Likelihood of delays in compensation of PAPs, which could escalate into disputes. (iii) Access roads to communities around the dam and reservoir area could be lost without alternative compensation. (iv) Likelihood of flooding of plantations in the command area during construction. (v) Insufficient skilled labour in their sectors to handle works for the dam and irrigation infrastructure.

Issues from locals- (i) Delays in terracing their land causing them to miss a season of cultivation, (ii) Worry that land demarcated for project use might not be exchanged for a reasonable compensation. (iii) Those cultivating in the valley demarcated for the reservoir and dam might not be compensated since land is a narrow wetland owned by Government by law, (iii) Possibility of construction works beginning without early warning, which could be before harvesting and hence causing a loss to the farmer. (iv) Likelihood of flooding of plantations close to the river during heavy rains of April. (v) Low wages already noticed for terracing compared to other similar projects within the area such as; VUP.

An issues report with raw data collected and issues raised during the field public consultation in the Muyanza project is presented in in *appendix 1* for reference.

Issues raised and responses addressing them during the stake holder engagement process were compiled and summarized in the *table 16* below and have been considered in proceeding chapters for impact assessment and incorporated in the Environmental impact and management plan.

Table 16: Summary of issues raised during Public consultation

Issues at hand	Stake holders	Response to issues at hand
Expropriation cost	local farmers/ Livestock farmers	Valuations for property lost to post harvest infrastructure has been done and compensation will follow. Accurate valuation of land, crops and homes for compensation will be guided by a Resettlement Action Plan (RAP) once detailed designs are complete and boundaries of affected areas are determined.
Destruction of Crops in the dam and reservoir area without earlier warning	Local farmers/ Livestock farmers	Clear planning schedule will be drawn, which will be used to inform farmers to avoid cultivation for the season construction commences.
Redundancy of farmers where terraces, the dam and reservoir will be constructed	Local farmers/local government authorities	Alternative source of income by employing them in the construction of the soil conservation(terracing) and irrigation infrastructure
Possibility of low wages to local workers during terracing and construction works.	Local residents of the area	LWH project coordination to ensure minimum wages by Rwanda labour law are followed by the contractor.
Oil spillage	Contractor / MINIRENA/ REMA	Restricted area proposed for re-fuelling or fuel storage that is cemented. Use of automobiles in good condition hence reducing on chances of oil leaking.
Dangerous borrow pits used at potential construction materials sites	contractor / Local authorities/ REMA	Refilling pits prior to the closure of the contract avoid injuries and planting vegetation to rejuvenate these areas.
Occupational health hazards	REMA/District and sector officials	Safety wear is proposed on site. Spraying water to reduce dust is also proposed.
Noise pollution	Local residents/ sector officials / REMA	Works such as; excavations, compaction that emit irritating noise will only be done during working hours (7h00-17h00). Use of automobiles in good condition (with certification from the "National Automobile Inspection centre") to minimise on noise emitted, Use of silencers for generators

Air/dust pollution	Local residents/ sector officials / REMA	Use of automobiles in good condition (with certification from the "National Automobile Inspection centre") to minimise on noise emitted, Use of silencers for generators.
Soil Erosion	Local authorities/ sector officials /REMA	Soil erosion prevention techniques are required, such as; terracing, contour bunds, afforestation. Excavation at stages to prevent huge soil hips liable to erosion. Soil compaction for completed zones
Fire outbreaks	Local authorities/ District and sector officials /REMA	Fuel storage restricted to only those authorized. Regular checks of electrical installations. Fire extinguisher equipment present and fire drills for workers as a form of protection from fire.
Loss of livelihood for those not practicing agriculture but within project area demarcations.	Local farmers/ brick makers/ sand miners/ livestock farmers	Sensitization of locals on profitability of Valuable crops over their current sources of income. Compensation for their losses and economic resettlement caused by the project from their mining areas.
Pollution and human health damage by exposure from poor pesticide and fertilizer management	REMA	Proposal to utilize an IPM. Technical support by Agronomists to farmers. Training of farmers in application of pesticides and fertilizers.
Water pollution	REMA/ MINIRENA/ Riparian countries sharing the receiving water bodies	Efficient use of fertilizers to avoid excess amounts washed away to the receiving waters. Baseline tests and progressive tests of water quality of surrounding receiving bodies (Muyanza river) to understand project effects on water quality and propose mitigation measures.
Water conflicts from Irrigation/ land consolidation	Local farmers/ Local authorities	Farmers organised under WUAs to manage the irrigation process.
Vandalism of irrigation infrastructure	Local farmers / Sector authorities	Regulations on penalties for perpetrators proposed. Punitive measures for perpetrators proposed. Community policing by cooperative members to avoid vandalism.
Increased spread of water related diseases (e.g. malaria, bilharzia)	Local farmers/ local authorities/LWH	Provision of Mosquito nets to locals for those who do not have. Growing the *Phytolaca decocandra* plant which prevents bilharzia snails from existing at the shores of water.

Canal siltation	Local farmers/Local authorities/LWH	Soil erosion control techniques on the hillside of the marshland. Regular inspection and maintenance of the canals.
Water logging and salinization	Local farmers/ local authorities/ REMA	Controlled release and use of water and proper drainage to the plantations to avoid water logging or salinization
Poor dam performance due to huge dead load caused by high sedimentation levels of the reservoir	Local farmers/ local authorities/LWH	Intensive Land husbandry on hillsides along the reservoir.
Drowning of livestock and humans and increased sedimentation from encroachment of the reservoir and Muyanza river	Local farmers/local authorities/ LWH	Establishment of a thick green belt along the reservoir and 50m green belt or silt trap between the river and the closest plantation.

CHAPTER 6: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENTS

This section entails assessment of impacts of the Muyanza LWH project. By nature, the proposed project has potential to cause negative as well as positive impacts on the biophysical environment and socio-economic setups. The magnitude of which will vary between the phases of project implementation. The assessment of the project impact given below is for the proposed intervention area including; the catchment areas, dam and reservoir area and command area.

The approach taken in this chapter is to analyse anticipated impacts expected throughout the project cycle;–planning/formulation, design, implementation (mobilization, construction and operational activities), monitoring and possible decommissioning. The impacts described below are both positive and negative, with mitigation measures proposed for the negative impacts.

6.1. POSITIVE IMPACTS

Development of Muyanza to embrace the possibility of terracing as land husbandry technique and the Irrigation scheme for large scale crop production identifies with many of the positive impacts of the proposed activities discussed in the proceeding sub-chapters.

6.1.1. Social Environmental impacts

6.1.1.1. *Employment creation*

Locals are already benefitting from job opportunities that have come with the terraces in the catchment areas upstream, with an estimation of 1000-1200persons employed per day. For a task to dig an area of 13m x 2m of a terrace, a person is paid 1,000Rwf. Furthermore manpower for the construction of the dam is likely to employ about 100 people per day and civil works for irrigation infrastructure to employ 500 people per day paid about 1,500Rwf as a casual labourer. This is a sure deal of an employment opportunity. It will not only benefit locals in these five (5) sectors but will attract skilled and unskilled labour from areas beyond.

6.1.1.2. Transfer of skills from the construction phase

Considering that the highest level of education in the project area is 12 year basic education, not much skilled labour can be found in this area. However, as the construction phase and the implementation of land husbandry technologies proceeds, locals will be able to acquire skills in masonry works from foreign expatriates which they can in turn apply at the operation stage for maintenance works of the small irrigation infrastructure such as; maintenance of sluice gates, stone masonry channels, water intakes, etc. Local residents have already acquired skills in making terraces, preparation of organic compost. E.g. over 1000 employed per day have already acquired skills in preparation of terraces. It is these skilled acquired workers that are again used to initiate new projects.

6.1.1.3. Affordability of education and increased access to medical Insurance

Increased crop yields, ability to bargain for profitable farm-gate price and incomes from employment at the construction works of the irrigation infrastructure and land husbandry terrace works, all this will hand the locals of the area the ability to pay school fees for their children and increase their access to medical insurance "Mituelle de santé" moving from the current sector average of 80% access to closer to the 100 mark. This will improve literacy levels, give children the opportunity of education and improve health status in the area.

6.1.1.4. Increased crop production by farming all year round

With the construction of the dam, reservoir and irrigation infrastructure in the command area, farmers in these areas of intervention will be able to grow crops all through the year as opposed to previously cultivating only during the two wet seasons (September-January, February-June) and facing drought in the dry season. This will eliminate the redundancy that occurred in the dry season. For example, from 2tons of maize per hectare (ha) to 4tons/ha, an anticipated is 1000tons of maize on 250ha is expected for this Season A, 275tons of beans are expected on 110ha and 10tons of peas on 5ha.

6.1.1.5. Productive use of hillsides

Introduction of hillside irrigation changes cultivation from the normal rain-fed type of cultivation of only two wet seasons to an all year cultivation. This implies that there is likely to be an increased agricultural production on the hillside as opposed to the common marshland irrigation.

6.1.1.6. Market access for agricultural products

Based on data from public consultation during the field visits, farmers' organization from groups to zonal committees and eventually to cooperatives allows farmers to bargain fairly the farm gate prices with profits without the influence of middle-men as is the case currently where farmers possess individual low bargaining power. These cooperatives will hence empower farmers economically. For example; farmers are now able to place a unit price of maize at 250Rwf/ha, when previously unit prices ranged from 150-200Rwf/kg depending on the bargaining by an individual farmer with middlemen.

Under such organisation, these cooperatives will also be able to find market for their products by ensuring production in large quantities, good quality and continuity of market supply of agricultural products.

6.1.1.7. Collective harvest for large quantities and market continuity

The Muyanza project will involve establishment of post-harvest infrastructure for storage of produce to promote large volumes of high value harvest, control market price of their produce and enhance continuity in supplying demanding markets for their produce, locally, regionally and internationally.

6.1.1.8. Increased Livestock fodder

The implementation of the project will increase livestock fodder; from grasses (such as; bracharia, chloris, etc.) and fodder shrubs grown along terraces and soil bunds to hold soil, forage and trees. This will increase livestock numbers in the area, increase dairy production in the area and also contribute to a well-balanced diet in the area.

6.1.1.9. Land Appreciation

With the coming of this project, land that was once less productive will now have well done terraces, irrigation all year round ensuring all season cultivation and increased. This could lead to appreciation of the land from 122Rwf/m^2 to much higher land price, all to the benefit of the locals of these areas.

6.1.1.10. Empowerment of farmers

By organizing local farmers into groups, zone committees, Cooperatives, Water Users Associations (WUA), they are empowered to dictate collectively terms during price negotiations, sensitized and trained on the efficient use of water as a valuable resource, use of modern irrigation techniques, use of improved seed and fertilizer to improve their produce, maintenance of irrigation infrastructure, thus imparting skills for improved production as well as to access markets, which they will utilize even after the project's exit.

6.1.2. Physical Environmental impacts

6.1.2.1. Soil Conservation through land husbandry

Traditional cultivation methods, deforestation on sloppy hills and high population density leading to fragmented land cultivation has largely contributed to the loss of soils to the erosive run-off.

LWH project activities in the catchment area involve comprehensive land husbandry techniques such as; 2300 ha for terracing and contour bunds and 50m belt around the reservoir of agro-forestry tree planting on hillsides and close to 367ha set for forest plantation on slopes above 60%, as means of reducing soil erosion, avoiding sedimentation of the reservoir, destruction of earth delivery canals and improving the soil moisture.

6.1.2.2. Increased land productivity

With the project supporting farmers by providing fertilizers in form of organic compost, DAP and availability of agronomists to follow up on farmers' practices, improved agricultural practices and land husbandry, the soil fertility is expected to improve, thereby increasing farm yield, for example from maize production previously at close to 2 tonnes per ha to an anticipated 4 tonnes of maize per ha after LWH support.

6.1.2.3. Flood control

From the field survey, it was observed that land along the Muyanza river bank and the strip of valley downhill is flooded during the wet season resulting in destruction of crops and making it difficult to cross over from these parts of Buyoga to Burega sector.
By constructing the dam to hold back the stream, the flow of Muyanza will be controlled to avoid any floods but instead store water in the reservoir for irrigation.

6.1.3. Biological environmental Impact

6.1.3.1. Habitat for fish and birds nesting

By developing a water reservoir, different fish species will be introduced in the massive water body hence a suitable habitat for fish. This would also mean fish would now be introduced to the household diet hence contributing to a balanced diet.
Also with introduction of the reservoir, its proposed buffer green belt will be habitat for different bird species nesting in these grasses and trees thereby improving the ecosystem in the area.

6.1.3.2. Reforestation

Part of the project is to promote tree planting on slopes above 60%. This will increase forest area in this area by 366.8ha of forest plantation from an existing scattered forest plantation of 46.6ha, hence increasing on the natural habitat and ecology of this area.

6.2. ADVERSE (NEGATIVE) IMPACTS

Adverse impacts are negative impacts from activities that will affect the physical, biological and socio-economic environment of the area of operation. These impacts have been elaborated under three phases; design and planning, construction and decommission phases. For each adverse impact, mitigation measures are proposed.

6.2.1. Design and Planning Phase

The design phase of this LWH project involved identification of suitable sites for land husbandry, infrastructure and undertaking of a detailed technical study. There is no adverse impacts expected at this stage, however, it recommended that best practices in the design of such a large dam are followed.
Borrowing from the safeguard policy on dam safety, for large dams, the following procedure shall need to be adhered to:

- reviews by an independent panel of experts (the Panel) of the investigation, design, and construction of the dam and the start of operations;
- Preparation and implementation of detailed plans: a plan for construction supervision and quality assurance, instrumentation plan, an operation and maintenance plan, and an emergency preparedness plan;
- Prequalification of bidders during procurement and bid tendering, and
- Periodic safety inspections of the dam after completion.

6.2.2. Construction Phase

The construction phase involves several activities including; preparation of terraces, drainage from these terraces, site clearing for the dam area, site installation, trench excavations, earth stripping, road network clearing and levelling, construction of a dam, reservoir and installation of canals/ pipes. Anticipated adverse impacts are discussed hereafter.

6.2.2.1. Impacts on Physical environment

6.2.2.1.1. Reduction of soil fertility parameters in terraced land

Whereas terracing is one of the most suitable land husbandry technique of reducing erosion on the steep slopes of site area and also the most effective way of making it productive, results from the comparative soil test of terraced and un-terraced soils indicate that terraced soils tended to be acidic and all other measured parameters including: mineral Nitrogen, available Phosphorus were lower than those measured in the non-disturbed land indicating relatively reduced fertility for terraced land.

Impact Significance

This impact is of medium significance in terms of magnitude, duration and spatial extent. It is an impact that will occur during the construction phase of establishing terraces. It occurs from alteration of the original soil composition and could eventually be irreversible if no mitigation measures are applied.

Mitigation Measure(s)

- As is applied by LWH on terraced soils, it is proposed that moderate amounts of lime are applied to terraced soils to raise the pH from acidic to neutral pH based on thorough soil tests. Currently 50kg/acres is applied with the guidance of the LWH agronomist.
- Application of organic compost to terraced soils to raise soil parameters such as mineral nitrates is recommended. Currently 100kg/acre or 10tons/ha is applied with the guidance of the LWH agronomist.

6.2.2.1.2. Gradual soil acidification from fertilizer application

As observed during the field visit, already terraced areas of the water catchment had Nitrogenous fertilizers applied to the soils. i.e. DAP, Urea and NPK in quantities of 1kg of DAP/ 1Acre, 0.5kg of Urea/Acre. These fertilizers contain phosporus and nitrogen, which have an acidic reaction with the soils increasing acidity of the soils. Continuous application of such fertilizers could result in progressive Soil acidification due to Ammonia nitrification.

Impact Significance

This impact is medium significance in terms of magnitude and spatial extent. It could possibly be high but the fact the Muyanza project includes application of lime to raise soil pH has reduced its significance. However more precaution is required as proposed in the mitigation measures.

Mitigation Measure(s)

- Use lime to raise the soil pH and precipitate soluble Aluminium ions and use well humified organic matter to complex Aluminium ions. Currently, 50kg/acres of lime is applied with the guidance of the LWH agronomist.
- Periodic soils tests are recommended to measure its nutrient levels, acidity levels and other soil characteristics that might determine the trend of soil fertility. This monitoring will guide decisions on what amounts and types of fertilizer are required for these soils and any techniques required to improve soil fertility in case it's depreciating.

6.2.2.1.3. Soil and water contamination from Oil spillage

During the dam and reservoir construction, heavy machinery, such as; excavators, graders, wheel loaders, etc., will be used for earth moving construction works. This equipment will require re-fuelling, maintenance works, repair works, which in effect result in oil spillage. Contamination of soils and run-off ending in the receiving bodies (Muyanza River) could cause water quality degradation, if no mitigation measures are implemented.

Impact significance

This impact can be considered of low magnitude, duration and spatial extent since it shall only be experienced during the early construction phases of clearing, excavating and compacting. It also will occur only at the dam and reservoir area and not to the other catchment areas. In order to avoid or reduce its occurrence mitigation measures are proposed.

Mitigation Measure(s)

- It is proposed that the Developer or Project Manager inspects the contractor's equipment, to confirm having machines and automobiles in good condition, certified by the " National Automobile Inspection centre", in order to reduce on the likelihood of oil spillage.
- Re-fuelling, oil change, maintenance works, repair works will need to allocated a restricted area, far from the water stream and marshland and preferably positioned in an area that have no adverse effects if degraded. E.g. site position for building or house construction. The area allocated for fuels shall need to have a cemented floor and a sand stock for use in the absorption of spilled oil.

6.2.2.1.4. Air and noise pollution

During construction, there will be movement of construction equipment at the project site. Dust and exhaust fumes that may cause air pollution as well as noise, is expected from earth moving activities by excavators, graders, trucks and bulldozers plus other machinery such as concrete mixers, dumpers, etc.

Impact significance

This impact can be considered of low magnitude, duration and spatial extent as it occurs only during the construction phase. Also, the area of the dam axis and reservoir is sparsely populated, with some of these communities in the vicinity likely for expropriation.

Mitigation Measure(s)

To reduce the effects of such activities, it is proposed that the following measures are implemented:

- Activities that create lots of noise or irritations, such as; vibrations, heavy equipment moving earth, excavations, shall be restricted to normal working hours (7h00-17h00) to prevent noise for neighbours at night ;
- The contractor is required to use equipment and automobiles that have certification of good working conditions from "National Automobile inspection centre" to avoid noise or exhaust fumes since automobiles in good condition will pollute less.
- LWH project coordination on site will ensure that contractors will be doing routine maintenance, repair of trucks and machines. This would reduce on the exhaust fumes and noise from the machines.
- The project will spray water regularly when clearing land to reduce the dust.
- Generators for use at the site shall have silencers to reduce on the noise emitted.

6.2.2.1.5. Soil Erosion and land slides

Activities including; preparation of terraces, site clearing, excavations for the dyke and reservoir, road clearing, excavation of trenches for irrigation delivery and distribution pipes, will all destabilise soil composition and expose it to the agents of erosion, mostly run-off, resulting in increased erosion and landslides at terrace and dam embankments. If not combated, it can develop into a cumulative impact of loss of valuable productive soils to the receiving waters, sedimentation of receiving waters, silting and blockage of delivering canals, and loss of agricultural productivity of the marshland.

Impact Significance

This impact shall be of low significance in terms of magnitude since a large part of the Muyanza project involves soil conservation methods such as; terracing and tree planting. The effect shall be during site clearance, excavation works, minimal effect in on the embankments of terraces.

Mitigation Measure(s)

Soil erosion effect can be avoided or reduced by implementing a number of measures. These are;

- As has already been observed for completed terraces, encourage the planting of Napier grass "Urubingo" along the embankments of terraces to hold soils and avoid erosion.
- Avoid excavation during rainy season.
- Plan to excavate the plot sections demarcated for construction, in stages to avoid opening up of big sizes of the area and increasing the level of risk to erosion at any one time.
- The project can possibly be fast tracked so that the time the land is left bear and exposed to potential erosion agents is minimized.

- Debris in the compaction and construction of the foundation for the structures should be resurfaced and levelled;
- After any excavation or trenching is completed on site, immediate backfilling and resurfacing should be done to avoid facilitation of erosion agents. Compaction will be necessary to stabilise the soil. Planting of grass on bare land, slopes of the dyke embankments to minimise erosion tendencies should be given priority.
- Avoiding vegetation clearance that will expose soil to agents of erosion during construction phase.
- Re-vegetating the cleared sites with local species of vegetation.

6.2.2.1.6. Fire outbreak

Construction works will require a fuel store for re-fuelling the heavy equipment used for earth works. Mistakes with handling fuels or electrical short circuits can easily result in fire out breaks that could cause serious damage. E.g. loss of equipment, property, bush fires and in some cases loss of lives to fires.

Impact Significance

This impact is of low in significance in terms of magnitude and spatial extent. It could occur only during construction phase and only in areas of refuelling or uninsulated areas, however, it is a precautious and avoidable impact.

Mitigation Measure(s)

Regular checks on electrical installations and proper insulation of cables, to prevent short circuits that could trigger fires.

- Specific area restricted to only authorized personnel, should be allocated for fuel storage.
- Such an area should have sufficient fire extinguishing equipment to stop fires escalating.
- Water tank automobiles with hose pipes need to be part of the equipment required at the sites, for purposes of extinguishing fires.
- Fire management drills for the workers should regularly be done.

6.2.2.2. Impacts on Biological Environment

6.2.2.2.1. *Loss of biodiversity on the hillsides and valley*

From the baseline data on biological environment of the project area, scattered forest plantations (mainly eucalyptus) of about 46.6ha lie mostly in the command area and there is hardly any in the water catchment area. It was also observed that most of the flora in the area are cultivated crops.

It is anticipated that terracing and irrigation infrastructure activity will reduce this area of forest plantation and changes in types of crops from common crops to high value could all reduce or cause changes in the fauna and probably the existing biodiversity. e.g. with more agroforestry fruit trees come fruit birds, with carrot and lettuce come rats and other rodents.

Impact Significance

This impact is of medium significance in terms of magnitude since it is an area that was originally rain forest but for such a long time has been replaced with human occupation, agriculture and scattered forest plantations. The effect of forest plantation loss will be felt much at the command area, while crop loss will be at the reservoir area. The loss of crop and trees in this area will be permanent and can only be offset.

Mitigation Measure(s)

- Inclusion of activity to grow more forest plantations to offset the project effect on forest will regenerate the lost biodiversity. LWH plans on growing forests on slopes above 60%, which is anticipated to contribute to an increment of 366.8ha of new forest plantation.
- As for changes in crops, whereas in the rainfed command areas the same crops or those agreed on with the land owner shall be planted, not much can be done in restoring biodiversity resulting in changes in crops. It shall be noted that locals had a hand in agreeing on these new crops.

6.2.2.3. Socio-economic Environment

6.2.2.3.1. Loss of houses, land, crops and access to public infrastructure.

Reference is made to the study's estimates of the property likely to be expropriated in sub-chapter 4.3.1.3 of the socio-economic environment. With about 14 houses and 3.9ha of land and 290m of access road on the left bank likely to be lost from the dam construction and about 1540m of road flooded by the reservoir perimeter of influence, this shall have an adverse impact on the livelihood of the Project Affected People (PAPs). It could affect their production systems; cause impoverishment from loss of their productive assets or income sources; relocation to environments where their productive skills may be less applicable and the competition for resources greater and weaken community institutions and social networks.

Impact significance

This impact can be of significant magnitude to the PAPs if not handled with appropriate measures. Such involuntary resettlement may cause long term hardships, impoverishment, cultural breakdown.

Mitigation Measure(s)

- Compensation of PAPs is estimated at 35Million Rwf equivalent to 50,000US$ for houses for expropriation and 4.4Million Rwf equivalent to 6,285US$ for land to be expropriated in the dam area of influence and replacement of access roads estimated to cost about 55Million Rwf an equivalent of 78,430US$.
- A Resettlement Action Plan (RAP) is proposed to guide the process of compensation for property to be expropriated. This RAP will be prepared under the guidance of the LWH

Resettlement Policy Framework (RPF). It shall include measures to ensure displaced persons are informed about their options and rights pertaining resettlement, offered choices and provided prompt and effective compensation at full replacement cost for losses of property. A grievance mechanism shall also be included in the RAP.

6.2.2.3.2. Income losses from missed season cultivation due to delays in terracing

Complaints from farmers and sector agronomists during field visits were observed, of missing seasons of cultivation due to delays in progress of terracing their land. This implies that the farmer losses the produce that he or she could have obtained that missed season hence a loss in home income and in most cases domestic food. It also affects targets of crop production set by local government officials for their respective district sectors.

Impact significance

This impact can be of medium magnitude to the affected farmers since it affects their apparent livelihood, however, it is not impact of regular occurrence and a number of measures have been applied by LWH.

Mitigation Measure(s)

- A clear implementation program indicating areas to be terraced, dates when they will occur and a monitoring exercise involving LWH staff, sector agronomists and zonal or cooperative committees should established. It should also be shared with the local farmers as an awareness campaign.
- Farmers who have been affected should be given an affirmative priority in employing them for jobs for terracing occurring at that time. This will be an alternative income source to sustain their domestic requirements.

6.2.2.3.3. Injuries by workers from construction and at borrow pits

During construction, workers will be subjected to situations that could be detrimental to their health and safety. A few examples include: Injuries caused by handling of construction equipment, spills and leakage of oils, injuries from stepping on or using sharp objects and fires.

Impact Significance

This impact is also of medium significance in terms of magnitude, since it directly affects the humans. Injuries are common in construction but can be reduced to an extent with safety precautions taken.

Mitigation Measure(s)

To avoid or reduce the effects of some of these occupational health hazards, it is proposed that the following measures are implemented:

- Workers on the site should be provided with appropriate protective gears such as; wellington boots, helmets, nose masks, eye goggles and overalls. Wearing of safety gear should be enforced on site by introduction of a safety compliance department.
- The contractor shall be required to have an insurance policy taking care of any injuries or deaths that might occur on site.

6.2.2.3.4. Diseases from construction activity

During construction, communicable disease hazards due to interactions among the workers or with service providers such as food vendors, dust from clearing and excavation works and fumes from vehicles and other machinery that might cause respiratory dysfunctions, Noise and vibrations from construction equipment causing temporary or permanent deafness. Not forgetting transmission of HIV from workers that have migrated to this region in such of work plus locals willing to spend more due to increased income from construction wages.

Impact Significance

This impact is also of medium significance in terms of magnitude, since it directly affects the humans. Contraction of diseases are common in construction but can be reduced to an extent with safety precautions taken.

Mitigation Measure(s)

To avoid or reduce the effects of some of these occupational health hazards, it is proposed that the following measures are implemented:

- Spraying water regularly to suppress excessive dust during construction, use of gas masks and googles for dusty sections is strongly recommended;
- The contractor together with local authorities is required to enforce acquiring medical insurance “mituelle de sante” for all workers as a means of affordability of treatment.
- Regular sensitization on ways of HIV prevention, importance of proper hygiene is important during execution of this project.

6.2.2.3.5. Loss of power, water and access roads

Construction works for a dam of crest width of 8m, crest length of 124m, height of 26m and reservoir covering close to 30ha will involve transportation and use of heavy equipment, for example; bulldozers, excavators, graders, trucks, among others. Such works will mean some of the surrounding existing roads, bridges, power lines, Muyanza trading centres and community settlements like Karambo community settlement could be destroyed by construction activity. For example, about 1.54km of road on the left side could be lost to parts of the reservoir and its buffer zone and 0.29km of road on the left bank to the dam area of influence.

Impact Significance

This impact shall be of medium in significance in terms of magnitude since it affects the existing access to the area, access to power and portable water. This is also so because this is a rural area, with not much utility infrastructure is there to be destroyed.

Mitigation Measure(s)

- An estimate of about 55million Rwf for road replacement of access roads lost to the dam and reservoir.
- After detailed technical design has been completed then an accurate map out of local infrastructure identifying existing infrastructure such as; water points, pipelines, power lines, homes, town centres, roads and bridges is required to guide on the most optimal site installation and site access. This could reduce on the impact of the project on existing infrastructure and cut on cost spent through compensation of this infrastructure.
- Once the affected area has been identified then a compensation plan for losses of infrastructure is necessary. This can be guided by the Resettlement Action Plan and qualified valuation of likely infrastructure lost.
- It is also proposed that some of this infrastructure (such as; water points, pipelines, power lines, roads and bridges) could be shifted to other areas and continue to serve the purpose it has always had.

6.2.3. Operation Phase

6.2.3.1. Physical Environment

6.2.3.1.1. Water contamination at compost sites

From the study's soil investigations, measurement of mineral nitrogen content from underlying soil samples of the compost sites showed relatively high mineral nitrogen content compared to other soils of the area. Such leached Nitrates may constitute a threat for ground or surface water pollution especially since a number were observed close to the Muyanza River.

Impact Significance

This impact is of medium significance in terms of magnitude and spatial considering that though it could pollute close water sources, composite is prepared in not so many scattered points of the project area.

Mitigation Measure(s)

- Nitrates leaching can also be reduced by selecting a composting site far from identified surface or ground water sources and in areas whose soils have been identified to have with low infiltration rate. Furthermore placing a shelter on the composting pile to reduce on excess water from rains soaking it and forming more leachate.

6.2.3.1.2. Modification of flows for downstream usage

Construction works for this irrigation scheme entail impounding water flowing in the Muyanza River from a watershed of 25.04km^2 by a single dam. It will require some temporary level of river diversion to construct the dam, filling of the reservoir, control of the quantity of water flowing through the inlet and outlet valves of the dam, all of which might affect the receiving population downstream and temporary destabilize the ecosystem dependent on the current river flow.
Further to the operation phase, when water will be drawn from the river thereby reducing the flow quantities, changing flood plains and affecting biodiversity downstream.

Impact Significance

This impact is of medium significance in terms of magnitude, severity and spatial extent. Its effect will be felt mostly during the filling of the reservoir, after which a regulated amount will continue to be released for human use downstream and also for ecological life to be sustained. If well designed can therefore be of short term effect.

Mitigation Measure(s)

- Design of dam should incorporate release on environmental flow of 0.012m^3/s at all times to maintain a specific water level downstream of the dam and maintain the existing ecosystem.
- Design should ensure a proper drainage network allowing for return flow from the farms into the stream.
- The existing staff gauge installed downstream of the embankment at the bridge should be routinely monitored to ensure the river flow rate does not go below the minimum river flow rate (environmental flow) at any one time.

6.2.3.1.3. Water pollution from fertilizers and pesticides

Use of fertilizers and pesticides is a non-point source potential for introduction of nutrients into the likely receiving waters downstream of the catchment plantations as a result of run-off. Agrochemical fertilizers such as; DAP, NPK and Urea ($CO(NH_2)_2$) containing compounds of Nitrogen, Phosphorus and Potassium and, proposed for boosting soil fertility and pesticides will very likely drain into the river and lakes.
Nutrients will cause de-oxygenation of the water bodies, in this case the Muyanza River, reservoir, and downstream recipients of its waters, leading to death of oxygen depend aquatic ecosystem. e.g. fish.
Such nutrients will also enhance evasive aquatic flora, the likes of water hyacinth, algae making it less oxygenated (a process called eutrophication) and restraining navigation and fishing activities in these waters.

Impact Significance

The impact could be of high significance in terms of magnitude and considering the quantities of chemicals applied. The effect of the impact will go beyond the non-point source of application on

the plantations either by runoff or soil infiltration later draining into surface and ground waters. If not regulated to have only adequate quantities applied, the impact of fertilizer and pesticide could be a long term effect.

Mitigation Measure(s)

- To avoid this impact, the farmers should adopt Integrated Pest Management practices proposed for these crops. For fertilizer, the farmers should be trained on the right application of fertilizer and safe use of pesticides.
- Under the LWH component A, local farmers shall be trained on the safe application of pesticides and fertilizers. This is a practice that can immensely contribute to the reduction of possible chemical pollution of the receiving waters. Training on pesticide application may be specifically directed to the quantities to apply, timing (when), and protective gears to wear among others and should be incorporated in the Pest Management Plan.
- Alternatively, a baseline test of the water quality and progressive tests are necessary to understand the effect of the project on the quality of water bodies and curb any likely impacts there may be before water quality deteriorates. This too can be entered in the MOU with the national University laboratory to monitor the quality of these waters for precaution purposes.

6.2.3.1.4. Water logging and salinization

There are four main ways through which salinization can occur in irrigation practice. These ways are:

- Addition of lime in most of the soils during the cultivation to boost the soil fertility.
- Residues of solutes applied to the soil in the form of artificial and natural fertilizers as well as some pesticides that have not been taken up by crops;
- Salts carried in irrigation water are liable to build up in the soil profile, as water is removed by plants and the atmosphere at a much faster rate than salts. The salt concentration of incoming flows may increase in time with development activities upstream and if rising demand leads to drain water reuse; irrigated regime is intensified, even though the saline layers might be far below the soil surface and the irrigation water applied is of high quality.

Based on the above means of salinization, there is a probability of salt build up to occur in the intervention areas especially through the residue salts and salt build up in the soil profile*.*

Impact Significance

The impact could be of high significance in terms of magnitude and considering the quantities of chemicals applied. The impact could have a long term deteriorating effect on the soil.

Mitigation

- With a properly determined crop water requirement, micro-management of irrigation water to specifically satisfy this need and regular monitoring of CropWat requirement to regulate the water quantity released to the catchments, the likelihood of water logging and salinization will be minimized.
- Training of farmers to regulate quantities of water used will be a long term investment in sustaining the chemical properties of the soil for continuous fertility.
- Regulated amounts of fertilizer applied based on actual nutrients required.

6.2.3.1.5. High sedimentation levels for the reservoir

The hillsides surrounding the area proposed for the reservoir were found to have slope categories in the range of >40% in the catchment area and 10-30% of the command area as per the slope classification map in *appendix* 5. Even with the terraces planned for the catchment area, there is still likelihood of some level of sedimentation into the reservoir resulting in dead load, drastically affecting the designed capacity of water collected in the reservoir hence lesser volumes of water and eventually low flows insufficient to meet the crop water requirement for the hillside plantations in the command area.

Impact Significance

The impact could be of low significance in terms of magnitude considering that the Muyanza project involves soil conservation practices already evident at the water catchment area leading to the reservoir.

Mitigation Measure(s)

- It is proposed that in addition to the radical terraces already being established in the catchment area, a green belt buffer zone or silt trap zone of at least 50m at the shores of the reservoir is proposed. It shall comprise of about 4 rows of vegetation to filter off sediment before it gets to the reservoir. Each of these rows shall have a thickness of about 10-15m. The first row most immediate to the reservoir may comprise of; emergent plants and grasses at the immediate of the shores, followed by a row of shrubs and followed by a row of agroforestry trees and then furthest uphill could Napier grass which may regularly be harvested and used as livestock fodder.

6.2.3.1.6. Clogging and damage of irrigation infrastructure due to the nature and quality of the river water

River water carries a large sediment load which is trapped behind the dam wall and may result in clogging in the water supply system as water is conveyed to the irrigated lands from the dam storage. Decay of algae at the bottom of the reservoir consumes more oxygen from the water rendering it capable of dissolving minerals, such as iron and manganese, from the river bed. As a

result, water released for irrigation from outlet may contain damagingly high mineral concentrations.

Impact significance

This impact is considered of medium negative significance considering the land husbandry applied at the upstream water catchment to reduce sediment and the silt trap.

Mitigation Measures

- Reservoir design has provided for dead storage to allow for settling of sediments and therefore reduces on the amount of sediments in the water conveyed for irrigation from the reservoir.
- Reservoir could be periodically flashed out to reduce on the dead storage, sediment and organic matter accumulating of a long period hence improving the water quality.

6.2.3.1.7. Water losses from evaporation and leakages

Impoundment of water in the reservoir will lead to increase in evaporation and seepage into the ground. Evaporation rates in this area amount to 75% of the rainfall which is quite significant. Terracing (approximately 62% of the catchment) will increase the surface area for evapo-transpiration and this will impact available runoff from the hills into the stream. Further still, there are possibilities of water losses to pipe leakages or open channel crack. The magnitude of this impact is considered to be medium negative.

Mitigation Measures

- Regular pipe inspections and leakage sensors could be introduced to the pipe irrigation to detect possible leakages early enough so as to reduce on avoidable water losses.
- Considering the combination of closed pipes ending in open channels for irrigation, open in the irrigation command area need to be lined in areas with pervious soils to prevent ground seepage of water into the soil.
- Design of the irrigation scheme should have proper draining allowing for runoff and return flow into the River as a means of recharging Muyanza.

6.2.3.2. Impact Biological Environment

6.2.3.2.1. Reduction of aquatic life due to reservoir eutrophication

Eutrophication of the reservoir from contaminated run-off by fertilizers (i.e. organic compost, DAP and Urea) applied on hillsides could possibly encourage resurgence of water hyacinth and any other aquatic weeds in the reservoir. This could mean less aquatic life for lack of oxygen.

Impact Significance

The impact could be of medium significance in terms of magnitude and considering quantities of nutrients from non-point sources of plantations uphill draining into the reservoir as runoff or by the stream.

Mitigation Measure(s)

- Controlled use of fertilizers and pesticides of adequate amounts on hillside cultivation to reduce on eutrophication from contaminated run-off.
- Periodic manual removal of weeds from the reservoir is proposed, to avoid the possibility of an uncontrollable invasion of the reservoir by weeds.
- Introduction of fish species that feed on invasive aquatic weeds into the reservoir hence reducing on the possibility of large quantities of weeds in the reservoir.

6.2.3.2.2. Loss of existing river biodiversity due to changes in temperature of water

Retention of water behind the dam may alter natural seasonal changes in temperature, disrupting the lifecycles of aquatic creatures that are dependent on thermal cues. For example; fish species and tadpoles used to the cool flowing water and not the stagnant water. Changes in the natural river temperature from cool fresh water to warm stagnant waters may also affect the amount of dissolved oxygen and suspended solids it contains and hence influence the chemical reactions taking place in it. This could encourage algae bloom which further depletes the oxygen levels. The impact was considered of medium negative significance.

Mitigation Measures

- No mitigation measure could be proposed as it was unavoidable.

6.2.3.3. Socio-economic Impact

6.2.3.3.1. Loss of income source for non-aligned project activities in the command area

A number of activities are done in the command area valley along Muyanza River, as examples; (i) brick making since there are clay soils in the valley and its immediate hillside, (ii) sand mining from the rivers. Such activities in the path of the irrigation infrastructure and land husbandry will be replaced. This implies that those dependent on these activities for an income will lose this source hence affecting their livelihood.

Impact Significance

The impact could be of medium significance in terms of magnitude and duration. Though it is an impact that will affect a certain portion of human livelihood in this area, it is of medium significance because the dominating source of livelihood in this area is agriculture and other sources of livelihood are of low influence.

Mitigation Measure(s)

- It is known that sand mining; brick making in wetland are degrading and hence not acceptable under the environmental protection policy of REMA. This would make brick laying and sand mining illegal in the wetland. Furthermore, since wetland is Government property, it is allowed to develop it especially for a public benefit such as this agricultural intensification for food security in the country.
- However, it is proposed that the brick maker and sand miners within the areas affected are all integrated into the irrigation scheme by allocating them plots of land for crop production
- Alternatively they could be compensated by shifting to areas of less environmental impact.

6.2.3.3.2. Health hazards from poor pesticide and fertilizer application

Part of Government policy is that farmers will be given improved seed and fertilizer, the project leaps further by providing pesticides for pest control. Use of fertilizer is crucial in improving soil fertility while pesticides will kill likely pests that might destroy crops.

Based on the LWH site coordination, fertilizer proposed for application is 10tons of organic compost/ha, DAP 1kg/acre, Urea 0.5kg/acre.

However, if applied by farmers out of ignorance, it might result in health hazards such as; respiratory tract diseases, skin irritation, eventual cancers, soil infertility, pest resistance and water quality contamination. Furthermore, might affect soil composition and texture eventually drastically affecting its functionality to produce crop.

Impact Significance

The impact could be of high significance in terms of magnitude and considering the quantities of chemicals applied. The effect on human health from exposure to continuous exposure to pesticides or fertilizers either directly or by food chain effect could be long term and irreversible if it turns out cancerous.

Mitigation Measure(s)

- Adapt the Integrated Pest Management (IPM) guide prepared for LWH to the crops proposed for this project. This is in compliance with the "pest management- OP/BP-4.09".
- In the meantime, the following criteria may apply to the selection and use of pesticides in such projects: (a) They must have negligible adverse human health effects. (b) They must be shown to be effective against the target species. (c) They must have minimal effect on non-target species and the natural environment. The methods, timing, and frequency of pesticide application are aimed to minimize damage to natural enemies. Pesticides used in public health programs must be demonstrated to be safe for inhabitants and domestic animals in the treated areas, as well as for personnel applying them. (d) Their use must take into account the need to prevent the development of resistance in pests. (e) It is required that any pesticides be manufactured, packaged, labelled, handled, stored, disposed of, and applied according to standards acceptable Internationally.

- Combined efforts of the LWH site Agronomist and those of the sector should be able to offer technical assistance to the farmers once the project has taken off. Their responsibility is determining which type of fertilizer and pesticides are required, amounts required for application, recommend the areas of application and will be charged with the responsibility of training and following up on how farmers adopt to these techniques hence reducing on the misuse of these products.
- Biological pest control may be introduced as a pilot test for this area, as a means of avoiding use of agro-chemicals. However, such an option is not feasible for this project area for reasons that biological control might be difficult to manage. Not knowing what other beneficial organisms to the soils might be consumed by the applied pest controllers, makes it difficult to manage.

6.2.3.3.3. Water conflicts arising from the creation of irrigation scheme

With the coming of the irrigation schemes that involves; land consolidation program for collective growing and harvesting, distribution of water through pipe irrigation, if the locals are not organized into institutional frameworks, might cause conflict over who gets water for irrigation and what amount is meant for each of the plots, quarters or sectors, who is wasting water by leakage or spillage. This can escalate in conflicts, enmity or vandalism.

Impact Significance

The impact could be of low significance in terms of magnitude and duration. It will be of short term effect or even avoided since Muyanza project encourages organizing farmers into groups, zone committees and cooperatives through which such issues can be resolved.

Mitigation Measure(s)

- Whereas initiatives have already been begun organizing farmers into groups, zone committees and eventually cooperative, there is need to have also Water Users' Associations (WUA) to manage distribution, maintenance of the irrigation infrastructure and resolve arising conflicts over water distribution within the marshland.

6.2.3.3.4. Vandalism of Irrigation infrastructure

With the coming of the project, a number of infrastructure will be made from metal, steel, concrete, PVC for example; sluice gates, valves, HDPE Pipes. It also should be noted that not all locals will be pleased with the project initiatives, later on the existence of petty thieves in the area. From experience of previous irrigation projects, if farmers are not organized in such as to have community policing to guard the infrastructure, they will be vandalized and sold elsewhere.

Impact Significance

The impact could be of low significance in terms of magnitude. With community policing encouraged in Rwanda and organized cooperatives operating in the project area, such an impact might be of short term scattered periods of vandalism.

Mitigation Measure(s)

- Early establishment of farm organization (i.e. into groups, zones and cooperative) as the management structure at the project site, sensitization of farmers to ensure project ownership and effecting community policing as a means of ascertaining security, will collectively avoid vandalism.
- Regulations on penalties to perpetrators convicted of vandalism are necessary. Punitive actions towards perpetrators by the authorities will facilitate compliance by the locals thereby avoiding vandalism.

6.2.3.3.5. Floods from reservoir over flow or dam collapse

Circumstances when the reservoir overflows or when the dam collapses and bursts should be envisioned. A reservoir of 2.2Million m^3 is a huge amount of water that could flood the immediate area downstream of the dam and the command area below may occur; causing soil erosion, crop destruction, destruction of property and in very severe cases killing people in the marshland and livestock at the hillsides closest to the marshland.

Impact Significance

The impact could be very severe and significant if it was to occur causing destruction of crops, homes and loss of lives. a devastating impact of huge irreversible effect.

Mitigation Measure(s)

The project has already championed precaution measures at the stage of project design of the dam.

- A Spillway has been designed with a weir 20 m long for the main dam has been designed for a 1000 year return flood with an estimated outflow of 100m^3/s, capable of a threshold flow of 3m water depth to act as a flood control structure. This means that should the water level exceed 23m height above ground, water will be evacuated via the spillway thereby avoiding the dam from being damaged or destroyed by water flowing on, over or against it.
- Also a Free board of 0.8m has also been designed for, to avoid erosion of the dam's material by an overtopping surface runoff which could remove masses of material whose weight holds the dam in place against the hydraulic forces acting to move the dam. With the dam protected, then it can hold water in the reservoir preventing it from flooding downstream or avoid the dyke from collapsing.
- A Cut-off trench shall be included in the design of the dam to reduce seepage and improve stability of the dam, preventing it from tipping to allow water from the reservoir to flood downstream.
- The design of the dam shall include a rock toe which will help relieve seepage problems in the downstream area of the dam on impervious foundation hence preventing it from collapsing as a result of seepage.

- Regular inspection of likely areas of weakness along the dam (such as; cracks, fissures) by qualified and experienced expert personnel is crucial to avoiding such calamities. In case of fissures, it can be cleaned off and concreted. For larger indentations or cracks, slush grouting should be used, which is a thick slurry mix of cement and water poured and bloomed into the larger cracks and fissures before any concrete is laid to fill the remaining indentations.
- It is recommended that a dam collapse preparedness plan is developed amongst the stakeholders. i.e. LWH, EWSA, District authorities, local authorities, Police and local farmers. This plan shall include; understanding the flow patterns of the rivers, regular rainfall runoff patterns, modeling of the flood flow in case of dam failure for prediction of the trend of areas that will be affected, planning of resources required to evacuate during floods and after, proposal of evacuation routes, specific Institutional responsibilities at the time of the dam failure, etc.
- The project proponent will engage the international dam safety committee to ensure independent review of the safety aspects of the dam construction and operation.
- Regular monitoring is essential to detect seepage and prevent failure. Downstream from the dam, seepage may be measured by increased flow from ground water springs in existence prior to the reservoir as might be caused by the pool of water behind the dyke.
- Also regular reservoir water level measures might indicate seepage. Continuous and sudden drop in the normal reservoir level could be sign that there is actual seepage that requires treatment to avoid collapse of the dam.
- Furthermore certain observations from routine inspections of the downstream face of the dam or contact of the embankments with the spillway or dam could indicate seepage. E.g. Growth of emergent plants in lush and dark green around the downstream face of the dam, slides in the embankment of the spillway or dam are possible signs of saturation of water in soils due to seepage, eroded soils in the shape of cone around the outlet of the downstream face of the dam, all these are signs of the possibility of seepage.

6.2.3.3.6. Increased spread of Water related diseases

In reference to social data from field public consultation, there were no resilient diseases observed by the locals. e.g. malaria, dysentery or diarrhoea.

With the introduction of a reservoir, this is likely to be conducive habitat for mosquitoes and bilharzia snails. This is likely to increase incidences of contracting water related diseases such as; malaria, bilharzia.

Water borne diseases such as; dysentery, diarrhoea, stomach-related disorders specifically infestation by worms, all resulting from using the irrigation water for domestic purposes (drinking and cooking).

Impact Significance

The impact of disease spread will be long term for as long as the reservoir is existing and drainage canals which are habitats for disease vectors and the scale and severity is also moderately high

and can be severe especially for children under 5 years and pregnant mothers who are vulnerable to malaria.
The scope of the impact will initially be localized but transmission of the disease is likely to extend the scope beyond the project area.

Mitigation Measure(s)

- As commitment to the health of the project beneficiaries, LWH is recommended to include in its plans planting of *Phytolaca decocandra* which will destroy the Bilharzia snails that serve as hosts of *shistosomiasis* along the shores of the lakes and river.
- In addition to this, the project may work along with MINISANTE in issuing mosquito nets for those who don't have, to reduce on the spread of malaria resulting from the created water mass in these areas. This shall go along with sensitization of sleeping under a mosquito net and its importance to the locals.
- The formed cooperatives shall need to work with local authorities in restricting locals from using water from the reservoir for domestic consumption. As a matter of fact, LWH should ensure the replacement of destroyed water points during construction works as alternatives close enough to the locals in order to prevent locals from resorting to fetching unhealthy water from the reservoir.
- The project may introduce fish in the reservoir that feed on mosquito larvae, hence reducing on mosquitoes that would have otherwise spread malaria.

6.2.3.3.7. Destruction of reservoir boundaries and pipes

With the irrigation project in place, there is a likelihood of local farmers encroaching the boundaries of the reservoir and irrigation pipes in cases of insufficient water supplied to the plantations.

Impact Significance

The impact will be short term considering locals are aware of the environmental law restricting a buffer zone of 10 m from water sources and they have the experience of local authorities already having grown napier grass along Muyanza river to protect it from encroachment by plantations.
Once a similar buffer zone is set, it is assumed the locals will respect as they have tried to for the river buffer.

Mitigation Measure(s)

- The recommended green belt or silt trap of at least 50m surrounding the reservoir and 10 m from the river to the nearest plantation shall act as buffer zone preventing locals from encroaching the reservoir.
- Pipes will be placed at minimum depth of 45cm and place an embedment material of 15cm thickness free of large stones or sharp edges to protect the bottom

6.2.3.3.8. Wastage of water

Ignorance of farmers on the irrigation especially since this hillside irrigation scheme is new in the area and hose pipes are not a common irrigation application in the area, could result in poor management of water distribution to hillside plantations. In-experienced people managing the water realized from the reservoir into the canals/pipelines, excessive amounts of water released into the plantations, water leakages in the piping system, could all result in wastage of water meant for efficient irrigation.

Impact Significance

The impact is of low significance especially since Muyanza project intends on organizing farmers into cooperatives, to manage issues arising at the catchment areas and also the irrigation facilities. This impact shall occur all through the operation phase but can be easily resolved technically through this organized farmers' structure.

Mitigation Measure(s)

- Establishment of Water Users Association (WUAs) to manage quantities of apportioned for each plantation hence reducing on likely water misuse. WUAs are required to have trained technicians in water management, infrastructure control and repair. These will be of technical assistance to WUAs in managing water losses.
- Frequent inspection and repairs of leaking infrastructure is necessary to reduce on losses of water through leakages.
- Water allocation infrastructure such as; sluice gates and water valves should only be managed by trained technicians. This will avoid excessive distribution of water thereby preventing wastage of water from the reservoir.

6.2.3.3.9. Drowning of children and livestock

Existence of such a large mass of water reservoir could encourage locals to fetch water from it, children to venture into swimming in the reservoir and livestock to drink from it. These activities expose mainly children and livestock to drowning in such a massive water body, if no precautions are taken to avoid encroaching the reservoir.

Impact Significance

The impact could be severe and high in terms of magnitude. It will be of high significance as long as the reservoir exists and shall require strict mitigation measures.

Mitigation Measure(s)

- A strictly maintained green belt buffer zone of at least 50m from the reservoir, described in the sub-chapters above, is recommended to prevent approach of the reservoir.
- Locals should be sensitized on the dangers of swimming in the reservoir. This could urge adults to prevent children or their livestock from accessing the reservoir.

- Among the established groups, zone committees, cooperative and part of the local authorities (for example, local defence), a team of people should be assigned the task of patrolling the reservoir to prevent children and livestock from drowning in the reservoir.
- Along the dam crest guard rails of at least 1m height should be placed to prevent children from attempting to swim or play in this water.

6.2.4. DECOMMISSIONING PHASE

The Irrigation infrastructure might remain in operation for many years provided maintenance of the facility is given due attention. However, the facilities may be abandoned because of fresh development projects or even more profitable resource exploitation identified for this area. If this happens, environmental as well as social adverse impacts might occur.

6.2.4.1. Physical Environment

6.2.4.1.1. Dust and noise Pollution from demolition activities

Dust and noise pollution might occur when demolishing the dyke, draining the reservoirs, filling canals and demolishing other infrastructure.

Impact significance

This impact can be considered of low magnitude, duration and spatial extent as it occurs only during the decommissioning phase. The dam area will by that time not be closely settled after a long time of its operation, which implies that the air and noise pollution will not significantly affect communities.

Mitigation Measure(s)

- Controlled draining of the reservoir is crucial; considering recipients downstream or even the plots in the command area from flooding plus avoiding the river embankments from eroding.
- To mitigate the health hazard, workers participating in the demolition shall require protective gear, such as; eye goggles, nose masks, overalls, wellington boots, gloves and working ear phones.
- Spray of water to reduce dust.
- Compaction of soils in areas where demolition is complete.
- For works that could cause noise, these will be done at hours when locals are out of the marshland, preferably in the afternoon.

6.2.4.1.2. Contamination and impaired Environment from demolition

In the event of future rehabilitations and upgrading of this site area, portions of the project infrastructure and associated facilities might need to be demolished and the necessity of disposal of demolished waste. Haphazard disposal might cause contamination/impaired quality of the receiving water bodies (Muyanza River), especially land and water resources.

Impact significance

This impact can be considered of fairly severe magnitude and spatial extent considering its contaminating impact on the existing river could trickle down to the receiving Nyabarongo River downstream.

Mitigation Measure(s)

- Monitoring of the waste disposal to authorized damping areas by MINAGRI, district and local authorities will be necessary to avoid contamination of receiving waters or causing human health hazards.

6.2.4.2. Socio-economic Environment

6.2.4.2.1. Land depreciation from abandoned Infrastructures

The Muyanza Irrigation project is established to run for a long time, as such decommissioning is not envisaged unless it occurs in unforeseeable eventualities which may force abandonment of Irrigation Infrastructure and other project facilities that may cause the land to depreciate or permanently render the project land useless.

Impact significance

This impact can be considered of fairly severe magnitude since the land that had previously appreciated from irrigation and high productivity, could at this stage lose its appreciation, leaving land owners at a loss of land and crop productivity hence affecting their livelihood.

Mitigation Measure(s)

- Establishment of cooperatives, income and profits earned from the irrigation scheme will ensure locals have savings in their SACCOs and businesses to turn to as alternative sources of income.
- LWH project policy to finance off-farm activities in areas of intervention will ensure locals have alternative means of income to resort to other than this particular project. e.g. basket knitting, tailoring, welding and carpentry.

6.2.4.2.2. Possibility of downstream flooding

During the demolition of the dyke and its spillway, it is likely that areas downstream might be flooded, for example; the command area, the main emissary (Muyanza river) banks eroded and downstream Rubona and Nyabarongo river. With a volume of water of about 2.8Million m^3 from the reservoir, this could result in loss of property, land, plantations and in some cases lives for those caught in the field at the time of the flood.

Impact Significance

The impact could be very severe and significant if it was to occur causing destruction of crops, homes and loss of lives downstream of the dam.

Mitigation Measure(s)

- Controlled draining of the reservoir by regulating the sluice gate release is crucial to avoid recipients downstream or even the plots in the command area from flooding plus avoiding the river embankments from eroding.

6.2.4.2.3. Loss of livelihood

It is envisaged that farmers and their families will be depending directly or indirectly on the irrigation scheme for income and food for their households. Decommissioning of the project means loss of livelihood.

Impact significance

This impact can be considered of fairly severe magnitude since most of the local farmers by this time would be dependent on the irrigation for high crop productivity. Losing it without an alternative could return them to two season planting as opposed to all year planting. It could also affect their livelihood by decreasing income earnings from crop productivity.

Mitigation Measure(s)

- It is anticipated that farmers would have gained a lot from project trainings and development, to enable them sustain themselves even without the project support. Communities would have organized themselves into Cooperatives dealing in commercial agriculture. They would have been introduced to saving at an early stage hence reaching out to their savings accounts to invest in other income earning businesses.
- Off-farm income earning activities would have been adopted by project beneficiaries such that loss of irrigation scheme would not have a huge impact on their livelihood, for example; Making of Rwandan traditional basket "Agaseke" on a large scale by women as an off-farm activity done after returning from their plantations, carpentry, welding and tailoring could be turned to as an alternative income earner.

6.3. CONSIDERATION OF ALTERNATIVES

6.3.1. Alternative site location

6.3.1.1. Choice of dam axis location

For the main dam axis of the 25.04km^2 watershed, six (6) axes profiles were identified during the topographical survey from which the dam axis that gave the best results was chosen, with a reservoir capacity of 2,200,000m^3 and a dam height of 26m and capable of irrigating 950ha.
The six dam axes profiles had similar physical, biological environmental characteristics. The upper hand the chosen dam axis had over the other five axes was that:

- It was located at a narrow valley that meant that it had a lesser area of influence for dam and reservoir construction than the other axes, implying that it would have less impact on property for expropriation thereby less impact on the human social and environment.
- With a lesser area of influence, this axis had lower effect on distorting social harmony of community settlements in the vicinity of the proposed dam axes.
- Furthermore, this chosen point of dam axis opened up to a wider reservoir area compared to the other axes, which meant only marshland area would be covered by the reservoir and hardly any hillside area as opposed to the rest of axes that could have the reservoir cover some areas of hillsides. This would mean increased cost for expropriation, loss of property for those land owners covered on those inundated areas of hillsides.

6.3.2. Alternative system/ technology application

6.3.2.1. Choice of system for irrigable area

In comparison of the possible irrigable area by the two different system designs; (i) canal system and (ii) piping system, there was indication that the irrigable area by each could reach up to:

- By canal system- irrigable area of 920ha
- By piping system- irrigable area of 865ha.

However, with the combination of the main and secondary network being piping system, an irrigable area of 950ha is achievable.

6.3.1.2. Choice of Technology/process alternative

Regarding the irrigation system two alternatives were examined:
a) Canal System, using canals for the main network and pipes for the secondary and
b) Pipe System, using pipes for the main and the secondary network.
In both alternatives the use of night storage reservoirs has been considered.

For the first alternative, the total length of the canals is 42km while for second alternative the total length of the main pipes is 26Km. The cost of the irrigation system for the canals is approximately 6,670,000,000 Rwf (9,880,000 USD) including the required road for the construction of the canals.

The cost for the pipe system is 5,400,000,000 (8,000,000 USD). The cost estimations have been based on the design with night storage reservoirs. **Based on these costs, the second alternative is considered as more efficient for the operation of the system**.

6.3.1.3. No-Project Alternative

This alternative of no-project alternative is considered not feasible on grounds of losing out on socio-economic grounds as discussed from the following facets:

- The areas already had agriculture practiced; however, the kind of subsistence farming has not benefited the local farmers in these areas compared to the potential anticipated from the use of water resources available. Use of water for irrigation would imply crop cultivation throughout the year without the interference of the dry season hence increased crop yield resulting in increased income.
- All year cultivation would mean no drought or hunger during the dry season (Season C).
- Terracing of the catchment areas has been observed in similar project areas in Nyanza and Rwamagana to reduce significantly soil erosion and to increase crop production in this area that was previously unproductive and exposed to high erosion levels.
- Commercialised farming, organisation of farmers in Cooperatives, delivers an opportunity of profitable farm-gate crop price bargaining, access to markets (regional and international) which would eventually bring in high revenues and the chance of application of advanced agricultural techniques for high yields.
- The coming of this project brings along high crop yield, which motivates the locals to adopt the habit of saving in bank accounts hence preparing for an economical independent future for their households.
- Government's achievement of food security, which means adequate sustainability of household food needs plus surplus crop yield to sell and earn a favourable income by a farmer in rural areas of the country.

Based on the above it is considered that No-Project alternative is not a plausible alternative.

CHAPTER 7: ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) described in Table 17 provides a way forward for implementation of the identified mitigation measures. LWH project coordination shall be responsible for overall implementation of the EMP. The project Environmental and social safeguards officer shall be designated to make day to day follow ups (e.g. supervision and liaising with stakeholders). The estimated costs for implementation of the mitigation measures are just indicative. Appropriate bills of quantities should clearly give actual figures. In any case the consultant used informed judgment to come up with these figures.

Table 17: Environmental and Social Management Plan

Phase	Activity	Adverse Impacts	Proposed Mitigation/Enhancement measures	Implementation schedule	Responsible Institution	Occurrence	Estimated costs (US$)
Construction phase	Removal and placing back of topsoil during terracing	Reduction of soil fertility parameters from terracing. e.g. reduced mineral nitrogen and phosporus	• Application of lime. 50kg/acre. • Application of organic compost. 100kg/acre	Lime is applied when the terrace has been completed. Compost applied before planting.	• LWH	Once	Cost of lime 40Rwf or 0.057US$ /kg Cost of organic compost 38.5Rwf or 0.055US$/kg. Total cost per season of 365ha is 142,350,000Rwf or 202,357US$
	Application of fertilizer	Gradual soil acidification from fertilizer application	• Application of lime. 50kg/acre. • Periodic soil tests to guide regulation of quantities of fertilizer applied	Lime is applied when the terrace has been completed. Soil tests after season	• LWH	Lime is applied once. Every 2 years.	Cost of lime 40Rwf or 0.057US$ /kg Cost of soil tests for each period of examination could in the range of 600 to 800 US$.

				harvest of the second year			
	Refuelling of construction equipment and vehicles. Mechanical repairs of equipment.	Soil and water contamination from oil spillage	• Only equipment and automobiles in good condition and certified by the "National Automobile Inspection centre" on site to reduce spillage. • Re-fuelling, oil change, maintenance works, repair works will be allocated a restricted area, far from the water stream or valley. • A cemented floor and a sand stock for use in the absorption of spilled oil is appropriate. • Oil interceptor to collect oil leaking.	During dam construction	• Contractors.	Repetitive through construction	10,000Rwf or equivalent 14.3US$ for each automobile good condition certification. Automatic Oil interceptor will cost 2200US$.
	During site clearance, excavation works, disposal of debris, supply of construction material, compression and vibrations.	Air and noise pollution	• Construction activities shall be restricted to normal working hours (7h00-17h00) to prevent noise for neighbours at night • Use of equipment and automobiles that have certification of good working conditions from "National Automobile inspection	Through the construction	• Contractor	Repetitive through the construction	Cost of sound meter level is about 110US$ for excessive noise avoidance. 5m^3 tank of water spray could cost up to 60,000Rwf or 85US$ per trip.

			centre" to reduce on noise or exhaust fumes emissions. • Ensure routine maintenance, repair of trucks and machines. • Spray water regularly when clearing land to reduce the dust.				
	Removal of topsoil during terracing, site clearing and excavation exposing the ground to potential erosion agents such as; wind and storm water Welding, electrical installations to or from the power source, refuelling of equipment, smoking on site.	Soil erosion and landslides Fire outbreaks	Apply Napier grass at the terrace embankments. Project fast tracked to minimise exposure to potential erosion agents. Immediate backfilling and resurfacing after excavation to avoid facilitation of erosion agents. Light compaction will be necessary to stabilise the soil. Re-vegetating the cleared sites with local plant species. Regular checks on electrical installations and proper insulation of cables, to prevent short circuits that could trigger fires. • Specific area restricted to only authorized personnel and with fire extinguishers, should be allocated for fuel storage. • Water tank automobiles with hose pipes need to be part of the	• During terracing preparation and through the construction phase • Throughout construction	• Contractor • LWH • Contractor	Once for Napier grass application during terrace preparation and repetitive during construction Any time during construction	300Rwf or 42 US cents/ acre for Napier grass. Total estimate cost for 2300ha is 6,900,000Rwf or 9,857US$ Cost of each trip of a water tank is 60,000Rwf equivalent 85US$. Each Fire extinguishers range of 35-75US$.

			equipment required at the sites, for purposes of extinguishing fires. • Fire management drills for the workers should regularly be done.				
	Site clearing resulting in destruction of trees and crops.	Loss of biodiversity on the hillsides and valley	• Forest plantation of slope >60% increasing forest area by 366.8ha.	• During terracing period	• LWH	All through terracing	Cost of trees for forest plantation is 75,000Rwf/ ha. Total cost could be 27.5Million Rwf or 39,300US$
	Site clearing and installation	Loss of houses, land, crops and access to public infrastructure	• Compensation of 14 houses and 4ha for land and 0.39km of access road in the dam area. • Compensation of 1.54km of road in the reservoir area.	• Before construction	• LWH	Once	Estimate cost of lost houses in dam area is 50,000US$ Cost of land lost in dam area is 6,285US$ Combined cost of road replacement is 78,430US$.
	Terracing	Loss of income from missed cultivation season due to delays in terracing	• A clear terracing implementation program understood by LWH, sector agronomists and farmers. • Affected farmers to be granted priority in employment of workers on terraces.	• Anywhere after previous seasonal harvest and before season cultivation.	• LWH	Through the terracing period.	1,000Rwf or 1.4US$/ person/ 26m^2 of land terraced.

	Preparation of terraces, excavations, construction of the dam embankment, compaction of soils for the reservoir and fixing of pipe irrigation	Injuries of workers from construction activity	• Appropriate protective gears for workers such as; wellington boots, helmets, nose masks, eye goggles and overalls, with assurance of compliance by a safety department. • An Insurance policy covering injuries or death at the site should be presented at contract signature.	• Through construction	• Contractor • LWH.	All through construction	Complete safety gear kit is up to 70,000Rwf or 100US$ per person. Insurance policy is determined against the contract price of works.
	Preparation of terraces, construction of the dam, the reservoir and fixing of pipe irrigation	Contraction of diseases by workers during construction	• Spraying of water regularly to suppress excessive dust during construction is strongly recommended; • Workers on site will be provided with appropriate protective gears such as; wellington boots, helmets, nose masks, eye goggles and overalls. • Enforcement of medical insurance "mituelle de santé" acquisition for all workers. • Regular sensitization on ways of HIV prevention and importance of proper hygiene is important during execution of this project.	• Through construction	• Contractor	All through construction	$5m^3$ tank of water spray could cost up to 60,000Rwf or 85US$ per trip. Medical insurance "Mituelle de sante" costs 1000-3,000Rwf per person equivalent of 1.5- 4.5US$/ person.

Operations	During site installation, site clearing and excavation, transportation and use of heavy construction equipment will occur that could destroy existing infrastructure	Loss of infrastructure such as power, water and access roads. i.e. combined road length of 1.83km lost to the dam and reservoir.	• Mapping out of existing infrastructure such as; water points, pipelines, power lines, homes, commercial centres, roads and bridges is required to guide compensation or replacement of this infrastructure. • A Resettlement Action Plan (RAP) and qualified property valuation can guide compensation of those affected.	• Before construction	• LWH. • EWSA. • Rulindo District	Once	Combined road cost of 55million Rwf or 78.430US$. Power lines and water collection points shall be replaced at the expense of EWSA.
	Preparation of organic compost manure	Water and soil contamination by leachate from compost sites	• Selective sites for compost preparation far from surface and ground water sources and preferably on soils with low infiltration rates	• A month before cultivation	Established Zonal committee and cooperative • LWH	Before every planting season	cost of compost heap preparation is 210,000Rwf or 300US$
	Regulation of water flow from dam through the sluice gates	Modification of flows for downstream usage	• Maintain an environmental flow of 0.012m^3/s downstream of the dam. • Design should ensure a proper drainage network allowing for return flow from the plantations into the stream.	• At the time of releasing water for irrigation	• LWH • Water User's Association (WUA)	All through operation	No cost applicable

ge	Application of excess fertilizers and pesticides to plantations which are eventually washed by run-off into receiving water bodies.	Water pollution from non-point sources	• Training of local farmers on the safe and appropriate amounts of application of pesticides and fertilizers. • Water quality tests to understand the impact of the project on the quality of water bodies and curb any likely impacts there may be before water quality deteriorates.	• Training before every season of planting. • Water quality tests at the end of every 2 years of cultivation	• LWH • REMA	Training twice a year. Tests once every 2 years	Cost of water quality tests might not exceed 150US$ for parameter tests per sample. e.g. parameters such as; E.C, Ph, P, N, TDS, CO_3^{2-}
	Application of fertilizers	Water logging and salinization	• Regulated water quantity released for irrigation based on crop water requirement could minimise occurrence of water logging and salinization. • Training of farmers to regulate quantities of water used will be a long term investment in sustaining the chemical properties of the soil for continuous fertility.	• Through the irrigation	• LWH • Formed WUA.	As long as irrigation scheme exists	Cost of training could be determined but could catered for under LWH Component A.
	Cultivation on the hillside catchment area of the reservoir.	High sedimentation levels in the Reservoir	• Terraces on the catchment area of the reservoir. • A Green belt or silt trap of at least 50m from the shores of the reservoir comprising of about 4 rows of vegetation to hold soils and filter off sediment before it	• Terraces before dam and reservoir construction.	• LWH. • Buyoga and Burega sector.	Once	Cost of reservoir green belt approximately 45.3ha could be 13.05Million Rwf or 18,643US$.

			gets to the reservoir. Each of these rows with a thickness of about 10-15m may comprise of; a row of emergent plants at the immediate of the shores (such as reeds, bulrush or cattails), followed by shrub row, then a row of agroforestry trees and then furthest uphill could be Napier grass, all regularly harvested.	• Green belt-once demarcations of reservoir have been established.			
	Irrigation	Clogging and damage of irrigation infrastructure from nature and quality of reservoir water	• Reservoir design allows for settling of sediments, reducing sediments in the water conveyed for irrigation from the reservoir. • Periodic flashing of dead storage from hence improving the water quality.	• Reservoir flashing out every 2 years.	• LWH • WUAs	Through the life cycle of the reservoir	No cost implication
	Irrigation	Water loss from evaporation and leakage	• Regular pipe inspection and repair of any leakages. • Installation of leakage sensors for the main and secondary pipes where possible. • Irrigation network to consider return flow from plantations to recharge Muyanza river.	Monthly inspection. Sensors installed at time of pipe installation. Recharge considered during design	• LWH • WUAs	through life cycle of irrigation network. Once for sensors and recharge design.	Cost of inspection and repair dependent on WUAs salary structure. To be determined at operation stage.

	Application of fertilizers on plantations of the upstream catchment.	Reduction of aquatic life due to reservoir eutrophication	• Periodic manual removal of weeds from the reservoir. • Introduction of fish species that feed on invasive aquatic weeds. • Controlled use of fertilizers and pesticides on hillside cultivation to reduce on eutrophication from contaminated run-off.	• Weed removal every 3 months. • Fish introduction once reservoir is filled.	Established cooperative. LWH. Cyinzuzi, Tumba, Mbogo, Buyoga Burega sector	Weed removal through reservoir life cycle. Fish introduction- once.	Cost shall be determined at the time occurrence of impact and implementation of mitigation measure.
	Impounding of water	Loss of existing river biodiversity from changes in water temperature	• Impact is unavoidable with no mitigation measure proposed	• None	• None	None	None
	Terracing and irrigation infrastructure replacing brick making and sand mining in command area	Loss of income source for people dependent on non-aligned project activities (e.g. brick making and sand miners)	• Integration of those affected into the irrigation scheme by granting them plots of land. • Alternative of compensation by shifting them to other areas of environmental suitability for these activities.	• Once irrigation infrastructure has been completed	• LWH. • Burega and Buyoga sectors.	Once	Cost of land compensation is 122Rwf/ m^2 or 17 US cents/m^2.

	Fertilizer and pesticide application	Human health hazards from poor pesticide and fertilizer application	• Adapt recommendation of IPM done for LWH. • Technical assistance to farmers by agronomists on how to use them. • Adopt biological pest control.	• Every time fertilizer and pesticides are applied.	• LWH • Sector agronomists.	Every time fertilizer and pesticides are applied.	Cost of training could be determined but could catered for under LWH Component A.
	Water distribution through the primary, secondary and tertiary canals/ pipes for irrigation of command area plantations.	Water conflicts from the creation of the Irrigation scheme	• Create Water Users' Association (WUA) which will manage the amount of water used for each plantation and also resolve arising conflicts over water distribution.	• Before commissioning irrigation infrastructure	• LWH • Sector Agronomists.	Once	No cost for creation of WUAs.
	Irrigation	Vandalism of Irrigation infrastructure	• Early establishment of cooperatives as the management of structure at the project site. • Community policing for security. • Penalties and punitive action for perpetrators convicted of vandalism.	• Every time vandalism occurs	• Formed Cooperative and WUAs • Burega and Buyoga sectors	All through the irrigation	Community policing estimated to cost 200US$/ month around the irrigated command area.

	Occurrence of the 1000yr flood or poor workmanship in construction of the dam resulting in its collapse during operation phase.	Floods from reservoir over flow or dam collapse	Dam design includes. • A Spillway with a weir 20 m long designed for a 1000 year return flood with an estimated flow of 100m^3/s, capable of a threshold flow of 3m water depth will act as a flood control structure. • Also a Free board of 0.8m to avoid erosion of the dam's material by an overtopping surface runoff causing the dam to collapse. • A Cut-off trench and rock toe should be included in the design of the dam. • Regular inspection of likely areas of weakness along the dam (such as; cracks, fissures) is crucial to avoid such calamities. In case of fissures, it can be cleaned off and concreted. For larger indentations or cracks, slush grouting should be used. • MINAGRI to engage an independent dam safety panel to ensure the technical review of the dam designs and preparation of the reports: (1) plan for construction supervision and quality assurance; (2) instrumentation plan; (3)	• Preparedness plan produced at the time of dam completion. • Inspections every 6 months	• LWH	Through the life cycle of the dam	Cost of repair depends on level of defect.

			operation and maintenance plan; and (4) emergency preparedness plan				
	Use of water from the reservoir by locals for bathing, washing clothes, drinking and cooking food.	Increased spread of water related diseases (such as; Bilharzia, malaria, dysentery, diarrhoea, etc.)	• Planting of *Phytolaca decocandra* which will destroy the Bilharzia snails that serve as hosts of *shistosomiasis* along the shores of the reservoir. • In addition to this, the project may work along with MINISANTE in issuing mosquito nets for all farmers to reduce on the spread of malaria. • Restrict locals from using water from the reservoir for domestic consumption.	Planting done once reservoir demarcations have been established. Issuing mosquito nets can be done at the time of dam commissioning	• LWH project • MINISANTE • Rulindo District. • Burega and Buyoga sectors	Once	Cost of a mosquito net is 2500Rwf equivalent of 3.5US$.
	Farmers cultivating closer to the reservoir, river and pipes laid for irrigation	Destruction of reservoir, pipes and river boundaries	• Maintain a clear and strict buffer zone of thick green belt is recommended at least 50m from the reservoir and 10m from the river (primary emissary) to the nearest plantation has already been planned for. • Pipe laid atleast 45cm depth with 15cm embedment material under	• All through the operation phase	• LWH • Buyoga and Burega sector. • Formed Cooperative.	All through the operation phase	Cost of reservoir green belt approximately 45.3ha could be 13.05Million Rwf or 18,643US$. Excavation, backfilling and compaction of pipe trenches cost

			to protect it. Pipe layout marked out.				2-3,000Rwf or 3-4 US$/ m^3
	Water released from the dam or day/night storage through pipes for irrigation of the plantations.	Wastage of water	• WUAs trained technicians to manage quantities apportioned for plantation from sluice gates to the valves so as to reduce water misuse. • Frequent inspection and repairs of leaking infrastructure. • Sensitization of farmers on proper management of water allocated for their plantations.	• Through the operation phase	• WUAs. • LWH.	As long as irrigation occurs	Valve replacement could cost in the range of 39-55US$ each at Ex-works price.
	Use of reservoir water by children for fetching water, washing clothes, swimming. Use of the reservoir as a drinking mound for livestock.	Drowning of children and livestock	• Maintain a thick proposed green belt buffer zone of at least 50m surrounding the reservoir to avoid penetration. • Locals should be sensitized on the dangers of swimming in the reservoir. • Patrolling the reservoir to prevent children and livestock from drowning in the reservoir. • Maintain guard rails of at least 1m height along the dam crest are recommended.	• Green belt worked all through the year. • Sensitization done annually and patrols are throughout the day. • Guard rails replaced when damaged.	• Buyoga and Burega sector. • Established cooperative.	As long as the reservoir exists	Cost of patrol, guard rail repair and sensitization cannot be currently determined. It shall depend on the level of work to be done of the mitigation.

Decommissioning Phase	Demolishing of the irrigation infrastructure	Land depreciation from abandoned Infrastructures	• Plan for a better income generating project for the area before this irrigation project is replaced.	• At the pre-feasibility stage of a replacing project	• MINAGRI • Existing cooperative.	Once	Cost can only be determined at the time of demolition.
	Demolition of the dam and irrigation infrastructure	Dust and noise pollution from demolition activities	• Protective gear, such as; eye goggles, ear phones and nose masks. • Spray of water to reduce dust. • Compaction of soils in areas where demolition is complete. • For works that could cause noise, these will be done at hours when locals are out of the marshland, preferably in the afternoon.	• During demolition	• Contractor.	All through the demolition period	Cost can only be determined at the time of demolition.
	Collapse of the dam during demolition	Possibility of downstream flooding	• Controlled draining of the reservoir is crucial to avoid recipients downstream or even the plots in the command area from flooding plus avoiding erosion of river embankments	• During demolition	• Contractor	Once when the dam is destroyed	Cost can only be determined at the time of decommissioning.

	Disposal of debris during demolition	Contamination and impaired environment	• Monitoring of the waste disposal in authorized damping areas to avoid contamination of receiving waters or causing human health hazards.	• During demolition	MINAGRI Farmers Cooperative. • District	Once during debris disposal	Cost of water quality test is 150US$ per sample.
	Decommissioning of the irrigation project	Loss of livelihood	• Farmers would have organized themselves into Cooperatives dealing in commercial agriculture. • Off-farm income earning activities as alternatives, for example; Making of Rwandan traditional basket "Agaseke" on a large scale by women as an off-farm activity done after returning from the plantations.	• After demolition	• MINAGRI • Existing Cooperatives.	After demolition	Cost can only be determined at the time of demolition.

CHAPTER 8: ENVIRONMENTAL MONITORING PLAN

In this chapter a monitoring plan is proposed in **Table 18** below indicating measurements of parameters, responsibility and cost estimates of outcomes of the proposed mitigation measures.

Table 18: Environmental and Social Monitoring Plan

Activity/ mitigation measures	Parameters	Indicator	Method	Frequency of measurement	Responsibility	Cost estimates (US$)
Soil tests to guide on nutrient requirement	pH, nitrates, ammonia, organic carbon, phosphorous, Exchange acidity	soil acidity and other parameter levels	• Soil quality tests of plantations	• Every 2years	LWH.	Cost of soil test is 800US$/ sample test of all parameters.
Lime and organic compost application	• Area applied	• Number of hectares	• Area measurement by GPS	• Every cultivation season	LWH	Cost of lime/ ha is 5000Rwf or 7.14US$. Cost of organic compost is 385,000Rwf or 550US$/ ha. Total cost per season on 365ha is 142.35Million Rwf or 203,357US$
Equipment and automobiles in good shape	• Certification from Automobile inspection centre	• Number of Automobiles with certification on site	• Counting qualifying automobiles	• Quarterly through the construction phase	• Contractor	No cost applicable to monitor.
Restriction of noise emitting activities to working hours.	• Sound decibels.	• Sound levels	• Application of noise monitoring systems.	• At the time of works that emit a lot of noise or vibrations, for	• Contractor	Cost of a sound meter level is about 110US$.

Use of certified construction equipment in good condition. Spraying of water to reduce dust.	• Greenhouse gas content (CO_2, CO, CH_4) and dust particles in the air.	• Air quality emission levels	• Gas emission tests	example; like; earth works or concrete vibrations. • During excavation and backfilling works	• Buyoga and Burega sector.	
Napier grass on terrace embankments and trees on terraces Regular inspection of electrical installations, Fire extinguishers, water tanks	• Planted area • Fire management equipment	Number of planted hectares (ha) • Number of fire extinguishers and water tanks	• Area measurement • Counting extinguisher equipment	• Every quarter of a year • Quarterly through the construction phase.	• LWH • Contractor • LWH.	For 2300ha terraced land about 6,900,000 Rwf or 9,875US$ 150US$/ trip to inspect.
Reforestation to offset lost forests Compensation for land and houses lost	• Planted area • Houses expropriated • Land expropriated	• Number of planted hectares (ha) • Number of houses. • Land area	• Area measurement • Counting of houses. • Area measurement	• Every quarter of a year • Once before construction	• LWH • LWH • Buyoga, Burega, Cyunzuzi Sector officials	27.5Million Rwf or 39,300US$ 39.4million Rwf or 56,285US$

Safety gear for workers	• Safety gear versus number of workers	• Number of workers with safety gear	• Counting.	• Quarterly through the construction phase.	• Contractor • LWH.	150US$/ trip to inspect.
Compensation of access roads	• Road length affected	Number of km	• Road measurement	• Once before construction	LWH Buyoga and Burega Sector	54.9million Rwf or 78,430US$
Green belt or silt trap	• Planted area	Number of planted hectares (ha)	Area measurement	• Annually	• LWH	13.05Million Rwf or 18,643US$
Modification of flows for downstream usage	• Water quantity	• Flow rate, Q (m^3/s)	Flow measurement records at the weir.	• Annually	• MINAGRI • LWH	250US$/ annual flow analysis and interpretation.
Water pollution	• Water quality	Nutrient load in water recipients from non-point sources (NO_3^-, PO_4^{2-}, K).	• Samples of water and soil quality tests.	• Twice a year.	• LWH	Cost of water quality tests might not exceed 150US$/ sample for a complete quality test.

CHAPTER 9: PRELIMINARY DECOMMISSIONING PLAN

Decommissioning of the proposed LWH irrigation project will become necessary when the project completes its life cycle or when there is change of use. In a situation where the Dam (Dyke and reservoir), delivery canals/ pipes, spillways, sluice gates and small civil engineering infrastructure complete their lifecycle, decommissioning process will typically involve dismantling of the equipment, demolition of dyke and reservoir, clearing of the site and reclaiming or restoring the affected land into a natural condition. It is assumed that the Community WUA or cooperatives at the time shall be able to fund and implement all aspects of the project decommissioning, including but not limited to all engineering, environmental assessment, permitting construction and mitigation activities associated with the removal of the infrastructure in accordance with this plan and mitigation of the project removal impacts on site. The community WUA or Cooperative, along with District authorities at the time shall monitor environmental impacts during and after project removal to respond to defined events during the monitoring phase.

9.1. CHANGE OF USE SITUATION

In situations where there is a change of use, the decommissioning process may entail demolition of existing facilities (i.e. the dam and irrigation infrastructure). Upon completion of the demolition, the affected land (i.e. especially dam and reservoir area) will need to be reclaimed or restored into a natural condition through landscaping and planting of vegetation.

9.2. END OF LIFE SITUATION

In a situation where the project infrastructure have completed their useful life, decommissioning process will entail demolition of the erected and dismantling of the structures including; the dyke, reservoir, delivery canals/pipes and any other small irrigation infrastructure installed. Site clearing and reclaiming or restoring the affected land into a natural condition will then follow.

Restoration of the affected land may involve; the filling in of any open pits and grading the land to its natural contours, then planting appropriate tree species and cover vegetation to hold the soil in place and to prevent flooding. Planting of trees however, may not be necessary if the site is immediately taken over for another development.

The debris resulting from the demolition will either be transported by licensed waste transporters for dumping at an approved damp site or used as base material for new construction work. The demolition process will entail removal of materials using crowbars and hammers, breaking of walling and reinforced slabs using sledge hammers and/or jack hammers, which utilize compressed air and lowering of materials from high to low levels.

The exercise will therefore entail working at high levels and all the necessary health and safety measures will need to be implemented including provision of personal protective equipment such as; safety harnesses, helmets, gloves, nose masks, safety shoes, overall, goggles and ear protectors.

Project decommissioning has five phases: (1) pre-removal monitoring; (2) permitting; (3) interim protective measures; (4) project removal and associated protective actions; and (5) post-removal activities, including monitoring of environmental and social economic activities.

The first phase will occur prior to removal of the project (i.e. within the first six months). The fourth phase – project removal and associated protective actions – will take place twelve months after closing business. The fifth phase will begin after total removal and due to nature of the project (medium scale, with relatively moderate impacts) removal and continue for at least one year. The description that follows outlines the activities that will occur in each phase:

- **Pre-removal Monitoring:** Pre-removal monitoring includes environmental and socio economic status of the project and the surrounding. This monitoring is essential to identify if there is any environmental or social liability which need to be settled before the permit for closure is given. This period will also be used to keep inventories of all assets and facilities that need to be disposed of and to prepare a final decommissioning plan for approval by REMA.
- **Permitting:** LWH project (if still in existence) or the Cooperative shall obtain all permits required to undertake removal of the project. This basically will include REMA, RRA, Rulindo District, MINIRENA, MININFRA.
- **Interim protective Actions:** This will take care of any interim protective measure that needs to be implemented to protect human health and environment, if any.
- **Project Removal:** As noted above, the removal of the project will be completed within twelve months.
- **Post-Removal Activities:** Post-project removal monitoring will continue for one year.

CHAPTER 10: CONCLUSIONS AND RECOMMENDATIONS

10.1. CONCLUSIONS

The Scoping Exercise has identified a number of issues pertaining to the proposed Muyanza LWH project at the five (5) sectors of Rulindo district. The issues/impacts have been assessed and described in some detail to gain an adequate understanding of possible environmental effects of the proposed project – from design to decommissioning, in order to formulate mitigation measures in response to negative aspects which have emerged. The Environmental Management Plan (EMP) provides a way forward for implementation of the identified mitigation measures. The EMP should be implemented as a prerequisite for a positive Record of Decision (RoD) by the appropriate authorities.

The estimated costs of implementing the mitigation measures are just indicative. Appropriate bills of quantities should clearly give the actual figures. In any case the consultant has used informed judgement to come up with these figures.

The Environmental Monitoring Plan provides parameters to be monitored and responsibility. While the consultant is aware that each monitoring aspect need to have a separate budget line, for small projects which are remotely located this does not make economic sense. The consultant is recommending that the Project Proponent (LWH) assigns the Environmental and social safeguard officer to undertake the monitoring of the mitigation measures for the project through its existence. This way the proponent will achieve sustainable project implementation at reduced cost for undertaking the monitoring. The figures given are considered to be absolute maximum such monitoring could cost. However, regular internal monitoring shall be carried out by the project proponent.

Given the nature and location of the development, the conclusion is that the potential impacts associated with the proposed development are of a nature and extent that can be reduced, limited and eliminated by the application of appropriate mitigation measures.

10.2. RECOMMENDATIONS

Based on the findings of this EIA study, our recommendations are:

- Periodic soil tests every 2 years to measure nutrient levels, acidity levels and relevant soil characteristics to determine the trend of soil fertility is necessary to guide the quantities of lime, fertilizer and compost application.
- Forest planting on slopes over 60% and tree planting on terraces is recommended to offset forest/trees lost during the terracing, dam, reservoir and irrigation infrastructure construction.

- Estimation costs were derived of 94.3million Rwf for compensation of houses, land and roads lost to the project construction activities, however, a more accurate figure a Resettlement Action Plan (RAP) should also be prepared for guidance in property valuation and compensation of those voluntarily or involuntarily displaced.
- A green belt or silt trap buffer zone of at least 50m along the reservoir and 10m buffer zone from the river is recommended to prevent encroachment of these water sources, act as filters to possible pollution and restrict children and livestock from drowning.
- Baseline and progressive water quality tests of the reservoir and the receiving primary emissaries (Muyanza River) are necessary to determine mitigation measures for likely non-point source water pollution.
- Water abstraction quantities require monitoring through periodic water level measures to avoid water resource depletion. An ecological flow rate of $0.012m^3/s$ has been recommended for the existing ecosystem downstream to be maintained.
- The existing Integrated Pest Management (IPM) prepared for LWH at its commencement should be adapted as guidance in pesticide application.
- Planting *Phytolaca decocandra* will destroy the Bilharzia snails that serve as hosts of *shistosomiasis* along the shores of the reservoir.
- Introduction of fish, in the reservoir that feed on mosquito larvae thereby reducing on their breeding. Also provision of mosquito nets, sensitization on the importance of sleeping under a mosquito net and encouraging locals on proper hygiene will reduce on the likelihood of contracting water related diseases.
- Periodic manual removal of aquatic weeds from the reservoir to avoid the possibility of an uncontrollable invasion of the reservoir by weeds rendering it non-navigable and incapable of providing sufficient quantities to effective irrigate the command area.
- Establishment of a cooperative and Water User's Association (WUA) for the Muyanza project to ensure well managed irrigation water distribution, land husbandry and irrigation infrastructure maintenance, collective crop harvest and economic development of farmers.
- Capacity building framework for project beneficiaries is recommended in a number of sectors such as; terracing, modern crop growing, irrigation techniques, irrigation infrastructure maintenance and management, water distribution, regulated fertilizer and pesticide application, management of cooperatives and importance of savings accounts.

Based on the study, the Consultant is of the opinion that most of the potential environmental impacts identified can be mitigated. The proposed environmental management plan and environmental monitoring plan if implemented will safeguard the integrity of the environment.

REFERENCES

1. *Aaby, B, and Jacobsen, J.(1979)* Changes in biotic conditions and metal deposition in the last millennium as reflected in ombrotrophic in Draved Mose, Denmark.
2. *Alloway, B .J (1990a)* the origin of heavy metals in soils. In: Alloway, B. J. (Ed.)
3. *Berrow , M. L. and Reaves, G. A(1986)* Total chromium and nickel content of Scottish soils.Geoderma,37, 15-27.
4. *Davies, B. E., (1990) Lead in : Alloway ,B. J. (Ed)* Heavy Matal in soils.pp. 177-196. Blackie, London; Wiley, New York .
5. *Davies, B. E. 1980.* Trace element pollution. In B. E. Davies (ed.), Applied Soil Trace Elements. New York: Wiley, pp. 287-351.
6. *East African Community, 2004.*East African protocol on environment and natural resources management.
7. *EDPRS 2008-2012*. Economic Development and Poverty Reduction Strategy.
8. *Fergusson, J. E. (1990)* The Heavy Elements: Chemistry, Environmental Impact and Health Effects. Pergamon Press, London
9. *FAO, 2010.*Manual on small Earth dams. A guide to siting, design and Construction.
10. *FAO. (2006a).* Guidelines for soil description Fourth edition. Rome: FAO.
11. *FAO. (2006b).* World reference base for soil resources, a framework for international classification, correlation and communication. Rome: FAO.
12. *Government of Rwanda, 2008.*Ministerial order No. 003/2008.Relating to the requirements and procedure for Environmental Impact Assessment, 2008.
13. *Government of Rwanda, 2008.*Ministerial order No. 004/2008.Establishing the list of works, activities and projects that have to undertake Environmental Impact Assessment, 2008.
14. *Government of Rwanda, 2008.*Ministerial order No. 007/2008.Establishing the list of Animal and plant species, 2008.
15. *Government of Rwanda, 2004.*National Land policy.
16. *Government of Rwanda, 2003.*The General census of population and housing in Rwanda of 16th – 30th August 2002.
17. *Government of Rwanda, 2004.*Sector policy on water and sanitation.
18. *National Institute of Statistics of Rwanda (NISR), 2009.*National Population Projection 2007-2022.
19. *Government of Rwanda, 2008.*Organic law 04/2005 of 08/04/2005.Organic law determining the modalities of protection, conservation and promotion of the environment in Rwanda.

20. *Government of Rwanda, 2005.*Organic law N° 08/2005 of 14/07/2005.Determining the use and management of Land in Rwanda.
21. *LWH (2014)* Prefeasibility Study, Feasibility Study and Detail Design of Multiple Land Husbandry, Dam and Hillside Irrigation Sites for 3,500 ha irrigation in different parts of Rwanda (Lot 1). Soil assessment report, social assessment report for Muyanza site.
22. *LWH, PAD.* LWH Project Appraisal Document.
23. *MINAGRI, 2008.*Strategic Plan for Agricultural Transformation II (SPAT II).
24. *McGeehan, S. L. and D. V. Naylor. 1992.* In Agronomy Abstracts. Madison, Wis.: Soil Science Society of America. p. 242.
25. *MINAGRI, 2007.* Crop Intensification Programme
26. *MINAGRI, 2011.* Fertilizer programme privatization and role of different institutions
27. *MINAGRI, 2009.* Procedures for fertilizer procurement and distribution
28. *Mokolobate M.S and Haynes, R.J. 2002a.* Increase in pH and soluble salts influence the effect that addition of organic have on concentration of exchangeable and soil solution Al. Eur. J. Soil Sci.53: 481-489
29. *Mokolobate M.S and Haynes, R.J. 2002b.* Comparative liming effects of four organic residues applied to an acid soil, Biol.Fertil. Soils 35: 79-85.
30. *Naramabuye, FX; Haynes, RJ; Modi, AT, 2008.* Cattle manure and grass residues as liming materials in a semi-subsistence farming system Agriculture Ecosystems and Environment vol. 124, no. 1-2, pp. 136-141
31. *National Museum Institute, 2008*. Provisional list of historical, cultural and archaeological sites of Rwanda.
32. www.**worldbank**.org/**safeguardpolicies**,

APPENDICES

APPENDIX 1: ISSUES REPORTS

COMPONENT: LWH MUYANZA Site
PROVINCE: NORTH
DISTRICT: RULINDO
SECTORS: Buyoga, Burega, Cyinzuzi, Tumba and Mbogo

Issues Report for Muyanza site

Project: LWH **Project title: Muyanza project.** Date: 5th, 17th- 20th June, 8th -10th July 2014	

Public consultation/ Field observations:

Methods for reaching stakeholders

The study was able to reach stakeholders in the following manner:

- *First category* of Government officials, which included; LWH, MINAGRI, RSSP, EWSA and REMA. A letter of introduction issued by LWH was used by the consultant to approach focal people in these institutions. By using the key guiding questionnaires in *appendix 3*, we were able to guide discussions and obtained relevant information on project activities.
- *Second category* of Local government officials, which included; Executive secretaries and agronomists for the sectors of project intervention. i.e. Cyunzuzi, Burega, Buyoga, Tumba and Mbogo. With the assistance of LWH coordination team we were able to approach these officials. Our discussions with them were guided by the social interview questions *in appendix 3,* from which information on project benefits, constraints in implementing the project and impacts likely to be caused by the project were reflected.

- *Third category* of locals (i.e. residents, farmers) who are either benefiting from the project or affected by it. These too were guided by the social interview questions *in appendix 3,* from which information on project benefits and adverse impacts were aired out.

Scheduling of consultation activities

Dates	Place	Activity
2nd June	Kigali	Meetings with: • LWH Safeguard specialist • LWH Project Engineer
5th June	Buyoga and Burega sectors	Field acquaintance visit • LWH Safeguard specialist • LWH Project Engineer
17th-20th June	Cyinzuzi, Tumba, Burega, Buyoga and Mbogo sectors	Meetings with: • LWH site coordination team. • Locals residents and farmers at terraces of the water catchment area. • Hydrological, ecological and environmental assessment of project areas
8th-10th July	Cyinzuzi, Tumba, Burega, Buyoga and Mbogo sectors	Meetings with: • All sector executive secretaries. • All sector agronomists. • Locals residents and farmers at dam and reservoir area. • Site visit to likely areas of expropriation at the dam axis and reservoir and post-harvest facility areas. • Ecological and environmental assessment of project areas
8th-11th July	Cyinzuzi, Tumba, Burega, Buyoga and Mbogo sectors	• Soil sampling. • Soil profiling.

Record of field consultation:

- **Cyunzuzi sector consultation**

Administrative organization of the area:

Comprises of; a population of 14,364 people, 3759 Households (HH), 224 Vulnerable HH, 3 primary schools (2 schools of 9 year basic education (YBE), 1 school of 12 YBE), no health centre- closest health centre at Ngoma a neighbouring sector.

73% homes accessed Medical insurance in the previous financial year.

Resources of the sector:

Mainly agriculture and livestock farming, other resources are; small time mining of cassetirite, brick making and sand mining.

Awareness of the project:

Good level of awareness and indicated that LWH had taken time to sensitize locals before the start of the project.

Locals appreciate that project comes along with benefits like: terracing of their lands along the steep slopes of the hills hence significantly reducing the loss of soils by erosion, job opportunities in making these terraces, supporting them with improved seed, DAP for fertilizers, training them on preparation of compost manure and in turn buying it from those who have prepared, expectant of increased crop productivity.

Land ownership:

Land registration has been completed.

Common Crops grown- climbing beans, maize, irish potatoes.

Other crops- vegetables, sweet potatoes, peas.

The project will maintain the same crops grown but encourage high value crops preferably vegetables and coffee.

Markets- None.

Cooperatives- legally registered coops are; COPIPEF, Izere absaruzi. Mostly dealing in agriculture and livestock farming.

Electricity:

Poor coverage of power. Only in centres, school and sector office.

Infrastructure:

The area is accessible through feeder roads constructed .The roads are earth roads, in some cases finished with compacted laterite and in some areas just compacted earth.

Cultural heritage:

The project site has no archaeological sites, cemeteries, traditional monuments, genocide memorial sites, religious structures.

Issues at hand-

- Worry by locals of their land transformed without valuable compensation.
- Worry that terracing delays and that means that they at times missing season of cultivation.

Mitigation measures proposed-

- Need to establish a means of compensation and assure the locals affected that they will be compensated.
- Farmers currently cultivating the areas of the dam and reservoir area should be compensated for crop loss and land.

- A resettlement action plan, covering the value of land and plantations affected for compensation, is required once detailed technical study is complete indicating the limitations of the irrigation infrastructure.

- **Burega sector consultation**

Administrative organization of the area:

Comprises of; An area coverage of 33km^2, 3 cells, 40 villages, a population of 13,253 people, 3116 Households (HH), 418 Vulnerable HH, 2 schools (1 school of 9 year basic education (YBE), 1 school of 12 YBE), 1 health centre, 2 town centres

81.6% homes accessed Medical insurance in the previous financial year.

Resources of the sector:

Mainly agriculture and livestock farming, other resources are; none.

Awareness of the project:

Very good level of awareness and indicated that LWH had taken time to sensitize locals before the start of the project.

Locals appreciate that project comes along with benefits like: with the dam the issue of Muyanza river flooding plantations in the valley will be manageable, terracing of their lands along the steep slopes of the hills hence significantly reducing the loss of soils by erosion, job opportunities in making these terraces, supporting them with improved seed, DAP for fertilizers, training them on preparation of compost manure and in turn buying it from those who have prepared, expectant of increased crop productivity.

Land ownership:

Land registration has been completed.

Common Crops grown- climbing beans, maize, sorghum, cassava, onions and peas.

The project will maintain the same crops grown but encourage high value crops preferably vegetables and coffee.

Markets- None.

Cooperatives- 5 legally registered coops of 31. Mostly dealing in agriculture and livestock farming, Just afew deal in coffee, sand mining and brick making.

Electricity:

Poor coverage of power. Only in centres, school and sector office.

Infrastructure:

The area is accessible through feeder roads constructed .The roads are earth roads, in some cases finished with compacted laterite and in some areas just compacted earth.

Cultural heritage:

The project site has no archaeological sites, cemeteries, traditional monuments, genocide memorial sites, religious structures.

Issues at hand-

- Worry by locals of their land transformed without valuable compensation.
- Worry that terracing delays and that means that they at times missing season of cultivation.

- Worry that the dam construction could start before warning cultivators, implying that their crops would be cleared in preparing the site and hence losses to the farmer.
- Insufficient skilled labour to take on the construction of irrigation scheme.
- Access roads to the dam are narrow and slippery.
- Flooding of the plantations in valley by Muyanza river during the wet season of April.

Mitigation measures proposed-

- Need to establish a means of compensation and assure the locals affected that they will be compensated.
- Farmers currently cultivating the areas of the dam and reservoir area should be compensated for crop loss and land.
- A resettlement action plan, covering the value of land and plantations affected for compensation, is required once detailed technical study is complete indicating the limitations of the irrigation infrastructure.
- **Buyoga sector consultation**

Administrative organization of the area:

Comprises of; An area coverage of 54km^2, 7 cells, 37 villages, a population of 22,000 people, 5,094 Households (HH), approximately 6,000 Vulnerable People, 9 schools (1 secondary school, 8 schools of 9 year basic education (YBE) and 12 YBE), 2 health centres.

86% homes accessed Medical insurance in the previous financial year.

Resources of the sector:

Mainly agriculture and livestock farming, other resources are; none.

Awareness of the project:

Good level of awareness and indicated that LWH had taken time to sensitize locals before the start of the project.

Locals appreciate that project comes along with benefits like: with the dam the issue of Muyanza river flooding plantations in the valley will be manageable, terracing of their lands along the steep slopes of the hills hence significantly reducing the loss of soils by erosion, job opportunities in making these terraces, supporting them with improved seed, DAP for fertilizers, training them on preparation of compost manure and in turn buying it from those who have prepared, expectant of increased crop productivity.

Land ownership:

Land registration has been completed.

Common Crops grown- climbing beans, maize, wheat and vegetables like; carrots, onions and cabbage. The project will maintain the same crops grown but encourage high value crops preferably vegetables and coffee.

Markets- 1 big market and 5 small markets.

Cooperatives- 7 legally registered coops. Mostly dealing in agriculture and livestock farming, Just afew deal in sand mining and brick making.

Electricity:

Poor coverage of power. Only in centres, school and sector office.

Infrastructure:

The area is accessible through feeder roads constructed .The roads are earth roads, in some cases finished with compacted laterite and in some areas just compacted earth.

Cultural heritage:

The project site has no archaeological sites, cemeteries, traditional monuments, genocide memorial sites, religious structures.

Issues at hand-

- Worry by locals of their land transformed without valuable compensation.
- Worry that terracing delays and that means that they at times missing season of cultivation.
- Worry that the dam construction could start before warning cultivators, implying that their crops would be cleared in preparing the site and hence losses to the farmer.
- Insufficient skilled labour to take on the construction of irrigation scheme.
- Access roads to the dam are narrow and slippery.
- Flooding of the plantations in valley by Muyanza river during the wet season of April.

Mitigation measures proposed-

- Need to establish a means of compensation and assure the locals affected that they will be compensated.
- Farmers currently cultivating the areas of the dam and reservoir area should be compensated for crop loss and land.
- A resettlement action plan, covering the value of land and plantations affected for compensation, is required once detailed technical study is complete indicating the limitations of the irrigation infrastructure.

- **Tumba sector consultation**

Administrative organization of the area:

Comprises of; An area coverage of 43km^2, 5 cells, 30 villages, a population of approximately 20,000 people, 4393 Households (HH), 8 schools (5 primary schools, 2 secondary school, 1 school of 9 year basic education (YBE), 1 school of 12 YBE), 1 health centre, 1 town centre.

85% homes accessed Medical insurance in the previous financial year.

Resources of the sector:

Mainly agriculture and livestock farming, other resources are; none.

Awareness of the project:

Good level of awareness and indicated that LWH had taken time to sensitize locals before the start of the project.

Locals appreciate that project comes along with benefits like: terracing of their lands along the steep slopes of the hills hence significantly reducing the loss of soils by erosion, job opportunities in making these terraces, supporting them with improved seed, DAP for fertilizers, training them on preparation of compost manure and in turn buying it from those who have prepared, expectant of increased crop productivity.

Land ownership:

Land registration has been completed.

Common Crops grown- climbing beans, maize, irish, wheat.

Other crops- peas, sorghum and sweet potatoes.

The project will maintain the same crops grown but encourage high value crops preferably vegetables and coffee.

Markets- 1.

Cooperatives- 14 legally registered coops. Mostly dealing in agriculture and livestock farming.

Electricity:

Poor coverage of power. Only in centres and sector office.

Infrastructure:

The area is accessible through feeder roads constructed .The roads are earth roads, in some cases finished with compacted laterite and in some areas just compacted earth.

Cultural heritage:

The project site has no archaeological sites, cemeteries, traditional monuments, genocide memorial sites, religious structures.

Issues at hand-

- Worry by locals of their land transformed without valuable compensation.
- Worry that terracing delays and that means that they at times missing season of cultivation.
- **Mbogo sector consultation**

Administrative organization of the area:

Comprises of; An area coverage of 41.5km^2, 4 cells, 32 villages, a population of approximately 17,150 people, 3850 Households (HH), 941 vulnerable HH, 5 schools (1 primary schools, 3 school of 9 year basic education (YBE), 1 school of 12 YBE), 1 health centre, 1 town centre.

86% homes accessed Medical insurance in the previous financial year.

Resources of the sector:

Mainly agriculture and livestock farming, other resources are; none.

Awareness of the project:

Good level of awareness and indicated that LWH had taken time to sensitize locals before the start of the project.

Locals appreciate that project comes along with benefits like: terracing of their lands along the steep slopes of the hills hence significantly reducing the loss of soils by erosion, job opportunities in making these terraces, supporting them with improved seed, DAP for fertilizers, training them on preparation of compost manure and in turn buying it from those who have prepared, expectant of increased crop productivity.

Land ownership:

Land registration has been completed.

Common Crops grown- climbing beans, maize, irish, wheat and vegetables.

The project will maintain the same crops grown but encourage high value crops preferably vegetables and coffee.

Markets- None.

Cooperatives- 8 legally registered coops of 33 coops. Mostly dealing in agriculture and livestock farming.

Electricity:

Poor coverage of power. Only in centres and sector office.

Infrastructure:

The area is accessible through feeder roads constructed .The roads are earth roads, in some cases finished with compacted laterite and in some areas just compacted earth.

Cultural heritage:

The project site has no archaeological sites, cemeteries, traditional monuments, genocide memorial sites, religious structures.

Issues at hand-

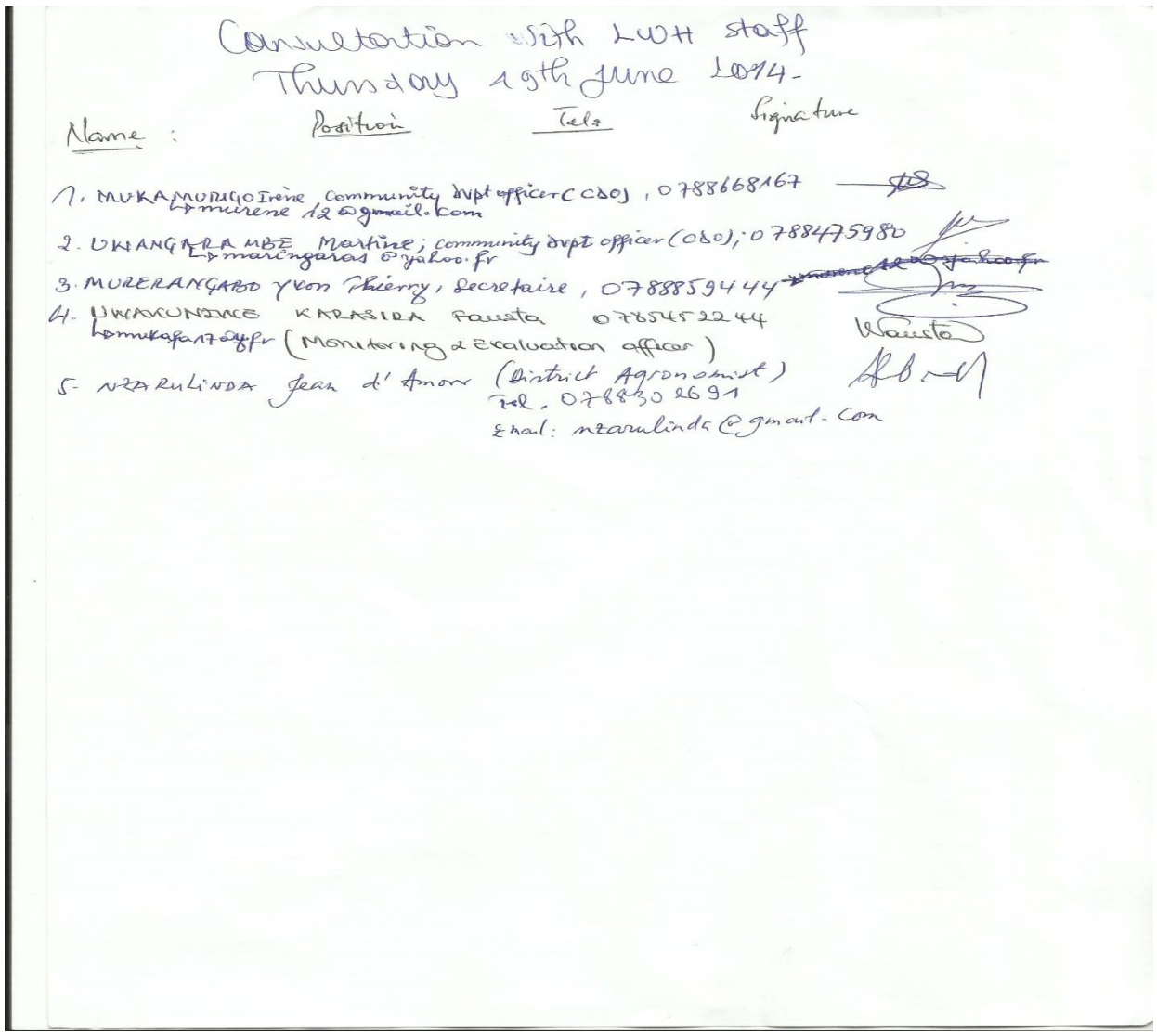
- Worry by locals of their land transformed without valuable compensation.
- Worry that terracing delays and that means that they at times missing season of cultivation.

APPENDIX 2: LIST OF PUBLIC OR PARTICIPANTS CONSULTED

Name	Institution & Position	Contacts
Theogene Habakubaho	LWH Safeguards specialist	0727191881
Kagenza	LWH Engineer	0788407891
Bruce Ndabazi	WASAC	0788453460
Gisele Umuhumuza	REMA	0785130407

Public consultation Friday 20th June 2014
Local residents

Name	Village	Cell	Sector	Signature
Tizeyimana Fiancsile 32ans	Kanunga	Karengeri	Burega	
Turalonawe jeberidi	Karambo	Busoro	Buyoga	
Nyiraminani Gaudence 45 46	Mukarange	Karengeli	Burega	
Mukahigiro Berensiru 51	Gasave	Butare	Buyoga	
Nyirakamana Berina 54ans	Gasave	Karengeli	Burega	
Mukandisi Sipenamsiya 40	gasare	Karemgore	Burega	
Niyorora Célésta 35	Karambo	Busoro	Buyoga	
Nyirahobugimana Keradigama	Karambo	Busoro	Buyogo-	
Mukeshimana Vestine 39				
NIYIGENA FORODOWARI 30	Kalambo	Busolo	Buyaga	
Singirankabo Valens 25 ans	Korowdo	Busozo	Bugoga	
	Karambo	Busoro	Buyoga.	
MDUWAYEZU James 78	KARAMPA	Busoro	Buyoga	
DUSENGE	KARAMBO	BUSORO	Byogo	
mukarukanda 74	Karambo	Busoro	Buyoga	
Ngirumpatse 41	karambo	Busoro	Buyoga	
Mukandayambaje 40	karambo	Busoro	Buyoga	
Haragirimana 60	Kibanda	Busora	Buyoga	
Nyirabagenzi 30	Karambo	Busoro	Buyoga	
Mukamana 45	Karambo	Busora	Buyoga	
Mukantaganda 35	karambo	Busora	Buyaga	
Uwitugalibye 34	Karambo	Busora	Buyoga	
Bigirimana 25	karambo	Busora	Buyoga	
Singirankabo 30	Karambo	Busoro	Buyoga	
Mugabo 29	Karambo	Busora	Buyaga	



Consultation with LWH staff
Thursday 19th June 2014.

Name :	Position	Tel :	Signature
1. MUKAMURIGO Irène (mirene12@gmail.com)	Community dvpt officer (CDO)	0788668167	
2. UWANGARA MBE Martine (marcngaras@yahoo.fr)	Community dvpt officer (CDO)	0788475980	
3. MURERANGABO Yvon Thierry	Secretaire	0788859444	
4. UWAMUNDANE KARASIRA Fausta (komukafan@yahoo.fr)	(Monitoring & Evaluation officer)	0785452244	Fausta
5. NZARULINDA Jean d'Amour	(District Agronomist) Tel. 0788830691 Email: nzarulinda@gmail.com		

Interview with Local leaders

Tuesday 8th July 2014

1. MUJIJIMA Jurithe E.S Cyinzuzi Sector
0788630278

2. BENDA Théophile - CYINZUZI Sector Agronomist
0788354998

3. MUDUYEREZU Emilien - E.S BUKEMA SECTOR
0783392 136

4. KAGUMAGI Strator - BUKEMA Sector Agronomist

5- MUHIGIRA Antoine S/E Buyoga

6 MUKANAGA Béatrice Agronome Buyoga

7 NIZEYIMANA M. Chantal 0788462389
0788111395 Agronome Tumba

8. DUSENGIMANA Augustin E.S. Mbogo
0783392112

APPENDIX 3: CHECKLIST OF KEY GUIDING QUESTIONS

Checklist of Key questions upon which impacts of the project may be established are in the table below:

No			Yes
A- Physical and Biological environment-will the LWH Muyanza site project:			
a)	Is the irrigation scheme dependent on water from the River Muyanza or is there an alternative source?		
b)	What kind of soils, vegetation, terrain is in the area? How suitable is it for the proposed irrigation scheme?		
c)	Any likely water sources around? Any likelihood of the project affecting or contaminating them?		
d)	Poor drainage that might eventually influence the risk of water-related diseases such as; malaria or bilharzia?		
e)	Operate within a fragile ecosystem areas (e.g. forests, wetlands) or threatened species?		
f)	Likelihood of soil salinity from Irrigation?		
g)	Any risks leading to increased soil degradation or erosion?		
h)	Impact on the quantity or quality of surface waters (e.g. Lakes, rivers, wetlands), or groundwater (e.g. springs)?		
i)	During construction and implementation any chances of solid or liquid waste production? Proposed disposal or treatment means?		
B- Socio-economic environment/ Impacts - LWH Muyanza site project:			
a)	Influence of the project on public health, proper sanitation and any other health facilities such as; medical insurance "Mituelle"?		
b)	Influence of the project on the education sector, through school construction, ability of farmer to afford school fees for their children?		
c)	Is the project going to facilitate off- farm agricultural activities?		
d)	Is its location around an area where there is an important historical, archaeological or cultural heritage site?		
e)	Is its location within or adjacent to any areas that are or may be protected by government (e.g. national park, national reserve, world heritage site) or local tradition, or that might be a natural habitat?		
f)	Depend on water supply from an existing dam, weir, or other water diversion structure?		
g)	Will the project displace homesteads, commercial centres, or individual plantations?- Voluntary and Involuntary resettlement		

Sociologist Interview Questionnaire

- **Interview guide with Local Population**

- Have you ever been told that the irrigation project for horticulture crop production? *Mwigeze mubwirwa ko hari umushinga wo kuhira ibihingwa?*

- How do you appreciate this project? *Uyu mushinga murawumva mute?*

- Do you think that some of the population will be displaced due to that project? If yes, are they already informed? *Ese mubona hari abaturage bashobora kuzimurwa? Niba bahari barabimenyeshejwe?*

- Are there school infrastructures and health centers? *Hano amashuri n'amavuriro arabegereye?*

- Don't you see any effects due to irrigation activities such malaria? *Ubu buryo bagiye kuzatega amazi bayagomera mubona nta ngaruka bizabagiraho? Ese nta malaria bishobora kubatera?*

- What are the main activities activities that enable you to earn money in this District? *Ni iyihe mirimo mufite yinjiza mafaranga?*

- Has you land been registered? *Ese ubutaka bwa hano bwose bwarabaruwe?*

- Do you think that this project will improve your living conditions? *Mubona uyu mushinga wo gutunganya igishanga no guhinga igihingwa kimwe hari icyo uzahindura ku mibereho yanyu ya buri munsi?*

- What are the consequences of the displacement of the population due to the project? *Ni izihe ngaruka zaba hari abaturage bimuwe kubera gahunda yo gutunganya iki gishanga?*

- Have you ever cultivated horticultural crops? If yes, where? If no, why? *Mwaba mwarigeze muhinga imbuto nibindi nkabyo? Niba ari yego, hehe? Ryari? Kuki mwabiretse? Niba ari oya. Kubera iki?*

- Do you see any consequences on your lives by project? *mubona hari ngaruka uyu mushinga uzagira ku buzima bwanyu?*

- There some insects that appreciate such crops, don't you see any effects due to these insects on your lives? *Ko hari udukoko n'udusimba twinshi dukunda ibibihingwa, ntidushobora kugira ingaruka ku buzima bw'abaturiye iki gishanga?*

- What can you suggest LWH that this project may be useful for your families? *Ni iki mwasaba LWH kugira ngo uyu mushinga uzagirire rwose akamaro imiryango yanyu?*

- **Interview guide with LWH staff**

- Are the population aware on the project of dam construction and development of irrigation infrastructure for increased crop production? If yes, when? If no, why? *Ese abaturage bagejejweho mbere gahunda yo gutunganya imirima nama terasi nokuhira kumi sozi? Niba ari yego, ryari? Niba ari oya, kubera iki?*

- Are they people who will be displaced due to the project ? *If yes are they informed? Ese hari abagomba kwimurwa kubera iyi gahunda? Niba ari yego, Abagomba kwimurwa barabizi?*

- The labor force who will be used in this project, are they from this area or elsewhere? *Ese abakozi bazakenerwa muri uyu mushinga bava muri aka gace cyangwa ahandi?*

- Does the project have a time limit? *Gahunda yo guhinga kuma terasi no kuhira imisozi ni gahunda izahoraho? Cyangwa ifite igihe izamara.*

- If there is any problem that affect the population due to this project, who will be responsible of that? *Ese hagize ikibazo kivuka kibangamiye abaturage ku mitunganyirize y'igishanga, ubwo byabarwa kuri nde?*

- Have you ever thought about the market for horticulture production? *Ese uyu mushinga utekerezwaho, mwatekereje n'aho abaturage babona isoko ryo kugurishirizamo ibibihingwa?*

- How can you assure the population that the project will improve the living conditions of the population? *Ni ikihe cyemezo mwaha abaturiye uyu mushinga ko wazazamura imibereho yabo?*

Interview guide with local authorities

- Have you ever been told that this project? *Mwigeze mubwirwa uyu mushinga?*

- How do you appreciate this project? *Uyu mushinga murawumva mute?*

- Do you think that some of the population will be displaced due to that project? If yes, are they already informed? *Ese mubona hari abaturage bashobora kuzimurwa? Niba bahari barabimenyeshejwe?*

- What are the main activities that enable you to earn money in this District? *Ni iyihe mirimo mufite yinjiza mafaranga?*

- Do you think that this project will improve the population living conditions? *Mubona uyu mushinga wo gutunganya igishanga no guhinga igihingwa kimwe hari icyo uzahindura ku mibereho y'abaturage banyu?*

- How many cooperatives or associations are they in this cell or sector? *Hari amacooperatives angahe cyangwa ama associations angahe muri aka kagari cyangwa umurenge?*
- What are the main activities in those cooperatives or associations? *Ayo makoperative cg amasosiations yibanda ku yihe mirimo?*
- How women or girls are represented? *Ubwitabire bw'abadamu muri aya makoperative buhagaze bute?*
- What are the main problems that face those cooperatives? *Ibibazo amakoperative akunze guhura nabyo ni ibihe?*
- What are the consequences of the displacement of the population due to the project? *Ni izihe ngaruka zaba hari abaturage bimuwe kubera gahunda yo gutunganya iki gishanga?*
- Are the population aware on the project of dam construction and development of irrigation infrastructure for increased crop production? If yes, when? If no, why? *Ese abaturage bagejejweho mbere gahunda yo gutegura ama terasi no kuhira imisozi? Niba ari yego, ryari? Niba ari oya, kubera iki?*
- If there is any problem that affect the population due to this project, who will be responsible of that? *Ese hagize ikibazo kivuka kibangamiye abaturage ku mitunganyirize y'igishanga, ubwo byabarwa kuri nde?*
- Have you ever thought about the market for the suggest crop production? *Ese uyu mushinga utekerezwaho, mwatekereje n'aho abaturage babona isoko ryo kugurishirizamo icyigihingwa?*
- How can you assure the population that the project will improve the living conditiond of the population? *Ni ikihe cyemezo mwaha abaturiye uyu mushinga ko wazazamura imibereho yabo?*
- How this project will help specifically vulnerable people of this Sector? *Ese uyu mushinga wo gutunganya iki gishanga by'umwihariko uzamarira iki abatishoboye?*
- How are you going to face the problem of students drop out due to looking for job? *Muzahangana mute n'ikibazo cy'abana bava mu mashuri bajya gushaka akazi mu mirima y'imiceri?*
- What can you suggest LWH that this project may be useful for your families? *Ni iki mwasaba LWH kugira ngo uyu mushinga uzagirire rwose akamaro imiryango yanyu?*

- **Interview guide with Cooperative or NGO members**

- How many cooperatives or associations are they in this cell or sector? *Hari amacooperatives angahe cyangwa ama associations angahe muri aka kagari cyangwa umurenge?*

- What are the main activities in those cooperatives or associations? *Ayo makoperative cg amasosiations yibanda ku yihe mirimo?*

- How women or girls are represented? *Ubwitabire bw'abadamu muri aya makoperative buhagaze bute?*

- What are the main problems that face those cooperatives? *Ibibazo amakoperative akunze guhura nabyo ni ibihe?*

- Do you think that horticultural crops and other food crops are convenient to replace your common local crops? *Mubona ibi bihingwa bya simbura ibyo mwari musanze muhinga?*

- Have you ever been told that this project? *Mwigeze mubwirwa uyu mushinga?*

- How do you appreciate this project? *Uyu mushinga murawumva mute?*

- Do you think that some of the population will be displaced due to that project? If yes, are they already informed? *Ese mubona hari abaturage bashobora kuzimurwa? Niba bahari barabimenyeshejwe?*

- Don't you see any effects due to irrigation activities such malaria? *Ubu buryo bagiye kuzatega amazi bayagomera mubona nta ngaruka bizabagiraho? Ese nta malaria bishobora kubatera?*

- Has you land been registered? *Ese ubutaka bwa hano bwose bwarabaruwe?*

- Do you think that this project will improve your living conditions? *Mubona uyu mushinga wo gutunganya igishanga no guhinga igihingwa kimwe hari icyo uzahindura ku mibereho yanyu ya buri munsi?*

- What can you suggest LWH that this project may be useful for your families? *Ni iki mwasaba LWH kugira ngo uyu mushinga uzagirire rwose akamaro imiryango yanyu?*

APPENDIX 4: MATRIX ANALYSIS

Impacts Analysis

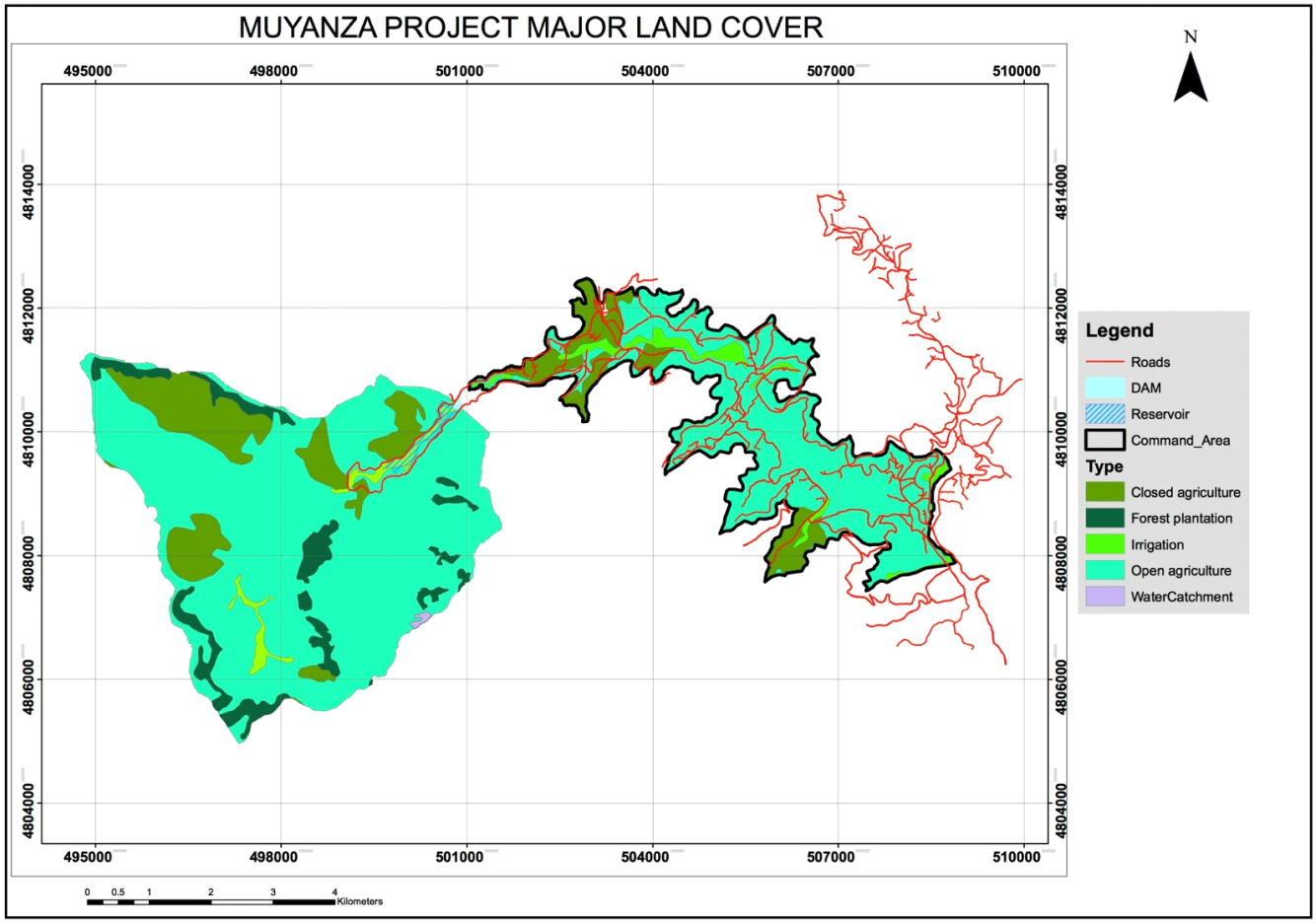
Environmental Impact	**Impact type**									
Muyanza irrigation development site	***Positive***		***Negative***						**Mitigation**	
1. Land husbandry terraces and Construction of the dam and development of the marshland for Irrigation	***Significant***	***Not significant***	***Significant***	***Not significant***	***Short term***	***Long term***	***Irreversible***	***Cumulative***	***Required***	***Not required***
Increase of production from farming all year through (all season)	**X**									**X**
Effective use of Muyanza hillside project area	**X**									**X**
Market access for agricultural products	**X**									**X**
Collective harvest for large quantities and market continuity	**X**									**X**
Increased crop yield	**X**									**X**
Affordability of education	**X**									**X**
Affordability of medical insurance	**X**									**X**
Employment creation	**X**									**X**
Transfer of skills during the construction phase	**X**									**X**

Soil conservation through land husbandry	**X**									**X**
Improved soil fertility	**X**									**X**
Agricultural Intensification	**X**									**X**
Increased Livestock fodder	**X**									**X**
Food security	**X**									**X**
Poverty Alleviation	**X**									**X**
Improved nutrition	**X**									**X**
Land Appreciation	**X**									**X**
Empowerment of farmers	**X**									**X**
Reduction of soil fertility parameters due to terracing			**X**		**X**				**X**	
Gradual soil acidification										
Oil spillage resulting in soil and water contamination			**X**		**X**	**X**		**X**	**X**	
Air and Noise pollution			**X**		**X**				**X**	
Soil Erosion and land slides			**X**			**X**	**X**	**X**	**X**	
Fire Outbreak			**X**		**X**		**X**		**X**	
Loss of biodiversity on hillsides and valleys			**X**			**X**		**X**	**X**	
Loss of land, houses and crops			**X**			**X**		**X**	**X**	
Income loss from missed season cultivation			**X**			**X**		**X**	**X**	
Injuries from construction works and borrow pits			**X**			**X**		**X**	**X**	
Diseases from interactions of construction activity			**X**			**X**		**X**	**X**	

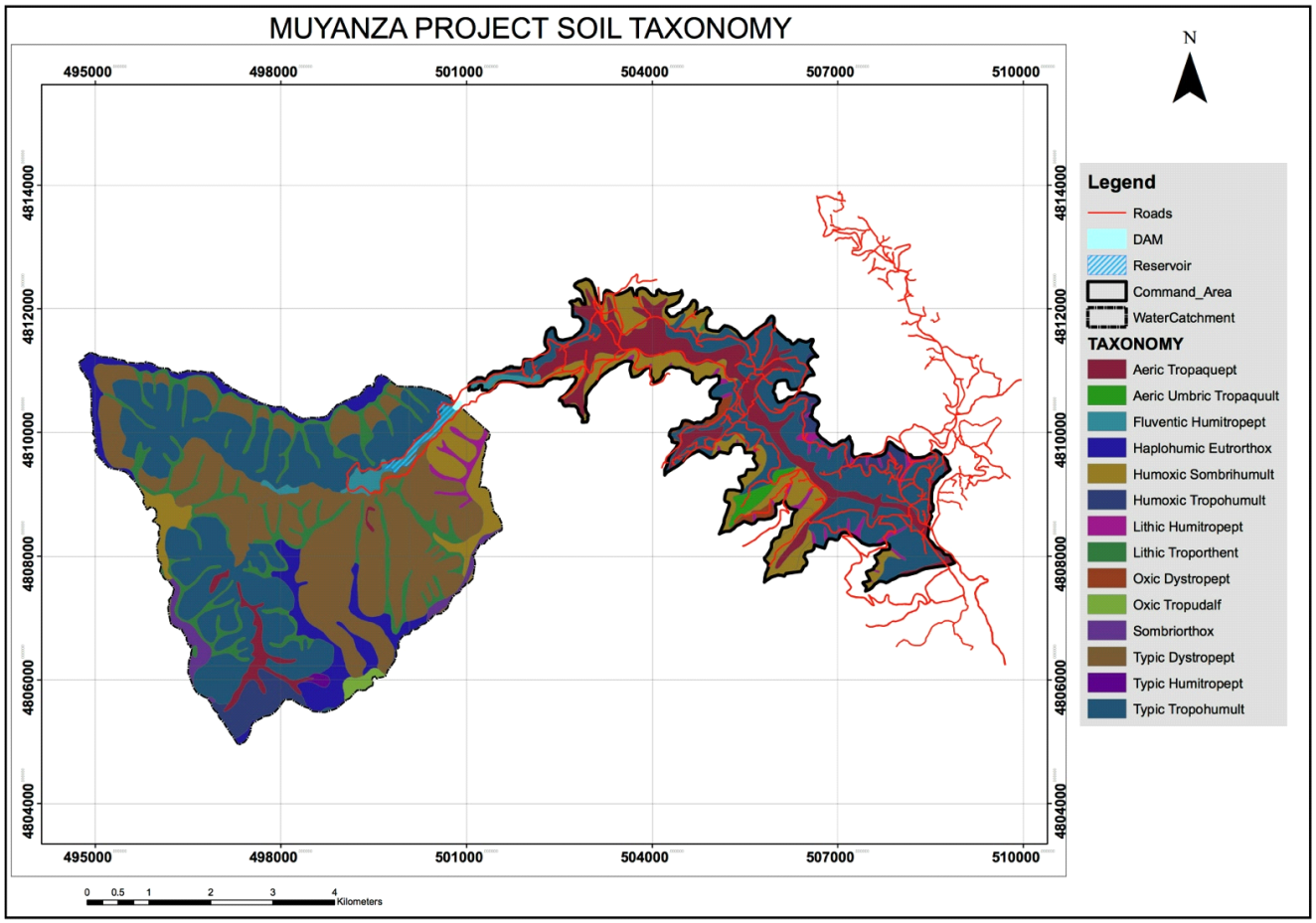
Loss of public infrastructure; power lines, portable water points and roads			**X**			**X**		**X**	**X**	
Water contamination at compost sites			**X**			**X**		**X**	**X**	
Modification of flows for downstream usage			**X**			**X**	**X**	**X**	**X**	
Water pollution by fertilizer and pesticide application			**X**			**X**	**X**		**X**	
Water logging and salinization			**X**			**X**		**X**	**X**	
High sedimentation levels			**X**			**X**		**X**	**X**	
Clogging and damage of irrigation infrastructure due to water nature and quality			**X**			**X**		**X**	**X**	
Water loss from evaporation and leakage			**X**			**X**		**X**	**X**	
Reduction of aquatic life due to reservoir eutrophication			**X**			**X**		**X**	**X**	
Loss of existing river biodiversity due to changes in water temperature.			**X**			**X**		**X**	**X**	
Loss of income source of people dependent on brick making and sand mining in the command area			**X**			**X**		**X**	**X**	
Health hazards from poor pesticide and fertilizer application.			**X**			**X**		**X**	**X**	

Water conflicts from the creation of irrigation scheme			**X**			**X**		**X**	**X**	
Vandalism of irrigation infrastructure			**X**			**X**		**X**	**X**	
Floods from reservoir over flow or pipe cuts			**X**						**X**	
Increased spread of Water related diseases			**X**			**X**		**X**	**X**	
Encroachment of the reservoir and primary emissary			**X**			**X**		**X**	**X**	
Abandoned Infrastructure			**X**			**X**	**X**		**X**	
Dust and noise pollution from demolition activities			**X**		**X**				**X**	
Contamination and impaired environment			**X**			**X**		**X**	**X**	
Loss of livelihood			**X**						**X**	

APPENDIX 5: MUYANZA LAND COVER MAP



APPENDIX 6: MUYANZA SOIL TAXONOMY



APPENDIX 7: TERMS OF REFERENCES

Background

The Government of Rwanda is pursuing a comprehensive Poverty reduction program which includes development and implementation of different sustainable development projects. The Land husbandry, Water harvesting and Hillside irrigation (LWH) Project is one of the development initiatives designed under the Ministry of Agriculture and Animal Resources (MINAGRI) and partly funded by the World Bank in order to tackle the issues related to food insecurity and rural communities livelihoods income.

The Project uses a modified watershed approach to introduce comprehensive and improved land-husbandry measures for hillside agriculture intensification. It also involves developing hillside irrigation for sub-sections of each site. The Project envisions the production of high-value horticultural crops with the strongest marketing potential on irrigated portions of hillsides of the watershed as well as the production of food crops and tree/shrub products on rained parts of the catchments.

It is in this regard that the Project will invest in water harvesting infrastructure, including water reservoirs construction and water conveyance at Muyanza (Rulindo district) site to enhance irrigated agriculture.

Although most project impacts are expected to be positive, some of the proposed civil works will have negative environmental and social impacts .

Therefore, this activity requires the preparation of an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP) in compliance with World Bank safeguards policies and National EIA regulations. For the purposes of this assignment, "environment" is defined as the biophysical environment, human uses of that environment (e.g. farming, fishing), and cultural property as defined in World Bank OP 4.11 Physical Cultural Resources. The EIA will be prepared in accordance with the requirements of (i) Article 67 of the Organic Law N° 04/2005 of 08/04/2005 determining the modalities of protection, conservation and promotion of environment in Rwanda; and (ii) applicable World Bank safeguard policies, especially OP 4.01 Environmental Assessment, OP 4.04 Natural Habitats, OP 4.09 Pest Management, OP 4.37 Safety of dams, OP 4.36 Forests and OP 4.12 Involuntary Resettlement. The objectives of the EIA are to ensure environmental due diligence according to Rwandan Law and the Safeguard policies of the World Bank.

OBJECTIVES OF THE ASSIGNMENT

The objective of the assignment is to assist MINAGRI/LWH to develop an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP) to ensure that the Muyanza sub-project are implemented in an environmentally and socially sustainable manner and in full compliance with Rwanda's and the World Bank's environmental and social policies and regulations.

The specific objectives are: (i) to assess the potential environmental and social impacts of the LWH Project's proposed irrigation and land husbandry infrastructure development in Muyanza site, whether positive or negative, and propose mitigation measures which will effectively address the impacts; and (ii) to inform the project preparation process of the potential impacts of different alternatives, and relevant mitigation measures (including implementation requirements).

BASIC DATA FOR MUYANZA SITE IN RULINDO DISTRICT

Water catchment: **25.04 Km^2**
Dam Height: **26 m**
Command Area: **Gross command area: 1030 ha 920ha net command area**
Canal: Total **canal** length **42 km / Pipe: 26km**
Reservoir area: **2.2 Million m^3**

- **SCOPE OF ASSIGMENT**

The present terms of reference were designed to guide the study for Environmental Impact Assessment of the works related to the construction of Dam and Hillside Irrigation Infrastructures at Muyanza site for the account of LWH following the conditions and the requirements of these terms of reference. The present study will consist of collecting and analyzing available data using appropriate techniques to achieve the goals of this consultancy. It will come up with realistic proposals and recommendations after consultations with Rwanda Development Board (RDB), REMA, MINAGRI, Districts authorities and LWH. The EIA study team will carry out environmental analysis and planning to support land husbandry and irrigation developments that:

- Realize agricultural benefits while improving catchment ecological services (eg. water retention, downstream flood mitigation, biodiversity) within and around the site;
- Minimize potential adverse environmental health impacts (eg. malaria, bilharzias, etc.) and pollution (runoff of fertilizers and pesticides, etc.)
- Assess climate change effects/impacts related to the proposed project and propose mitigation/adaptation measures.
- Conduct a cumulative impact assessment of irrigation projects in Rulindo District.
- Identify opportunities and provides specific measures for the conservation or restoration of ecological services (eg. water retention, downstream flood mitigation, biodiversity) within and around the site;

- Provide design and operation measures to minimize the risk of pollution and environmental health impacts;

The EIA study team will also provide an environmental management plan that:

- prescribes other mitigation measures needed to ensure long-term subproject sustainability, including institutional capacity building for environmental management at all levels, public safety measures during construction and operational phases of the project, management of domestic water sources, cattle watering facilities on hillsides, etc. and,
- Outlines indicators and sets up a monitoring program to track agricultural and environmental and social performance of the target watersheds and implementation of the mitigation measures for the refinement of future management action as required.

In order to gather the required data, field surveys in Muyanza site and their surrounding catchments will be required. This will be done in close collaboration with LWH, MINAGRI, Rwanda Development Board (RDB), and other project stakeholders. In each site, the study will include mapping sensitive natural habitats and important ecological conservation zones and working with SPIU RSSP/LWH Environmental Officer, RDB and REMA to consider alternatives and what irrigable hillside conservation zones can be retained and/or enhanced around and within each subproject. All site locations must be described fully with clear maps to make the task of planning and monitoring easier during the implementation of the mitigation measures for the identified impacts. The study will also contain a socio-economic baseline to present any social risks relevant to the project.

To carry out this study, the selected firm will conduct assessment of any type of environmental and social adverse impacts on physical and/or human environments. This includes, but not limited to:

- Water level in the affected waterways
- Water pollution
- Public safety
- Effects on Natural Habitats
- Change in land use,
- Soils and terrain,
- Vegetation,
- Flora and fauna,
- Hydrology and hydrogeology
- Aquatic resources,
- Physical cultural resources, and

- Socio-economic resources
- Construction Phase impacts: air quality, human health, noise, etc.

In addition, the selected firm will analyze available project alternatives to ensure sustainable water provision to the irrigated hillside for at least two seasons of crop production per year.

The selected firm will conform to the regulations of Rwanda Environmental Management Authority (REMA) regarding EIA process in Rwanda and will prepare the EIA in compliance with World Bank Operational Policies, especially OP 4.01 Environmental Assessment, OP 4.04 Natural Habitats, OP 4.37 Safety of dams, OP 4.36 Forests and OP 4.09 Pest Management.

Hillside irrigation activities in Muyanza site may have potential adverse impacts on the environment. The present Terms of Reference were prepared not only to guide the evaluation of extent of negative impacts of the project on the environment, but also to identify realistic measures capable to avoid, reduce, compensate or mitigate the identified negative impacts during implementation of the project.

The evaluation of potential impacts will therefore include the following: magnitude of impact, geographic extent, duration and frequency, and degree to which the impacts are reversible or irreversible.

3.1. Legislative Requirements of EIA

Requirements for EIA include identification of relevant legislations and guidelines (local, National, World Bank, as well as international) in line with environmental impact assessment for irrigation projects. This should include appropriate norms and standards for irrigation projects.

- **Review of Baseline Data**

Assemble, evaluate and present baseline data on the relevant environmental characteristics of the Project area. Include information on any changes anticipated before the project commences. Include the following information:

(a) Physical environment: geology; topography; soils; climate; ambient air quality; surface and ground-water hydrology; ecological flow analysis for existing streams, existing water pollution discharges; and receiving water quality.

(b) Biological environment: flora; fauna; rare or endangered species; sensitive habitats, including parks or preserves, significant natural sites, etc.; species of commercial importance; and species with potential to become nuisances, vectors or dangerous.

(c) Socio-economic environment (include both present and projected where appropriate): population; present land use; planned development activities; community structure; employment; distribution of income, goods and services; recreation; public health; cultural properties.

(d) Analysis of interactions likely to occur with all activities in the vicinity and cumulative impacts on the environment.

- **Description of the project**

Detailed project description covering the area of influence (spatial and temporal boundaries), location, layout, different activities related to the project etc:

- Project size and land requirement
- Description of all activities associated with all development stages from conception to closing, staffing and employment related to each phase of the project,
- Description of all equipments associated with all development stages of the project
- Description and estimation of water requirements, water availability, nature and quantities of wastes generated in different phases of the project and description of wastes disposal plans, etc.

- **Public consultation**

The firm will propose, for LWH approval, a thorough program of consulting the public during the detailed EIA study. The purpose of this consultation program will be to assist LWH to both inform all interested parties about the subproject and to solicit their views about it. Specifically, the Consultant will propose an effective, comprehensive public consultation strategy which includes at least:

- A list of stakeholders or audiences to be consulted;
- Methods for reaching these stakeholders/audiences;
- The scheduling of consultation activities; and
- How the consultation efforts will be analyzed and used.

The consultant shall provide evidence of public consultation including but not limited to munities, signed list of participants, photos and outcome of consultations. The consultations should be conducted twice for these project sites: first time when the initial screening and scoping is completed; then, after the draft EIA/EMP is developed.

After consultations are conducted, key points should be incorporated into the draft EIA/EMP reports. EIA/EMPs should, in turn provide recommendations to the project design.

- **Impacts prediction and analysis**

This will consist of identifying and describing adverse impacts as well as environmental risks associated with the execution of the proposed project. The study will be particularly focused but not limited to the following parameters:

- **Site selection and screening**

In this section:

- Describe how project sites are selected and screened.
- Prepare site selection criteria for sites that have not yet been identified.
- Develop a methodology and tools for screening chosen sites for potential negative environmental and social impacts.

- Develop suitable screening procedures to assess the possibility of involuntary resettlement or displacement arising from construction of infrastructure or civil works.

Possible criteria include:

- Impact of dam construction on public infrastructure (roads, electric wires, channels, burrow areas, terraces, farm plot developments, changed water management regime, fertilizer and pesticide use, etc.);
- Social impacts related to the displacement of the people and livestock (flooded zones, silt trap zone and the command area to be developed) ; potential employment opportunities (with indication if the opportunities are temporary or permanent),
- Impacts on flora and fauna, particularly on endangered species, if relevant;
- Impacts on cultural heritage, such as archeological sites, graves, sacred places/objects, if relevant;
- Waste management: opportunities got re-use or recycling of construction waste such as mixture of cement concrete, pieces of timber, etc.;
- Soil erosion, infiltration of water into the irrigation channels and disturbance of the vegetation.

- **Water supply**

Assessment of possible impacts on the quality and nature of the water source and water supply include:

- Impacts related to the nature of water source, its quality, conveyance techniques towards irrigated land;
- Changes in the natural hydrology of the rivers and water courses ;
- Changes in the temperature of water affecting the ecosystems associated with water resources;
- Impacts of increased salinity on the soil surface affecting sustainable agricultural production if not properly managed;
- Impact related to the establishment of irrigation systems likely to affect environmental characteristics of irrigated agriculture;
- Impacts related to water losses in the conveyance system which may increase the hydrostatic level;
- Impact related to the combination of poor quality of water supply system and increased hydrostatic level which may affect the sustainability of the irrigation system;
- Impacts related to water discharge and water extraction from the river which in the absence of a specific study, may lead to the trans-boundary impact affecting neighboring countries.

Water management techniques:

Possible impacts to be screened for with regard to water management techniques include:

- Increase in soil salinity resulting from high ground water tables, poor drainage and over-irrigation.
- The puddles of water likely to occur due to an excessive or poor irrigation water management;
- The commercialization of agricultural inputs and produce may lead to mobile sources of water pollution (agrochemicals including fertilizers and pesticides) ;
- The high concentrations of nitrate or other chemicals in the drinking water;
- The increased incidences of malaria and schistosomiasis, cholera, typhoid, dysentery, especially in the irrigation channels and water reservoir;
- Detailed soil survey will be conducted to determine whether the soil of the command area is suitable for the horticulture production; etc.

Analysis of alternatives:

- Describe alternatives that were examined in the course of developing the proposed Project and identify other alternatives which would achieve the same objectives. The concept of alternatives extends to siting, design, technology selection, construction techniques and phasing, and operating and maintenance procedures. Compare alternatives in terms of potential environmental and social impacts, capital and operating costs, suitability under local conditions, and institutional, training, and monitoring requirements.

To the extent possible, quantify the costs and benefits of each alternative, incorporating the estimated costs of any associated mitigating measures.

Include the "no project" alternative, in order to demonstrate what would reasonably be expected to occur to environmental and social conditions in the foreseeable future, based on existing ongoing development, land use, and regulatory practices and other relevant forces.

- **Mitigation Measures**

Recommend feasible and cost-effective measures to prevent or reduce significant negative impacts to acceptable levels and enhance positive impacts.

Provide a detailed description for appropriate reduction and compensatory measures as well as the design and the description of equipment and operational procedures (considered relevant) to respond to those impacts or to avoid or reduce the risks with the cost associated.

Describe and precise roles and responsibilities of different actors to be involved in effective implementation of the proposed mitigation measures.

Explain how the project would comply with the requirements (including consultation) of the Bank's Environmental Assessment Policy (OP 4.01) and the environmental requirements of other applicable Safeguard policies (e.g., Natural Habitats (OP 4.01), Forests (OP 4.36), Involuntary

Resettlement (OP 4.12), Cultural Property (OP 4.11), Pest Management (OP 4.09), and Safety of dams (OP 4.37).

The mitigation measures will consider but not be limited to the following

- Policy interventions;
- Role of expertise and technology;
- Role of system management;
- Role of irrigation/agricultural practices;
- Socio-economical impacts.

Environmental Management Plan (EMP):

Prepare an Environmental Management Plan (EMP) including proposed work programs, budget estimates, schedules, staffing and training requirements, and other necessary support services to implement the mitigating measures.

The Environmental Management Plan includes the following components:

Mitigation

The EMP will be presented in tabular form and covers all anticipated significant adverse impacts, mitigation measures, implementation schedule and highlights the responsibility of people and institution involved as well as the costs required.

Monitoring

The monitoring section of EMP, presented in tabular form, provides a specific description and technical details of monitoring measures including the parameters to be measured, methods to be used, frequency of measurements, responsibility of different actors involved in effective implementation of the proposed mitigation measures especially at lower level and an estimation of the cost of the implementation of the proposed mitigation measures.

4. REPORTING

4.1 Reporting requirements

The findings of the reviewed relevant literature and field visits will be compiled into separate reports, i.e. 1 report per site. Each report will be based on the above terms of reference and will be submitted to LWH in three printed copies, along with an electronic copy on CD, for evaluation and approval. The report will be presented to the public during consultative sessions involving relevant stakeholders for their views on the report.

The following format is suggested for the EIA report:

Executive summary

This concisely discusses significant findings and recommended actions.

Introduction :

- Background to the project

- Objectives of the study
- Methodology

Policy, legal, and administrative framework

This part discusses the policy, legal, and administrative framework within which the EA is carried out. This should include both national and international legislations.

Baseline data

This section assesses the dimensions of the study area and describes relevant physical, biological, and socio-economic conditions, including any changes anticipated before the project commences. It also takes into account current and proposed development activities within the project area but not directly connected to the project. Data should be relevant to decisions about project location, design, operation, or mitigatory measures. The section indicates the accuracy, reliability, and sources of the data.

Project description.

This part concisely describes the proposed project activities and its geographic, ecological, social, and temporal context, including any offsite investments that may be required (e.g., dedicated pipelines, access roads, power plants, water supply, housing, and raw material and product storage facilities). It indicates the need for any resettlement plan with a map showing the project site and the project's area of influence. It provides detailed information on the following:

- Location of the study area and description of the current use of the location, project objectives and size;
- Detailed description of the project, extent in time and space;
- Description of activities related to all implementation stages from the inception, staffing and employment related to different stages of the project;
- Description of all activities and farming techniques to be used during all farming seasons of the year;
- Description of all activities which will follow from the execution of the project (construction of road, ware house etc);
- Description of prevention and security measures, water and energy supply, wastes treatment and evacuation.

Analysis of alternatives

This section **s**ystematically compares feasible alternatives to the proposed project site, technology, design, and operation--including the "without project" situation--in terms of their potential environmental impacts; the feasibility of mitigating these impacts; their capital and recurrent costs; their suitability under local conditions; and their institutional, training, and monitoring requirements. For each of the alternatives, quantifies the environmental impacts to the extent possible, and attaches economic values where feasible.

It states the basis for selecting the particular project design proposed and justifies recommended emission levels and approaches to pollution prevention and abatement.

Environmental and Social impacts Analysis

This part predicts and assesses the project's likely positive and negative impacts, in quantitative terms to the extent possible. It explores opportunities for environmental enhancement, identifies and estimates the extent and quality of available data, key data gaps, and uncertainties associated with predictions, and specifies topics that do not require further attention. The impact analysis will also include climate change impact and mitigation/adaptation measures.

The impact is assessed by:

- Nature (positive/negative, direct/indirect)
- Magnitude (severe, moderate, low)
- Extent/location (area/volume covered, distribution)
- Timing (during construction, operation etc, immediate, delayed)
- Duration (short term/long term, intermittent/continuous)
- Reversibility/irreversibility
- Likelihood (probability, uncertainty)
- Significance (local, regional, global)

For each identified impact, the consultant shall propose mitigation measures and at the end of this chapter a summarized table should be established.

Environmental Management Plan (EMP) and Monitoring plan:

This section includes two components: Environmental Management Plan (EMP) and monitoring plan (MP). The EMP and MP should be presented in tabular format.

- **EMP:** for each project phase(planning phase, construction phase and operation phase) an Environmental Management Plan is present and should include and not limited to:
    - Activity
    - Adverse impacts of the subproject;
    - Proposed mitigation measures,
    - Implementation schedule;
    - Responsibility of people and institution involved
    - Occurrence/incidence
    - Estimate of the costs required

Monitoring plan:

- Activities
- Parameters to be measured
- Indicator
- Method used to measure the parameter

- Frequency of measurements
- Responsibility of people and institution involved
- Estimate of the costs required

Conclusions and Recommendations

The report should also include all information necessary to the project review such as lists of data sources, project background reports and studies, and any other relevant information to which the developer/consultant's attention should be directed. It should provide also detailed designs/plans of construction, the water canalization and waste water treatment systems, etc.

References

These are written materials both published and unpublished used in the study preparation.

Appendices

- List of EIA report preparers –individuals and organizations
- Record of interagency and consultation meetings, including consultations for obtaining the informed views of the affected people and local non Governmental organizations (NGOs). The record specifies any means other than consultations (e.g. Surveys) that were used to obtain the views of the affected groups and local NGOs.
- Tables, maps presenting the relevant data referred to or summarized in the main text.

4.2 Report presentation and Deadlines

Draft report of the EIA for each site will be presented within 45 calendar days from the date of signing the contract by both parties. LWH will have 5 calendar days to check the document and request some modifications on it. The modifications to be made on the document will be submitted to the consultant in writing and must be integrated during the editing of the final version. The final version of EIA report for each site will be presented within 15 calendar days after submitting the comments to the consultant**.** LWH will have 5 working days to check the documents. The final draft EIA report will be sent to World Bank for review and request some modifications on it, if any. The consultant will have 5 days calendar to incorporate all comments from World Bank. The Final version of the EIA report for each site will be presented in 3 printed copies and one CD.

While conducting this assignment, the firm will be requested to present to the client a monthly progress report. However, the client may request the firm at any time to present any desired clarification about the progress of the assignment when it is determined to be necessary.

The final reports of the EIA will be submitted to RDB for approval and the World Bank for no objection. In the event RDB or the World Bank require some clarifications to be made on the report, the consultant holds the responsibility to address issues raised until the Certificate of approval is issued.

Once reports are approved, they will be disclosed in Rwanda and submitted by the GoR to the Bank for disclosure through the World Bank InfoShop, according to Bank policy on Access to Information.

5. QUALIFICATIONS AND EXPERIENCE REQUIRED

5.1 Qualifications and experience required for the firm

The firm to be qualified for this study will have a vast experience in consultancy services with at least 2 references in Environmental Impact Assessment studies related irrigation infrastructure water management and other public infrastructures.

5.2 Qualifications and experience required for the key personnel

To realize this assignment, the selected firm will recruit competent and qualified personnel with proven experience in similar services. Key personnel needed for this study by **the firm** will have the minimum qualifications below:

- Team Leader with minimum Masters Degree in Environmental Science or related fields and with a background in soil and water management for the Assessment of Impact on the Environment,
- Ecologist or specialist in Biology (Botany or Zoology) with minimum Bachelor Degree to evaluate potential impacts of the project activities on the flora and fauna of the project site and its surrounding, and propose alternatives;
- Specialist in Soil management with minimum Bachelor Degree to analyze potential impacts of the project activities on soil of the command area and its surrounding, and propose the alternatives;
- Hydrologist or Water resource management Specialist with minimum Bachelor Degree to assess impacts on water resources due to water consumption, and downstream impacts on water regime.
- Specialist in sociology or related fields with minimum Bachelor Degree to evaluate potential impacts of the project activities on socio-economic conditions of the population in the study areas.

The key personnel must have the following minimum experience:

(i) The Environmental Specialist (Team leader) for Environmental Impact Assessment (E.I.A): Experience in environmental studies*:* 5 years; specific experience: 5 references in Environmental Impact Assessment.

(ii) The Ecologist or specialist in biology (botany or zoology): experience in the domain of ecology: 5 years; specific experience: 2 references in Assessment of Impact of project activities on the flora and flora

- *(iii) The Soil Scientist:* experience in soil studies: 5 years; specific experience: 2 references in assessment of impacts on soil resources due to land husbandry works, irrigation, use of chemicals;
- *(iv) The Hydrologist or water resource management specialist*: experience in the domain of hydrology: 5 years; specific experience: 2 references in assessment of impacts on water resources due to water consumption, and downstream impacts on water regime;

(v) The Specialist in sociology or related fields: experience in the domain of social studies: 4 years; specific experience: 2 references in Assessment of Impact of project activities on the socio-economy.

Notes:

- ***The firm must attach the certificate of completion for each reference;***
- ***The key personnel must attach the CV, notified degree and completion certificate for each reference.***

6. STUDY DURATION AND LEVEL OF EFFORT

The assignment will last for two months and involve approximately 40 man days of Consultant

APPENDIX 8: PROFILES OF THE PARTICIPATING CONSULTANTS

SONGA Silvin- holds a MSc in Environmental Science and Technology and BSc in Civil engineering. He has over 7 years professional experience in the field of environmental assessment and management and 10 years professional experience in civil works, construction related fields and public procurement. He has worked on various projects as team leader of the Environmental Assessment, projects in sectors such as; Irrigation projects, green house agriculture, mining projects, road and bridge construction projects, building and house constructions, schools and hospitals, among others.

Basalirwa Brenda- holds a MSc in Water resources engineering and a BSc in Civil Engineering. She is a Water Resources Engineer with over 11 years' experience in planning, management, design and construction supervision of water resources infrastructure; with proven skills in project and contract management, general program co-ordination, monitoring and evaluation. Skilled in climate change impact assessments and analysis including statistical downscaling of GCMs and mainstreaming of downscaled results into water resources development projects. Conversant with water resources studies, Environmental and Social Impact Assessment Studies, hydrological, hydrodynamic and groundwater modelling, GIS & remote sensing.

Prof. Naramabuye Francois Xavier- holds a Phd in Science and Agriculture sciences, MSc in Applied environmental soil science and BSc in soil science and Rural engineering. He has over 15

years of experience in studies involving soil science. He is senior lecturer in the department of soil science for the University of Rwanda (UR).

KALIBANA Marara Celestin- holds a MSc in Biology and BSc in Botany. He has over 15 years' experience as a consulting Ecologist in mainly Environmental Assessment assignments. Assignments that included; marshland rehabilitation for purposes of large scale agriculture of rice, rehabilitation of 17 inland lakes and their watershed areas in Rwanda, water supply projects, road construction and other commercial buildings.

Nyiransabimana Venantie- holds a MA in Gender and Development and BA in Sociology and is currently completing a PhD in Gender. She has 7 years' experience as a consulting sociologist in environmental assessments of marshland rehabilitation projects for agricultural purposes, socio-economic assessments for rural development projects that involve; feeder road rehabilitation, school construction, rural electrification, water projects, among others.