NILE BASIN INITIATIVE

Nile Equatorial Lakes Subsidiary Action Program

Kagera River Basin Management Project

FEASIBILITY STUDY FOR *KARAZI* WITHIN THE FEASIBILITY STUDIES FOR 4 SMALL MULTIPURPOSE DAMS IN THE KAGERA RIVER BASIN

FEASIBILITY STUDY REPORT - Final version

DECEMBER 2012

TRACTEBEL Engineering GDF SUEZ *acting under the commercial trademark of* COYNE ET BELLIER Ingénieurs Conseils

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Project : **Feasibility studies for 4 small multipurpose dams in the Kagera River Basin**

Subject : **Feasibility Study Report – Final report about Karazi site in Tanzania**

Comments : **The following names will be used from now for the 4 dam sites: Taba-Gakomeye in Rwanda, Karazi in Tanzania, Buyongwe in Burundi, and Bigasha in Uganda**

This report includes the detailed findings of the various water use and water demand studies, the environmental and social examination and the detailed technical, financial and economic assessment of Karazi selected dam site.

This study was carried out by Tractebel Engineering with the following contributions:

- CACG (compagnie d'aménagement des coteaux de Gascogne) for all the study about irrigation ;
- GEOGEOPHY for all the geophysical investigations ;
- Southern Mapping Company for all the aerial survey (LiDAR);
- Technical Resources Services for the studies about geotechnical investigations, socio-economic survey, water supply, aquaculture and livestock watering studies as well as economic and financial analysis.

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FEASIBILITY STUDIES FOR 4 SMALL MULTIPURPOSE DAMS IN THE KAGERA RIVER BASIN
Feasibility Study Report for Karazi dam

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INITIALS AND ACRONYMS

ASTER	Advanced Space-borne Thermal Emission and Reflection Radiometer
CDC	Community Development Committee in Rwanda
CWR	Crop Water Requirement
DEA	Directorate of Environmental Affairs in Uganda
DEM	Digital Elevation Model
DRC	Democratic Republic of Congo
EAC	East African Community
EBCR	Economic Benefit to Cost Ratio
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
ENSAP	Eastern Nile Subsidiary Action Program
ESIA	Environmental and Social Impact Assessment
ETo	Potential Evapotranspiration
FWL/FSL	Full Water Level/ Full Supply Level
GIS	Geographic Information System
GPS	Global Positioning System
GWh	Giga Watt hour
HH	Household
HSS	Hydro Steel Structure
HV	High Voltage
ICOLD	International Commission on Large Dams
IESE	Initial Environmental and Social Examination
IMP	Irrigation Management Plan
IWR	Irrigation water requirement
IWRM	Integrated Water Resources Management
KRBMP	Kagera River Basin Management Project
kV	Kilo Volt
LiDAR	Light Detection And Ranging
LSU	LiveStock Unit
LVBC	Lake Victoria Basin Commission
LVEMP	Lake Victoria Lake Victoria Environmental Management Project
MAF	Mean Annual Flow
MAR	Mean Annual Runoff
MINAGRI	Ministry of Agriculture and Animal Resources of Rwanda
MININFRA	The Ministry of Infrastructures of Rwanda
MINIRENA or MINELA	The Ministry of Natural Resources of Rwanda
MOL	Minimum Operating Level

Mm3	Million Cubic Meters
MW	Mega Watt
MWL	Maximum Water Level
NBI	Nile Basin Initiative
NEA	National Environment Act in Uganda
NEL-COM	Nile Equatorial Lakes Council of Ministers
NEL-CU	NELSAP Coordination Unit
NELSAP	Nile Equatorial Lake Subsidiary Action Program
NEL-TAC	Nile Equatorial Lakes Technical Advisory Committee
NEMA	National Environmental Management Authority in Uganda
NEMC	National Environment Management Council of Tanzania
NGO	Non-Governmental Organization
NWL	Normal Water Level
O&M	Operation and Maintenance
OP	Operational Policies
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PMU	Project Management Unit
REMA	The Rwanda Environment Management Agency
RGPH	Recensement Général de la Population et de l'Habitat General Census of Population and Habitat
RN	Cote de Retenue Normale Full Water Level
SAP	Subsidiary action program
SRTM	Shuttle Radar Topography Mission
SSR	Sequential Steam flow Routing
SVP	Shared Vision Program
ToR	Terms of Reference
TIWRMD	Trans-boundary Integrated Water Resources Management and Development
UICN	Union Internationale pour la Conservation de la Nature International Union for Nature Conservation

EXECUTIVE SUMMARY

The project area is located in Nyakakika Ward, Nyabiyonza Division, in Karagwe District of Kagera Region. The dam site is located on a seasonal River, the Karazi stream, between Chabuhora and Kayungu villages This River is an affluent of the Kagera River.

The aim of the study was to undertake the feasibility study for a dam with emphasis on agricultural development (irrigation, livestock and fisheries production), water supply, energy and other uses.

The first investigations gave the following results:

- The topographical survey was undertaken to produce rectified colour images and a digital terrain model (DTM) of the dam site and the potential irrigation area. Digital colour images were also taken and rectified to produce colour orthophotos of the project area. The survey was flown at a height of approximately 800m and an image pixel size of 10cm has been produced. The results of such level of accuracy offered by the LiDAR survey were an asset for the performance of numerous engineering activities of this study including the irrigation study and the environmental and social studies. These results have led to review the topographical data of previous studies such as reduction the potential control area for irrigation.
- Geophysical investigations have checked the suitability of the selected site for the construction of the dam and appurtenant structures. The used methodology was the electrical resistivity techniques based on the response of the earth to the flow of electrical current. 2D geological profiles were generated with stratification and water table readily usable in the study. The investigation depth was about 25 meters.
- Complementing the geophysical investigations, the Consultant performed geotechnical investigations in the form of four test-pits dug to 4 to 8m depth in naturally consolidated soils in order to sample the composition and structure of the subsurface. The geophysical and geotechnical investigations have found that the overlaying material is suitable for dam core with 8 to 12 meters of black greyish stiff clay with high plasticity overlaying the bedrock in the project valley. On the banks, the thickness of the lateritic soils is reduced to approximately 5 meters.
- Karazi dam site is located about 1 320 m above sea level. The site is located in the lower part of the Kagera River basin also called the West Victoria Lake region. This zone is characterized by moderate relief and more arid conditions. The catchment area is 213 km². Average annual rainfall is about 919 mm with two rainy seasons with the peak occurring in April during the main rainfall period.
- There is no gauged station that could be used as a reference for the hydrological study. Approaches are very limited by the lack of data. As a consequence, inflows at dam site were estimated.
  - The annual runoff within the period 1962-2009 is about 0,95m^3/s, with a quite pronounced seasonal pattern due to arid conditions and dry periods without flows. The discharge is totally nil during the month of January and from June to August.
  - The net losses due to evaporation are about 8% of the annual inflow.

  - The annual sedimentation rate at Karazi site has been estimated about 0,11Mm^3 per year. Therefore, the outlet threshold has been set 5m above the minimum ground elevation, giving a dead storage is 4,12 Mm^3 representing more than 35 years of sedimentation storage.
- Based on an estimated water demand of 20Mm^3, the optimization of the reservoir capacity was carried out in order to determine what should be the reservoir capacity for the above water demand (0,63 m^3/s) with an acceptable deficiency (10%). It leads to determine a full supply level of 7,5 meters above the ground level given a guaranteed discharge equal to the water demand.
- Based on this above findings, an initial environmental and social examination has found that the main impacts could be:
  - the loss of water resources through evaporation, as the net losses due to evaporation are estimated to be about 8% of the annual inflow;
  - the loss of grazing land, as the reservoir will inundate an area of 271 Ha at Maximum Water Level, mainly dedicated to livestock;
  - the risk of poaching, as the access road (B182 road, non-asphalted) crosses the north-eastern part of the Burigi and Kimisi Game Reserve, 10 km from the dam site.

All the previous investigations led to carry out the detailed design scheme for Karazi dam with the following characteristics:

Dam Type	Homogeneous earthfill
Maximum height	9,50 m (from the natural ground level)
Crest length	518,74 m
Maximum width at NGL	57,75 m
Slope of upstream face	2.5H:1V
Slope of downstream face	2H:1V
Plan alignment	straight
Dam Crest level	1 323,50 m asl
Full Supply Level	1 321,50 m asl
Maximum water level	1 322,75 m asl
Minimum operational level	1 319,00 m asl

The cross section of the dam consists of homogeneous earthfill material protected by a layer of filter material which in turn is protected by 1,25m thick riprap on both upstream and downstream faces. An internal filter zone will accept seepage flows from fill materials without the build-up of excess hydrostatic pressure. The crest width is 6m, the upstream slope is 2,5H:1V, and the downstream slope is 2H:1V.

The uses of the dam could be as follows:

- Irrigation with a designed perimeter covering a geographical area of 570 ha, from which it is expected a reduction of approximately 6 % due to the right of way of canals and drains, leading to the net irrigated area estimated at 493 ha. The perimeter would cover a distance of 18 km between the dam and the downstream protection dyke, divided in 2 sectors, one of 248 ha directly supplied by the dam and the other of 245 ha which would need the construction of a diversion weir. As no river bed exists, it will be necessary to build a protection dyke and a channel on one side of the marshland to allow floods to pass through the irrigated perimeter without damaging it. A lot of crops and cropping patterns may be adopted. However, it is recommended beginning with only one rice crop per year with some proportion of maize and vegetables. Furthermore, some part of the perimeter could be dedicated to forage crops. It should be noticed that the irrigation water demand has been evaluated according to the worst scenario in terms of water demand: double rice cropping on the whole area.
- Water supply: The proposed scheme covers the following wards in Karagwe (including a newly created district): Nyakahanga, Bukangara, Ihembe, Nyakatuntu, Kakulaijo, Kiruruma, Part Nyakisimbi, Nyaishozi, Nyakabanga / Chabuhora, Nyabionza and St. Michael / Nyaishozi. About 24 106 households are expected to benefit from the project.
- Livestock watering: The design has been produced for 72 000 livestock units with 30 water points, each one with a capacity of 7 000 litres.
- Taking into consideration that aquaculture was expressed as a least priority water use by the local Authorities, that there is no use in the Project area for such activity, this activity could be developed at first as pilot project with 15 fish ponds.

The following summary presents the project with the dam construction estimated to 18M US$ as detailed in the following table.

	Cost US $
Preliminary works	2 426 544
Dam	13 857 588
Spillway	1 480 473
Bottom Outlet	134 785
Hydro Steel Structure Equipment	81 075
Total	**17 980 465**

The summary of costs for all the components of the project is included in the following table.

Water Use Component	**Capital Investment Costs US $ for the first stage**	**Capital Investment Costs US $ for the next stages**	**Capital Investment Costs US $ TOTAL**
Dam	17 980 000		17 980 000
Irrigation	5 332 000	6 004 000	11 336 000
Potable Water Supply	27 300 000		27 300 000
Livestock Water Supply	2 996 000	599 000	3 595 000
Aquaculture	672 000	1 824 000	2 496 000
Sub-total	**54 280 000**	**8 427 000**	**62 607 000**

The economic analysis is presented over 25 years to year 2037. Three economic indicators are calculated as follows:

- Economic Internal Rate of Return (EIRR) that has to exceed 12% the economic cost of capital,
- the Economic Net Present Value (ENPV) that has to be positive for a viable project, and,
- the Economic Benefit to Cost Ratio (EBCR) that has to be greater than unity 1.

The economic analysis for the multipurpose dam with the objectives of irrigation, water supply, fish ponds and livestock watering give the following results:

- EIRR: + 29,5%
- ENPV: US $ 49 507 000
- EBCR: 1,67

The economic analysis for different scenarios shows that the project is economically viable only if the water supply is part of the whole project.

Water supply show economic performances taking into consideration indirect revenues and collective increased incomes related to project nature and activities (such as time saving for fetching water, appreciation of land, economic growth and employment).

Irrigation project is not economically viable if implemented alone, due to the high cost of the irrigation scheme, because of the narrowness of the downstream valley.

1. INTRODUCTION

1.1. Preamble remarks

Following the inception mission, the names of the four dams have been renamed as follows:

- Taba-Gakomeye (Rwanda),
- Karazi (Tanzania),
- Buyongwe instead of Kiremba (Burundi),
- Bigasha instead of Omumukura (Uganda).

1.2. Background of the study

The Nile Basin Initiative (NBI) is a partnership of the riparian states[1] of the Nile, which endeavours to develop the River Nile in a cooperative way, to share socio-economic benefits, and to promote regional peace and security. The NBI's Strategic Action Program is composed of two complementary programs: the basin wide Shared Vision Program (SVP), which aims at building confidence and capacity all over the basin, and Subsidiary Action Programs (SAPs), which initiate concrete investments on the ground in the Eastern Nile and in the Nile Equatorial Lakes sub-basins.

The Nile Equatorial Lakes Subsidiary Action Program (NELSAP)[2] implements three river basin projects, among which the Kagera River Basin Management Project (KRBMP). Its objective is "to establish a sustainable framework for the joint management of the water resources of the Kagera river basin and prepare for sustainable development oriented investments, in order to improve the living conditions of the people and to protect the environment". The Kagera River Basin lies West and Southwest of Lake Victoria, and its total area of 59 800 km² is distributed among Burundi, Rwanda, Tanzania and Uganda. It has a population of nearly 15 million people.

The Kagera basin is characterized by a low productive peasant agriculture and water scarcity for grazing and household. In many places, the population pressure is increasing and triggers off land degradation, deforestation, loss of soil fertility and over exploitation of wetlands. Eventually, climate change and its various impacts are likely to make the situation even more stressful.

[1] Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. Eritrea is as an observer.

[2] The countries of the NELSAP: Burundi, DR Congo (DRC), Egypt, Kenya, Rwanda, Sudan, Tanzania, and Uganda.

The link between poverty and water scarcity is nowadays acknowledged and well known. According to the International Water Management Institute, the whole area is going to suffer from economic water scarcity in 2025. These countries could have enough water resources to meet their needs, only by setting up infrastructures and regulation systems. Hence, improving water infrastructures and management will be of a crucial importance.

Furthermore, agriculture remains the economic mainstay: there is an increasing need to develop irrigation in the area. As for livestock and aquaculture, they remained relatively underdeveloped in most of the places. Eventually, in rural areas, the population has a very low access to electricity and safe water supply, which dramatically impedes the development of the Basin.

Thus, to tackle the abovementioned basin issues, the NELSAP and the KRBMP procured Tractebel Engineering - Coyne and Bellier to undertake a feasibility study of 4 small dams, that is to say below 15m according to World Bank classification criteria, one in each country:

- Taba-Gakomeye dam in Rwanda,
- Bigasha dam in Uganda,
- Karazi dam in Tanzania,
- Buyongwe dam in Burundi.

This study is carried out in parallel with an Environmental and Social Impact Assessment (ESIA).

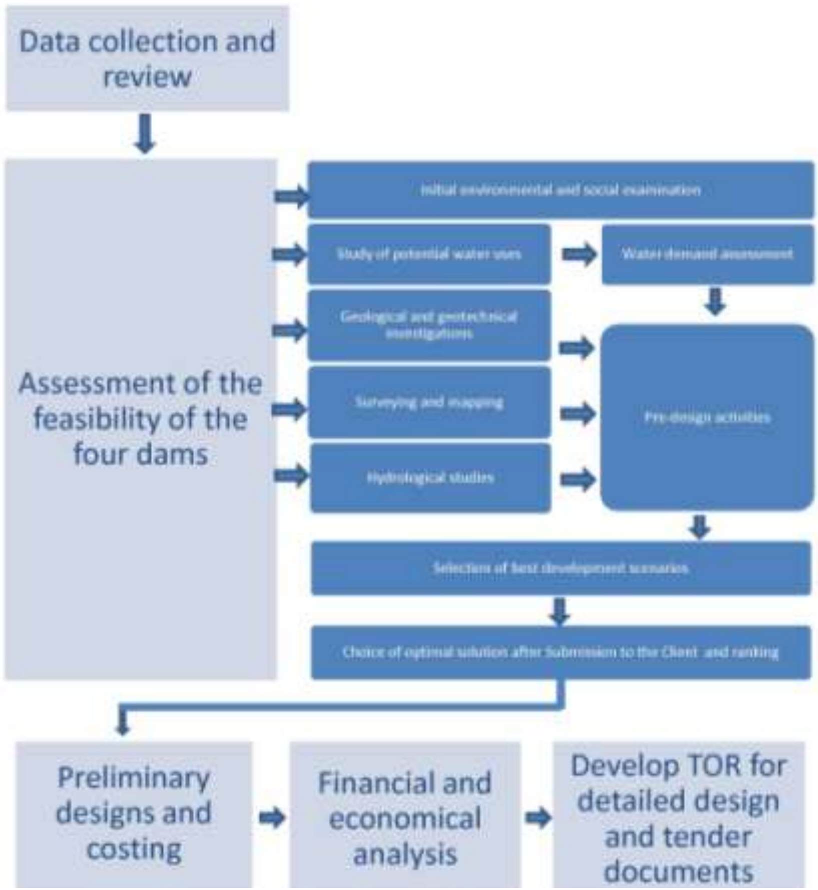
1.3. Study objective

According to the Terms of Reference (ToR), the following objectives for this study are as follows:

- To carry out detailed feasibility studies including preliminary designs and cost estimates for the four small dams, with emphasis on agricultural development (irrigation, livestock, aquaculture and fisheries production), water supply, energy and other uses, as found to be permitting;
- To undertake preliminary environmental and social examinations in order to comply with the international standards and environmental and social requirements of the national environmental management agencies and the World Bank's safeguard policies;
- To develop Terms of Reference for the detailed designs and tender documents for implementation of the selected projects.

To fulfil these objectives, the following activity flow chart (see Figure 1) has been followed all along the study.

Figure 1: Activity flowchart of the feasibility studies for Kagera Project



1.4. Place of the feasibility study report within the Project cycle

This report comprises, as requested by the ToR,

- The technical studies, including:
  - Description of multipurpose storage reservoir projects;
  - Design of the 4 selected dams' infrastructure and appurtenances;
  - Detailed technical, financial and economic assessment of the multipurpose dam sites; and
- The preliminary concept of a local water development program, including:
  - the detailed findings of the various water use studies regarding agriculture, fisheries, livestock, hydropower, water supply, etc;
  - the detailed findings of water demand assessment,
  - the recommended project implementation approach;
- The initial social & environmental examination of the projects;
- The terms of reference for the detailed designs and tender documents.

1.5. Main constraint in the project cycle

The inception report mentioned that one of the main issues was the Light Detection Aerial Ranging (LiDAR) topographical survey. The LiDAR survey was critical in the schedule of the Project in order not to delay the overall project activities.

Due to the constraint to get all the flight clearances for the aerial survey, the LiDAR survey results for Tanzania was received early April instead of February. It should be noticed that the interpretation of the data from aerial survey takes time. Thus, the uses of these data have delayed the overall study.

2. DESCRIPTION OF THE KAGERA PROJECT

2.1. Regional context

The countries of the NELSAP have identified a number of projects to promote poverty alleviation, economic growth, and reversal of environmental degradation in the sub-basin. The investments are grouped into two major programs: Natural Resources Management and development of projects, and the Power Trade and Development program. The two programs target investments in agricultural development, fisheries development, water resources management, water hyacinth control, hydropower development and transmission interconnection. The Natural Resources Management sub program consists of three Integrated River Basin Management projects, namely Kagera, Mara and Sio – Malaba - Malasiki River Basin Trans-boundary Integrated Water Resources Management and Development Projects. The Projects are aimed at poverty reduction and achieving socio-economic development through the rational and equitable use of the shared water resources of their respective River Basins.

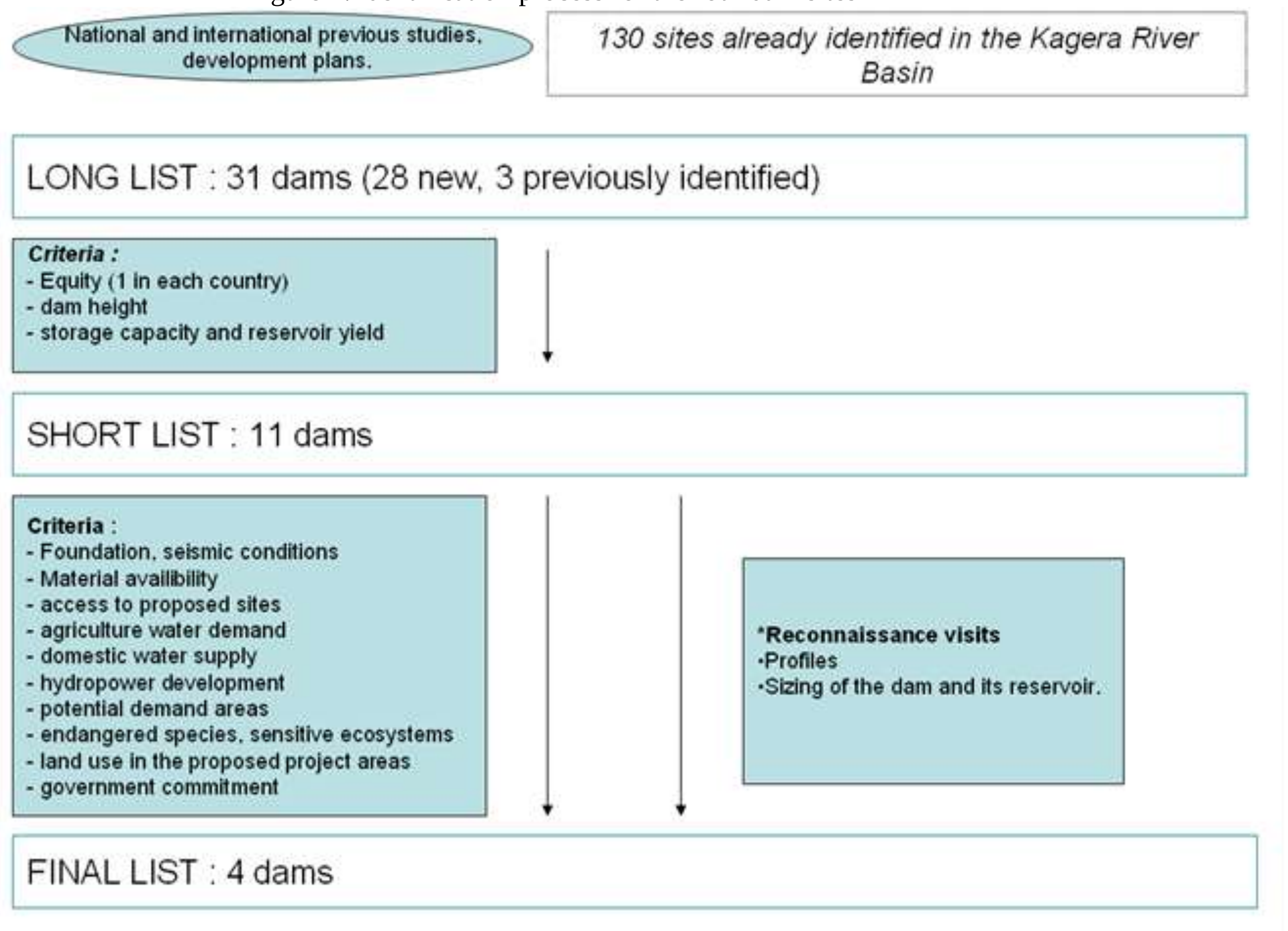
The project objective of the Kagera Trans-boundary Integrated Water Resources Management and Development Project is to establish a sustainable framework for management of water resources of Kagera River Basin, in order to prepare for sustainable development oriented investments that will improve the living conditions of people while protecting the environment.

The NBI/NELSAP has received grant financing from the World Bank Nile Basin Trust Fund towards preparation of a strategic portfolio of regional water resources investment projects in the Kagera River Basin and has applied part of the proceeds of this grant to undertake consultancy services for a feasibility study for development of four small multipurpose dams/reservoirs with emphasis on agricultural development (irrigation, livestock, aquaculture and fisheries production), energy, water supply and other uses, which is the purpose of this study.

2.2. Project history

The Kagera River Basin Management Project recently completed a study [a] for identification and rapid assessment of potential small dams for the multipurpose uses of agricultural development, hydropower generation, water supply, etc. The study identified 28 new dam sites and made preliminary assessment of 3 previously identified dams from the Rwanda Irrigation master plan. From this list of 31 sites, 11 sites were selected. From the shortlist of the 11 sites, after applying technical considerations, four sites, one for each country, have been finally selected. The scheme below highlights the identification process:

Figure 2: identification process for the four dam sites

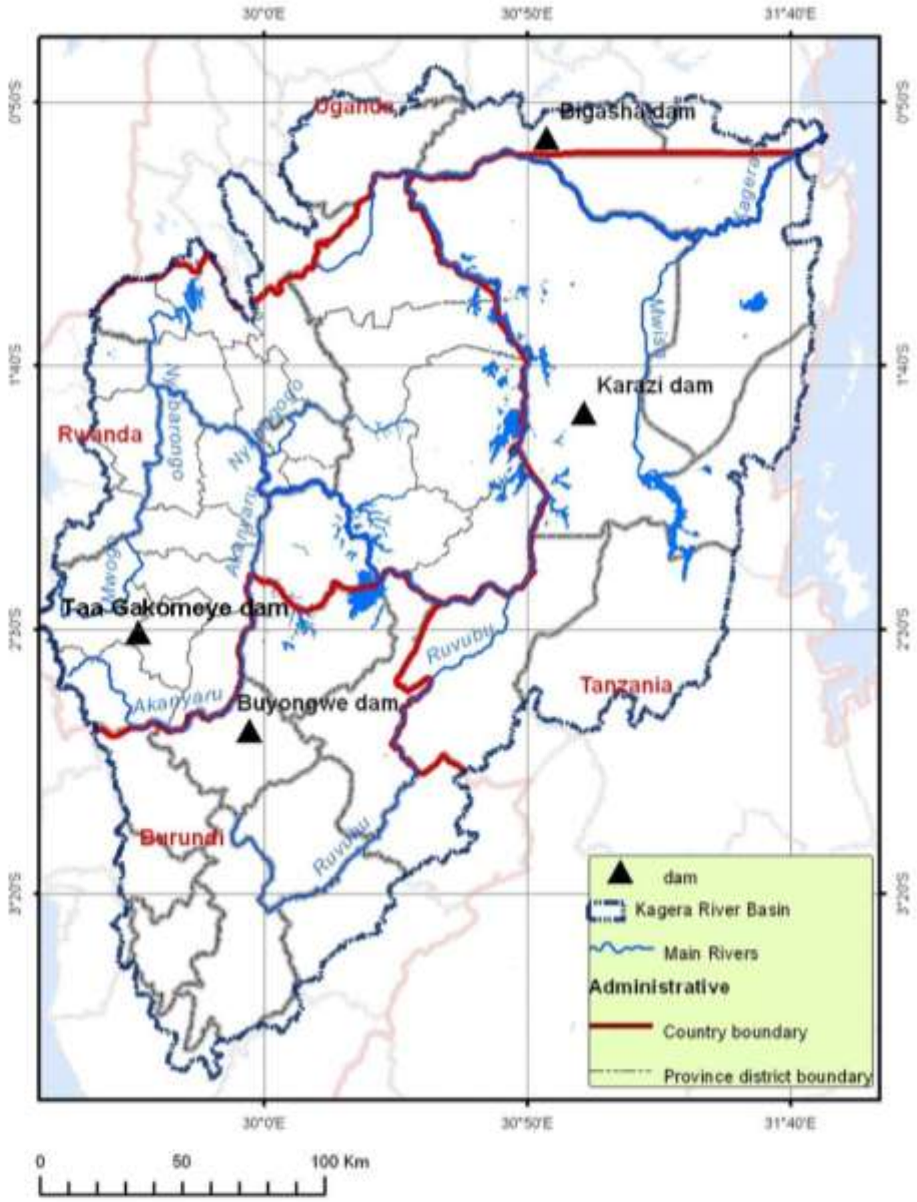


However, the study did not consider environmental and social economic considerations in the identification of the dam sub-projects. Thus, the aim of this present study is the feasibility studies for these four priority multipurpose dam sites, which study will assess the technical, social, economic & financial, and environmental viability of these multipurpose dam projects.

2.3. Location of the Project

The locations of the sites are shown on the following map within the Kagera River Basin.

Figure 3: location of the four sites within Kagera Project



Source: terms of reference of this study (from USGS-SRTM-NVE-CGIS-NUR)

The coordinates for the axis of each dam based on the terms of reference have been recorded as follows:

Table 1: Coordinates of the four dam sites

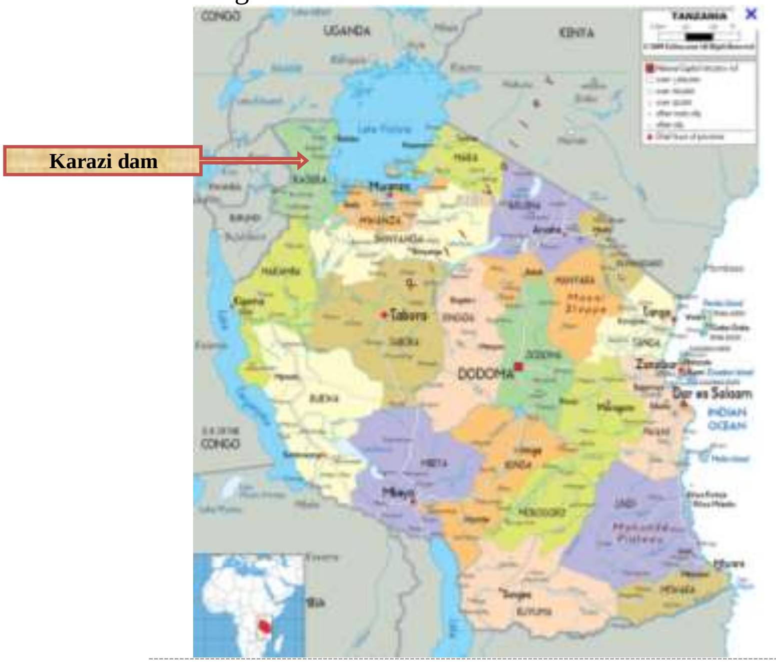
(WGS84 system)

Country	Dam site	Y (DD)	X (DD)	Z (m)
Rwanda	Taba-Gakomeye	-2,50775	29,60169	1659
Burundi	Buyongwe	-2,81669	29,95647	1382
Tanzania	Karazi	-1,82336	31,01526	1324
Uganda	Bigasha	-0,94818	30,89745	1261

2.4. Location of Karazi site

The United Republic of Tanzania is divided into 30 regions, which is divided in districts. The following map presents the different regions of Tanzania and the localisation of the Karazi dam.

Figure 4: Location of Karazi dam in Tanzania



Source: www.vidiani.com

The project is located in Karagwe district belonging to Kagera region situated in the North-Western corner of Tanzania. The regional capital is Bukoba Town, which is about 1 500 km from Dar Es Salaam by road. This region shares borders with Uganda to the North, Rwanda and Burundi to the West, the Kigoma and Mwanza Regions to the South and Lake Victoria to the East.

Karagwe District includes 40 Wards and 116 villages. It should be noticed that Karagwe District has been recently sub-divided into two namely Karagwe and Kyerwa districts.

The dam site is located on a seasonal River, the Karazi stream, between Chabuhora and Kayungu villages in Nyakakika Ward, Nyabiyonza Division, in Karagwe District of Kagera Region. This river is an affluent of the Kagera River.

The coordinates for the axis of the proposed dam have been recorded as follows:

Table 2: Karazi dam axis coordinates

DAM AXIS COORDINATES					
Karazi - Tanzania					
	31,01717	-1,82251	279427,29	9798435,78	Right
	31,0123	-1,82453	278885,57	9798211,78	Left

With the irrigation area, the whole project extends to Kibondo and Nyabiyonza wards of Karagwe and Kyerwa districts.

3. METHODOLOGY

This chapter will present the methodology used all along this report for each specific investigations.

3.1. Methodology for the LiDAR surveying and mapping

3.1.1. Context

The existing maps mentioned in the ToR are 1/50 000 scale (probably 10/15m interval isohyets) and therefore not usable as reference for the tasks under consideration, in particular for dam and appurtenant workings as well as for irrigation design.

A Light Detection And Ranging (LiDAR) survey was undertaken covering reservoir footprint and working areas as specified in the Terms of Reference. LiDAR is an optical remote sensing technology that can measure the distance to, or other properties, of a target by illuminating the target with light, often using pulses from a laser. Another advantage of this technology was the possibility of getting high definition aerial pictures which are of high interest for the social and environmental as well as for the irrigation studies.

3.1.2. Methodology

3.1.2.1. LIDAR POINT PROCESSING

For the purpose of processing the laser points, the ITRF2008 Geographical ellipsoidal coordinates were used. This is necessary as GPS works in the ITRF2008 datum with ellipsoidal heights.

The trajectory was calculated using *Precise Point Positioning* (PPP) as no base stations were occupied for the duration of the aerial survey. The trajectory for each flight was post processed using *Waypoint DGPS* software, which combines the 1 Hz GPS readings with the 200Hz inertial measurement system (IMU) readings and outputs a smoothed “best estimated” trajectory for the laser scanner and camera positions.

Following this, the laser points were processed into raw ENH points, using Optech’s *DASHMap* Survey Suite. The output was in the ITRF2008 UTM36 South projection but with ellipsoidal heights.

The final output is in the required ITRF08 UTM36 South projection, with orthometric heights based on the EGM2008 geoidal model.

3.1.2.2. LIDAR CALIBRATION

Overlapping LiDAR points from adjacent aircraft trajectories were used to check the LiDAR calibration for heading, roll, pitch and scale. These values were then used to make small flight-specific adjustments to the LiDAR data.

3.1.2.3. LIDAR POINT TRANSFORMATIONS

The LiDAR points were transformed from the ITRF2008 UTM36 South ellipsoidal coordinate system to the ITRF08 UTM36 South orthometric coordinate system using the EGM2008 geoidal model.

3.1.2.4. LIDAR POINT EDITING

A "1st run" automatic classification was carried out on the raw LiDAR points using *TerraSolid's TerraScan* software to separate the LiDAR points into ground hits and non-ground hits. This results in a greater than 95% correct classification. After this, a manual classification was done over the required area to edit the points with gross classification errors that may have occurred in the automatic classification process.

As requested, the points were also thinned into "key points":

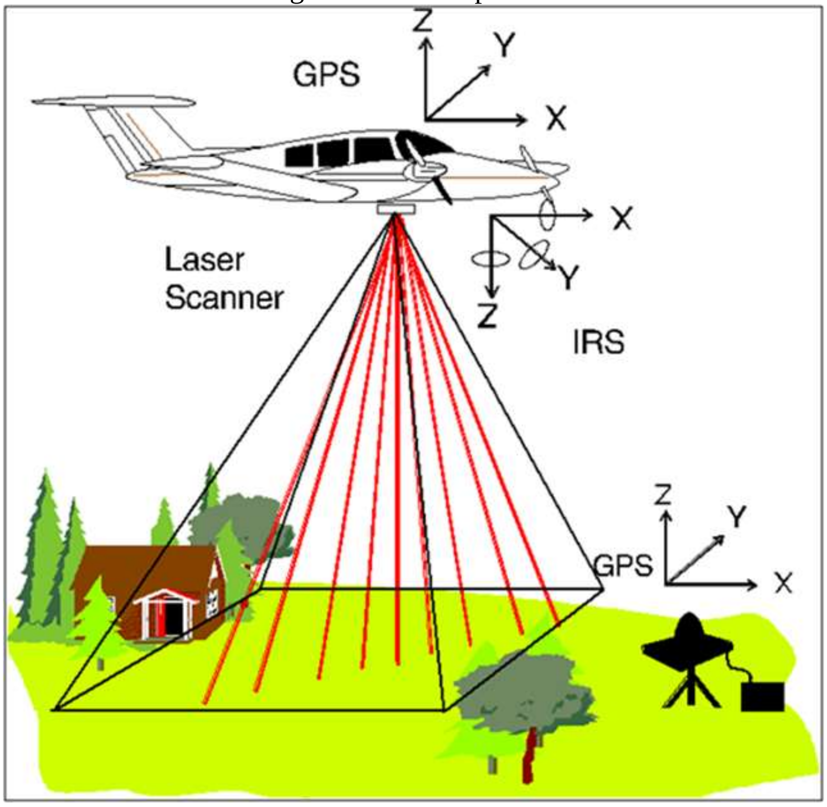
- *Ground* key points are defined in such a way that where a rapid change in elevation occurs, the density of the points is maintained and as such the slope is always well defined. However, where there is relatively little change in elevation the density of the points is reduced because of the fact that far fewer points are required to accurately define the surface.
- *Non-ground* key points are thinned in such a way that the density of point clusters, such as those that define a tree, will be reduced in a manner that still accurately defines the random shape. Points that define elements with a more linear (and less random) shape, such as a power line, will not be as extensively reduced however, so as to maintain the accuracy in the changes of elevation and position relative to the ground surface.

3.1.3. Results

The topographical survey was undertaken in Tanzania to produce rectified colour images and a digital terrain model (DTM) of the project area. The survey was carried out using an aircraft mounted LiDAR system that scanned the ground below with a 70 kHz LiDAR resulting in a dense DTM of the ground surface and objects above the ground as shown on the following figure.

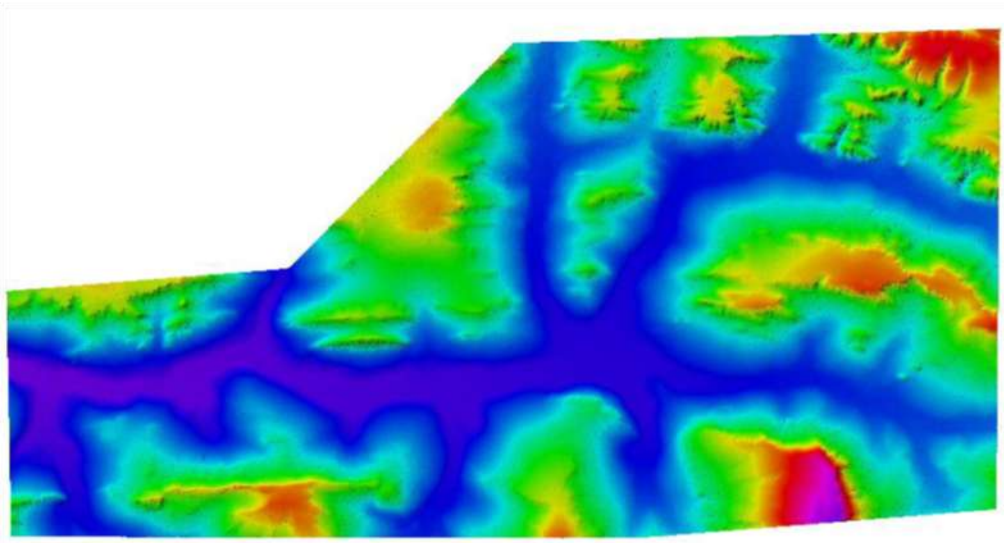
Digital colour images were also taken from the aircraft and rectified to produce colour orthophotos of the project area. The survey was flown at a height of approximately 800m and an image pixel size of 10cm has been produced.

Figure 5: LiDAR process



The project extent was defined on the basis of existing map as well as inception field mission. The shaded relief map for the project area is represented as follows.

Figure 6: Karazi site shaded relief map in Tanzania



Topographical maps based on the LiDAR data have been produced for the dam site (see maps in Appendixes).

The data could lead different type of topographical maps that has been used all along this report.

3.2. Methodology for the geophysical and geotechnical investigations

3.2.1. Introduction

Geophysical and geotechnical investigations have been performed geo-referencing the essential soil and rock features so as to establish the engineering properties of rocks and soils, check surficial deposits and reveal tectonic-structural patterns.

Geophysical investigations have checked the suitability of the selected site for the construction of the dam and appurtenant structures. The geotechnical investigation campaign gave a factual picture of the site and of their characteristics so that the setting out of the workings can be adapted.

3.2.2. Geophysical methodology

The geophysical investigations took place from the 21 to the 31 of January 2012. The methodology was based on electrical resistivity techniques which are based on the response of the earth to the flow of electrical current. Measurements are made by placing four electrodes in contact with the soil or rock. A current is caused to flow in the earth between one pair of electrodes while the voltage across the other pair of electrodes is measured. The depth of measurements is related to the electrode spacing. Several types of electrode configuration and survey geometry exist in resistivity measurements.

Figure 7: Measurements at site

A 2D resistivity profiling consists in a succession of vertical electrical sounding, but interpreted by inversion, with a calculation of the lateral and the topographical effects. In this case, the distance between two electrodes is 5 m on the dam site. The number of electrodes varies from 24 to 48. The investigation depth is about 25 meters.

In these geological contexts, refraction seismic is not adapted. The fresh rock, which is outcropping, presents a very fast velocity. If weathered rocks underlay, it is invisible. On the other hand, the resistivity method is able to visualise this possible geology. More, it is able to locate faults which are difficult to determine with the seismic refraction method.

3.2.3. Geotechnical methodology

In addition to the geophysical investigations presented above, the Consultant performed geotechnical investigations in the form of 10 test-pits dug to 5m depth in naturally consolidated soils in order to sample the composition and structure of the subsurface. The test-pits aim at complementing the geophysical investigations and at checking the potential permeability of the reservoir so that the geological hazards are mitigated.

The location of the test-pits were properly selected with the Geophysical Engineer and the Civil Infrastructure Engineer and recorded by GPS. The procedures and methods used in the profiling of the test pits adhere to internationally accepted codes.

Figure 8: Location of auger pits at Karazi dam site

Test pitting was undertaken manually to the maximum depth (about 5m) or refusal, whichever occurs first.

After excavation all test pits were photographed and profiled by a qualified engineering geologist. Soil samples were taken where required, following which test pits were backfilled:

- Soil Classification (5 samples per test pit):
    - Specific gravity
    - Sieve analysis

- Water absorption
- Silt content
- Moisture content
- Atterberg Limits

➢ Strength and Deformation Test (2 per pits):
- Direct Shear Test
- Compaction MDD
- California Bearing Ratio – 3 ptd 97% MDD
- Consolidation Test - Œdometer
- Permeability Test – constant Head

The Consultant identifies, geo-references possible source of construction materials and took samples for laboratory testing to assess their engineering properties. The aggregate tests (2 per quarry) will consist on:

- Los Angles Abrasion
- Aggregate Crushing Test
- Sodium Sulphate
- Specific gravity + Water Absorption
- Soluble salts
- Aggregate Impact Value
- Alkali reaction.

3.3. Methodology for the hydrological study

3.3.1. Context

The availability of hydrological records has conditioned the way of executing the studies: if no direct data is available, the determination of the classic parameters has been carried out by correlation to neighbouring known catchments or through internationally accepted methods.

The results included in this report are the main results for each site in order to understand the findings of the entire report. The hydrological report is annexed in the Appendix H.

3.3.2. Monthly discharge computation

For the proposed dam site at Karazi, no gauging station was identified in the vicinity of the site. The Consultant deduced the monthly discharge record from the discharge record computed at Bigasha dam site:

$$Q\ Karazi\ = \frac{Qyr\ (Karazi)}{Qyr\ (Bigasha)} \times Q(Bigasha)\ .$$

Results are discussed in the section dedicated to the inflows analysis.

3.3.3. Methodology for the sediment measurements

For the sedimentation issues, guidelines from World Meteorological Organization and Dr. Mkhandi S.H. report from Department of Water Resources Engineering recommended that the sampling points for suspended sediment have to be located at the hydrometric stations. Indeed, sediment measurements have to be coupled to discharge measurements to compute relationships between liquid and solid discharge measurements. A sediment measurement campaign will not be relevant without gauging.

Thus, in order to assess the sedimentation rate, the Consultant has used existing sedimentation data within the catchment area (see Appendix H).

3.3.4. Methodology for the optimization of the reservoir capacity

3.3.4.1. OBJECTIVE OF THE OPTIMIZATION

Dams mainly serve to ensure an adequate supply of water by storing water in times of surplus and releasing it in times of scarcity, thus also preventing or mitigating floods. Dams that have small storage capacity in relation to the gross Mean Annual Runoff (MAR) are known as “annual dams”. They are likely to fill from empty every year except the very worst seasons or even single floods.

The methodology adopted is a Sequential Steam flow Routing (SSR) and according to this method a continuity equation of the water volumes is applied to calculate reservoir levels and therefore reservoir volumes, evaporation and outflows from spillway and outlet structure.

The erratic inflow of the river passes through the storage reservoir will be delayed and attenuated as it enters and spreads over the reservoir surface. Water is then released through a controlled outlet.

The optimization consists of determining the minimum reservoir capacity which allows an average constant water release with an acceptable deficiency.

3.3.4.2. METHODOLOGY

The aim of the reservoir operation simulation is to determine the total reservoir capacity which will meet the downstream demand. The methodology used to perform the reservoir operation studies was as follows:

- A series of monthly water inflows at each dam site, over a number of years sufficient to be representative of the long-term flow pattern was established;
- The downstream water demand with the aim of allocated all inflows available was established;
- The balance between the water flowing into the reservoirs and the water flowing out of the reservoirs (water demand, spillage, and evaporation) was determined on a monthly time-step basis. The results of the balance are the volume and the levels of the reservoir at the end of each month, and the water provided to meet the demand.

- The simulations were performed assuming that the reservoirs capacity is constant throughout the whole period of simulation (38 years). Allocation for sediment storage has been taken into account by setting the outlet structure threshold above the dead storage level.
- A criterion defining the ability of the reservoirs to meet the water demand has been established. This criterion quantifies the frequency and the volume of shortfalls that might occur and answers the question regarding the risk of not meeting the demand. The definition of water demand shortfall (deficiency) is the number of month when the water demand is not satisfied divided by the total number of month of the simulation.

Several reservoir capacities were tested for which the deficiency has been evaluated. For each of those reservoir capacities, the discharge guaranteed 10% of the time has been computed.

3.4. Methodology to define the water uses and water demand

3.4.1. Methodology for the water demand

The chapter about water uses and water demand aims to describe at first the existing water uses in the Project area (irrigation, water supply, livestock watering, aquaculture, hydropower), then to assess the potential demand and finally check the technical and economic constraints of the associated installations and finally state about a feasibility development level for each potential water use.

3.4.1.1. IRRIGATION WATER DEMAND METHODOLOGY

Irrigation water requirement:

Irrigation water requirement (IWR) depends on several factors, including cropping patterns, crop-growth periods, crop coefficients (Kc), potential evapotranspiration (ETo), effective rainfall and deep percolation for rice paddies.

Irrigation water requirement is calculated by multiplying crop area and crop water requirement (CWR) of respective crop. Crop water requirement is usually measured in terms of evapotranspiration and depends on climatic conditions and constraints in each area. The irrigation water requirement for each crop is estimated as follows:

$IWR = \Sigma Crop\ Area \times [CWR - Effective\ rainfall]$

CWR of the paddy crop is estimated as:

$CWRrice=[\Sigma(KcricexETo+ Deep\ percolation]$

Crop water requirement (CWR) for other crops is estimated as:

$CWRother\ crops=\Sigma(Kcother\ crops\ xETo$

Water demand forecasting for irrigation:

Agricultural water demands are primarily a function of the following:

- Meteorological conditions;
- Crop type;
- Cropped area for each type of crop;
- Type of irrigation method and irrigation efficiencies;
- Water charges (to be discussed with the local Authorities).

In estimating future agricultural demands the changes in one or more of the above factors must be predicted. Owing to the potential for changes in the future and the relatively few variables, component analysis is the forecasting methodology likely to yield the best results.

Component analysis is a forecasting method based upon the usage of water by individual components. The expected trends in water demand of each component (e.g. changes in irrigation technology, climatic changes, crop type and irrigation area) should be analysed separately and the overall result assessed.

Meteorological conditions are yet changing due to the effects of global warming. For agriculture, the basic factors are rainfall and evaporation rate. As rainfall decreases and/or evaporation rates increase, the irrigation needs increase or vice versa.

Changes in crop type may also have a significant impact on water demands, which may or may not be positive. High value crops such as bananas and garden vegetables generally have higher water requirements than, for example, grain crops.

Changes in cropped area may either be a difference in total surface, if new land is developed or cultivated land becomes fallow, or be the result of variations of crop type, if the surface of one crop type is changed to accommodate changes in another type.

Losses and inefficiencies usually account for a significant proportion of total irrigation requirements both for lack of proper drainage and for improper technologies. Their impact may be alleviated through various improvement programmes and the specialist will have to determine the chances and extent of these.

Creating water user associations can also affect water demand and use. The main purpose behind water user associations is to assure better access to water and unbiased equity in distribution. Hence, while water user associations are beneficial in many ways, their establishment may increase water demands. Water charges have a significant impact on water demands because of the incentive to reduce waste in water application, though consideration must be given to willingness to pay and ability to pay on the part of the water users (but this would not be applicable to the conditions prevailing in the four sites concerned).

Changes in irrigation technology may also affect the water demand. Modern technologies that deliver water to the plant more efficiently reduce overall demand by diminishing field losses and non-beneficial evapotranspiration.

Improvements of water management and irrigation system operation at field level also reduce irrigation water use by improved efficiency and reduced losses.

Other means of limiting agricultural water uses is practising new techniques such as precision irrigation and deficit irrigation, though the aptitude of farmers to adopt such techniques must be assessed and assistance extension services supplied if too low.

3.4.1.2. WATER SUPPLY DEMAND METHODOLOGY

Water supply requirement:

In general estimating rural water demand and use is difficult because the majority of rural domestic water supply systems are manpowered or unmetered, data concerning domestic rural water demand and use is often expensive and time consuming to collect and the level of service provided by the water supply system is often unknown.

There are two key methods of assessing rural domestic demand and use. These are:

- Indirect methods, where the quantity of water consumed is calculated from population levels and estimated demand levels in terms of per capita consumption;
- Direct methods where socio-economic surveys and participatory techniques involving the relevant stakeholders are used to estimate the current and future water demand and use.

The Consultant has followed indirect approach which is considered as the most practical method. For such approach, the following information is required:

- Population data;
- Per capita water demand;
- Unaccounted for water levels i.e. the difference between the total quantity of water abstracted and the quantity of water consumed.

Forecasting water supply demand:

Historical information for domestic water demand and use in rural zones is unlikely to be available. This means that it is impossible to directly assess the future rural domestic water demand and use through trend analyses. The two most important factors that affect future domestic water demand and use are:

- Population growth (the annual ratio of the area is very high);
- Change in the level of service due to an upgrading trend in the water supply needs.

Population growth can be estimated from national, regional or local trends. It should however be noted that improvements in infrastructure, such as multipurpose water schemes, may step up the population growth above the average.

Upgrading of water supply schemes and the consequential changes in the level of service are difficult to predict. It has been postulated that the upgrading of rural water supply schemes is related to Tariff levels where distribution metered network can be planned (in suburban zones).

For sake of simplicity and accounting for the inaccuracy of statistical data, the Consultant will make assumptions concerning the upgrading (e.g. from a reservoir connection to a communal borehole to house connection).

The increase in water demand may also be estimated from other areas where similar upgrading of the water and sanitation infrastructure has occurred.

Tanzanian Water Design Manual provides following data per capita demand based on levels of service. The following table has been finally adopted for this assignment.

Table 3: Water supply data per capita demand

Water Supply	Urban	Peri-urban	Rural
Communal Water Points / others	30%	60%	80%
Yard Taps	20%	20%	20%
Multiple Taps House Connection	50%	20%	0%

This document provides as well the levels of services, based on affordability, meaning income levels. The following table provide the level of services per capita demand.

Table 4: Level of services per capita

Levels of Services	Litres / person / day
Communal Water Points / others	25
Yard Taps	70
Multiple Taps House Connection	150 for high income 100 for middle income as a mean – 120 lpd

On these data, it is normal practice to add 30% to the domestic water demand for non-domestic demand.

This Manual in Section 4.7 reports as well system losses that have to be accommodated for in the production end. It states that the 25% is grossly underestimated. For piped system therefore, a 30% is added to total water demand for losses.

Table 4.21 of the Manual gives peak day factor for various users varying between 1.00 and 1.50 and the weighted one normally used is 1.15, as the climate variance is not significant in the tropical climate.

3.4.1.3. WATER DEMAND FOR LIVESTOCK

Water requirement for livestock:

The livestock water requirement is estimated by multiplying the number of livestock animals times the water use per head of livestock (Litre/day per animal).

Water demand forecasting for livestock:

The forecasting of the future water demand for livestock will be primarily based on the assumption that the water use per head is kept constant (according to the breed and purpose of the stock) and the livestock number is projected on the base of the growth trend in past years.

Section 4.6.4 of *Tanzanian Water Supply Design Manual* is dedicated for livestock water demand assessment. The livestock unit is defined as follows:

One Livestock Unit (LSU) is equivalent to:

- one head of cattle
- 2 donkeys
- 5 goats or sheep

- 30 heads of poultry (hens, ducks etc)
- 0.5 or 0.33 high grade dairy cow

Livestock growth depends on land carrying capacity and water availability. If both conditions suffice then 10 years growth can be up to 25% and 20 years growth up to 50% at an annual rate of 2,6% for cattle and 2% for goats / sheep.

The Manual recommends 25 litres/LSU/day and segregated as follows:

- Dairy Cow: 50 - 90 litres/day (50 adopted)
- Local Cattle: 25 litres/day
- Sheep and goat: 5 litres/day
- Donkey: 12,5 litres/day
- Pig: 10 litres/day
- Poultry: 30 litres/100 birds/day

This methodology has been used for this report.

3.4.1.4. WATER DEMAND FOR FISH FARMING

The section will deal with fish production using ponds (closed system) and neither cage nor continuous (open system) flow. In addition, the ponds that will be proposed will not be mechanized for aeration or pelleted feeds.

According to the “Inland fisheries and aquaculture” report (Patrick Dugan et al., 2007), mechanically aerated and pelleted feeds can produce fish up to 10000 kg/Ha. The cage production can produce up to 100 kg/m3. On the other hand normal pond fish production is as follows:

- regularly stocked and fertilized Tilapia: 1 000 to 2 000 kg/Ha of pond/year
- as above but with brewery waste, oil seed cakes, brans and manure: 3000 to 5000 kg/Ha/year
- unfertilized ponds: 320 kg/Ha/year

In the “Guiding principles for promoting aquaculture in Africa” (FAO and Worldfish Paper No 28, 2006), full fish ponds design procedure has been provided. The tank size is normally L:W:D = 30:3:1 in order to maximize the flushing. Fish farming water demand is not significant after catering for evaporation and percolation into soils and will mainly depend on space available for ponds installation. Alternatively, the ponds size should be dependent on the demand for fish in the locality and the existing marketing system.

In the “Strategic assessment of warm water fish farming potential in Africa” (FAO by Kapetsky, Technical Paper 27), the relationship between population density and the occurrence of fish farming is studied: based on assumptions about farm-gate sales, population density is interpreted as local market potential.

Fish farms do occur at densities of <5 persons/km^2 and a limited amount of data from Zambia and Tanzania indicates that even at these densities, there are commercial activities.

There is a tendency for the density of fish ponds per district to increase with increasing population density. However, because the population data are in rather broad ranges, attempting to develop a regression relationship was not possible. To examine the effect of local demand on fish farming potential, the following assumptions were made to estimate the number of *subsistence* and commercial farms that could be supported by farm-gate sales at given population densities.

The assumptions were:

- Pond area of 0,04 ha sizes and an output of 2 t/ha/year for a subsistence farm; respective area and output for a modest commercial farm at 0.4 ha pond sizes and 3 t/ha/year;
- Farm-gate sales confined to an easy walking distance: a 2 km radius of the farm for a subsistence farm; a 4 km radius for a commercial farm due to an implicit proximity to an all-weather road, making a commercial farm more easily accessible for walk in and drive in customers than for a subsistence farm.
- A potential market of 1 kg of fish/person/year for a population within a 2 km radius for a subsistence farm and the same for a population within a 4 km radius for a commercial farm. One kg of fish/per caput is about 10% of all Africa mean fish consumption per caput.
- 50% of the output sold at the farm-gate for a subsistence farm and 25% of the output for a commercial farm.

The consultant has used the population density to establish demand for fish and by extension demand for fish ponds at dam site.

3.4.1.5. HYDROPOWER DEVELOPMENT

Simulation has been carried out for power generation at dam site. The methodology is the same as described in chapter 3.3.4 about optimization of the reservoir capacity, except that the water demand is now defined by the requirement of energy production.

Initially, the firm energy at dam is determined, that is to say energy production that can be provided by the reservoir at a given failure rate (failure admitted here: 10% of the maximum time). This production is the average energy response, assumed constant throughout the year.

In the simulations, the firm energy is determined by iteration according to a monthly time step, changing the value of the demand to obtain the rate of deficit (or failure) desired.

The calculation allows for variations in the height of the reservoir between the Full Supply Level (FSL), above which the excess water spilled, and the Minimum Operating Level (MOL) below which energy can be produced (deficit).

In a second step, the secondary energy produced is computed. Secondary energy is the energy obtained by turbine of excess water, once the energy product is guaranteed and the reservoir is full.

The total energy is then defined as the sum of firm energy and secondary energy.

Every month, the energy produced is determined by the following formulae:

$$E = P \times Nb \times 24$$

$$P = Q \times g \times \Delta H \times \rho$$

Where:

P:	Power in kW
E:	Energy in kWh
Nb:	Number of days in the month
g:	9,81 m/s²
ΔH	net head
ρ	Turbine efficiency

It is to be noted that in this simulation, the power demand is constant and the water demand varies accordingly depending on the available net head (reservoir water level). The head losses has been assumed to be 10% of the total head and the turbine efficiency equal to 0,8.

3.4.1.6. ENVIRONMENTAL FLOW REQUIREMENT

The Hydrological Index Method is one of the various approaches used to estimate environmental flow requirements. This method is based on simple indices, as a percentage of average annual flow or a percentile from the flow duration curve, on monthly basis. The indices used for environmental flow assessment in various countries of the world are provided below:

- France: A hydrological index is used in France, where the freshwater fishing law (June, 1984) required that residual flows in by-passed sections of River must be a minimum of 1/40 of the mean annual flow (MAF) for existing schemes and 1/10 of the MAF for new schemes (Souchon and Keith, 2001).

- United Kingdom: In regulating abstractions in UK, an index of natural low flow has been employed to define environmental flow. Q95 (i.e. that flow exceeded 95% of the time) is often used. The figure of Q95 was chosen purely on hydrological patterns. However, the implementation of this approach often includes ecological information (Barker and Kirmond, 1998)

- USA (Tennant method): Tennant (1976) developed a method using calibration data from hundreds of sites on rivers in the mid-western states of the USA to specify minimum flows to protect healthy River environment. Using USGS data, this method is based on aquatic habitat being very similar when they are carrying the same proportion of the average flows. Ten percent of the average flow is a minimum instantaneous flow recommended to sustain short-term survival habitat for most aquatic life forms (Poor or minimum habitat). Thirty percent is recommended as a base flow to sustain good survival conditions for most aquatic life forms and general recreation (fair and degrading habitat). Sixty percent provides excellent to outstanding habitat for most aquatic life forms during their primary periods of growth and for the majority of recreational uses. In a large River, it can be useful in developing a quick response, such as for evaluating water right application potential impacts.

Taking into account that the four Kagera dam sites are characterized with poor or minimum habitats, an environmental flow of 10% of the MAF have been retained for a permanent River. Furthermore, such a criterion is also applied in France for new schemes.

For a temporary River, it is recommended to take into account ecological information.

3.4.2. Methodology for the evaluation of each potential water use

3.4.2.1. CONTEXT

SWECO has carried out the "Development of Kagera Integrated River Basin Management and Development Strategy" study for NELSAP in 2010. In the table 1.5 of the main report, a water use prioritization exercise has been carried for each district or province and has been expressed in the following summary table. This table shows that the water supply is always the main prioritization.

Figure 9: Water use prioritization

No.	Administration	Water Supply and Sanitation	Soil and Water Conservation	Irrigation and Drainage	Fisheries	Flood Mitigation	Drought Mitigation
1	2	3	4	5	6	7	8
	Burundi						
1	Kirundo	H	H	H	H	H	H
2	Ngozi	H	H	H	L	H	M
3	Kayanza	H	H	M	L	M	M
4	Muramvya	H	H	L	X	L	M
5	Bujumbra R.	H	H	X	X	X	L
6	Mwaro	H	H	L	X	L	M
7	Bururi	H	H	X	X	X	L
8	Rutana	H	H	X	X	X	M
9	Gitega	H	H	H	L	H	M
10	Ruyigi	H	H	L	L	L	M
11	Karuzi	H	H	M	L	M	H
12	Cankuzo	H	M	L	L	L	M
13	Muyinga	H	M	M	L	M	H
	Tanzania						
1	Ngara	H	M	L	L	L	H
2	Biharamulo	H	M	L	L	L	H
3	Karagwe	H	M	H	H	H	H
4	Muleba	H	L	L	H	L	H
5	Bukoba	H	L	H	H	H	M
	Uganda						
1	Rakai	H	M	L	X	L	H
2	Isingiro	H	H	M	L	M	H
3	Mbarara	H	H	L	X	L	H
4	Ntungamo	H	H	M	X	M	H
5	Kabale	H	H	L	X	L	M
6	Kisoro	H	H	X	X	X	H

H = *high* M = *medium* L = *low* X = *insignificant*

No.	Administration	Water Supply and Sanitation	Soil and Water Conservation	Irrigation and Drainage	Fisheries	Flood Mitigation	Drought Mitigation
1	2	3	4	5	6	7	8
	Rwanda						
1	Musanzi	H	H	M	H	M	L
2	Gakenke	H	H	M	L	M	L
3	Rulindo	H	H	L	X	L	L
4	Gikumbi	H	H	L	X	L	L
5	Nyabihu	H	H	M	X	M	L
6	Ngororero	H	H	L	L	L	L
7	Rutsiro	H	H	X	X	X	L
8	Karologi	H	H	L	L	L	L
9	Nyamagabwe	H	H	L	X	L	M
10	Nyaroguru	H	H	H	X	H	M
11	Gisagara	H	H	H	L	H	H
12	Huye	H	H	L	X	L	H
13	Nyanza	H	H	H	L	H	H
14	Ruhango	H	H	H	L	H	H
15	Muhanga	H	H	H	M	H	M
16	Kamonyi	H	H	H	L	H	H
17	Nyarugenge	H	H	H	L	H	H
18	Kicukiro	H	H	H	L	H	H
19	Gasabo	H	H	M	X	M	H
20	Bugesera	H	H	H	H	H	H
21	Rwamagana	H	H	H	H	H	H
22	Ngoma	H	H	H	H	H	H
23	Kirehe	H	L	H	H	H	H
24	Kayonza	H	L	M	H	M	H
25	Gatsibo	H	L	M	H	M	H
26	Nyagatare	H	L	M	H	M	H

H = *high* M = *medium* L = *low* X = *insignificant*

Source: "Development of Kagera Integrated River Basin Management and Development Strategy" by SWECO in 2010

3.4.2.2. ANALYSIS

This above study and the socio-economic survey reported in appendix K lead to prioritize the water demand. However it should be taken as well into consideration the technical feasibility of each use as well as the economic analysis.

3.5. Methodology for the Initial Environmental and Social Examination (IESE)

3.5.1. Position within the Study and goals

The environmental and socio-economic analysis has been carried out since the beginning and concurrently with the engineering studies. Consequently, the former will orientate the latter in order to develop the most needed water uses according to requirements and capacities of the riparian population, to minimize and mitigate the impacts of the dam and reservoir construction on physical, biological and human environment and to reduce such impacts.

Planned at the early stage of the project development, the IESE may also orientate and bring inputs (and reciprocally) to the regulatory ESIA studies (carried out independently by another consultant), if the time schedules of both allow for.

Regarding environmental issues, the present study is to be considered as preliminary since environmental feasibility, identify environmental challenges, main impacts and mitigation actions will be actually addressed by the ESIA consultant.

The overall output is the Initial Environmental and Social Examination Report concluding on the "environmental feasibility" of the scheme. Conclusions have been based on the impact assessment for the project and the justification of fatal flaws or critical impacts, if any, for the concerned project.

3.5.2. Regulatory context of projects financed by the World Bank

3.5.2.1. LARGE DAM DEFINITION CONTEXT

The World Bank distinguishes between small and large dams in the Operational Policy 4.37 as follows.

(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--for example, an unusually large flood-handling requirement, location in a zone of high seismicity, foundations that are complex and difficult to prepare, or retention of toxic materials. Dams under 10 meters in height are treated as large dams if they are expected to become large dams during the operation of the facility.

This definition of "large dams" is based on the criteria used to compile the list of large dams in the World Register of Dams, published by the International Commission on Large Dams (ICOLD).

3.5.2.2. WORLD BANK OPERATIONAL POLICIES

The World Bank group has served as a forerunner by defining Operational Policies (OP) that serve as guides as part of the assessments of the projects submitted to this body for financing. The Bank classifies each proposed project to determine the appropriate extent and type of Environmental Assessment. The World Bank classifies the proposed project into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts.

The main directives and policies that apply here are the following:

- OP 4.01: "Environmental assessment";
- OP 4.04: "Natural habitats";
- OP 4.11: "Physical cultural resources"
- OP 4.12: "Involuntary resettlement": For Kagera Project, it is worth to mention that:
    - "Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs";
    - "Where impacts on the entire displaced population are minor, or fewer than 200 people are displaced, an abbreviated resettlement plan may be agreed with the borrower".
- OP 4.37: In this OP, the World Bank considers that "generic dam safety measures designed by qualified engineers are usually adequate" for small dams.
- OP 7.50: "Projects on international waterways".

3.5.3. Regulatory context within the NBI

The NBI has taken steps to put in place systems and mechanisms to ensure environmental and social safeguards in all its interventions at the following three key levels:

- Basin-wide level,
- Sub-basin (SAP) levels,
- Project level.

The NBI has issued an Environmental Assessment Framework for Regional Power Projects and a Preliminary Environmental and Social Management Framework for Project Preparation and Implementation.

It should be noticed that, as a rule, any project funded through development partner funding will be subject to internationally accepted environment screening, following Wold Bank guidelines and / or development partner requirements.

It is specified that some environment and socio-economic key issues should be taken into consideration for mitigation measures during the ESIA.

4. TECHNICAL STUDIES

4.1. Introduction

This report will take into consideration the findings of the interim reports, which has changed the design of the project. Thus, this chapter will present first the main findings of all investigations and surveys, meaning:

- Aerial survey;
- Geophysical and geotechnical investigations;
- Hydrological analysis;
- Water uses and water demand.

The preliminary design and costing could then be presented taking into account the previous results and the decision of the country following these findings.

Based on these design results, the initial environmental and social examination will then give the first results mainly based on the aerial survey.

4.2. Aerial survey for Karazi site area

4.2.1. Context

The topographical survey was undertaken on the 22nd, 24th and 26th February 2012 to produce rectified colour images and a digital terrain model (DTM) of the project area following the methodology described in the chapter 3.1.

The survey was carried out using an aircraft mounted LiDAR system that scanned the ground below with a 70 kHz LiDAR resulting in a dense DTM of the ground surface and objects above the ground.

Digital colour images were also taken from the aircraft and rectified to produce colour orthophotos of the project area.

The survey was flown at a height of approximately 800m and an image pixel size of 10cm has been produced

4.2.2. Results

Two beacons were placed, constructed and painted for the site. The points are SMCA120201 and SMCA120202. The values of these surveyed points are as follows:

<u>Coordinate system: ITRF08 Geographic</u>

Name	Longitude	Latitude	Ellipsoidal Height (m)	Orthometric Height (m)
SMCA120201	-1 47 10.2041	31 00 44.1236	1306.08	1318.57
SMCA120202	-1 50 33.4073	31 00 31.4843	1332.83	1345.27

Coordinate system: ITRF08 UTM36 South

Name	Easting	Northing	Ellipsoidal Height (m)	Orthometric Height (m)
SMCA120201	278 876.10	9 802 454.56	1306.08	1318.57
SMCA120202	278 492.25	9 796 211.38	1332.83	1345.27

The map 08 in the Appendix D was defined based on the aerial survey. The reservoir has been drawn at FWL for a 9,5m dam as defined in this study.

4.2.3. Main characteristics for Karazi reservoir

Based on these above results, the characteristics of the reservoir dam have been defined using the new topographical data issued by LiDAR survey as summarized in the following table and have been compared to the ToRs data.

The reservoir has been drawn according to the final dam height in the Appendix D.

Table 5: Characteristics of Karazi dam

KARAZI	*ToR*	*New data*	*Final dam design*
Dam height (m)	*14*	*14*	**9,50**
Storage capacity at FWL (Mm^3)	*30*	*30,84*	**9,20**
Crest Width (m)			**6**
Dam crest Length (m)	*470*	*620*	**518,74**
Reservoir Width maximum(Km)		*3*	**2,11 at MWL**
Reservoir Length maximum (Km)	*2,80*	*4*	**3,4 at MWL**
Full Supply Level (m)		*+12m(1326m)*	**+7,50** (1321,50m asl)
Maximum Water Level (m)			**+8,75** (1322,75m asl)
Reservoir surface area at FWL (km^2)		*3,71*	**2,36**
Reservoir surface area at MWL (km2)	*4,51*	*4,39*	**2,71**
Contributing catchment area (km^2)			**213**
Catchment sediment yield ($Tons/km^2/yr$)	*226*	*614*	**576**

4.3. Geophysical and Geotechnical Investigations

The geophysical survey carried out on Karazi dam site has been calibrated by four boreholes and tests pits located along the proposed dam axis (see the following figure).

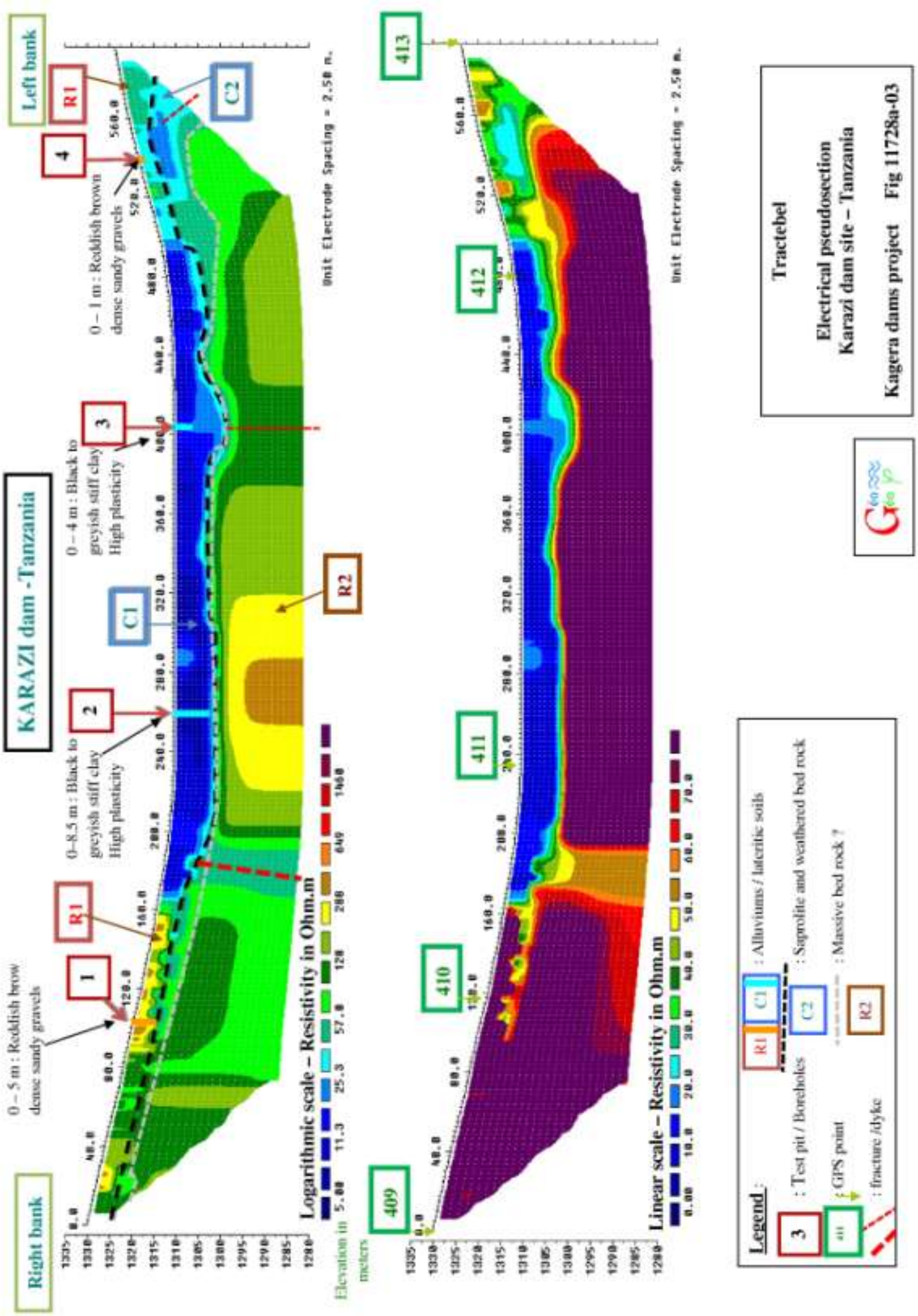
Figure 10: Location of auger pits at Karazi dam site

In the valley, 8 to 12 meters of black greyish stiff clay with high plasticity overlay the bedrock. On the banks, the thickness of the lateritic soils is reduced to approximately 5 meters (see the following photo and results in Appendix I).

The overlaying material is suitable for dam core as it is practically impervious (< 10-8 m/s) after compaction while still plastic. Its grain size properties display a percentage of fines below 80 microns greater than 40 %. The plasticity index is higher than 12 and the liquid limit higher than 30.

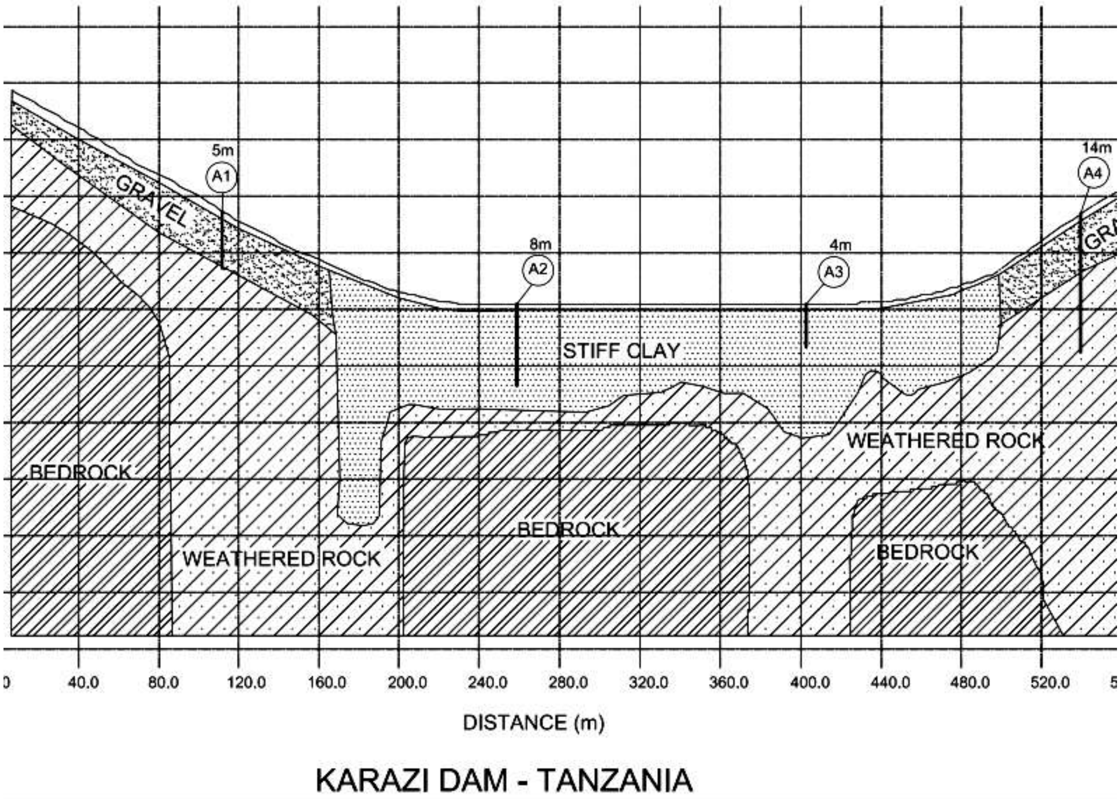
Figure 11: Black greyish clay overlaying the dam foundation

Figure 12: Electrical pseudo-section at Karazi site



The dam axis profile has been compiled in the following figure using the auger holes logging for the over burden soils and the 2D Imaging for the saprolite (weathered rock) and the bedrock bottom.

Figure 13: Geotechnical profile of Karazi dam axis



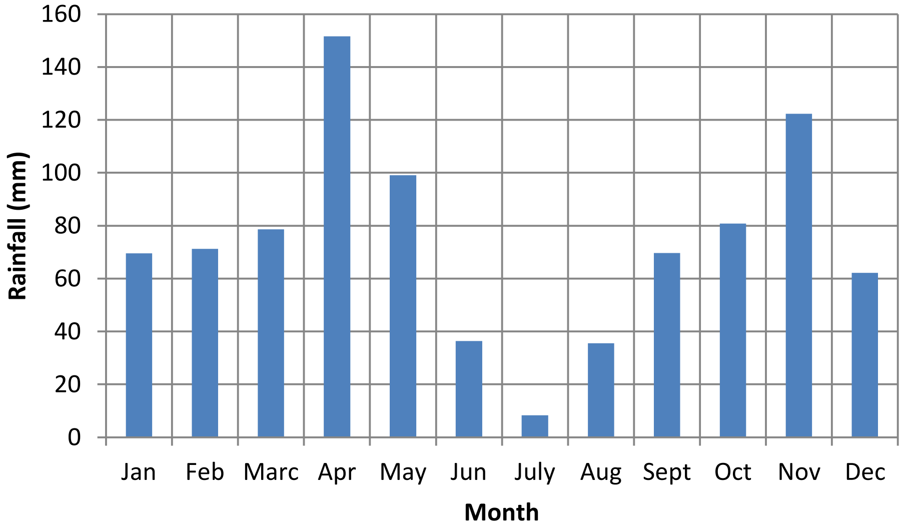
4.4. Hydrological results for Karazi dam site

4.4.1. Context

Karazi dam site is located about 1 320 m above sea level, on Karazi River, which is a seasonal river. The site is located in the lower part of the Kagera River basin also called the West Victoria Lake region. This zone is characterized by moderate relief and more arid conditions.

The catchment area is 213 km² and its altitude is in the range 1 738 – 1 300 m above sea level. Average annual rainfall is about 919 mm. There are two rainy seasons with the longer south-easterly monsoon between February and May with the peak occurring in April and the shorter north-easterly monsoon from about September to November as represented in the following figure.

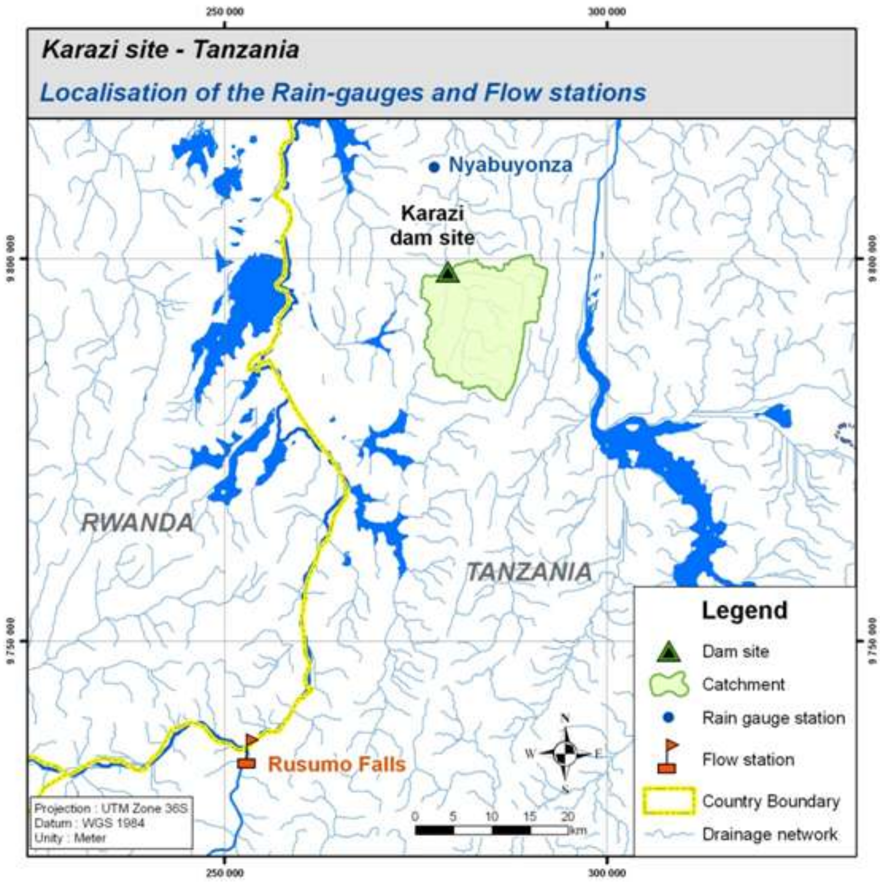
Figure 14: Monthly rainfall at Nyabuyonza rainfall station in the vicinity of Karazi dam site.



4.4.2. Data

Rainfall information has been collected from the AQUALIUM database provided by the Client. Only one rainfall station has been found to provide reliable rainfall data: Nyabuyonza located in the close vicinity of the catchment (Figure 15). No gauging stations with a reliable discharge record have been found in the vicinity of the site.

Figure 15: Localisation of rain gauge and gauging station for Karazi dam site



4.4.3. Inflows

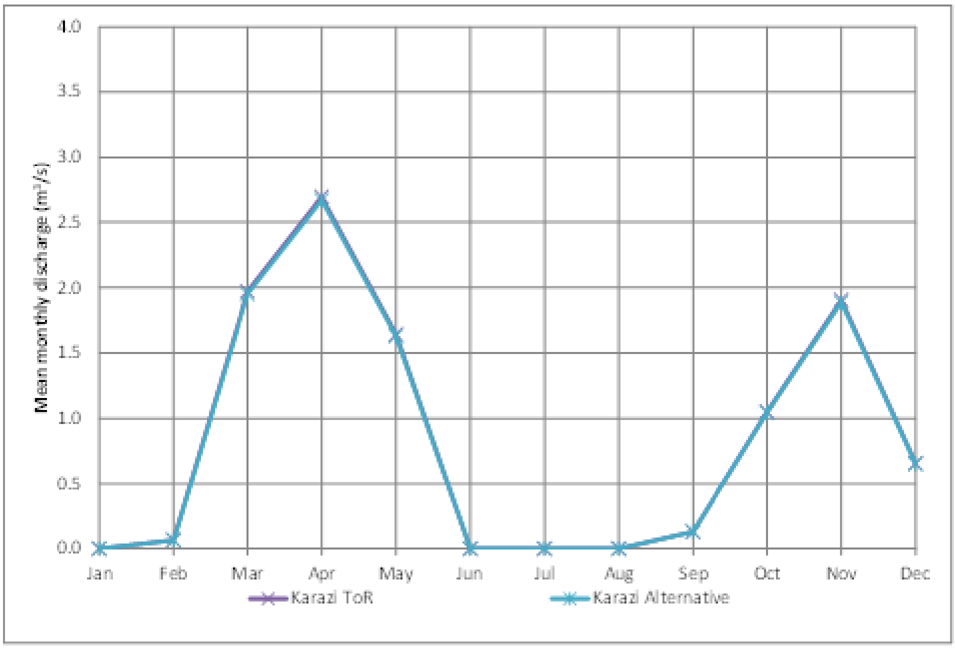
For Karazi dam site, there is no gauged site that could be used as a reference and approaches are very limited by the dramatic lack of data. As a consequence, inflows at dam site are estimated at a monthly time step by applying the following formula:

$$Q\ Karazi\ = \frac{Qyr\ (Karazi)}{Qyr\ (Bigasha)} \times Q(Bigasha)$$

where Qyr (Karazi) is equal to 0.84 m3/s and Qyr (Bigasha) is equal to 0,40 m^3/s (both deducted from water balance considerations with runoff coefficient equal to 0,135 (Ruizi River at Mbarara, Uganda)).

Mean monthly inflows are presented in the Figure 16. Two peaks corresponding to rainy seasons can be observed in April and in November. The seasonal pattern is quite pronounced due to more arid conditions and dry periods without flows in January and between June and August.

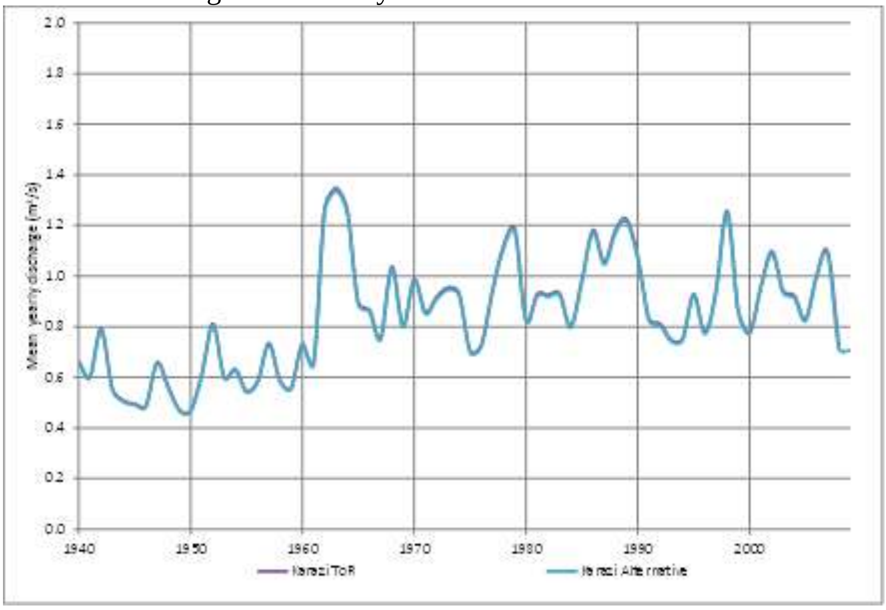
Figure 16: Mean monthly inflows at Karazi dam site for the 1940-2009 period



Yearly inflows at Karazi dam site are presented in the below Figure 17. The rise in runoff observed in the Nile Equatorial Lakes region in the early 1960ies appears clearly. Two periods can be distinguished: a pre-1960 period with moderate runoff level (mean discharge = 0,60 m^3/s) and a post-1960 period with a high runoff level (mean discharge = 0,94 m^3/s).

Annual variability is rather high. Maximum mean yearly discharge (1,35 m^3/s in 1963) represents a +60% increase of the mean discharge (0,84 m^3/s), and minimum mean yearly discharge (0,47 m^3/s in 1950) a -45% decrease of the mean discharge.

Figure 17: Yearly inflows at Karazi dam site

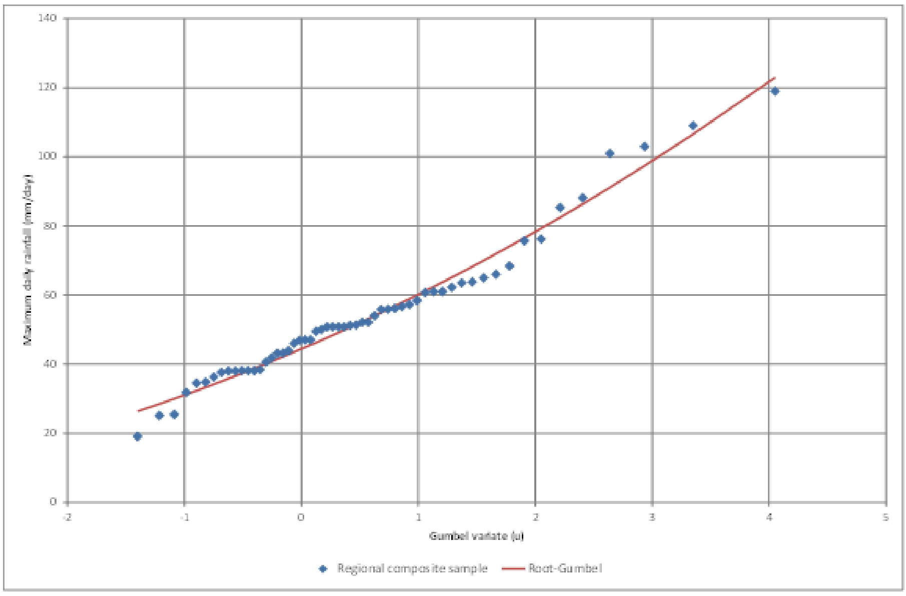


4.4.4. Floods

4.4.4.1. MAXIMUM DAILY RAINFALL

For Karazi dam site, daily rainfall records at 4 rainfall stations located in Uganda and Tanzania are processed. The station year method is applied to establish one regional composite sample of maximum daily rainfall. The sample has a size of 57 station-years. A root-Gumbel distribution is convenient to describe this sample (Figure 18).

Figure 18: Karazi dam site - Regional composite sample of maximum daily rainfall and Root-Gumbel distribution



Maximum daily rainfall for return periods ranging from 2 to 10 000 years are deducted from the root-Gumbel distribution. PMP is calculated using the Hershfield's formula.

The 24-hour rainfall over the catchment is deducted from maximum daily rainfall by applying both an area reduction factor and the Weiss correction factor equal to 1.13 (Table 6).

Table 6: 24-hour rainfall over Karazi catchment for different return periods

T	Pdmx(T)	P24(T)	P24-Karazi (ToR)	P24-Karazi (Alt)
(year)	(mm/day)	(mm)	(mm)	(mm)
2	50	56	46	46
5	69	78	63	63
10	83	94	76	76
20	98	111	90	90
50	119	135	109	109
100	137	154	125	125
200	155	175	141	142
500	181	204	165	165
1 000	202	228	184	184
2 000	224	253	204	205
5 000	255	288	233	233
10 000	280	316	255	256
PMP	398	450	363	364

4.4.4.2. FLOOD HYDROGRAPHS

The Consultant made use of the USSCS approach to compute the flood hydrographs. Broadly speaking, this approach consisted in deducting flood hydrographs from 24-hour rainfall distributed according to a given storm profile. Results are given in Appendix H. The calculated Francou-Rodier's indexes for peak discharge are in the range 2.47 (return period T=20 years) – 4.73 (PMF).

Table 7: Karazi dam site - Discharge

Return period T	T=20	T=50	T=100	T=1000	T=10000	PMF
t (hours)	Hourly discharge (m3/s)					
Peak discharge (Qp) (m3/s)	31	53	79	234	488	692
Mean daily discharge (Q24) (m3/s)	16	30	45	117	228	324
Qp/Q24	1.86	1.74	1.76	2.00	2.14	2.14
K(Qp)	2.47	2.87	3.16	3.94	4.48	4.73

4.4.5. Sedimentation

Due to the lack of local sediment sampling data (see chapter 3.3), the Consultant made use of a regional sediment database and an empirical formula to estimate the sediment yields at Karazi dam site. Broadly speaking, the empirical formula is a relation between the sediment yields and the runoff. The catchment area is also taken into account. The regional sediment database is first processed in order to calibrate this relation. Then, the relation is applied to Karazi catchment in order to estimate the sediment yields. Eventually, the sedimentation rate of the reservoir is assessed by applying Brune's approach. The sedimentation rate is highly dependent of the storage capacity of the reservoir. Thus, these results should be revisited when the design changes. Main results are given in the following table.

With a storage capacity of about 9,24 Mm^3 for 9,5m high dam, the ratio of storage capacity to mean annual inflows is high (31%). As a consequence, the annual sedimentation rate is quite insignificant and the site is likely not exposed to siltation.

Table 8: Karazi - Sediment yields and sedimentation rate of the reservoir

Dam Site	Dam Height	Area	Rainfall	Runoff	Sediment Yield (in suspension)	Total sediment Volume	Storage Capacity (C)	Mean annual inflows (I)	Capacity Inflow ratio (C/I)	Trap efficiency (Brune)	Annual sedimentation rate
	(m)	(km²)	(mm)	(mm)	(t/km²/year)	(m3/year)	Mm3	Mm3	-		
Karazi (ToR)	14,0	213	919	124	576	108 522	22,70	26	0,86	97%	0,5%
Karazi (final design)	9,5	213	919	141	593	111 661	9,24	30	0,31	94%	1,1%

4.5. Water uses and water demand for Karazi site

4.5.1. Context

As seen in the previous chapter about the optimization of the reservoir, the best dam's height has been confirmed to 14 meters with a FSL = 1 326m, based on hydrological analysis. The dam height should as well take into account the water demand forecast for the optimization of the dam height.

4.5.2. Irrigation

4.5.2.1. INSTITUTIONAL FRAMEWORK

The Agricultural Sector Development Strategy, finalized in 2001 highlights irrigation development as a key to impede food scarcity. It underscores development of smallholder irrigation systems, based on water harvesting technology.

4.5.2.2. WATER USES FOR IRRIGATION

a) Literacy context

According to the Agricultural water in the Nile Basin report [b], the priority irrigation schemes are already designed. Two of them are to be developed in Karagwe district: one in Kashasha Valley (3 500 ha irrigated) and one in Kabale Valley (2 000 ares).

This report highlights as well that many examples illustrates tried practices for community managed irrigation systems in Tanzania. Through close involvement of communities, various projects supported by the World Bank for instance show how incentives for wide adoption can be achieved.

b) Field context based on the field mission carried out in February 2012

No irrigation perimeters have been developed until now in Karagwe district. One scheme is currently being built, Mwisa irrigation scheme. It is designed as a surface irrigation scheme for rice cultivation.

<u>The Karazi valley</u>:
At the dam site, the Karazi valley follows a south-north direction (see Figure 25).
Karazi River is a non-perennial one, and thus flows only during rainy seasons. In fact there is no pronounced river bed, but rather several little channels across the valley. These latter are marked by a wetter vegetation.

The valley is narrow. Its bottom reaches 250 m at the dam site. It widens to 400 m around 1 km downstream from the dam site and up to 6 km from it. Then, the valley becomes again very narrow, less than 200 m, particularly after merging with a small tributary coming down at the level of Kayungu village, 7 km downstream from the dam site. This section remains partially flooded all year round (see Figure 22).

The bottom of the valley reaches again 400 m width 10 km downstream from the dam site. Around 20 km north of the dam site, the valley is called Kashanda valley and it becomes swampy.

It can be noted that 2 to 4 km upstream of the dam site, the valley is wider and may stretch to 400 m wide.

<u>Soils and land present use</u>:

The bottom of the valley bears black clayey soils with hydromorphic features (see Figure 23). It is not cultivated. A vegetation of grasslands with savannah bushes is grazed by a lot of cattle (see the below figures). Trees are often surrounded by mounds of ants.

There is a marked transition between the flat valley and its sides. Slopes bear red ferrallitic soils, which are also little cultivated at the dam site. Their vegetation consists of bushes and grass; nevertheless, gullies may be seen on some bare places which have been probably overgrazed or trampled on by cattle.

The left side of the valley is more developed, particularly towards the villages on the left ridge of the valley, around 4 km westward of the Karazi River (Chabuhora, Nyakakika, Nyakabanga, Kayungu). There, the landscape is dominated by banana plantations, mainly grown on the hills, but which can also come down until the higher parts of the tributaries (see Figure 20). A lot of other crops are grown: maize, beans, groundnuts, millet, sorghum, coffee, potatoes, sweet potatoes, cassava, yam, cocoyam, different kind of vegetables (tomatoes, onions, cabbage).

Figure 19 : Karazi valley, 1.2 km downstream of the dam site

Figure 20 : Karazi valley, little left tributary 1 km downstream of the dam site

Figure 21 : Karazi valley, 4 km downstream of the dam site

Figure 22 : Karazi valley, 7 km downstream of the dam site

Figure 23 : Karazi valley, soil pit at the dam site

Figure 24 : Karazi valley, livestock near the dam site

4.5.2.3. IRRIGATION POTENTIAL ASSESSMENT

Due to the narrowness of the valley, the potential command area for irrigation purpose is somewhat limited (see the following figure).

If possible, a location of the dam 2 or 3 km upstream of the present location would allow a little more irrigated area.

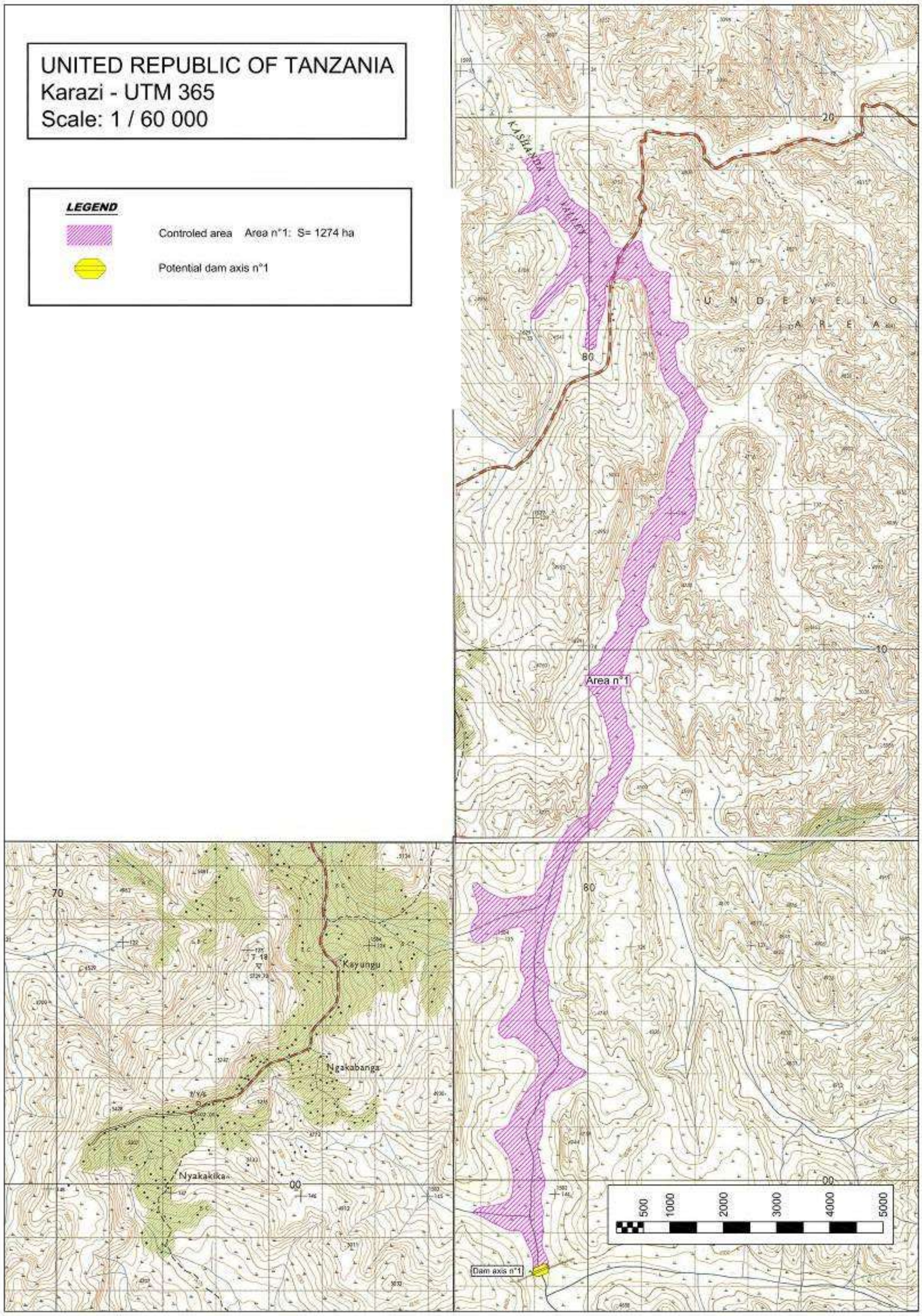
The rough extent of the controlled area has been first estimated as about 1 000 ha, based on the 1/60 000 map. However the valley is very narrow and the extent of the potential irrigated area is very long, around 20 km downstream the dam axis. Therefore, it is recommended to split the irrigation perimeter in several independent blocks for technical reasons (such as loss of water) in particular less than 20 km long in the local context.

If there is a customary migration corridor for cattle, the perimeter shall avoid it. Except in this case, the area of the irrigation perimeter shall be closed to cattle roaming. In compensation, it is proposed to dedicate a part of the irrigated area to forage crops to replace the poor natural grasslands.

The natural conditions of the area lead to orientate the project toward rice production as a first objective. Rice is not commonly grown in the district of Karagwe, due to the absence of irrigation improvements. The Mwisa Irrigation scheme, presently under construction, will be designed for rice cropping. In fact, there is a demand for rice in the district and rice is presently imported from other regions.

Thus, is it proposed to design the irrigation perimeter for rice. However rice will be introduced progressively so that the peasants will have time to get skills for growing it. A double cropping season is currently implemented on the hillsides. It can be the same in the valley bottom. Thus, one season could be dedicated for rice and the second one for another crops, maize and vegetables for example. In the future, some parts of the perimeters could move toward two rice seasons cropping. A part of the perimeter could be dedicated to high productive forage crops, such as elephant grass, desmodium or alfalfa.

Figure 25: Karazi potential irrigated area



Topographical data analysis

Switching from low accuracy 1/60 000° topographical map to high resolution LIDAR survey associated with orthophotographs triggered a reduction in controlled area (ie. the area where the water derivate upstream in the main canal can flow to irrigate plots) of about ½ of the total first estimate.

Table 9: Evolution of controlled area during the project

	First estimate based on 1/60 000° map	Second estimate based on Lidar survey	Reduction (%)
Upstream perimeter (area 1)	500 ha	259 ha	48,2%
2 perimeters (area 1 + 2)	1 000 ha	523 ha	47,7%

Even though this drop in the area suitable is usual, the value is high at that stage because others reductions are likely to happen during later stages of design, due to general arrangement of blocks (although works are man-made and therefore it is easier to adapt to uneven shape of elementary plots), the necessity to have a drainage system, some high or low spots, access, etc.

Potential crops and cropping pattern:

The main crop will be rice which will be grown during the rainy seasons, i.e. either from September until January (rice 1), or from February until June (rice 2). In each case, one month more shall be planned in nursery before transplantation. Irrigation will be used for nursery, to secure the water needs at the beginning of the crop cycle, and to flood the crop.

A double cropping pattern will be applied.

Many possibilities may arise. Four have been envisaged as case study, to get a range of possible irrigation water requirements:

- firstly, a rice/maize rotation, to limit the area of rice as long as this new cultivation will be overcome,
- secondly, a double rice cropping, when the peasants will be used with the rice cultivation,
- thirdly, a rice/vegetables rotation, to provide the neighbouring towns with these two kind of staple products,
- lastly, a maize/vegetables rotation if it is wished to limit the irrigation water consumption,
- in any of these latter cases, one option will be studied introducing 10% of forage crops.

It is expected to reach a yield of 3 t/ha for rice, 2.5 t/ha for maize, from 2 to 6.0 t/ha for vegetables, depending on the crop which will be grown, and from 10 to 15 dry matter t/ha for the forage crops.

Crops water requirements:

Irrigation water requirements are computed by calculating a water balance for every period of 10 days (hereafter called a decade).

The Reference Evapotranspiration ETo (Penman-Monteith formula) is very close for all regions of the four dams and it has been taken an average of 5 stations of the FAO climwat database: Rubona and Butare in Rwanda, Biharamulo and Bukoba in Tanzania, Mbarara in Uganda. The nearest station Muyinga in Burundi has not been taken into account, because it has very high figures during the dry season, which seem overestimated.

The mean annual ETo reaches 3.6 mm/day. The total annual ETo reaches 1297 mm (see Figure 26). ETo is slightly lower during the rainy months and slightly higher during the driest ones.

Rainfall has been considered at the station of Biharamulo in Tanzania (altitude 1480 m, latitude -2.63°, longitude 31.31°) (see Figure 27). The total annual rainfall reaches 956 mm and the effective rainfall (Pe) reaches 781 mm after correction using the FAO method.

The meteorological year is usually divided into four periods: a short dry season in January-February, the long wet season from March until May, the dry season from June until September and a short wet season from October until December. The chart (Figure 27) shows this distribution, with a long dry season until October, with a short wet season mostly in November and a short dry season mostly in January.

A set of crop coefficients was selected for each crop all along the crop development cycle.

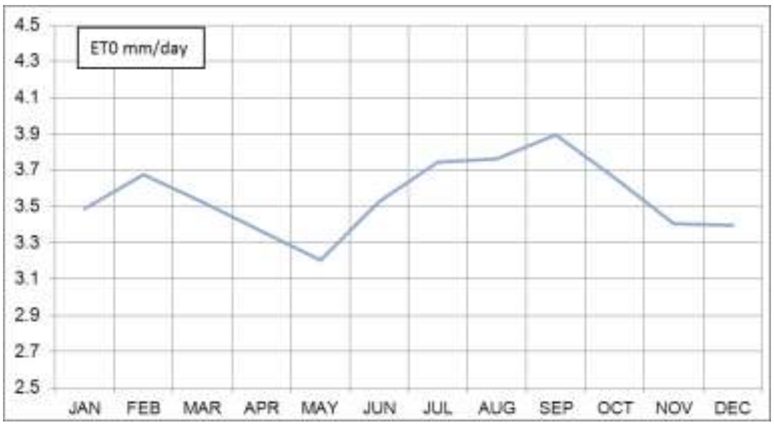
The irrigation water requirements (I) are calculated as follows:

I = kc Eto – Pe where kc is the crop coefficient

I = 0 if Pe of the considered decade > kc Eto

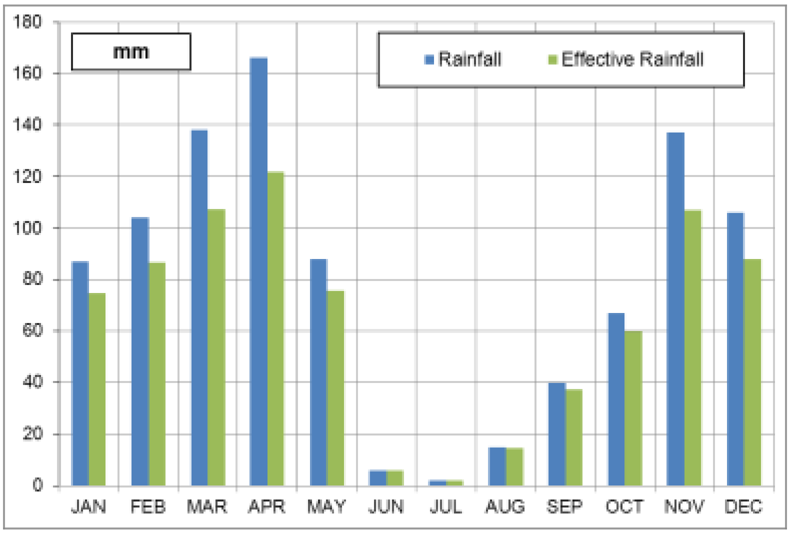
In the case of rice, it shall be added an amount of water to saturate the soil before transplanting the seedlings, and other amounts for percolation losses and to maintain a water layer in the field.

Figure 26 : Mean daily reference evapotranspiration in the region of the projects



(Source : Climwat FAO)

Figure 27 : Rainfall and effective rainfall at Biharamulo, Tanzania



(Source : Climwat FAO)

For each possible crop, the Table 10 summarizes the total irrigation water requirement, expressed in m3/ha for the whole crop cycle, and the maximum base flow in l/s/ha.

The base flow (specific flow) is the hypothetic flow which would be required to meet the irrigation amount of the decade while taking into account a daily irrigation duration of 24 hours. It is expressed in l/s/ha (litre per second per hectare).

This basic unit flow will be later proportionally increased while considering the real possible daily irrigation time to define the irrigation duty. This later depends on the way which is chosen to irrigate.

Table 10: Crops, expected yields and water requirements

Crop	planting time	length of development	expected yield	irrigation water per ha	maximum unit flow l/s/ha
		days	t / ha	m^3 / ha	at 24 h / day
Rice 1	1st Sep	150	3.0	11 000	1.5
Rice 2	1st Feb	150	3.0	11 000	1.4
Maize 1	1st Sep	150	2.5	1 100	0.2
Maize 2	1st Feb	150	2.5	1 100	0.4
Vegetables	1st Jun	120	2 to 6	3 500	0.4
Forage crops	perennial	360	10 to 15 DM	5 400	0.4

DM dry matter

<u>Volume of irrigation water:</u>

Large volumes of water appear necessary for rice. They are not strictly crop water requirements, as 60 to 70% of the crop evapotranspiration is secured by the effective rainfall. They are mostly required for the initial saturation of the soil (200 mm) and then to compensate percolation (hypothesis to provide 120 mm every month) and to maintain a water layer (100 mm).

Two cases have been taken into consideration, called “rice1” and “rice 2”.

Rice 1 represents what is locally considered as the main cultivation season, beginning in September. Rice 2 is a cultivation implanted in February, what is considered as the secondary cropping season. Nevertheless, the required volumes of irrigation water are the same in the two cases.

The irrigation water requirements of maize are much lower as 80% of the water demand can be provided by the effective rainfall, in the both common growing seasons. It would be the same for any crop grown during these seasons.

Vegetables require more irrigation water, as they are grown during the dry season. This is also the case of forage crops as they grow all along the year.

Base flow (specific flow):

It reaches 1.4 to 1.5 l/s/ha in the case of rice cropping and 0.4 l/s/ha in the case of the other non-flooded crops, including the forage crops.

Thus, a base flow of 1.5 l/s/ha shall be kept to provide the possibility to grow rice, while 0.4 l/s/ha are sufficient in case of no growing it.

Cropping pattern:

A lot of crops and cropping patterns may be adopted. This will probably move during the first years of the development of the perimeter.

It is recommended to begin with only one rice crop per year, either 100% of the perimeter with rice during the main season (September to January), followed by other kind of crops during the secondary season (February to June), or 50% of the perimeter with rice during the main season while the remaining 50% will be grown with rice during the secondary season. In the latter case, the use of irrigation water will be better balanced all over the year.

Out of rice, it will be grown some proportion of maize and some proportion of vegetables. These latter will be preferentially grown during the dry season both for better sanitary and market conditions.

Furthermore, some part of the perimeter will be dedicated to forage crops which will be harvested and not grazed. It is recommended to keep at least an area of 10% of the perimeter, but it can be adjusted following more accurate evaluation of fodder needs.

Project discharge:

Canals system must be designed to meet the peak base flow by taking into account both real possible irrigation duration and system efficiency. This will define the scheme irrigation duty.

With a surface irrigation system, it is usually preferable to avoid night time irrigation because human presence is required for controlling the flows in the furrows or basins. Thus, the maximum duration is set at 12 hours per day.

Regarding efficiency, which is the ratio of water delivered at the plot to water withdrawn from the reservoir, thus revealing the overall transfer losses, we propose to take a 60% efficiency into account.

Then, the irrigation duty is computed as follows:

Irrigation duty = Specific flow (24 hours l/s/ha) / Irrigation duration (hours/24) / Efficiency

The irrigation duty will depend on the wish to grow rice or not. These two cases have been envisaged (see the below figure), which are called 1 in the first case and 2 in the second one.

Table 11: Crops, expected yields and water requirements

Irrigation system	Maximum irrigation duration	Efficiency	Irrigation duty
	hours	%	l/s/ha
Surface irrigation 1	12	60	5.1
Surface irrigation 2	12	60	1.4

1 based on rice cropping; 2 without rice cropping

4.5.2.4. IRRIGATION WATER DEMAND

Total yearly irrigation water consumptions have been computed following different cropping patterns (see the following table) and are calculated for a 100 ha scheme unit.

4 cropping patterns are envisaged, each one with two scenarios, firstly without forage crops and secondly with 10% forage crops. The three first ones are based on rice; they differ from each other in the second crop, maize, other rice, or vegetables, that is to say a dry season crop in this latter case.

The introduction of forage crops doesn't much change the required amount of water. As expected, the rice area and the irrigated area during the dry season are the two determining factors in the water consumption.

Table 12: Total yearly irrigation water consumption for a 100 ha scheme

Cropping pattern	*% of crops* and gross volume of water m^3 *					
	Rice 1	**Rice 2**	**Maize**	**Vegetables**	**Forage**	**TOTAL**
1 rice/maize rotation	*50%*		*50%*			
	550 000		55 000			**605 000**
1 rice/maize rotation with forage crops	*45%*		*45%*		*10%*	
	495 000		49 500		54 000	**598 500**
2 rice/rice cropping	*50%*	*50%*				
	550 000	550 000				**1 100 000**
2 rice/rice cropping with forage crops	*45%*	*45%*			*10%*	
	495 000	495 000			54 000	**1 044 000**
3 rice/vegetables rotation	*50%*			*50%*		
	550 000			175 000		**725 000**
3 rice/vegetables rotation with forage crops	*45%*			*45%*	*10%*	
	495 000			157 500	54 000	**706 500**
4 maize/vegetables rotation			*50%*	*50%*		
			55 000	175 000		**230 000**
4 maize/vegetables rotation with forage crops			*45%*	*45%*	*10%*	
			49 500	157 500	54 000	**261 000**

** taking into account the conveyance efficiency*

As the cropping pattern 1 was chosen as preferential solution by the client, the total annual water consumption of the scheme is given in the following table, assuming a net irrigated area of 493 ha.

Table 13: Total yearly irrigation water consumption for the scheme

	gross volume of water m3*
Net irrigated area ha	**493**
Cropping pattern type	
1 rice/maize rotation	2 982 650
1 rice/maize rotation with forage crops	5 634 990
2 rice/rice cropping	10 846 000
2 rice/rice cropping with forage crops	5 146 920
3 rice/vegetables rotation	3 574 250
3 rice/vegetables rotation with forage crops	3 483 045
4 maize/vegetables rotation	1 133 900
4 maize/vegetables rotation with forage crops	1 286 730

***** *taking into account the conveyance efficiency*

The irrigation water demand has been evaluated according to the worst scenario in terms of water demand: double rice cropping on the whole area.

4.5.2.5. ENVIRONMENTAL AND SOCIAL ISSUES

The main constraint for the future development of Karazi area will be the preservation of current use that should be organized, either by sharing the land (not developing part of the valley) or by promoting fodder cropping in irrigated area.

4.5.3. Livestock watering

4.5.3.1. INSTITUTIONAL AND LEGISLATIVE FRAMEWORK

The Ministry of Livestock and Fisheries Development has the mandate of overall management and development of livestock resources.

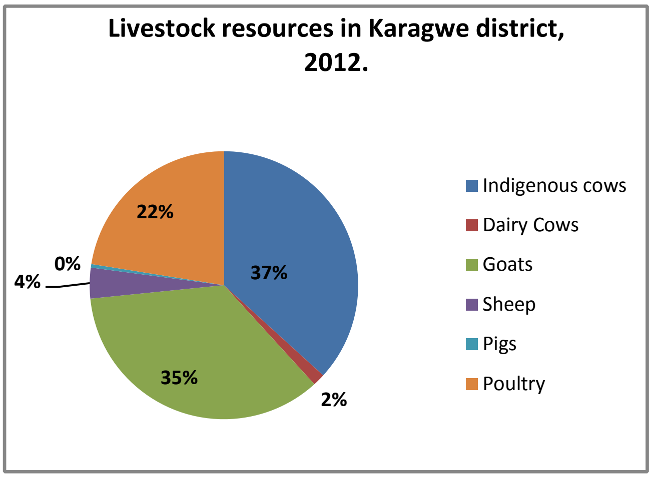
The Agricultural and Livestock Policy of Tanzania, 1997, sets principles for livestock resources management in Tanzania.

Permanent pastures are about 40% of land uses in Tanzania.

4.5.3.2. LIVESTOCK RESOURCES

In the area of the project, the community relies mainly on agro-pastoralism. The district has a large number of livestock. The following figure underlines the current livestock resources in Karagwe district and its repartition.

Figure 28: Livestock resources in Karagwe district, 2012



	Heads
Indigenous cows	139 000
Dairy Cows	5 600
Goats	133 000
Sheep	14 000
Pigs	1 600
Poultry	85 000
Total	*378200*

To avoid conflict, the communities have settled agreements: the eastern valley should be used for agriculture activities and the western valley for pasture and grazing.

Many cattle water points were found in the valley and had water during the wet seasons. During the dry seasons, the livestock should move about 20 km to a nearby lake.

4.5.3.3. LIVESTOCK WATERING ASSESSMENT

The below proposal should be reviewed taking into consideration the other water use for the Project. It foresees the following components:

- Intake at the Dam
- Shared Canal with Irrigation to Livestock Water Points down stream of the dam or a transmission main to allotted grazing land upstream or elsewhere in the vicinity.
- Cattle dips

The downstream valley is narrow. The water conveyance for livestock could be either by extending the irrigation canals into the grazing land or by installing transmission mains to the valley further downstream or to other grazing land.

To avoid conflict, a part of the valley is recommended to be devoted to pasture and grazing. For the time being, it is the western area.

4.5.3.4. LIVESTOCK WATER DEMAND

Water demand calculation is presented below using the design criteria adopted for this assignment as given in the chapter 3.4.1.3. Based on the estimation of livestock population, the present and future livestock water demand is estimated as follows assuming that 40% of the livestock is in the Project area. It is also assumed that by year 2037, the population will increase by 25%.

Table 14: Livestock water demand estimation at Karazi site

Type	Demand lpd	2012		2037	
		Numbers	m3/day	Numbers	m3/day
Beef Cattle	25	55,600	1390	69,500	1738
Dairy Cattle	40	2,240	90	2,800	112
Pigs	10	640	6	800	8
Sheep and Goats	5	58,800	294	73,500	368
Poultry	30 per 100 birds	34,000	10	42,500	13
TOTAL m3/d			1,790		2,238
Annual Demand m3/year			0.65 million m3		0.82 million m3

This estimation should be considered cautiously due to the lack of data in the Project area.

4.5.3.5. TECHNICAL CONSTRAINTS

The livestock watering should not be considered as a main use of the dam for economic reasons. However, it could be associated with other uses.

4.5.4. Aquaculture

4.5.4.1. LEGISLATIVE CONTEXT

The following documents are relevant to the fisheries sector in Tanzania:

- National Fisheries Sector Policy and Strategy Statement of 1997.
- The Fisheries Act No. 6 of 1970 has been reviewed and replaced by the new Fisheries Act No. 22 of 2003 which is now operational.
- The Fisheries regulations of 2005 have been endorsed by the government and have been in force since October 2005.

Aquaculture and fishponds are not adequately covered in the above polices.

4.5.4.2. WATER USES FOR AQUACULTURE IN THE PROJECT AREA

In Karagwe district, fish ponds are being promoted, but with chicken instead of rabbits. No fish pound existed in the project area due to water scarcity.

4.5.4.3. WATER DEMAND FOR FISH PONDS

a) Aquaculture water demand

Based on an estimated present population density of about 95 person/km2, the table below gives two options of ponds, subsistence or commercial fish farming:

Table 15: Estimation of maximum water ponds need

	2012		2037	
	subsistence 2 km radius 2t/Ha/year size 0.04Ha	commercial 4 km radius 3 t/Ha/year size 0.4 Ha	subsistence 2 km radius 2t/Ha/year size 0.04Ha	commercial 4 km radius 3 t/Ha/year size 0.4 Ha
population density	95	95	294	294
population	1 194	4 776	3 695	14 780
fish consumption kg @ 1kg/person/year	1 194	4 776	3 695	14 780
Pond Area Ha	0,60	1,59	1,85	4,92
Numbers of ponds	15	4	46	12

Taking into consideration that each pond has an average depth of 1,20m, that the annual evaporation is assumed to be 1300 mm, that soil percolation is assumed to be 1500 mm/year for sandy clays at a percolation rate of 0.5 x 10^{-7}/sec., the fish farming theoretically estimation are therefore as follows and the maximum volume of water required for fish farming is also calculated below:

Table 16: Estimation of maximum water demand for aquaculture for Karazi site

Parameters	2012		2037	
	subsistence size 0,04 Ha	commercial size 0,4 Ha	subsistence size 0,04 Ha	commercial size 0,4 Ha
Numbers of ponds	15	0	20	7
Volume	7 200	0	9 600	33 600
10% exchange daily / annually	262 800	0	350 400	1 226 400
Evaporation 1.3m/ year	7 800	0	10 400	36 400
Seepage 1.5m/year	9 000	0	12 000	42 000
Volume m3/year	286 800	0	382 400	1 338 400
Total Volume m3/year	0,29 Mm3		1,72 Mm3	

The theoretically estimation of the volume required for fish farming is estimated to 3 million m^3 for 15 fish ponds without taking into consideration the phases of the implementation.

b) Technical constraints for aquaculture

It should be considered that aquaculture is no practised in the Project area. The development of such activity will require including training on the use with the implementation. It should as well require further investigations about the wish of the local population for such development as the social assessment has found a low interest for such activity.

4.5.5. Hydropower development

4.5.5.1. LEGISLATIVE FRAMEWORK

The following documents are relevant to the energy sector in Tanzania:

- The Energy Policy of Tanzania of 1992
- The National Energy Policy for Tanzania of 2003

4.5.5.2. ENERGY SUPPLY IN THE PROJECT AREA

No hydropower development project has yet been identified. As for electricity coverage, only two urban centres have access to electricity in the project surroundings: Kayanza and Omurushuka. Electricity network is now being extended to Chanamisa town.

A 20 km distribution line is being installed from Karagwe town.

4.5.5.3. HYDROPOWER POTENTIAL ASSESSMENT

The used methodology is the same as described in the chapter 3.4.1.4

a) Energy production

The results are summarized in the following table:

Table 17: Energy production results for Karazi site

Name	Full Supply Level (m)	Firm Power (kW)	Mean Power (kW)
KARAZI	12	69	83

b) Economic analysis

The aim is to present the economic profitability of the project through simple criteria such as cost per kWh delivered and the benefit / cost ratio.

The economic analysis requires two assumptions which are the discount rate and the selling price per KWh.

The discount rate "a" compares expenditures or revenues that are not performed at the same time. It represents an interest rate reflecting the preference for the present of any investor. Thus a cash flow occurring in n years will be the same value as the same financial flows occurring in the current year divided by (1 + a)n. The discount rate is usually set by the authorities for its investments by domestic companies or financial institutions. It usually ranges between 5% and 15% and is even higher than the financial resources are scarce. The update makes it possible to make comparable financial flows including schedules of revenues and expenses are different.

In this study, the hypothesis was a value of 10% for the discount rate which is often taken as a reference.

The cost per kWh is estimated equal to 0,15 Euros/kWh. The benefit after 30 year of exploitation is given in the following table:

Table 18: Benefit of energy selling for Karazi site

Name	Full Supply Level (m)	Firm Energy (kWh/year)	Benefit after 30 years (Euro)
KARAZI	12	604 854	940 171

Each of these potential benefits must be compared to the overall cost of investment cost of the construction of the micro-powerhouse (civil engineering, site facilities, access road, civil works, hydro-mechanical equipment, transmission line…) plus the annual expenses required for the maintenance. According the experience of the consultant on similar project, all these cost will not be less than 1,2 millions of Euros. Thus the site would be not viable economically.

4.5.6. Water supply

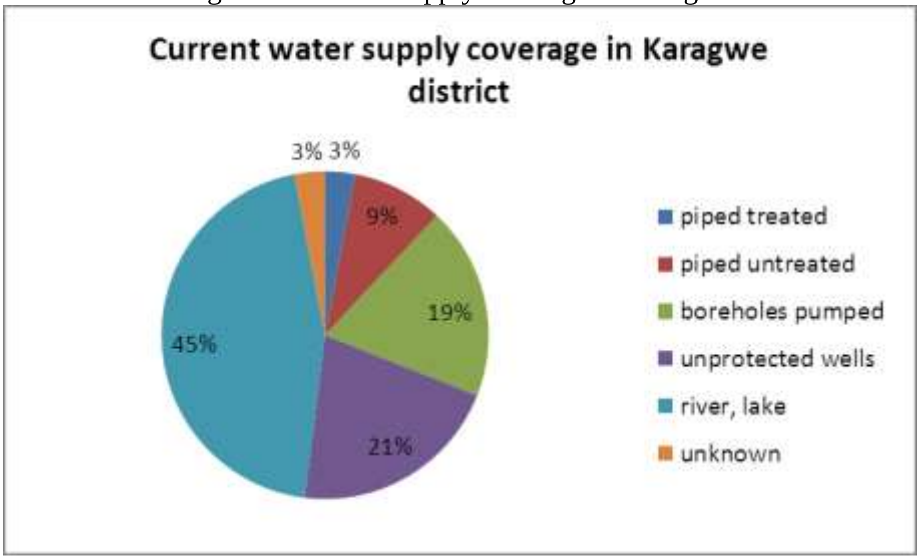
4.5.6.1. LEGISLATIVE CONTEXT

There are several strategic documents for the water sector in Tanzania. According to the National Water Policy produced in 2002, access to drinking water remains the highest priority among other water uses. The National Water Sector Development Strategy 2005-2015, issued in February 2005, is highly relevant for the project for it proposes policy implementation guidelines.

4.5.6.2. WATER SUPPLY USES

According to the socio economic survey, only 23% of Karagwe district population has access to safe water. The following figure highlights the water supply coverage repartition in Karagwe district:

Figure 29 : Water supply coverage in Karagwe district



However, there are numerous medium deep and deep boreholes that have been drilled in this district.

During the field mission, it has been noted that communities rely on groundwater with traditional wells and boreholes, some of them with hand pumps. The distance for water fetching is long (2 to 5 km) as most of the villages are located at the top of the hills. There is scarcity of water in the district.

World Bank funded rural water supply project by installing boreholes in three villages.

4.5.6.3. POTABLE WATER DEMAND

Water demand calculation is based on a water demand per capita of 20 litres/person/day (lpd). The present and future water demand is estimated based on the methodology described in the chapter 3.4.1.2 as follows:

Figure 30: Estimated water supply demand for Karazi site

Water Supply	Urban	Peri-urban	Rural	2012			2037		
				Urban	Peri-urban	Rural	Urban	Peri-urban	Rural
Population	levels of services			56,056	21,270	120,532	270,622	47,894	271,400
Communal Water Points / others	30%	60%	80%	16,817	12,762	96,425	81,186	15,180	217,120
Yard Taps	20%	20%	20%	19,285	3,363	2,552	19,285	54,124	5,060
Multiple Taps House Connection	50%	20%	0%	1,682	510	0	135,311	5,060	0
Water Demand m3/d	per capita lpd			m3/d	m3/d	m3/d	m3/d	m3/d	m3/d
Communal Water Points / others	25			420	319	2,411	2030	380	5428
Yard Taps	60			202	153	1,157	3247	304	3257
Multiple Taps House Connection	120			202	61	-	16237	607	0
Sub-Total m3/d				824	533	3,568	21,514	1,290	8,685
Non-domestic 30% m3/d				247	160	1,070	6,454	387	2,605
Total m3/d				1,071	693	4,638	27,969	1,677	11,290
30% losses m3/d				321	208	1,391	8,391	503	3,387
Grand Total m3/d				1,393	902	6,029	36,359	2,181	14,677
				8,324 m3/d			53,217 m3/d		
Annual demand including Bugene, Omurushaka and Kayanga towns (m3/year)				3,0 million m3			19,4 million m3		
Annual demand without urban towns (m3/year)				2,53 million m3			6,153 million m3		

The water demand option that has been kept for the study is the last one (excluding the urban towns such as Bugene, Omurushaka and Kayanga) due to the distance of the towns from the dam site.

These data should be considered with cautious, as should be reviewed during the detailed design.

4.5.6.4. POTABLE WATER DEMAND ASSESSMENT

The location of the villages (at the top of the hills) is an issue for the supply of water. Further detailed investigations should be studied for the implementation of a type of water supply.

4.5.7. Environmental flow requirement

Following the methodology mentioned in the chapter 3.4.1.6, the environmental flow has been estimated to nil taking into account that the River is seasonal. No environmental impacts have been found to justify taking into consideration an environmental flow at the stage of this study. It is recommended in the detailed design to take into consideration the ecological environment in order to define the most appropriate flow keeping in mind that the Karazi site has two dry seasons with no flows.

4.5.8. Evaluation of development scenarios

Evaluation of water uses

During the socio-economic survey, the local communities expressed the following point of view about the priorities water uses:

1) potable water supply
2) electricity
3) irrigation
4) livestock watering
5) aquaculture

The below table summarizes the merits and demerits of each water uses based on the above chapters.

Table 19: Evaluation of the water uses scenarios for Karazi site

Water uses	Existing Use	Demand assessment	Feasibility of installation
Water supply	**Low**	**High**	**Medium**
Irrigation	**Low**	**Medium**	**Medium**
Livestock watering	**High**	**Medium**	**Medium**
Aquaculture	**Low**	**Low**	**Medium**
Hydropower	**Low**	**Medium**	**Low**

Thus, aquaculture and hydropower seems to be the less relevant use to implement for this site.

Analysis of findings

The water use review allows estimating the appropriate dam height to deliver the required water demand with an acceptable deficiency. The following table gives the maximum water demand option excluding the urban towns such as Bugene, Omurushaka and Kayanga due to the distance.

Table 20: Summary of water demand for Karazi site

Water Use Type	Water demand (m3/year)	
	2012	2037
Water supply demand	2 530 000	6 153 000
Irrigation water demand	5 500 000	11 000 000
Livestock water demand	650 000	900 000
Aquaculture demand	290 000	1 720 000
Total (m3/year)	**8 970 000**	**19 773 000**
Total (m3/s)	0,28	0,63

About water uses, it should be noted that potential land use conflict between pastoralists and farmers should be taken into consideration in the case of development of irrigation.

For energy supply, the site would be not viable economically as mentioned in the chapter 4.5.5.3 due to the small discharge capacity. Thus, this water use was excluded from the potential uses to develop.

Karazi site has two dry seasons with no flows. Storage is therefore necessary for the above use developments.

4.6. Optimization of the reservoir capacity for Karazi site in Tanzania

4.6.1. Objective of the optimization

Dams mainly serve to ensure an adequate supply of water by storing water in times of surplus and releasing it in times of scarcity, thus also preventing or mitigating floods. Dams that have small storage capacity in relation to the gross Mean Annual Runoff (MAR) are known as “annual dams”. They are likely to fill from empty every year except the very worst seasons or even single floods.

The methodology adopted (see chapter 3.3) is a Sequential Steam flow Routing (SSR) and according to this method a continuity equation of the water volumes is applied to calculate reservoir levels and therefore reservoir volumes, evaporation and outflows from spillway and outlet structure.

The erratic inflow of the river passes through the storage reservoir will be delayed and attenuated as it enters and spreads over the reservoir surface. Water is then released through a controlled outlet.

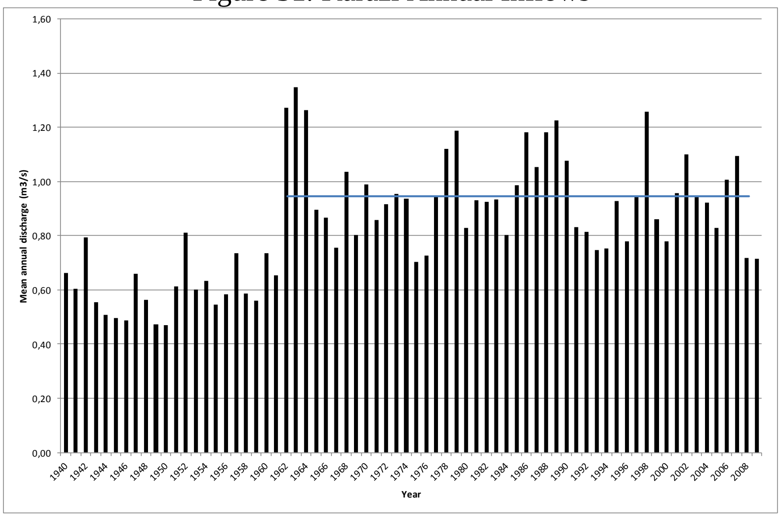
The optimization consists of determining the minimum reservoir capacity which allows an average constant water release with an acceptable deficiency.

4.6.2. Runoff for Karazi dam

For the proposed dam site at Karazi, no gauging station was identified in the vicinity of the site. The Consultant deduced the monthly discharge record from the discharge record computed at Bigasha dam site.

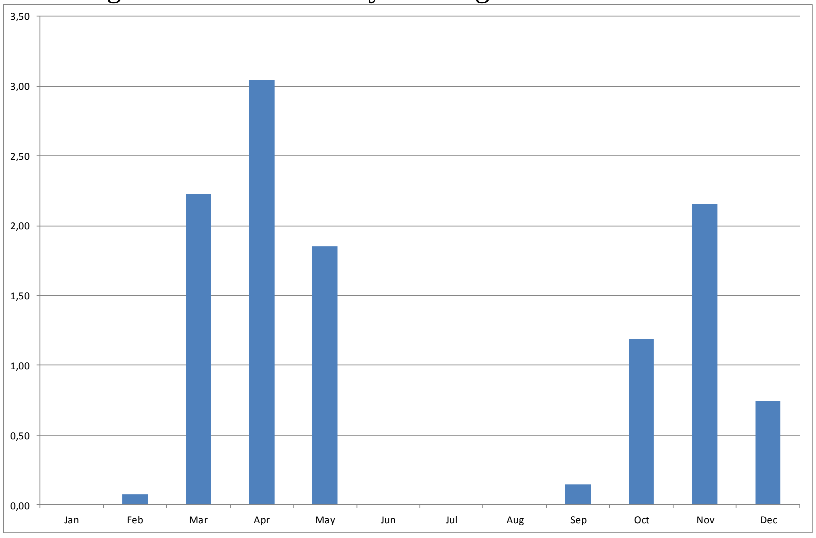
As observed in the region since 1940, the rise in runoff in the early 1960ies appears clearly. Two periods can be distinguished: a pre-1960 period with a moderate runoff level and a post-1960 period with a high runoff level. It has therefore been decided to simulate the reservoir only over the period 1962-2009, corresponding to a long series of 48 years (see hydrological report in Appendix H).

Figure 31: Karazi Annual Inflows



The annual runoff within the period 1962-2009 is about 0,95 m^3/s, with a quite pronounce seasonal pattern due to arid conditions and dry periods without flows. The discharge is totally nil during the month of January and from June to August.

Figure 32: Mean monthly discharges at Karazi dam site



4.6.3. Evaporation for Karazi dam

The following table summarizes the result of the computed Net Evaporation at the Karazi dam site. The net losses due to evaporation are about 8% of the annual inflow.

Table 21: Estimated evaporation at Karazi reservoir

	Karazi	Precipitation		Original evapotrans piration (mm)	Evaporation (mm)	Net Evaporation (mm)	Catchment Area (km²)	Runoff (mm)	Dam Height (m)	Reservoir Surface Area (km²)	Net losses due to evaporation /Inflows
	Altitude (m)	Yearly Amou	Distribution	based on CR(	Lower Kagera						
		919		0,181			213	141	9,5	2,71	8,0%
January		47	5,1%	34	120	86					
February		64	7,0%	47	108	61					
March		120	13,0%	88	117	29					
April		143	15,5%	105	106	1					
May		110	12,0%	81	114	33					
June		24	2,6%	18	124	106					
July		19	2,0%	14	146	132					
August		35	3,8%	26	163	137					
September		65	7,1%	48	136	88					
October		93	10,1%	68	127	59					
November		118	12,8%	86	110	24					
December		83	9,0%	61	117	56					
Total		919	100%		1 488	814					

4.6.4. Water demand at Karazi dam

The following table gives the maximum water demand option excluding the urban towns such as Bugene, Omurushaka and Kayanga due to the distance.

Table 22: Summary of water demand for Karazi site

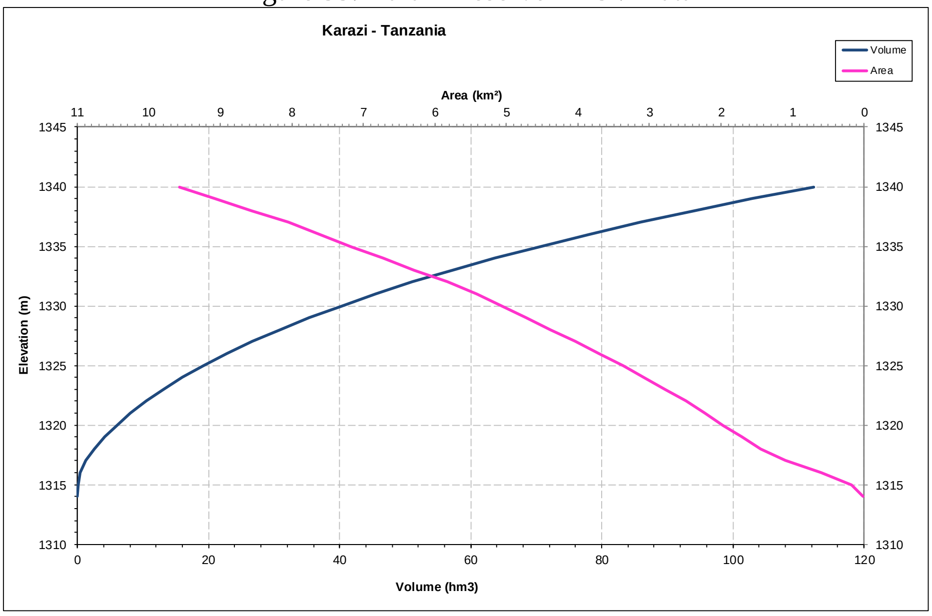
Water Use Type	Water demand (m3/year)	
	2012	2037
Water supply demand	2 530 000	6 153 000
Irrigation water demand	5 500 000	11 000 000
Livestock water demand	650 000	900 000
Aquaculture demand	290 000	1 720 000
Total (m3/year)	**8 970 000**	**19 773 000**
Total (m3/s)	0,28	0,63

The objective of the optimization is to determine what should be the reservoir capacity for the above water demand (0,63 m3/s) with an acceptable deficiency (10%). All the following simulations are carried out with this constant water demand.

4.6.5. Reservoir Data

Based on the new topographical data (LiDAR data), the surface and the volume of the reservoir versus the height of the dam were determined according to the height-volume-surface (HSV) curve as follows.

Figure 33: Karazi Reservoir HSV Data



4.6.6. Minimum Operation Level

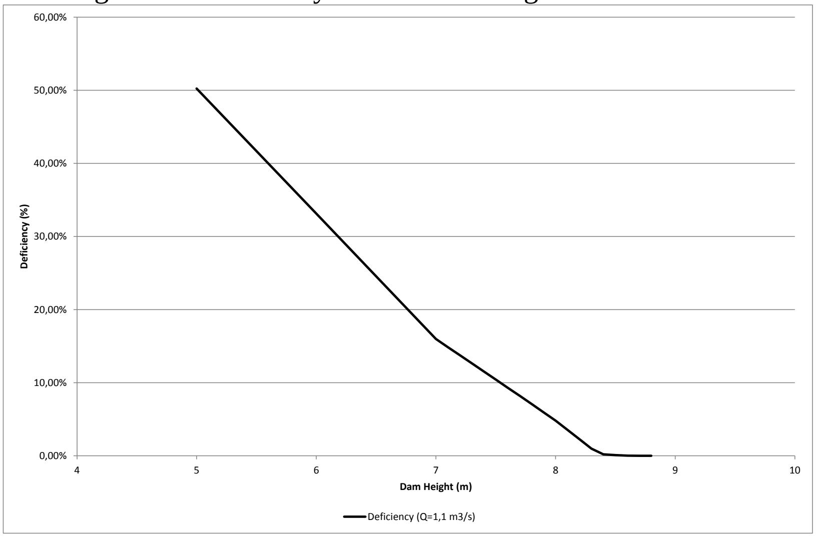
As sediment will be trapped, the reservoir storage capacity will decrease. Therefore, the outlet structure must be set at an elevation above the expected siltation level. Under this level, the water stored will not be used and commonly called as “dead storage”.

The annual sedimentation rate at Karazi site is about 0,11 Mm3 per year. Therefore, the outlet threshold has been set 5m above the minimum ground elevation, giving a dead storage is 4,12 Mm3 representing more than 35 years of sedimentation storage.

4.6.7. Deficiency and discharge guaranteed

The following figure represents the deficiency (percentage of months when the demand is not satisfy) versus the FSL height. Of course, more the reservoir capacity is big, more reliable will be the reservoir to satisfy the demand.

Figure 34: Deficiency versus Dam Height for Karazi dam

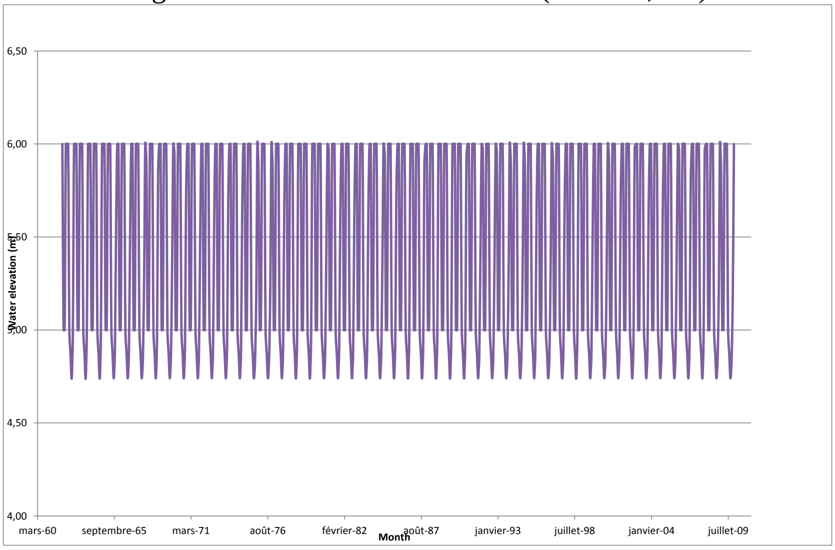


This curve can be divided into two different zones:

- Zone 1: Below a FSL of 8,5m above the minimum ground level, the curve is constantly decreasing. The reservoir has a too small capacity to store the water during the wet season and to deliver it constantly during the dry season.

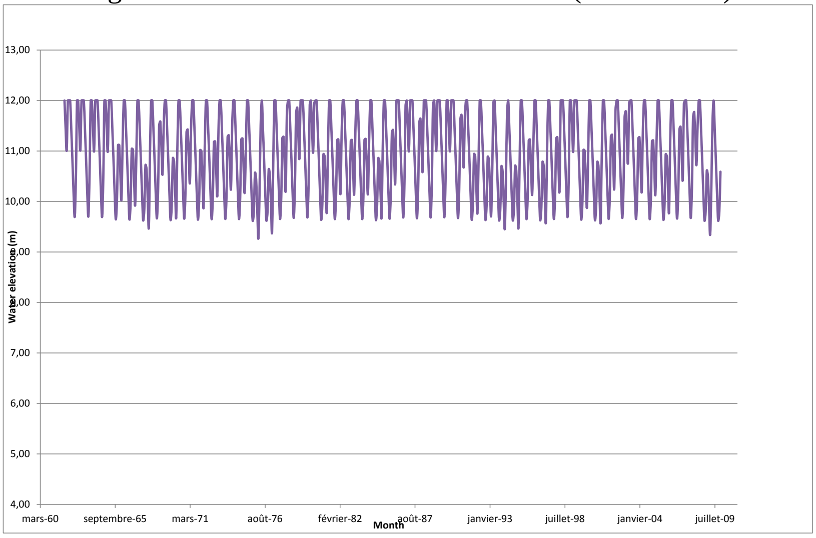
  The following figure shows the water elevation in the reservoir along the simulation period. It can be seen that the reservoir is empty for every single year meaning a poor reliability of the reservoir to provide the demand. The water level is often under the Minimum Operation Level (here 5m) due to the evaporation losses.

Figure 35: Karazi Water Elevation (FSL = 6,0 m)



- Zone 2: Above a FSL of 8,5 m, the deficiency is always nil. The reservoir capacity is too important related to the water demand. The following figure shows the water elevation in the reservoir along the simulation period. It can be seen that both the bottom outlet level is never reached and the water elevation varies only between the two first upper meters. A trench of about 2 to 2,5 metres above the Minimum Operation level is adequate.

Figure 36: Karazi Water level simulation (FSL = 12 m)

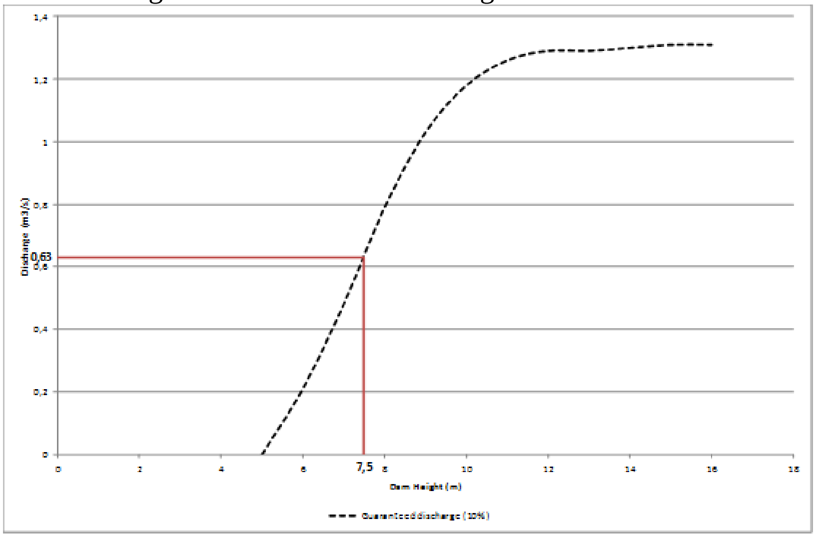


The Figure 34 curve shows that a deficiency of 10% in providing the water demand of 10% required a Full Supply Level at 7,5 metres. The following figure shows the water elevation in the reservoir along the simulation period with this 7,5m FSL. The reservoir is also full quite often (but not every year) and seldom under the Minimum Operation Level given an acceptable reliability of 90%.

Figure 37: Karazi Water level simulation (FSL = 7,5 m)

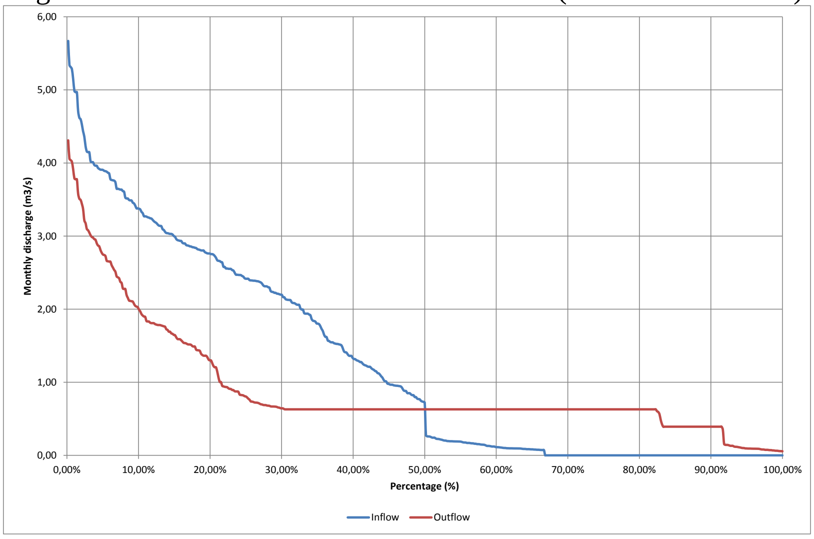
Another meaning is to evaluate the guaranteed discharge for different FSL of the dam and to choice the FSL given a guaranteed discharge equal to the water demand. The following figure showing the discharge guaranteed 10% of the time versus the dam's height confirms the optimization of a Full Supply Level to 7,5 meter.

Figure 38: Guaranteed discharge for Karazi dam



With a full supply level of 7,5 meters above the ground level is adopted, the following figure shows the discharge variability without (Inflow) and with the dam (Outflow). The deficiency to provide 0,63 m3/s is 10,43 %.

Figure 39: Flow duration curve at Karazi dam (Inflow and outflow)



5. DETAILED DESIGN AND COSTING FOR KARAZI DAM

5.1. Introduction

The main characteristic of the dam is as follows:

Table 23: Main characteristics of Karazi dam

KARAZI	***Final dam design***
Dam height (m)	**9,50**
Storage capacity at FWL (Mm^3)	**9,20**
Crest Width (m)	**6**
Dam crest Length (m)	**518,74**
Reservoir Width maximum(Km)	**2,11 at MWL**
Reservoir Length maximum (Km)	**3,4 at MWL**
Full Supply Level (m)	**+7,50** (1321,50m asl)
Maximum Water Level (m)	**+8,75** (1322,75m asl)
Reservoir surface area at FWL (km^2)	**2,36**
Reservoir surface area at MWL (km2)	**2,71**
Contributing catchment area (km^2)	**213**
Catchment sediment yield ($Tons/km^2/yr$)	**576**

The outlets works design is described in Appendix J. The drawings are included in the Appendix E.

5.2. Area of the project

The Project area is defined as the location and vicinity of the physical project works area, the area to be flooded by the reservoir, and the off-site construction areas. The map 13 in the Appendix C shows the overall project area including:

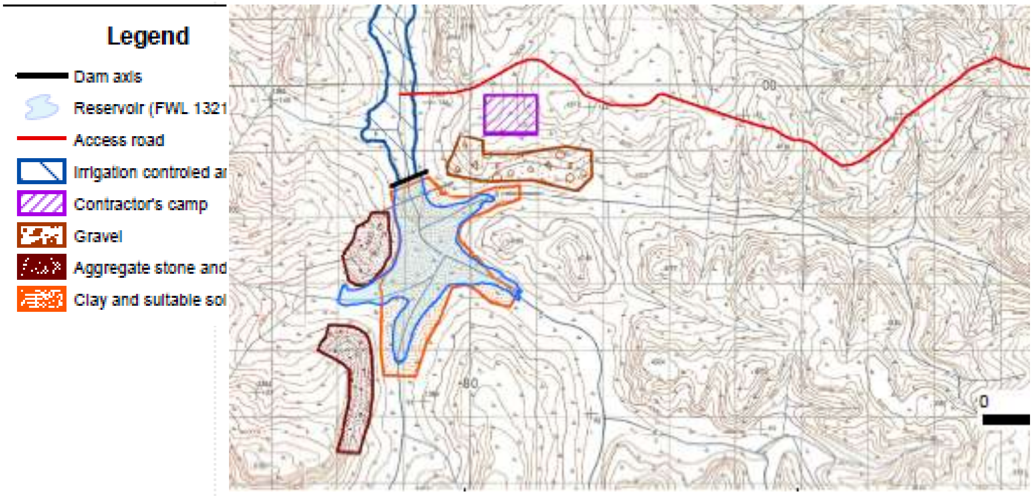
- The dam axis,
- The reservoir created due to the dam,
- The potential contractor's camp taking into consideration the topographical map (flat area for buildings as well as the access road),
- The access road which is currently a trail from the village at the top of the hill where the B182 non asphalted road could be reached.
- The extracted material area such as the clay material for the embankment dam from the valley upstream that should be mixed with the gravelly materials from hill sides, as well as a suitable rock face for concrete work that should be identified within a 5 km radius in the nearby hills (northern side) where the contractor could install a crusher for aggregates and sand.
- The potential irrigated area.

5.3. Characteristics of site work

The duration for the site work is estimated to be 7 months.

Size camp is estimated based on 30 containers (20 for personnel and 10 for offices and others), meaning around 700m2. It is located as shown on the following figure and detailed on the map 13 in the Appendix C.

Figure 40: site work for Karazi



The number of workers is estimated to 100 from which it is recommended to hire locally unskilled labour.

Heavy machinery for such dam is estimated to include 2 bulldozers, 2 cement trucks, 2 compactors, 2 hydraulic shovels, 2 wheel loaders, 5 trucks, 1 grader. The equipment would require parking lot estimated to 900m2.

It has been estimated that the waste material could reach 100 000 m^3.

5.4. Components of the dam

The paragraphs hereafter will describe the different components of the dam as well as its characteristics.

5.4.1. Full supply level

The Figure 38 about the guaranteed discharge versus the dam height (see chapter 4.6.7) agglomerates the results of the optimization of the reservoir capacity and the water demand in 2037. A Full Water Supply of 7,5m is sufficient to provide the water demand with an acceptable deficiency level. According to the topographical map, this corresponds to 1 321,50 m asl.

5.4.2. Freeboard and Maximum Water Level

The freeboard is the vertical distance between the crest of the embankment and the reservoir water surface. The Full Supply Level and the dam's crest are respectively set at 1321,5 and 1323,5m, allowing a 2m freeboard.

The minimum freeboard must be provided to prevent overtopping of the embankment by wave action which may coincide with the occurrence of the inflow design floods. The height of the waves generated by winds in a reservoir depends on the wind velocity, the duration of the wind and the fetch.

At Karazi dam site, with a fetch of about 1,5 km and a wind of 80 km/h, the wave height will be about 0,75 cm.

The maximum water level should therefore not exceed the level 1322,75m (0,75cm under the dam's crest). The next step is to determine the minimum spillway length respecting this data. The ditto computation is explained in the following chapter.

A small parapet on top of the dam crest will protect against wave ride-up.

5.4.3. Karazi Spillway hydraulic design

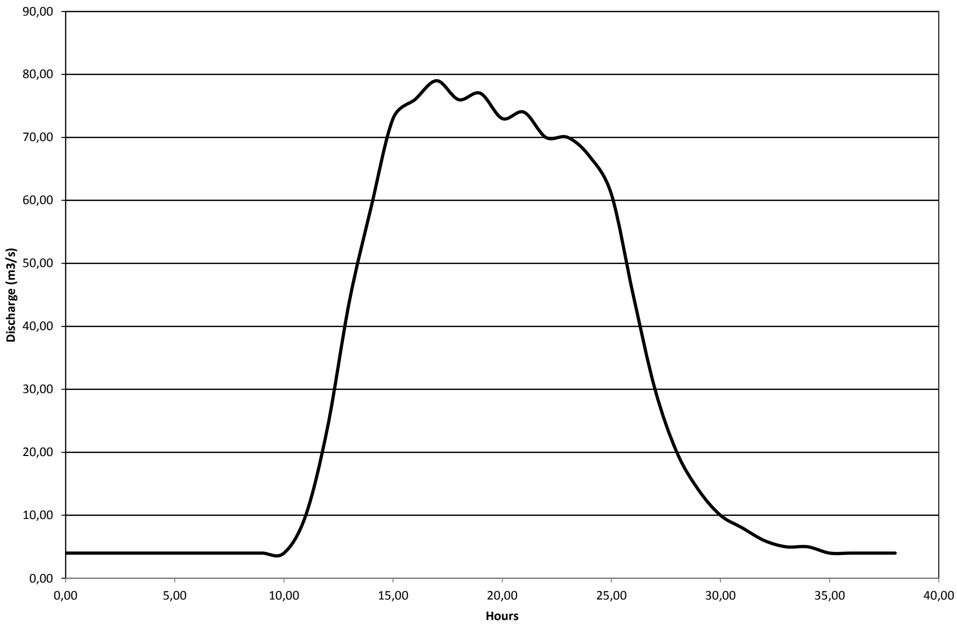
Design Flood

The proposed spillways at the feasibility stage will be a free spillway, located on the bank which presents the better geological condition for its foundation and flow restitution.

The dam has relatively low risk due to the fact that it will be located in a rural area without inhabitants in the river valley. Failure of the dam results in no probable loss of human life and low economic and/or environmental losses. According to the guidelines for dam safety applying in the region, the design flood to be considered is the one with an annual exceeded probability of 1/100.

The corresponding flood hydrographs have been computed in the hydrology study and are reported in the following flowing chart.

Figure 41: 1/100 hydrograph flood at Karazi site

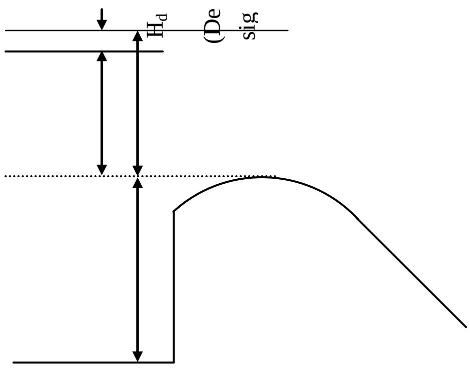


The maximum discharge is 79 m3/s.

Spillway Crest Shape

The crest shape of the ogee approximates to the profile of the lower-nappe falling from a sharp-crested weir. For discharges at design head, the flow glides over the crest with no interference from the boundary surface.

The design head is the maximum head occurring during a 100 year-return period flood, i.e. approximately 1,50 m. with a depth approach equal to 2m, the discharge coefficient will be approximately equal to 2,10.



Karazi Flood Routing

The discharge over an ogee crest is given by the equation:

$$Q = CLH_e^{3/2}$$

Where:

Q = discharge (m^3/s)
C = variable discharge coefficient (-)
L = effective length of crest (m), and
H_e= head being considered on the crest (m)

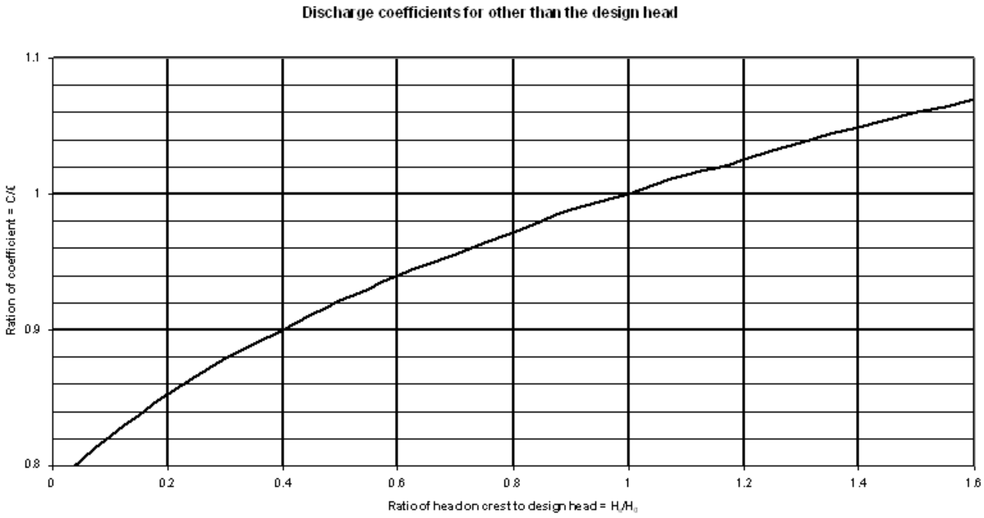
The discharge coefficient C, depends on the following factors:

> Pier and abutment effects: No bridge is foreseen across the spillway crest. Rounded abutments with headwalls placed not more than 45° to direction of flow will provide negligible contraction effect.

> Effect of head difference from design head: The discharge coefficient is not constant and assumes other values when the actual head on the crest varies from that used to determine the crest shape.

> Approach channel losses: The spillway is located against the dam itself. Therefore, the ogee is directly in contact with the reservoir without any approach channel. The corresponding losses can be considered as negligible.

The following figure shows the variation of the discharge coefficient.



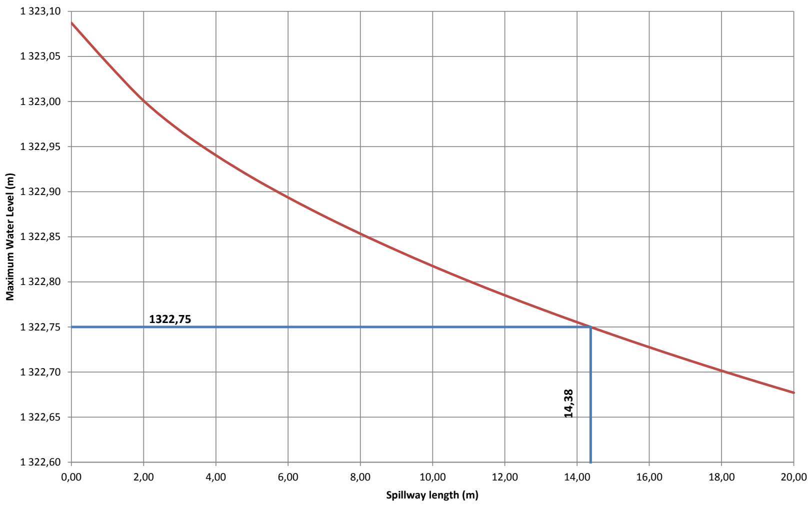
H_0 = design head

H_e = actual head on the crest

Karazi Flood Routing

A flood routing computation using Excel software with the above data has been undertaken for several spillway lengths. Results are summarized in the following graph.

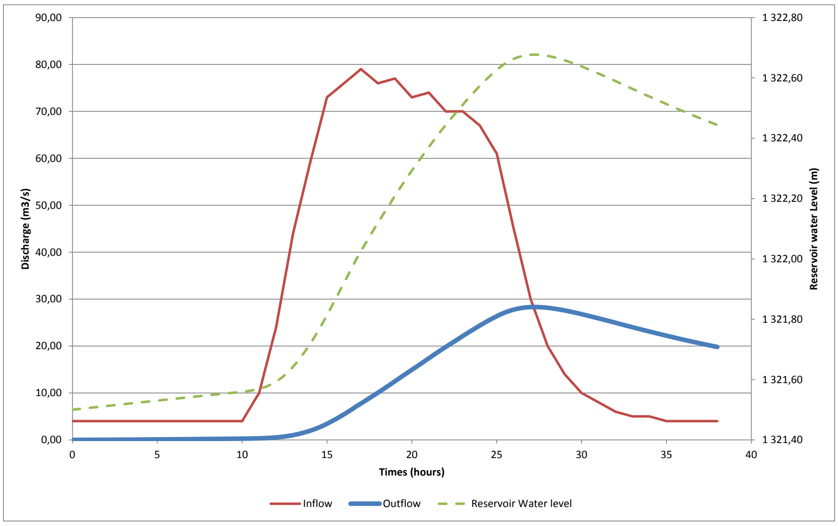
Figure 42: Karazi flood routing graph



On the above chart, the Maximum Water Level of 1322,75 as defined in chapter 2 required a minimum length of the spillway to 14,48, rounded to 15 meters.

The flood routing with such length of the spillway is summarized in the following chart.

Figure 43: Karazi flood routing



The maximum water level reached is 1322,74 with a peak outflow discharge of 28,31 m3/s.

5.4.4. Reservoir statistics

With the above results, the main characteristics of the dam is summarised below:

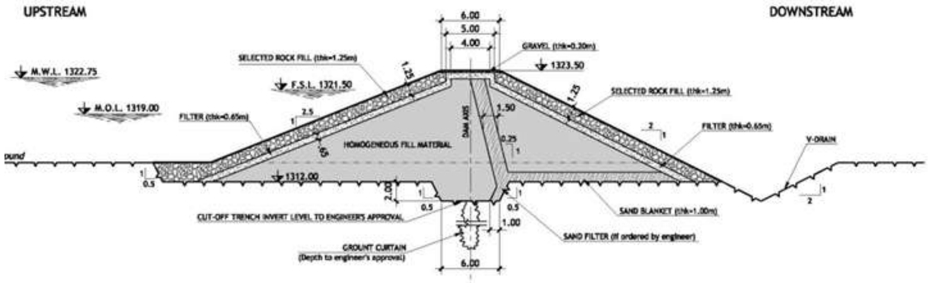
Dam Type	Homogeneous earthfill
Maximum height	9,50 m (from the natural ground level)
Crest length	518,74 m
Maximum width at NGL	57,75 m
Slope of upstream face	2.5H:1V
Slope of downstream face	2H:1V
Plan alignment	straight
Dam Crest level	1 323,50 m asl
Full Supply Level	1 321,50 m asl
Maximum water level	1 322,75 m asl
Minimum operational level	1 319,00 m asl

5.4.5. Typical cross section

The cross section of the dam consists of homogeneous earthfill material protected by a layer of filter material which in turn is protected by 1.25m thick riprap on both upstream and downstream faces. An internal filter zone will accept seepage flows from fill materials without the build-up of excess hydrostatic pressure.

The crest width is 6m, the upstream slope is 2.5H:1V, and the downstream slope is 2H:1V.

Figure 44: Typical cross section of the dam



Feasibility stability analysis has been undertaken on the highest cross section of the dam using characteristics of material obtained from the site investigation. The STB 2010 software using simplified Bishop's Methods has been used. The analysis output is presented in the Geophysical and Geotechnical Report (see Appendix I). In the same way, seepage analysis and settlement are available in the foresaid report. All results are satisfactory.

5.4.6. Foundation design

The dam footprint will be stripped of all grass, trees, excessively plastic soil and any deleterious material. Thereafter the cut-off trench will be excavated to a minimum depth of 3 m or to groutable rock foundation.

Although the maximum head of water at full supply level will only be 7,5 m, this head of water is capable of causing piping problems within a short space of time, hence the relatively deep cut-off which will lengthen the seepage path.

Badly broken areas on the downstream side of the cut-off-trench will be covered with a 500mm thick sand filter to prevent the migration of fine particles under seepage forces. Areas which have negative slopes on the sides of the cut-off trench will be treated with masonry. Shotcrete, dental concrete and slush grout will be applied where necessary.

Grouting will be undertaken to a maximum depth of 10m. The grouting procedure will follow the "stage grout split spacing method" with primary holes at 12m centres, secondary holes at 12m centres and tertiary holes at 6m centres. All primary holes will be drilled to a depth of 12m and all other holes will be drilled to 6m. Control holes will be drilled to depths up to 18m to check on effectiveness of grouting.

5.4.7. Instrumentation

Instrumentation on the dam will be in the form of settlement studs, which will be positioned along the downstream edge of the embankment crest at 50m intervals.

There will be a V-drain running along the downstream toe of the dam. Seepage water accumulating in the drain will be measured by 3 V-notches. Two will be in the toe drain while the third will be in the exit channel leading to a suitable discharge point.

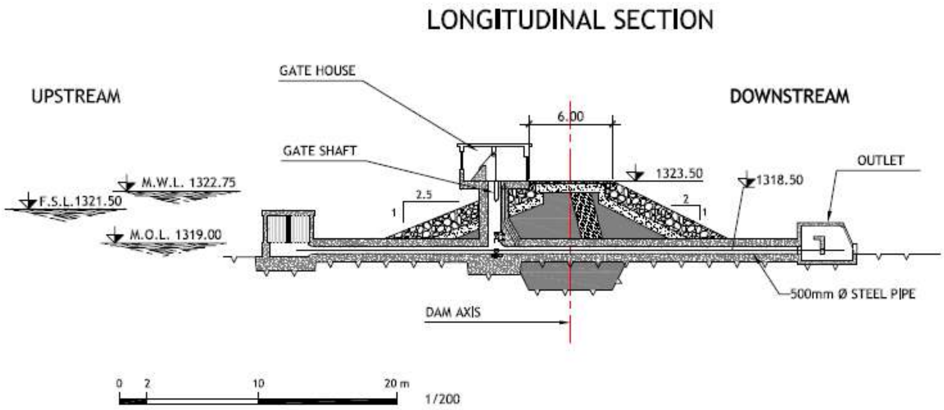
5.4.8. Outlet Works

Description

The outlet works at each dam will comprise:

- Intake trash screen
- Upstream pressure conduit
- Gate shaft and gate house
- Downstream pressure conduit
- Stilling basin

Figure 45: Example of longitudinal section for the outlet structure



Intake and trash screen

The bottom of the intake and trash screen will be at the minimum operation level (MOL) of each reservoir. The axis of the pressure conduit will be 1.10m below the MOL. The intake is 2,8m square in plan with the trash racks axes positioned on a 3,30m square.

The trash screen consists of 2m long 110mm outside diameter PVC pipes filled with reinforced concrete placed at 292mm centres. There are eight 300mm-diameter reinforced concrete columns supporting the concrete bulkhead which will be on top of the trash rack pipes. A bay of removable trash rack pipes is provided to facilitate entry into the intake should the need arise. These removable racks will be provided with lifting lugs to facilitate removal from their position.

The clear spacing between the trash rack pipes will be 182mm and there will be 40 of these spaces giving net area of flow of 14.56 m2. The velocity through the trash screen will be 0.2 m/s. Assuming a 50% clogging of the trash screen, the velocity through it for the peak discharge would be 0,4 m/s, quite below the limiting velocities between 0.9 m/s and 1.22 m/s (Ref. Advanced Dam Engineering, page 689).

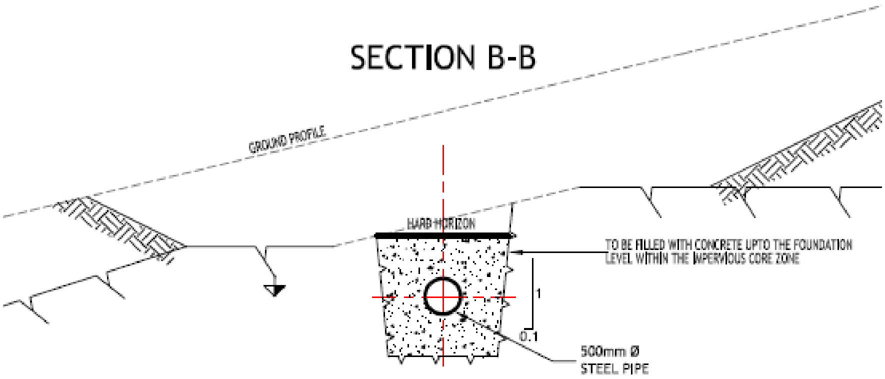
The velocity inside the intake will be about 0,5 m/s.

Figure 46: Example of similar intake (Swaziland)

Upstream conduit

The upstream conduit consists of a steel pipe encased in reinforced concrete, founded on rock throughout. The upstream end will be slightly flared to reduce entry losses. The conduit will discharge water into the gate shaft positioned 5,5m upstream of the dam axis.

Figure 47: Illustrative upstream conduit cross-section



Gate shaft and gate house

The gate shaft will be 3m by 2m with 600mm thick reinforced concrete walls. The service gate to close the downstream conduit will be lowered through the gate shaft.

The service gate house will be on top of the gate shaft with a floor level equal to the settled crest level of the embankment. The gate house will be 5m in diameter and 2.5m high with a 200mm thick reinforced concrete roof. The gate house walls will be 300mm thick. The gate house will contain the steel service gate which will be suspended at the floor level from a winch system and two supports.

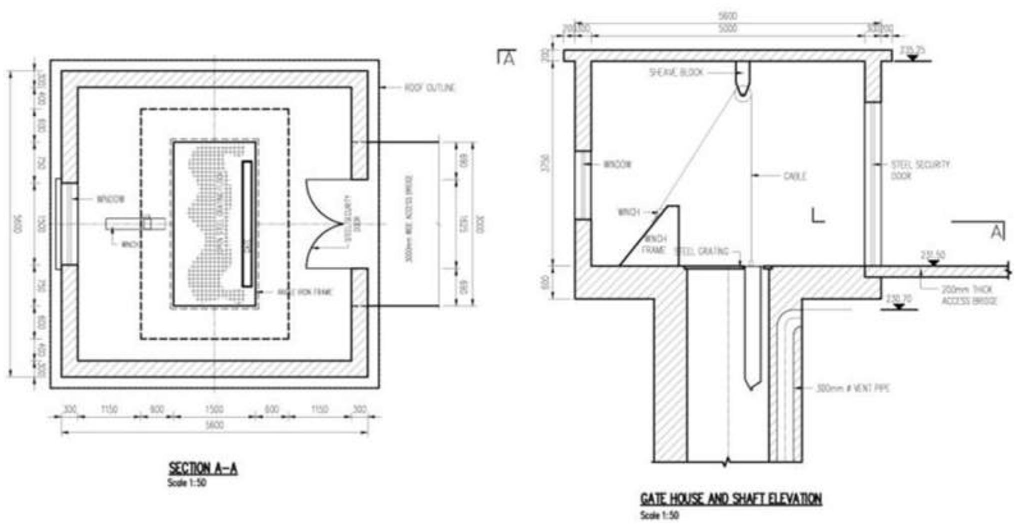


Figure 48: Illustrative gate chamber details

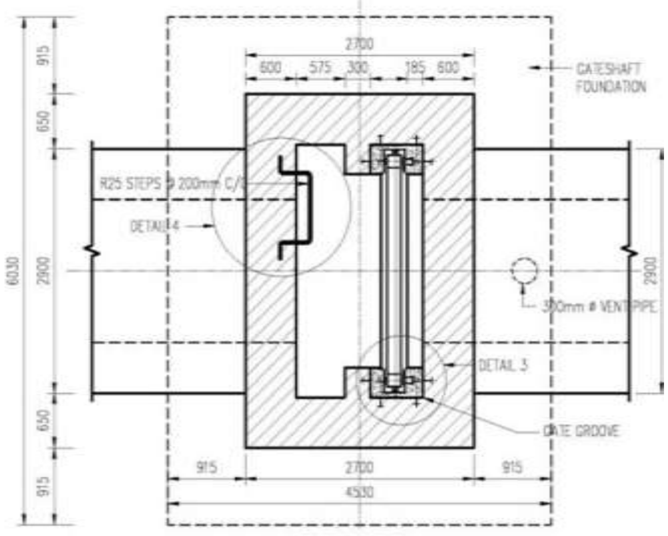
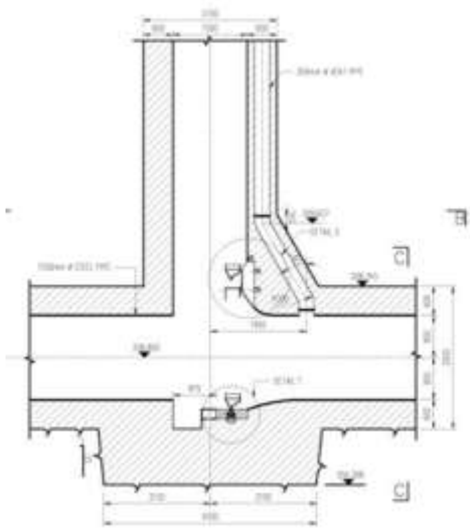


Figure 49: Illustrative gate shaft details

Downstream pressure conduit

The downstream pressure conduit starts at the gate shaft. The upstream end will be bellmouthed to provide good entry conditions. There will be a striker plate below the bellmouth where the gate will rest when lowered down. The gate will be on-seating, i.e. kept in place by the water pressure.

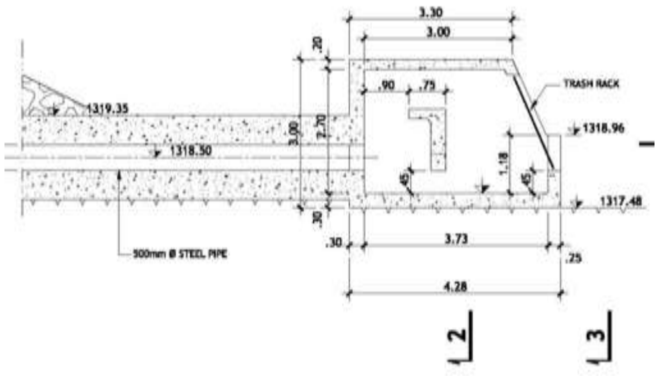
Figure 50: Illustrative bottom of the gate shaft



The pressure conduit will be encased in 600mm thick reinforced concrete which will be cast in a purpose made trench, excavated into hard rock.

Stilling Basin

The pipe will discharge into a stilling basin. The water jet will hit a baffle wall. The energy will be dissipated in the stilling basin before its restitution to downstream. Trashracks will be placed at the far end of the stilling basin in order to achieve the dissipation and to protect the structure against human aggression.



Computation

The outlet works have been designed for the water demand estimated to be 0,63 m^3/s in 2037 when the reservoir is at its minimum operation level (1319,00). In Appendix J, the discharge of the bottom outlet versus the pipe diameter has been computed. A pipe diameter of 500mm is required to fulfil the requirement.

5.4.9. Karazi Spillway civil works

Location and general layout

The spillway for the Karazi Reservoir will be located in the left side of the dam where geological conditions offer better condition. The spillway will be orientated in line with the dam, discharging downstream of the toe of the dam into the River (see the drawings in the appendix E).

Spillway components

The spillway consists of the following:

- Approach channel
- Spillway ogee
- Spillway chute
- Stilling basin
- Return Channel

Approach channel

The approach channel will be excavated into the lateritic soil and slightly weathered down to the sound rock. This will allow a minimum approach depth to the spillway over flow sill of 2m, which is conducive to more efficient spillway discharge. Excavation of the spillway approach channel will involve the removal of overburden down to formation level.

The approach channel has side slopes of 2H:1V to ensure stability since the overburden.

Ogee spillway

Shape

The spillway overflow sill has been designed as an ogee spillway 15 meters long. The ogee profile provides a hydraulically efficient control structure with a high coefficient of discharge where the upper curve of the ogee conforms closely to the profile of the lower nappe of a ventilated sheet of water falling from an ogee-type weir. For discharge at the designed head, the flow glides over the crest with no interference from the boundary surface and attains near-maximum discharge efficiency.

The ogee shape terminates when the downstream face slope (0,8h:1V) formed by the tangent to the ogee profile intersects the vertical upstream face of the ogee at maximum water level 1 321,50 m.

Ogee concrete sill

The ogee concrete sill for both the main and auxiliary spillways will be a plain mass concrete (CVC) structure of 20/64 concrete grade. The structure will have skin reinforcement in the form of wire mesh on its periphery to prevent thermal cracking. Construction joints every 15m will have PVC waterstops. Each block will be set at different elevation depending on the rock level.

Stability

The ogee structure will be subjected to water loads (static and dynamic). Although the foundation will be consolidation grouted and a grout curtain provided to prevent seepage, it is assumed that these measures might still not fully preclude seepage water through the foundation and therefore uplift pressures are possible at the varying water levels.

Calculation at the PMF loading case may show that anchor bars are necessary for the actual ogee structure to counter uplift pressure, and anchor bars are necessary on the sloping face to counter sliding.

A system of drains is to be incorporated to ensure that all seepage water is evacuated from below the ogee. The drainage system consists of 150mm diameter half round perforated PVC pipe, laid at 1m centres across the entire length of the ogee in the upstream-downstream direction. Water flows into these drains is discharged into the River.

Grouting

Consolidation grouting will be carried out in the spillway foundation over the whole area to be covered by the ogee structure in order to stabilise the rock which may have become disturbed during excavation. Consolidation grouting will be at 3m staggered centres to a depth of 3m.

Curtain grouting will be undertaken in primary and secondary holes spaced at 12m and tertiary holes at 6m centres, in stage not exceeding 6m length. Grout holes will be drilled vertically on a single line along the ogee spillway axis.

Concrete basin

A concrete basin has been designed at the toe of the ogee structure in order to protect the foundation from the energy gained by the water after flowing over the control section. The concrete slab is about 20 meters long. Then the water will flow up to the river within an excavated trench.

Return channel

After passed throw the stilling basin, flow reach the open channel and flows over the bedrock layer until attaint the riverbed. Laterals walls measuring between 2.00m and 2.50m should be constructed all along the channel to protect excavation banks. No bedrock surface treatment is expected, except in some special cases to be defined.

5.5. Dam safety monitoring and management system

Karazi is less than 12m, categorized them in the lowest category of dams. Accordingly, only simplified studies shall be conducted with general layout drawings of the dam and outlet works. Moreover, this dam has relatively low risk due to the fact that it is located in a rural area without inhabitants in the River valley. Failure of the dam results in no probable loss of human life and low economic and/or environmental impact.

According to the guidelines for dam safety from the World Bank, the monitoring procedures and instrumentation have been designed to confirm that the structure is performing in accordance with the design.

In this case, sudden changes in seepage, abnormal settlement patterns and slope movements will be the symptoms of deterioration in the embankment and/or foundation. Instrumentation has been then chosen so as to be able to determine whether these foresaid changes are occurring.

1. The settlement studs positioned along the downstream edge of the embankment crest at 50m intervals will permit the settlements patterns follow-up.

2. The V-drain running along the downstream toe of the dam will allow to follow-up the seepage trough the dam body and its foundation.

3. Inspection routine of the completed dam and associated structure (spillway and bottom outlet) on a weekly basis must be implemented during the operation live. During this inspection, damage or abnormal situations will be recorded.

5.6. Karazi Dam cost estimation

The costs presented hereafter are the average of several prices applied in works done in different African countries. It was privileged to consider projects which present similar geographical conditions.

As the quantities are small for this type of work, the cost of provision of machinery may represent a significant portion of the total cost and is not included in this analysis.

A summary of the costs is presented in the following table.

Table 24: Dam costs

	Cost US $
Preliminary works	2 426 544
Dam	13 857 588
Spillway	1 480 473
Bottom Outlet	134 785
Hydro Steel Structure Equipment	81 075
Total	**17 980 465**

The bill of quantities for the dam is described as follows:

Figure 51: Bill of quantities for Karazi dam

Désignation des prix	Unit	Quantity	Unit Price	Total Cost
General Items				**2,426,544**
Site Installation	LS	5.0%		777,696
Demolition of site installation	LS	2.5%		388,848
Access road (10 km) maintenance	km month	240	5,250.0	1,260,000
Dam				**13,857,588**
Clearing and grubbing	m^2	26,375	0.2	5,275
Excavation in loose material	m^3	44,613	7.0	312,288
Excavation in rippable material	m^3	15,950	45.0	717,750
Backfill homegeneous material (sandy clay)	m^3	112,500	10.0	1,125,000
Backfill Transition/Filter	m^3	33,125	100.0	3,312,500
Rip Rap	m^3	35,000	162.0	5,670,000
Drilling and grouting	ml	3,900	180.0	702,000
Class 20/38 mass concrete	m^3	227	485.0	110,216
Formwork	m^2	1,768	16.0	28,280
Reinforcement	T	2.3	3,000.0	6,818
Monitoring	0.50%			59,951
Miscellaneous	15%			1,807,512
Spillway				**1,480,473**
Excavation in loose material	m^3	14,016	7	98,109
Excavation in rock	m^3	4,672	85	397,109
Class 20/38 mass concrete	m^3	1,498	485	726,740
Formwork	m^2	1,143	16	18,288
Extra cost for the formworks with single curvature of radius < 5m	m^2	33	25	825
Finishing	m^2	108	12	1,296
Reinforcement	T	15	3,000	45,000
Anchor bolt	ml		15,000	0
Miscellaneous	15%			193,105
Bottom outlet				**134,785**
Trench in rock material	m^3	50	85.0	4,250
Class 20/38 mass concrete	m^3	117	485.0	56,512
Class 30/38 concrete for reinforced concrete	m^3	72	585.0	41,994
Formwork	m^2	547	16.0	8,749
Reinforcement	T	1.9	3,000.0	5,700
Miscellaneous	15%			17,581
HSS Equipment				**81,075**
Steel Pipe diameter 500 mm	ml	35	300.0	10,500
Fixed roller gate 1m x 1m	U	1	60,000.0	60,000
Miscellaneous	15%			10,575
			TOTAL	**17,980,466**

6. DESCRIPTION OF DETAILED DESIGN SCHEMES FOR KARAZI

6.1. Introduction

The development schemes follow the decision taken by the country for the use of the dam. It is recommended that Water User Association(s) should be formed to manage the project water resources, and to serve as a tool for conflict management and other related matters.

6.2. Irrigation scheme

6.2.1. Design standards

- **Irrigation duty**

As shown in the chapter 4.5.2, the first estimate of the irrigation duty gave a value of 5,1 l/s for rice based cropping pattern. This estimate has been calculating using the following assumptions:

- Rice double cropping on the whole area
- Irrigation time: 12 hours a day
- Overall efficiency (canals + on plot): 60%

A regional analysis of the commonly adopted irrigation duties values showed a range between 3,7 and 4,2 l/s, much lower than the first estimate.

Therefore, as the peak requirement is, as usual for rice cropping, the soil preparation (mudding), the adopted assumption for that period is a daily irrigation time of 16 hours. This is allowing a reduction of the irrigation duty down to 3,83 l/s, hence approximately 20%.

This of course has also implication on canal cross-sections: according to Manning's formula, a reduction in the discharge triggers a reduction in canal cross-section, assuming longitudinal slope and Manning's coefficient are invariant.

- **Diversion weir**

Hydraulic design

The diversion weir should be designed for routing without damage or overtopping of earth sections a flood of 50 years return period. The weir will certainly operate downstream submerged for high floods, but at that early stage energy dissipation is calibrated to dissipate the energy of 50 years flood.

Cross section

Crest width will be 6 m to allow small vehicles crossing for the diversion weir to allow the use of the structure as a major crossing of the marshland. Concrete sections will be only 4 m wide (single circulation lane), as they are short.

In the earth section, side slopes will be 1.5/1.

Minimum freeboard will be 0,3 m.

Compaction criteria will be 95% OPM except for fill around or under concrete structures, where it will be 98%.

It will consist in 3 sections, from right bank to left bank:

- Security spillway, masonry made and including a downstream stilling basin made also of masonry;
- Desilting and/or drainage sliding gate;
- Earth section with left bank canal intake (trashracks, upstream or central shaft, sliding gate, culvert).

Foundation is not known at this early stage. To be conservative, a 2 m deep cut off trench has been taken into account in the design.

- **Canals**

Main canals

General arrangement / longitudinal slope
Main canals (one on each bank) are designed for an irrigation duty of 3,83 l/s/ha, taking into account all losses and irrigation needs of rice crop. Due to the very flat area, the canal should be built with a minimum longitudinal slope of 1/1000. This might be challenging for construction (only 50 cm difference in elevation for 500 m length) but compulsory to actually control the whole area.

Construction materials
Main canals should be built with selected materials, with some minimum requirements in terms of plasticity index and water tightness.

Freeboard
Standard freeboard is taken equal to 0,3 m.

Standard section
In cut and fill
While building in cut and fill (ie. along a contour line), main canal will have the following features:

- Side slopes 1/1
- Crest width : 1 m upstream, 1 m downstream

In fill
While building in fill (ie. across a thalweg), main canal will have the following features:

- Side slopes 1/1
- Crest width : 1,5 m upstream, 1,5 m downstream

Secondary canals

General arrangement / longitudinal slope

Secondary canal are mainly built perpendicular to the river, to supply water to tertiary canals parallel to the general direction of the river. The longitudinal slope follows the natural transverse slope of the marshland (1/1000 to 3/1000), except if water speed is too high. In that case, drop structures should be built. Secondary canals are designed to supply tertiary canals with a minimum 20 cm elevation difference in the worst case.

Construction materials
Secondary canals should be built using materials locally extracted, especially from drains, to minimize transport and increase production. Hence, maintenance requirements and infiltration rate are likely to be higher. However, the short length of theses canals will keep the efficiency to acceptable values.

Freeboard
Standard freeboard is taken equal to 0,2 m.

Standard section
Fill and cut and fill sections will be similar.

- Side slopes 1/1
- Crest width : 0,5 m both banks

Tertiary canals

General arrangement / longitudinal slope
Tertiary canal are mainly built parallel to the general direction of the river. The longitudinal slope will follow the natural long slope of the marshland (1/1000 to 2/1000), except if water speed is too high. In that case, drop structures will be built. Tertiary canals are built with a water level 30 cm above the natural ground, to allow for a headloss of 10 cm and a water level inside the basins of 20 cm.

Construction materials
They will be built using materials locally extracted, especially from drains, to minimize transport and increase production. Hence, maintenance requirements and infiltration rate are likely to be higher. However, the short length of theses canals will keep the efficiency to acceptable values.

Freeboard
Standard freeboard is taken equal to 0,2 m.

Standard section
Fill and cut and fill sections will be similar.

- Side slopes 1/1
- Crest width : 0,5 m both banks

- **Crossing structures**

Culverts or box culverts
These structures are used for road and drain crossings, the design is made according to pilot drawing in the appendix F.

Siphons

Siphons are used to cross major lateral thalwegs, where the cost of construction of a canal is prohibitive because of its height above natural ground. They comprise one inlet shaft with silting facility and trashracks, a concrete pipe with eventually manholes every 100 m, an outlet shaft. In principle, the inside diameter is more than 800 mm to allow human visits for cleaning or maintenance purposes. In the case of Karazi perimeter, the little discharge of canals is not allowing such large pipes. Therefore, a great attention will be paid to silting structures upstream the siphon. Typical long section of a siphon is given in drawing in the appendix F.

- **Control and security structures**

Security spillways
Security spillways are inserted at the end of canals and on the main canal, when the section is reduced. It consists in a surface weir and an evacuation canal to the nearest drain. It could be associated to a discharge limitation structure to limit the downstream discharge to the capacity of the reach.

Division boxes
Division boxes are used for regulating the discharge at secondary and tertiary canals intakes. A typical drawing, referenced in the appendix F is describing the structure.

Drop structures
Drop structures are used to accommodate too high slopes on canals. In this project, they will mainly be used between main and secondary or tertiary canals, downstream the division boxes. They are described by typical drawing in the appendix F.

6.2.2. Layout of the scheme

- **Main features of the perimeter**

The designed perimeter is covering a geographical area of 570 ha, out of which the bulk area is 523 ha. It is expected a reduction of approximately 6 % in the net irrigated area, due to the right of way of canals and drains, and minor adjustments to be done at final design stage. Therefore, the net irrigated area could be estimated at 493 ha.

The perimeter is spreading on a 18 km distance between the dam and the downstream protection dyke. It is divided in 2 sectors, one of 248 ha directly supplied from the dam and the other of 245 ha which will need the construction of a diversion weir.

As no river bed exists, it will be necessary to build a protection dyke and a channel on one side of the marshland to allow floods to pass through the irrigated perimeter without damaging it. The protection criteria will be a 20 years flood with a 50 cm freeboard and just less than a 50 years flood with no freeboard.

- **Diversion structure**

The choice of this section has been made because of its narrowness and its upstream position with respect to area 2. The diversion weir will have a length of approximately 200 m and a maximum height of 1,5 m.

The 2,5*1,5 sluice gate will route a 10 years flood. The additional security spillway will be able to route a 50 years flood without overtopping of the embankment's crest.

- **Main canal**

Water for area 1 will be supply by one right bank main canal directly coming from the dam outlet structure. It will follow the edge between the marshland and the surrounding hills, 1,5 to 3 m above the elevation of the marshland, and be mainly build in cut and fill section.

Main canal has a length of 7,17 km and a total discharge (at the intake) of 0,99 m^3/s, allowing the irrigation of 248 ha split in 22 blocks. One siphon and 3 culverts or elevated flumes will be necessary to cross main lateral thalwegs.

From a diversion weir across the valley, 8,5 km downstream the dam, area 2 will be supplied by one left bank main canal, same construction and shape as area 1 canal. It will have a length of 7,8 km and a total discharge of 0,97 m^3/s, allowing the irrigation of a gross area of 245 ha split in 24 blocks. 3 culverts or elevated flumes will be built to cross major lateral thalwegs.

- **Secondary canals**

As the perimeter is quite narrow, the length of secondary canals will be short. They will be perpendicular to the general direction of the valley and they number is estimated to 22, ranging from a length of 155 m up to 700 m for area1 and 24 ranging from 204 m to 543 m for area 2.

- **Tertiary development**

Tertiary development includes tertiary canals and drains, basins terracing (form dykes and field ditches), as well as land levelling (+/- 10 cm). Elementary plots dimensions are taken equal to 100 m x 50 m for a hectareage of 0.5 ha, to allow the use of machinery in soil preparation. Typical arrangement of a block is given in drawing in the appendix F.

- **Protection dyke**

The dyke is designed not to be overtopped by a flood of maximum discharge of 47m^3/s for the sector 1 and 85m^3/s for the sector 2. These figures correspond roughly to a 45 years flood. It will be built parallel to the limit of the marshland, on left bank for the upstream section (sector 1) and on right bank for the downstream one (sector 2).

- **Drainage system**

Drainage system will consist in the construction of a lateral channel, so that it is possible to route a 10 years flood without submersion of plots for more than 3 days. A secondary and tertiary drainage system will be collecting water coming from the plots as well as the tributaries.

6.2.3. Cost estimate for irrigation scheme

The proposed bill of quantities is given in the following table for the 2 sectors. The cost per hectare developed is therefore estimated at 22 994 $/ha. Compared to other schemes, this cost is high mainly due to the length of main canals because of the narrowness of the valley.

Table 25: Irrigation costs for Karazi site

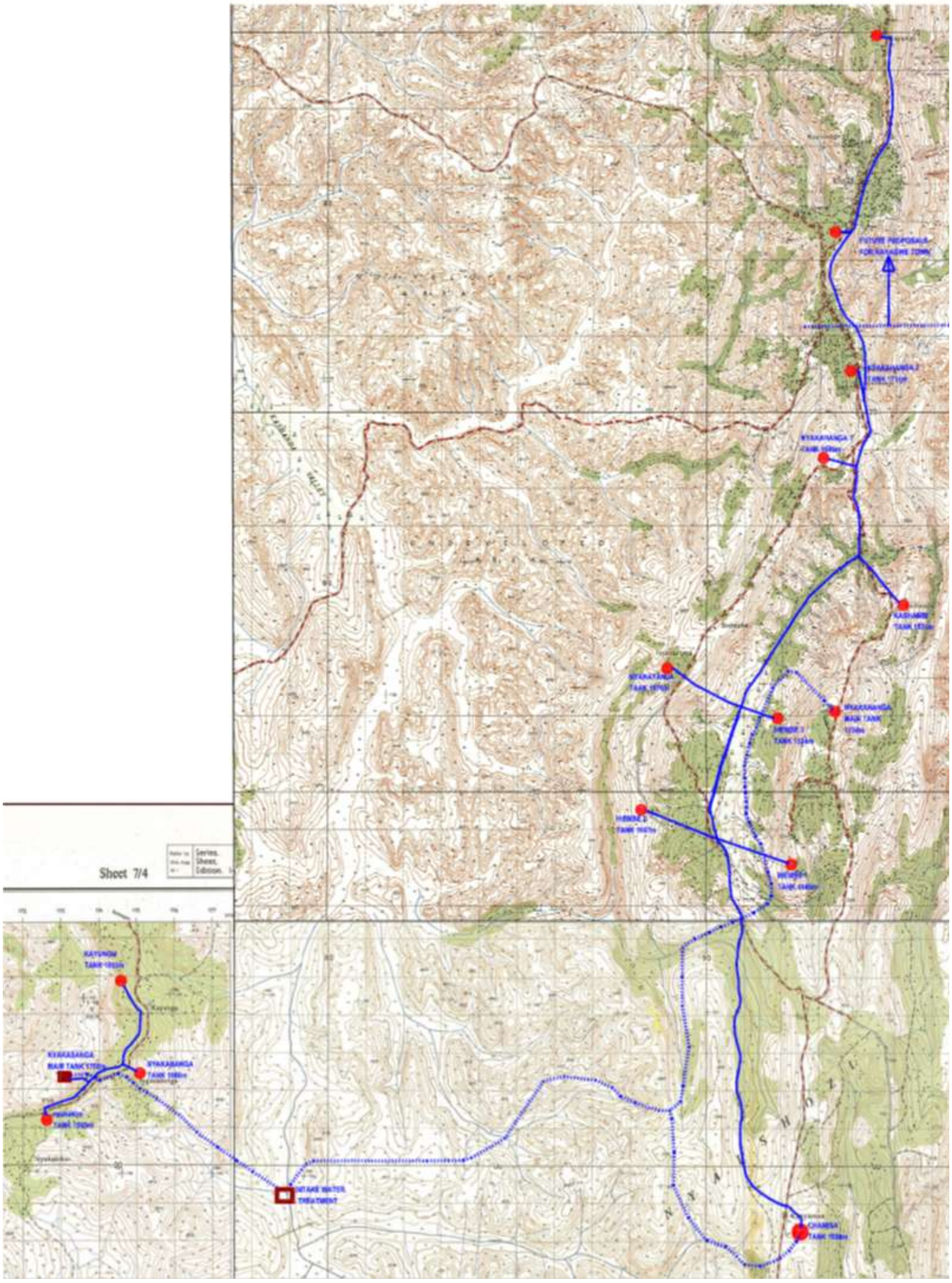
Items	Unit	Area 1 248 Ha	Area 2 245 Ha	Total Quantity	Unit Price US $	Total Cost
Preliminary and general items (15% of total cost)						
Miscellaneous	15%			1	1 375 037	1 375 037
Sub total						**1 375 037**
Access road						
Clearing and grubbing area of works	m^2	48 000	48 000	96 000	0,18	17 280
Common excavation and form road base layer	m^3	12 000	12 000	24 000	15	360 000
Laterite layer for roads (thickness 10 cm)	m^3	4 500	4 500	9 000	40,0	360 000
Formwork rough face	m^2	300	400	700	14,0	9 800
Class C25/C30 concrete for reinforced concrete - supply and placement	m^3	30	40	70	405	28 350
Reinforcement	T	3	4	7	2 700	18 900
						794 330
Canals & drains (main - primary - secondary)						
Clearing and grubbing area of works	m^2	110 000	185 000	295 000	0,18	53 100
Common excavation in canal and form compacted embankments (OPM 95%)	m^3	171 000	190 000	361 000	15,0	5 415 000
Formwork rough face	m^2	700	250	950	14,0	13 300
Class C25/C30 concrete for reinforced concrete - supply and placement	m^3	70	25	95	405	38 475
Reinforcement	T	6	2	8	2 700	21 600
Stone masonry for small structures	m^3			0	135	0
Concrete culverts DN 300	ml		-	0	124	0
Concrete culverts DN 800	ml	83	-	446	170	75 863
Miscellaneous	10%			1	561 734	561 734
Sub total						**6 179 072**
Tertiary development						
Form tertiary canals and drains	m3	14 000	15 000	29 000	9	261 000
Land levelling +/- 10 cm without topspoil removing	ha	234	238	472	4 500	2 124 000
Land levelling +/- 10 cm with topspoil removing	ha	0		0	13 500	0
Miscellaneous	10%			1	238 500	238 500
Sub total						**2 623 500**
Diversion weir						
Clearing and grubbing	m^2	0	3 500	3 500	0,18	630
Excavation in loose material	m^3	0	7 500	7 500	5	37 500
Class C20 mass concrete - supply and placement	m^3	0	200	200	383	76 600
Class C25/C30 concrete for reinforced concrete - supply and placement	m^3	0	100	100	405	40 500
Reinforcement	T	0	12	12	2 700	32 400
Backfill homegeneous material (sandy clay) using excavated	m^3	0	7 000	7 000	7	49 000
Backfill Transition/Filter	m^3	0	500	500	90	45 000
Rip Rap	m^3	0	200	200	146	29 200
Miscellaneous	10%			1	31 083	31 083
Sub total						**341 913**
Hydromechanical Equipment						
Steel pipe DN 500	ml		10	10	290	2 900
Steel pipe DN 300	ml	0	-	0	175	0
Steel pipe DN 200	ml		-	0	125	0
Steel pipe DN 150	ml			0	100	0
Trashracks 1,5 m x 1,0 m	U	0	1	1	4 500	5 466
Sliding gate 2,5 x 1,5 m	U	0	1	1	9 000	6 559
Sliding gate 1,5 m x 1,0 m	U	0	1	1	4 500	5 466
Miscellaneous	10%			1	2 039	2 039
Sub total						**22 429**
					Total	**11 336 280**

6.3. Water supply scheme

6.3.1. Layout of the scheme

The scheme for the development of the water supply has been designed as follows following the findings and the recommendations of the client. Details designs should be carried out at later stage during the detailed design study.

Figure 52: Water supply scheme



6.3.2. Design of the water supply

The proposed scheme as shown in the above map cover following wards in Karagwe (including a newly created district) : Nyakahanga, Bukangara, Ihembe, Nyakatuntu, Kakulaijo, Kiruruma, Part Nyakisimbi, Nyaishozi, Nyakabanga / Chabuhora, Nyabionza and St. Michael / Nyaishozi.

The project comprises the following equipment all implemented in one phase:

- Intake at the Dam of capacity 0.162 m3/s
- Water treatment plant of total capacity 14,000 m^3/d
- Low lift pumps – 0.162 m^3/s, 4 pumps (each Q – 0.053 m^3/s, H – 15m and Power 12 Kw – 3 in duty and 1 standby) x4,
- High lift pumps following two stations (the static heads are too high, each station will a have a set of booster pumps along the transmission mains):
    - Nyakasanga Pump Stations (for Nyakasanga, Nyakakika, Nyakabanga and Kayungu) – (0.035 m^3/s capacity) at water level 1326 masl and a booster station at 1500 masl – each to have 3 nrs pumps (each Q – 0.017 m^3/s, H – 192m and Power 48 Kw – 2 nrs duty and 1 standby).
    - Nyakahanga Pump Stations (for Nyakahanga, Chanamisa, Ihembe, Kashamba and surrounding areas) – (0.125 m3/s capacity) at water level 1326 masl and a booster station at 1486 masl, each to have 4 nrs pumps (each Q – 0.042 m^3/s, H – 176m and Power 112 Kw – 3 nrs duty and 1 standby).
- Transmission mains – three sets as follows :
    - Nyakasanga Transmission Main - 225 mm and length 6.5 km to Nyakasanga Main Tank 1680 masl - 35 l/s
    - Nyakahanga Transmission Main - 400 mm of length 11.0 km (Chanamisa branch) capacity 125 l/s and 400 mm of length 16.5 km to Nyakahanga Main Tank 1734 masl – 95 l/s
    - Chanamisa Branch Transmission Main - 225 mm 6.5 km to Chanamisa Tank 1680 masl – 30 l/s
- Main Storage tank – 3 tanks r.c concrete tanks (Nyaksanga 600 m3, Nyakahanga 2,200 m3, Chanamisa 900 m3)
- Distribution - Gravity mains from main tanks to village tanks

Pipe diameter (mm)	Length (m)
100	0
150	17,200
175	0
200	7,400
225	700
250	2,500
300	5,200
350	2,000
Total	**35,000**

- Villages storage tanks will be elevated masonry tanks comprising as follows:
    - 350 m^3: 3
    - 425 m^3: 7
    - 600 m^3: 1

- Secondary & tertiary mains:

Pipe diameter (mm)	Length (km)
50 PE	96
75	64
90	64
150	32
Total	**256**

- Meters and communal kiosks
  - Zonal meter: 14
  - Domestic meters: 650
  - Communal kiosks: 640
- Electrical Transmission
  - transmission cable: 23 km
  - sub-station with transformers: 2 sets

The project is small and therefore could be implemented in one Phase. However, it should be noticed that energy should be provided.

6.3.3. Cost estimate for the water supply scheme

The investment costs for water supply have been evaluated as US $ 27 288 000 as shown in the following table and detailed in the Appendix N.

Table 26: Water supply costs

		NYAKASANGA	NYAKAHANGA	Total
A	Water Treatment	815 600	3 262 400	4 078 000
B	Pumping Stations	544 080	397 824	941 904
C	Transmission Mains	1 202 500	4 931 500	6 134 000
D	Storage Tanks	660 000	2 113 000	2 773 000
E	Gravity Transfer Mains	450 500	2 800 800	3 251 300
F	Secondary & Tertiary Distribution Mains	1 596 000	5 700 000	7 296 000
G	Meters and Communal Kiosks	420 500	1 490 000	1 910 500
H	Power to WTW and PS	367 650	535 483	903 133
	TOTAL	**6 056 830**	**21 231 007**	**27 287 837**

6.4. Livestock water points

6.4.1. Design for the livestock water points

The main irrigation canals could have outlets in the opposite side (away from irrigation) for livestock water points in the form of cattle troughs, located where space in the valley is available. About 30 such locations have been identified as shown on the maps in the Appendix M.

The design has been produced for the following livestock population of 72000 livestock units and will increase in 2037 to 90 000.

The required troughs are 20 at first to 26 in future, each of capacity 10 000 litres. However, in order not to overcrowd the valley and to keep livestock herd separate to avoid disease transmission, 25 water points are proposed to be increased to 30 by 2037, each one with a capacity of 7 000 litres. Access road is included for each trough as well as compacted gravel land around the trough to protect against erosion by cattle movement. Each trough has one side with short heights for smaller animals such as goats and pigs and the other side for cattle. The trough has a concrete apron to maintain good hygienic and sanitary condition. A PVC pipe supplies water from the main canal into the trough.

The manure collected at the water troughs is stockpiled for feeding the fish, as both the fish ponds are in close vicinity.

6.4.2. Cost estimate for the livestock water points

25 livestock watering points could be installed in Phase 1 and 5 more in Phase 2. Each trough costs about US$ 120 000 as described in the Appendix N.

The total costs is about US$ 3 595 000 as described in the following table.

Table 27: Costs for livestock watering project

SUMMARY	Description	Quantity	Unit	US $ Rates	Total Amount US $
Phase 1	Watering Points	25	Sets	119,828	2,995,700
Phase 2	Watering Points	5	Sets	119,828	599,140
TOTAL					**3 594 840**

6.5. Fish farming

6.5.1. Design for fish farming

The communities do not have experience with fish ponds and therefore pilot projects will be necessary with a pilot in phase 1, followed by Phase 2 that will cover the whole valley.

The numbers of the required ponds are calculated based on population density which is about 95 persons/km^2 and could increase to 294 persons/km^2 in year 2037. The following table gives two options of ponds, subsistence or commercial fish farming.

Table 28: Estimated number of fish ponds

	2012		2037	
	subsistence 2 km radius 2t/Ha/year size 0.04Ha	commercial 4 km radius 3 t/Ha/year size 0.4 Ha	subsistence 2 km radius 2t/Ha/year size 0.04Ha	commercial 4 km radius 3 t/Ha/year size 0.4 Ha
population density	95	95	294	294
population	1,193	4,775	3,694	14,779
fish consumption kg @ 1kg/person/year	1,193	4,775	3,694	14,779
Pond Area Ha	0.60	1.60	1.85	4.93
Numbers of ponds	15	4	46	12
Proposed project	15	0	20	7

For the time being, the subsistence fish farms could be installed using community based organizations. In the future to year 2037, commercial fish farming may be promoted with the increase of demand.

The gross area required for the ponds may be 2 to 3 times the net pond area. The main irrigation canals would have outlets in the opposite side (away from irrigation) for filling up the fish ponds. The fish ponds are located in areas without use for irrigation. About 27 locations have been identified as shown on the maps in the Appendix M.

The ponds are made with earthwork of cut which are used to form the dykes. The ponds do not exceed one meter deep. Each subsistence pond is 15m x 30m in plan size while the commercial pond is about 45m x 90m depending on space available. Lime is added at the bottom to neutralize the acidic soils.

The species of fish could be sardine type (dagaa), fillet stripped, tilapia, catfish, Nile perch, and trout. The average fish yields for tilapia could reach 5 – 8 tons/Ha/year while for catfish 15 – 20 tons per Ha and per year. The fish yield is assumed to be 4 tons/Ha/year for small ponds and 8 tons/Ha/year for commercial ponds.

6.5.2. Cost estimate for fish farming

The costs estimate for the fish ponds development has been phased in two phases:

- Year 1 & 2 for 15 small ponds (0.6 Ha) as pilot project
- Year 10 & 11 for 20 small (0,8 Ha) + 7 large commercial ponds (2.8 Ha)

The estimated cost is about US $ 48 000 for each small pond (0,04 Ha). It is about US$ 141 000 for commercial pond (0,4 Ha) as described in the Appendix N.

The total costs is about US$ 2 500 000 as described in the following table.

Table 29: Costs for fish ponds project

Fish Farm	**Rate US $**	**Phase I**		**Phase 2**		**Total**	
SUMMARY		**Qty**	**Amount US $**	**Qty**	**Amount US $**	**Qty**	**Amount US $**
Small Ponds (Nrs)	44 811	15	672 165	20	896 220	35	1 568 385
Commercial Ponds (Nrs)	132 604	0	0	7	928 228	7	928 228
TOTAL			**672 165**		**1 824 448**		**2 496 613**

7. INITIAL ENVIRONMENTAL AND SOCIAL EXAMINATION FOR KARAZI PROJECT

7.1. Introduction

The Project area is defined as the location and vicinity of the physical project works area, the area to be flooded by the reservoir, and the off-site construction areas (see map 13 in the Appendix C).

7.2. National legislative and institutional framework

7.2.1. Environment

a) Legislative and institutional context in Tanzania

The National Environmental Policy, issued in December 1997 aims at ensuring sustainability, security and equitable use of natural resources without degrading the environment.

The 2004 Environmental Management Act No. 20 provides a legal and institutional framework for sustainable management of the environment, prevention and control pollution, waste management, environmental quality standards, public participation, environmental compliance and enforcement. It sets principles for the protection and management of river beds and shores. It provides that construction works in these areas cannot be carried out prior to obtaining permit or authorization issued by the Minister responsible for the Environment.

The 2004 Environmental Management Act gives the National Environment Management Council (NEMC) mandates to undertake enforcement, compliance, review and monitoring of environmental impacts assessments, research, facilitate public participation in environmental decision-making, raise environmental awareness and collect and disseminate environmental information.

b) Regulations regarding environmental impact studies in Tanzania

The regulations about environmental studies should follow the above requirements to carry out the ESIA in Tanzania:

- The National Environment Policy in 1997 defines an "Environment Impact Assessment (EIA) regime" in the following paragraphs:
  - Para. 65 - Chap 4 details the instruments for Environmental Policy;
  - Para. 66 – Chap 4 underlines that the institution of public consultations and public hearings in the EIA procedures is one of the "cornerstone" of the EIA process;

- The Environmental Management Act in 2004 states that EIAs are mandatory prior to the beginning or financing of project defined in the third schedule of the Act. The part n°105 of the Act describes the procedures and the document to produce. The National Environment Management Council (NEMC) is responsible for ensuring and monitoring the EIA procedure. After the submission of an EIA, the NEMC shall decide whether Public Hearings are required or not. It is noted that only registered experts or firms are allowed to carry out impact assessment. The Environmental Management Act 2004 also provides the framework for Environmental Audit and Environmental Monitoring procedures.
- The 2005 Environmental Impact Assessment and Audit Regulations (G.N No 349) describe the specific regulations concerning the EIA and Audit procedures.

c) International environmental treaties signed or ratified by Tanzania

Based on existing documents, Tanzania has ratified the following Conventions: Convention on Biological Diversity, Convention on International Trade in Endangered species, RAMSAR Convention on wetlands of international importance, United Nations Convention to Combat Desertification, African Convention on the Conservation of Nature and Natural resources (Algiers convention).

7.2.2. Water management

a) Institutional context in Tanzania

The responsibility for policy formulation and regulations concerning all aspects of water resources are vested in the following administrative units:

- The Ministry of Water designs policy and national strategy for water resources development. It ensures execution of the national strategy for all the water uses.
- The Ministry of State for Regional Administration and Local Government is responsible for water supply and sanitation services implementation. It ensures the coordination of the roles and duties of local authorities and community organizations:
    - In small towns, water supply is covered by District Urban Water Supply;
    - In rural areas, water supply is covered by Community Owned Water Supply Organizations.
- The Basin Water Boards design water management plans, guidelines for construction of water resources structures. They also collect and analyse data for water resources management, monitor water use and pollution and serve as a channel of communication to water users.

b) Legislative context in Tanzania

The following legislative texts describe the legislative context about water management in Tanzania:

- The 2009 Water Resources Management Act and 2009 Water Supply and Sanitation Act govern the water sector and are the main legislation concerning the use of natural resource.
- The Water Utilisation (General) Regulations GN No 370 of 1997 contains detailed procedures and prescribed forms to apply for water rights.

- According to the National Water Policy issued in 2002, access to drinking water remains the highest priority among other water uses.
- The National Water Sector Development Strategy 2005-2015, issued in February 2005, presents policy implementation guidelines.

7.2.3. Land tenure management

a) Legislative and institutional context in Tanzania

The Minister for Lands, Housing and Human Settlements Development is responsible for the coordination of land policy and for registration of land documents. The following legislative texts have to be taken into consideration:

- The 1997 National Land Policy provides guidance and directives on land ownership and tenure rights and taking of land and other land based assets. The policy stipulates organization and procedures for valuing assets and delivery of compensation. The overall aim of the policy is to promote and ensure a secure land tenure system in Tanzania that protects the rights in land and resources for all its citizens.
- The fundamental principles of the National Land Policy have been incorporated in the new land Laws: The Land Act n°4 operational since 2001 governs reserved land (such as statutorily protected or designated land, land for public utilities, wildlife reserves and land classified as "hazardous) and general land (including woodlands, rangelands and urban and sub-urban areas that are not reserved for public use), whereas the Village Land Act governs village land (including registered village land, land demarcated and agreed to as village land by relevant village councils, and land that villages have been occupying and using as village land for 12 or more years).
- The 2004 Land Amendment Act defines the compensation, for involuntary relocation and settlements, which fulfils the World Bank safeguard policies requirements.

In Tanzania, land tenure is mixed and based on customary rules, colonial and post-colonial regulations. It is to be mentioned that following the independence, all land is considered public land.

7.3. Preliminary description of existing environmental and socio-economic conditions

7.3.1. Physical environment

a) Geology

The general geological map shows Precambrian basement complex, especially sandstones, silstones, shales, quartzites, conglomerate, phyllites and metasediments.

At the dam site, the rocks are not outcropping, except upstream, where a quartzite veining is located on the middle of the left bank. On the two banks, the soil is made with lateritic clay and sandy gravels. In the valley, the clay is swampy, with possible pit.

b) Climate

Tanzania has a tropical climate. According to Dr. Mkhandi S.H. [a], the climate of Karagwe district is characterized by a dry climate. The Project area received an average rainfall of 919 mm per year.

c) Hydrology

This part is included in the previous hydrology chapter (see chapter 4.4).

Karazi dam site is located on Karazi River, which is a seasonal river. Thus, the data for the site are low. The site is located in the lower part of the Kagera River basin also called the West Victoria Lake region.

d) Groundwater

According to Dr. Mkhandi S.H. [a], groundwater monitoring has never been carried out in Kagera River Basin in Tanzania although it plays an important role as a source of water supply in a number of districts which fall within the Kagera River Basin including Karagwe district.

e) Water quality

According to Dr. Mkhandi S.H. report [a], water quality monitoring in Kagera River Basin on the Tanzanian side has been carried out in an adhoc basis. However, the report stipulated that there is no formal water quality monitoring network on the Tanzanian side.

No water quality analyses have been found about Karazi stream although a formal water quality monitoring is done in Tanzania. However, the analyses carrying out in Dr. Mkhandi S.H. report [a] in the Kagera river basin in 2004 and 2008 indicated that:

- the pH average was about 6.5 indicating that the water was slightly acidic, but within the expected value for natural waters;
- the observed values of electrical conductivity were less than 120 μS/cm, indicating that the impact of human activities on water quality within the basin was still low;
- the relatively higher values of total phosphorus (300 – 500 μg/l. in 2008) and the presence of nitrogen were most likely attributed to livestock rearing in the basin and agro-chemical releases from the agricultural activities practiced along the river;
- the high turbidity values along the main Kagera River were attributed to high suspended materials mainly sediments resulting from erosion taking place in the upper reaches of Kagera basin in Burundi and Rwanda.

Water quality determination is an important element towards an understanding of River ecosystem health.

7.3.2. Biological environment

a) Flora and Fauna

The Kagera River floodplain influences the groundwater forests in the Tanzania side (Minziro, Munene and Ruarian Forest Reserves). The forest vegetation is known to be unique for its biodiversity and from an important ecological component of the floodplain ecosystem that helps to regulate the flow of water throughout the Kagera River System. The dry forests comprise tree species that provide an important source of medicinal plants and harbour important species of mega-fauna such as elephants, Uganda kobs, oribis, waterbucks, topis, giraffes, impalas, zebras and leopards.

The site is located in a sub-tropical climate region evidenced by the short grasses and scattered shrubs characteristic of dry savannah vegetation. No forest is located in the Project area.

As the Karazi stream is temporary, no aquatic biodiversity has been identified during the survey.

b) Conservation and protection

The following wetlands in Tanzania are classified by the Ramsar Convention: Malagarasi-Muyovozi Wetlands, Lake Natron, Kilombero Valley Foodplain, Rufiiji-Mafia-Kilwa Marine Ramsar Site. None of these wetlands is in the surroundings of the project's area.

Rubondo Game Reserve (450 km^2, established in 1980) is in the north-eastern region of Tanzania, just south of Lake Victoria near border of Rwanda and Burundi, in the Kagera River Basin. This Game Reserve is located about 60 km from the dam site, out of the Project area.

Burigi Game reserve (2 200 km^2, established in 1972) is situated in Kagera region in the North Western part of Tanzania. It derives its name from Lake Burigi, which are fresh water lake and a major water source in the reserve. The large part of the reserve is swampy vegetation surrounded by riverine forest and papyrus beds with some relict forest. This habitat supports variety of wild animals and birds such as, impala, eland, hippopotamus, waterbucks, elephants, sable, roan antelope Sitatunga, shoebill storks, cattle egrets and fish eagle.

Biharamulo Game Reserve (1 300 km^2, gazetted in 1959) is situated in Kagera region. The reserve forms a single ecosystem with Burigi (see above) and Kimisi Game reserves. It also forms part of the northern limit of miombo woodland in Africa, supporting a great diversity of vegetation type including forest, thickets, woodlands, bushlands, grasslands and swamps. Tree species in the reserve include *commiphora jubernadia*, *Branchstegia spp, Acacia sieberiana, Acacia Senegal Mark-hamia obtusifolia and Balanites aegyptica.* Animal species found in Biharamulo Game Reserve include Lion, Elephant, Buffalo, Eland, Lesser Kudu, Impala, Hippopotamus, Giraffe, Zebra, Roan antelope, Sitatunga, Sable, Aardvark and Red colobus Monkey. Bird species found in the area include Marabou stork, Hornbill and Guinea fowls.

The Ibanda Game Reserve (200 km^2, established in 1974) is located in the extreme north-western region of Tanzania, shares border with Uganda and Rwanda in the Kagera River Basin. Another portion of the game reserve is sharing border with northern portion of Rwanda's Akagera National Park. The game reserve is under pressure due to poaching and illegal harvesting of timber and uncontrolled bush fires. However, this Game Reserve is located about 90km from the dam site.

The Akagera National Park (1 200 km^2, established in 1934) is located about 40km downstream of Karazi dam site, in eastern Rwanda, border to Tanzania. The Kagera River flows along its eastern boundary feeding into several lakes, creating the largest protected wetland in central Africa.

All these areas have been drawn on the map 04 in the Appendix A.

7.3.3. Socio-economic context

a) Characteristics of the population

According to the 2002 Census, Karagwe district population is 425 476 people (4,8 people by household). The estimated population in 2011 is 542 517 with a growth rate of 2,9% per year.

The household size is estimated to be 5.

b) Social environment

<u>Health</u>

The District includes 32 dispensaries and 12 health centres. No one is in the Project area. The closest hospitals are Bukoba regional referral Hospital, Bugene district hospital and Nyakahanga district hospital.

The mean diseases are accurate respiratory disease and Malaria.

<u>Education</u>

The literacy rate is about 67%. Each village has a primary school; each ward has a secondary school.

<u>Energy supply</u>

The electricity supply is limited to towns (Karagwe, Bugene and Katanga).

<u>Land tenure</u>

Land is mainly customary owned.

In the Project area, there are Village Land Management Committees having demarcated land for rearing cattle and for agricultural to avoid conflicts. These committees should be consulted for any agricultural project.

No cultural heritage site has been found in the Project area.

c) Economic environment

In Karagwe district scale, 79% of the population relies on agricultural activity. The size of the agricultural plot is less than 4 acres for 77% of household.

Livestock and plantation agriculture (maize, banana, beans, cassava and potatoes) are the economic activities in the downstream area. The crops are mainly grown for subsistence and depending on rain as source of water. The valleys are largely unfarmed upstream. However, most of the foothills touching the valley have banana plantations. The Project area is mainly devoted to grazing areas for cows.

Small lakes such as the Ikimba, Burigi, Rushwa, and Rwakajunju provide fishing opportunities for residents of the Karagwe District.

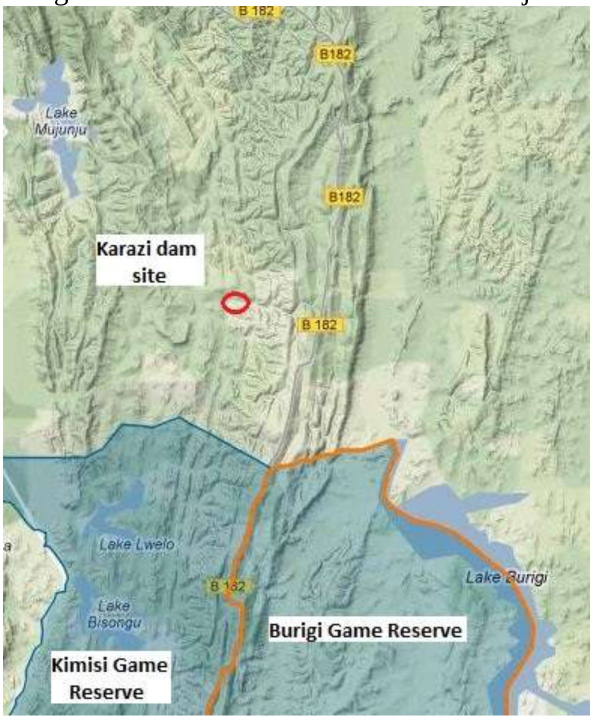
The valley of the dam project has been known to flood during the wet period and cut off the roads crossing it disrupting activities in the communities. On the other hand, during the dry season, it can really become hot and dry curtailing agricultural processes.

7.4. Preliminary identification and assessment of potential impacts

The preliminary potential impact examination has identified the following impacts for a dam of 9,5m high.

- About physical environment:
  - Loss of water resources through evaporation will be a consequence of the Project: The net losses due to evaporation are estimated to be about 8% of the annual inflow.
  - The reservoir will inundated an area of 271hectares at MWL, which will change the nature of the physical environment, by becoming water coverage.
- About biological environment:
  - The access road (B182 road, non-asphalted) crosses the north-eastern part of the Burigi and Kimisi Game Reserve, 10 km from the dam site. The construction phase could have an impact on the Reserve such as the poaching.

Figure 53: Game reserves near Karazi Project



Source : 2012 Google - 2010 UNEP-WCMC

> No other protected area should be impacted by the Project due to the distance of the protected areas from the Project. However, the SEIA should confirm this assumption, in particular downstream the Project.

- About socio-economic environment:

> No villages or settlements should be affected by the Project as there is no inhabitant in the Project area (see map MA08 in Appendix D);
> No major infrastructures or cultural heritage site should be impacted;
> Tracks might be cut by the reservoir. The study should map the rural tracks used by the communities. However, the new access road will open up the area.
> Grazing area (around 250 hectares) will be mainly affected. Banana plantations could be affected by the reservoir. According to the LiDAR survey, 6,77 ha of plantations could be inundated at the Maximum Water Level (see map MA08 in Appendix D).
> Water diseases should be studied with the presence of the reservoir.
> The main impact could be the potential conflict of interests between livestock development and future irrigated lands. It should be taken into consideration during the social assessment of the ESIA.

7.5. Elements of an environmental and social management plan

As the project do not lead as a major resettlement as defined by the World Bank (OP 4.12), this project will not lead to carry out a full resettlement management plan as defined by the Operational Policy of the World Bank.

However, the environmental and social management plan should mainly take into account the following measures:

- Deforestation program for using the wood before impounding;
- Reforestation and erosion-prevention programme;
- The materials to build the dam within the identified areas (see map 13 in the Appendix D) should avoid the agricultural land as well buildings.
- Compensation for the loss of plantations and replacement for the lost agricultural land;
- Compensation and replacement for the loss of pastures resources;
- Health and safety measures such as protection again malaria;
- Creation of Water User Association(s) to manage the project water resources, and to serve as a tool for conflict management and other related matters.

Consultations with the local population will be the core of the plan in order to avoid any conflict for the land uses between agriculture and livestock activities.

8. ECONOMIC AND FINANCIAL ANALYSIS

8.1. Introduction

Following the findings in the chapters 5 and 6 as well as the appendix N, the economic analysis has been carried out for each component of the project, as different institutional departments are involved.

This economic analysis presents hereafter only the main water uses components of the project, meaning irrigation and water supply developments.

To show the viability of the project, economic benefits have to exceed economic costs. The costs are divided between investments costs and Operations and Maintenance (O&M) Costs. The benefits includes time saving for fetching water and health benefit (for water supply project), land appreciation, increased income and VAT benefit.

8.2. Conversion Factors – Financial to Economic Costs

Economic costs are net of market distortions resulting from transfers such as taxes, levies, fees and/or subsidies, for which shadow values are applied. VAT and import duty on components has therefore not been considered in unit costs. Also rent for leasing land and repayment of loan have been considered as transfer payments and therefore not included in the costs.

On the other hand, the proportion of crops grown that is consumed at home is also considered as a benefit and thus as sales revenue. Farm-gate sales are considered for the analyses against farm exported prices to city centres which may be 2 to 3 times more but would be distorting the sale prices.

Each category of capital costs and operating and maintenance (O&M) costs are broken down into categories such as traded material, non-traded material, skilled labour, unskilled labour, others (such as transport, overhead costs) and transfer cost (taxes, subsidies, levies). These financial costs have been converted from domestic currency to US dollars currency and multiplied with respective conversion factors, to obtain economic prices.

It is noted that the five countries Tanzania, Uganda, Kenya, Rwanda and Burundi have harmonized all their taxes, duties and levies.

Detailed information is not available to calculate accurately the conversion factors and they are therefore estimated as follows.

- Traded Materials (imported / exported goods) - 1.31 (The Standard Conversion Factor = 1 / 1.31 = 0.763 (includes fertilizers, pesticides, tools)
- Energy including electricity (subsidized otherwise unaffordable) – 1.25
- Non-Traded Materials (road, water, drainage etc) - 1.00

- Unskilled Labour - 0.70 reflected from high unemployment in the country and the readily available unskilled labour – the market wage rate is lower than the recommended wages (it is noted that the legislated minimum wage is BFr 160/day, unreasonably low last established in 1990s while the government recommends BFr 1,500/day to investors, while it the market wage was BFr 1,000/day). The shadow wage factor = 0.7
- Skilled Labour - 1.00
- Transfer Costs (taxes) - 0.00

For the project, therefore the composite conversion factors used will be:

- Capital Costs: 0.9
- O & M Costs: 0.84

8.3. Dam

8.3.1. Investments costs

The costs of dam and appurtenant structure have been estimated according to unit price method, derived from similar projects:

- The dam cost is estimated to US$ 17 980 000 as detailed in the chapter 5.6.
- Operation and Maintenance (O&M) costs are estimated to 2.89% of initial investment, meaning US$ 519 600.

The ESIA[3] has provided the costs for the environmental management plan as US$ 317 600 and for the resettlement action plan as US$ 436 300 USD, meaning a total of US$ 753 900 to add to the total cost of the project.

8.3.2. Conversion Factors – Financial to Economic Costs

The economic costs as found in the following table are obtained from financial capital costs and O & M costs of the project by multiplying with the conversion factors discussed above.

Financial Costs			Economic costs		
Capital Cost US $	Annual O &M Costs US $	ESMP & RAP costs US$	Capital Costs US $ CF 0.9	Annual O & M Costs US $ CF 0.84	ESMP & RAP costs US$ CF 0.84
17 980 000	519 600	753 900	16 182 000	436 464	633 276

[3] Carried out by Newplan in 2012

8.4. Costs and benefits for irrigation development

The economic analysis is based on costs (investments, operations and maintenance) and benefits of the project. Benefits take into account the comparison of two situations: with or without project.

8.4.1. Investments Costs

The costs of the irrigation scheme have been evaluated according to the unit cost method. Unit costs have been derived from similar projects carried out in the lake region and elsewhere but by applying remoteness factors.

With the dam, the net irrigation area concerns 493 Ha, and the associated costs are evaluated to US $ 11 336 000.

Stage 1 **Net 248 Ha**	**Stage 2** **Net 245 Ha**	**Total** **Net 493 Ha**
US$ 5,332,000	US$ 6,004,000	US$ 11,336,000

8.4.2. O & M Costs

Maintenance costs cover for parts, spares, sundries and labour for the normal routine and periodic maintenance and also repairs. On the other hand operating costs are costs related to the operation of the irrigation scheme. This is not duplicated with the input required for the crops. These costs can be firstly estimated to 2,86% of initial investment as described in the Appendix N.

8.4.3. Conversion Factors – Financial to Economic Costs

The economic costs as found in the following table are obtained from financial capital costs and O & M costs of the project by multiplying with the conversion factors discussed above.

PHASE	**Financial Costs**		**Economic costs**	
	Capital Cost US $	Annual O &M Costs US $	Capital Costs US $ CF 0.9	Annual O & M Costs US $ CF 0.84
Phase 1	5,332,000	159,960	4,798,800	135,966
Phase 2	6,004,000	180,120	5,403,600	153,102
Total	11,336,000	340,080	10,202,400	289,068

8.4.4. Benefits

8.4.4.1. CROPS

The valley is not used for cultivation. Cultivation is limited to the hill sides. Without project means no crops.

With irrigation, two seasons cropping is proposed. Rice is proposed as both season's crop. The price difference between imported and local grown rice is 20%.

To simplify the calculations, farm-gate selling prices are considered which also reflect all the inputs such as family labor, hired labor, animal energy, fertilizers, seeds, pesticides, land, transport and tools for growing and harvesting the crops.

The producer mean prices are the average farm-gate price US$/ton between the dry and the wet seasons as given as follows:

Year	**Producer or Farm-gate Prices US $/ton**			
	Maize	Beans	Rice	Vegetables
2011	320	640	1,280	565
2012 estimated	325	670	1,300	600

The production costs vary with and without irrigation. Their percentage compared to the final price is given in the following table:

Crop	**Producer Price US$/ton**	**Rain-fed**				**Irrigated**			
		Yield Ton/Ha	**% of price**	**US$/Ha**	**US$/ton**	**Yield Ton/Ha**	**% of price**	**US$/Ha**	**US$/ton**
Rice	1,300	0.5	65%	423	845	3.0	55%	2,145	715
Maize	325	0.5	40%	65	130	2.5	30%	245	98
Beans	670	0.5	40%	134	268	1.5	30%	300	200
Vegetables	600	1.0	40%	240	240	4.0	30%	720	180

The gross margin is calculated as follows:

Crop	**Output Value Producer Price US $/ton**	**Rain-fed crops**			**Irrigated Crops**		
		Input costs		**Net Benefit US$/ton**	**Input costs**		**Net Benefit US$/ton**
		% of price	**US$/ton**		**% of price**	**US$/ton**	
Rice	1,300	65%	845	455	55%	715	585
Maize	325	40%	130	195	30%	98	227
Beans	670	40%	268	402	30%	200	570
Vegetables	600	40%	240	360	30%	180	420

The net benefit is the difference between the “with” and “without” project benefits. The irrigation scheme shows to increase the farmers’ annual revenue of US $ 807300 in Phase 1 and increases to US $ 1 614 600 in Phase 2.

8.4.4.2. LAND APPRECIATION

The irrigation project will result in increased yield and therefore appreciate in value. The present average valley land market price is assumed to be US$ 1 000/Ha. With irrigation development, it is assumed an increase of land value from 3 000 to 4 000 US$/Ha, meaning:

- In Phase 1: 248 Ha x $3 500 = US $ 868 000
- In Phase 2: 245 Ha x $3 500 = US $ 857 500

A total of US $ 1 725 500 as one-time benefit is estimated.

8.4.4.3. INCOME DUE TO ECONOMIC GROWTH

The enhanced economic growth due to irrigation project will create more jobs or opportunities in business including chain value support for farm inputs and transportation of products. It is estimated a benefit of US$ 2 260 080/year assuming that 20% (3 600 people) of the unemployed people in the area (estimated to 18 000) will acquire job from the economic growth, and assuming a current wage about TShs 2692/day (US $ 1.72/day) in the agriculture sector and rural areas.

8.4.4.4. INCREASED INCOME DUE TO PROJECT CONSTRUCTION ACTIVITIES

The construction in the villages and the town will create job opportunity for the communities. It is estimated that 20% of the projects costs require unskilled labour and during O & M, 20% of the activity includes unskilled labour.

PHASE	**Financial Costs**		**Financial Benefits X = 20% x Cost**	
	Capital Cost US $	Annual O &M Costs US $	Capital Cost US $ one time	Annual O &M Costs US $
Phase 1	5,332,000	159,960	1,066,400	31,992
Phase 2	6,004,000	180,120	1,200,800	36,024
Total	11,336,000	340,080	2,267,200	68,016

8.4.4.5. VAT BENEFIT

It is assumed that 10% of the construction costs and annual O & M costs remain at source attracting 18% VAT, making it a benefit as follows:

PHASE	**Financial Costs**		**Financial Benefits to HHs X = 10% x 18% x Cost**	
	Capital Cost US $	Annual O &M Costs US $	Capital Cost US $ one time	Annual O &M Costs US $
Phase 1	5,332,000	159,960	95,976	2,879
Phase 2	6,004,000	180,120	108,072	3,242
Total	11,336,000	340,080	204,048	6,121

8.4.4.6. SUMMARY OF ALL BENEFITS

The total economic benefits are summarized in the following table.

Table 30: Summary of all benefits

Benefit Type	**US$ / year**	**US$ once**
Irrigation Increased Yield		
Phase 1	807 000	
Phase 2	1 615 000	
Land Appreciation		
Phase 1		868 000
Phase 2		857 000
Increased Income – Economic Growth		
Phase 1	1 130 000	
Phase 2	2 260 000	
Project Construction Activities		
Phase 1	32 000	1 066 000
Phase 2	68 000	1 201 000
VAT remain in district		
Phase I	3 000	96 000
Phase 2	3 000	108 000
TOTAL Benefits		
Phase 1	1 972 000	2 030 000
Phase 2	3 946 000	2 166 000
Conversion Factor	0.874	0.874
Economic Benefits		
Phase 1	1 724 000	1 774 000
Phase 2	3 449 000	1 893 000

8.5. Costs and benefits for water supply

8.5.1. Investments Costs

The investment costs for water supply have been evaluated as US $ 27 300 000 as shown in the chapter 6.3.3.

8.5.2. Operation and Maintenance Costs

These costs have been estimated according to the review of financial performances of similar project in the region (Tanzanie, Kenya, Gambia…).

Operation and Maintenance (O&M) costs cover for parts, spares, sundries and labour for the normal routine and periodic maintenance and also repairs. These costs can be estimated to about 15% of initial investment as detailed in the appendix N.

Table 31: Operational and maintenance costs for water supply

Investments costs	**O&M costs**	
US $ 27 300 000	15%	US $ 4 095 000

8.5.3. Conversion Factors – Financial to Economic Costs

The conversion factors as described in the Appendix N have been determined as follows:

- Capital Costs: 0.96
- O & M Costs: 0.88

Financial Costs		**Economic Costs**	
Capital Cost US US $	Annual O &M Costs US $	Capital Costs US $ CF 0.96	Annual O & M Costs US $ CF 0.88
27 300 000	4 095 000	26 208 000	3 603 600

8.5.4. Benefits

The benefits accrued from a water supply projects are simply that people obtain an improved, healthy and secure living environment without being displaced. Water supply projects have been proved to be effective entry point for poverty alleviation. The investments they have already made to their properties are actually enhanced. Recognizing title and security of tenure makes a positive contribution to both the economic prospects of the poor, as well as to the national economy. Experience has shown in similar water supply and sanitation projects are associated with social and economic benefits that are particularly high, are significant in fall in infant mortality rates, fall in crime rates in other countries, and regularization of land tenure results significant private investments.

Benefits include:

- community empowerment resulting from participatory approach and forming community based organizations – enabling the community to identify, organize and manage future projects, thus enhancing future development and reducing risks and generally resulting in economic growth
- improved water supply connection to those who do not have presently – reduced fetching distance and therefore time saving. After the implementation of the water supply project, the domestic water points will be closer within 200m walking distance, and the fetching time is estimated to be about 10 min
- improved power supply to those who do have at present
- improved environmental condition and standard of living
- improved health conditions, reduction in diseases and savings in health bills
- increased investments and economic development activities, improved livelihood
- increased land and property values
- employment during construction period

About 120 532 people (24 106 HHs) are expected to benefit from the project (future 2037 population 271 400 meaning 54 280 HHs). The present statistics show rural household incomes are assumed to be about $100 per month (TShs 2000000/HH/year).

8.5.4.1. TIME SAVING FOR FETCHING WATER

Improved water supply creates cost savings to the community due to time saving in fetching (walking + waiting) for water, reduced storage requirements and no boiling and are considered where they are significant.

It is assumed more than 70% households use wells, water holes, ponds and direct rivers and streams. The per capita consumption in rural areas is estimated at 25 litres per day and per person. The average fetching distance is assessed as about 70 minutes for every 20 litres bucket. If the government recommended wage US$ 1,72/day, the gained productive time value is estimated to 385 US$ by household yearly.

8.5.4.2. HEALTH BENEFITS

Health benefits from reduced health bills, reduced deaths and increased productive times resulting from this project.

Health Bills

ESIA survey records 10% of monthly income (making it US $ 10/HH/month) is spent on medical and health related expenses. The proportion is high implying that at least one member of the household is sick every two weeks. The district statistician expressed that diarrhea and intestinal worms are common after malaria.

The water supply is estimated to reduce by 30% the medical expenses, than the annual saving per household could be estimated to US $ 36.

Productive time

Based on the ESIA survey, it is assumed 30% of the households reported to have a person sick every two weeks. The yearly lost productive time could then be estimated to 34,6 person day by household of lost productive time.

If the water supply project improves health by 30%, the lost time would be reduced by 30% which could be estimated to save yearly US$ 17,8 by household.

8.5.4.3. SALE OF WATER SERVICE AS BENEFIT

The project is targeting rural areas where the existing water supply is not extensive and is assumed to be 20% coverage. The new proposed water supply project will therefore have non-incremental supply of 20% and incremental supply of 80%. The existing water supply is presently subsidized either free or with very low payments. In economic analysis, economic price of water has to be taken into account even if it is subsidized. In this analysis, 100% of the project supply is considered as incremental and at a price Willingness to Pay which with sensitization is at the Affordability or Ability to Pay being 4% of disposable income.

Estimating that 4% of the household income of US$100/ is affordable for water supply and that a household uses 25 litre per day, each household is estimated to pay US$ 1,11/m3, meaning an annual benefit of US$ 48 by household.

8.5.4.4. APPRECIATION OF LAND VALUES

Water supply projects could increase land values benefiting land owners and thus house values. It has been estimated that about 25% of the properties which are located near water points and along the pipe lines could increase in value incrementally by 25% after the water supply project is implemented.

It is assumed that the present land values is $0,2/m^2 and that each household plot or premise is assumed to be 1 800 m2.

The net increase in land value per household is then estimated to reach US$ 22,5.

8.5.4.5. INCREASED INCOME DUE TO ECONOMIC GROWTH

The enhanced economic growth due to water supply project might create more jobs or opportunities in business.

It is estimated that about 30% of the population being working age are unemployed meaning 1,44 persons per household, and that about 10% of the unemployed could get a job from the economic growth due to the project. The annual benefits due to the economic growth could then be estimated to US$ 90,4 by household.

8.5.4.6. INCREASED INCOME DUE TO PROJECT CONSTRUCTION ACTIVITIES

The construction will create job opportunity for the communities. It is estimated that 20% of the projects costs require unskilled labour and during O & M, 20% of the activity includes unskilled labour.

Financial Costs		**Financial Benefits X = 20% x Cost / number of HH**	
Capital Cost US $	Annual O &M Costs US $	Capital Cost US $ by HH	Annual O &M Costs US $ by HH
27 300 000	4 095 000	226	32

8.5.4.7. VAT BENEFIT

It is assumed that 10% of the construction costs and annual O & M costs remain at source attracting 18% VAT meaning a benefit as follows:

Financial Costs		**Financial Benefits to HHs X = 10% x 18% x Cost / number of HH**	
Capital Cost US $	Annual O &M Costs US $	Capital Cost US$ by HH	Annual O &M Costs US$ by HH
27 300 000	4 095 000	20,4	3

8.5.4.8. SUMMARY OF ALL BENEFITS

The total economic benefits are estimated to US$ 12,9 million annually and US$ 5,7 million upon completion of the project as detailed in the following table.

Table 32: Benefits of water supply project

Benefit Type	US$ /HH/year	US$ /HH
Fetching Distance Saving	385	
Health Improved	53.8	
Sales of Water Annual	48	
Land Appreciation		22.5
Increased Income – Economic Growth	90.4	
Project Construction Activities	32	226
VAT remain in district	3	20.4
TOTAL Benefits	612	268
Conversion Factor 0.88	0.88	0.88
Economic Benefits	535	235

8.6. Economic analysis

For the economic analysis, outlay of costs and benefits from the earlier sections are presented over 25 years to year 2037. Three economic indicators are calculated:

- Economic Internal Rate of Return (EIRR) that has to exceed 12% the economic cost of capital,
- the Economic Net Present Value (ENPV) that has to be positive for a viable project, and,
- the Economic Benefit to Cost Ratio (EBCR) that has to be greater than unity 1.

The economic analysis has been carried out for different scenarios, as follows:
Scenario A: Irrigation + water supply + fish ponds + livestock watering
Scenario B: Irrigation + water supply
Scenario C: Irrigation only
Scenario D: Water supply only

8.6.1. Economic analysis for implementation of irrigation + water supply + fish ponds + livestock watering

The economic analysis for the multipurpose dam with the objectives of irrigation, water supply, fish ponds and livestock watering give the following results:

- EIRR: + 29,5%
- ENPV: US $ 49 507 000
- EBCR: 1,67

In addition, four sensitivity analyses were carried out as follows:

- Scenario I : increase costs by 15%
- Sensitivity II : decrease benefits by 15%
- Sensitivity III : increase cost by 15% and decrease benefits by 15%

Scenario	EIRR	ENPV (US $)	EBCR
Scenario A	+29,5%	49 507 000	1,67
I: + 15% Increase in Costs	+23,8%	38 374 000	1,45
II: – 15% Decrease in Benefits	+23,1%	31 730 000	1,43
III: 15% Increase in Costs and 15% Decrease in Benefits	+18,3%	20 597 000	1,24

It should be noticed that this scenario shows economic performances taking into consideration indirect revenues and collective increased incomes related to project nature and activities.

8.6.2. Economic analysis for implementation of irrigation + water supply

The economic analysis for the multipurpose dam with the objectives of irrigation and water supply only give the following results:

- EIRR: +28,8%
- ENPV: US $ 43 033 000
- EBCR: 1,62

In addition, four sensitivity analyses were carried out as follows:

- Scenario I : increase costs by 15%
- Sensitivity II : decrease benefits by 15%
- Sensitivity III : increase cost by 15% and decrease benefits by 15%

Scenario	EIRR	ENPV (US $)	EBCR
Scenario B	+28,8%	43 033 000	1,62
I: + 15% Increase in Costs	+23%	32 616 000	1,41
II: – 15% Decrease in Benefits	+22,4%	26 942 000	1,39
III : 15% Increase in Costs and 15% Decrease in Benefits	+17,5%	16 525 000	1,21

8.6.3. Economic analysis for implementation of irrigation only

The economic analysis for the dam with the objectives of irrigation only gives the following results:

- EIRR: +10,3%
- ENPV: - US $ 2 063 000
- EBCR: 0,918

In addition, four sensitivity analyses were carried out as follows:

- Scenario I : increase costs by 15%
- Sensitivity II : decrease benefits by 15%
- Sensitivity III : increase cost by 15% and decrease benefits by 15%

Scenario	EIRR	ENPV (US $)	EBCR
Scenario C	+10,3%	(2 063 000)	0,918
I: + 15% Increase in Costs	+7,9%	(5 822 000)	0,798
II: – 15% Decrease in Benefits	+8,2%	(4 731 000)	0,811
III : 15% Increase in Costs and 15% Decrease in Benefits	+6,0%	(8 491 000)	0,705

If irrigation is only developed, the Karazi irrigation project could not be economically viable as all the indicators appear negative. This result is mainly due to the length of main canals, because of the narrowness of the valley.

8.6.4. Economic analysis for implementation of water supply only

The economic analysis for the dam with the objectives of water supply only gives the following results:

- EIRR: 22,1%
- ENPV: US $ 24 753 000
- EBCR: 1,364

In addition, four sensitivity analyses were carried out as follows:

- Scenario I : increase costs by 15%
- Sensitivity II : decrease benefits by 15%
- Sensitivity III : increase cost by 15% and decrease benefits by 15%

Scenario	EIRR	ENPV (US $)	EBCR
Scenario D	+22,1%	24 753 000	1,364
I: + 15% Increase in Costs	+20,9%	22 153 000	1,314
II: – 15% Decrease in Benefits	+20,1%	17 448 000	1,284
III : 15% Increase in Costs and 15% Decrease in Benefits	+15,4%	8 239 000	1,117

If water supply is only developed, the Karazi water supply project could be economically viable as all the major indicators appear negative. This is mainly due to the indirect benefit such as the time saving for fetching water.

8.7. Summary of economic analysis

The following summary presents the project with dam construction estimated to 18M US$. The summary of costs for all the projects is included in the following table.

Table 33: Costs of the project

Water Use Component	**Capital Investment Costs US $ for the first stage**	**Capital Investment Costs US $ for the next stages**	**Capital Investment Costs US $ TOTAL**
Dam	17 980 000		17 980 000
Irrigation	5 332 000	6 004 000	11 336 000
Potable Water Supply	27 300 000		27 300 000
Livestock Water Supply	2 996 000	599 000	3 595 000
Aquaculture	672 000	1 824 000	2 496 000
Sub-total	**54 280 000**	**8 427 000**	**62 607 000**

The economic analysis for different scenarios shows that the project is viable only if the water supply is part of the whole project.

Water supply show economic performances taking into consideration indirect revenues and collective increased incomes related to project nature and activities (such as time saving for fetching water, appreciation of land, economic growth and employment).

Irrigation project is not economically viable if implemented alone, due to the high cost of the irrigation scheme, because of the narrowness of the downstream valley.

9. TERMS OF REFERENCE FOR DETAILED DESIGN OF THE DAM AND TENDER DOCUMENTS

9.1. Description of the Detailed Design phase for dam

The Detailed Design (DD) is the key phase for all projects as it shall put down the base of the construction contract defining technically and financially the works in such details to allow the Contractor fairly and correctly quoting these and then carrying out the job reducing the risk of claims at minimal level.

The main technical sections of DD are:

- Drawings: in sufficient number for depicting clearly the workings and the overall ways of construction leaving to the Contractor his specific field of choice (equipment, etc.). The Drawings shall be supported by the related supporting calculations. The Detail Design Drawings shall cover the entire range of the project as follows:
- General layout,
- Hydrological and meteorological data,
- Geological available mapping and sections,
- Planview and main sections of each appurtenant working,
- Guidelines for reinforcement,
- Watertightness principles and specific details,
- Grouting and drainage features,
- Civil works stages for hydromechanical equipment,
- Hydromechanical equipment and energy supply,
- Hydroelectric plant (if any),
- Monitoring apparatuses and gear.

In case of an EPC type of contract, the scope being only to outline the Basic features of the project, the number of Drawings may be reduced and more details left to the Contractor's ingenuity.

- Specifications : describing in detail the qualities to be assured and the methods to be respected through the various stages of preparation (procurement of materials, treatment, transport, placing, etc.) for achieving the required result ;
- Programme: a reasonable schedule of the works based on similar projects in comparable conditions.
- Bill of Quantities: a detailed list of the quantities of the Works to be executed corresponding to the items to be priced.

The contractual sections depend upon the intentions of the Client on the type of contract structure:

- Owner's Managed Contract with full production of Construction Drawings and Supervision under Owner's guide (assuming the larger part of risk);

- Engineering, Procurement and Construction Contract leaving the Contractor free in a broader project frame (and assuming the larger share of risks).

The choice between the two options (or any other intermediate) should be decided by the Client in order to adjust the production of the documents to his decision.

9.2. Terms of reference and tender documents

The below text (written in *italic*) is the proposed terms of reference for Karazi dam:

Consulting Services to Undertake Detailed Design Studies for a Small Multipurpose Dam at Karazi site in the Kagera River Basin

1. Background

1.1 Introduction

The Nile Basin Initiative (NBI) is a partnership of the riparian states[1]that seeks to develop the Nile River in a cooperative manner, share substantial socio-economic benefits, and promote regional peace and security through its shared vision of "sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources". NBI's Strategic Action Program is made up of the Shared Vision Program (SVP) and Subsidiary Action Programs (SAPs). The SAPs are mandated to initiate concrete investments and action on the ground in the Eastern Nile (ENSAP) and Nile Equatorial Lakes (NELSAP) sub-basins.

The Kagera River Basin Management Project is one of the three river basin projects implemented under the NELSAP. The objective of the Kagera RBM project is to establish a sustainable framework for the joint management of the water resources of the Kagera river basin and prepare for sustainable development oriented investments, in order to improve the living conditions of the people and to protect the environment. The Kagera River Basin lies west and southwest of Lake Victoria in the equatorial zone of Africa between the latitudes of 0°45' and 3°55' South and longitudes of 29°15' and 30°50' East. It has a total area of about 60,000 km2 which is distributed among Burundi (22%), Rwanda (33%), Tanzania (35%) and Uganda (10%). The Kagera River is the principal tributary of Lake Victoria Basin, and as such is commonly considered as the source of the White Nile. Most of the basin lies between elevation 1,200 and 1,600 m.a.m.s.l. and consists largely of woody and grassland savanna. The mountainous areas in the west and northwest, which mark the Nile-Congo Divide, rise to altitudes of more than 2,500 m.a.m.s.l. The Kagera River rises in the western highlands of Burundi and Rwanda. Its main tributaries are the Ruvuvu River, which drains an area of about 12,300 km2 in central and northern Burundi, and the Nyabarongo River, which drains about 16,000 km2 in west central and eastern Rwanda. The Nyabarongo discharges into Lake Rugwero in southeastern Rwanda on the border with Burundi. Below Lake Rugwero the river is known as the Kagera, and it marks the southern border of Rwanda with Burundi and Tanzania to the confluence of the Ruvuvu. At the border of Uganda and Tanzania, Kagera River is joined on the left bank by the Kagitumba River, which drains 5,200 km2 of northeastern Rwanda and Southern Uganda. The main tributaries in the lower reach are the Mwisa and Ngono Rivers, which drain 2,000 km2 and 3,200 km2 respectively of the Kagera Region in Tanzania on the right bank of the Kagera River.

During the feasibility study, one studied dam site was Karazi dam, a project that aims to improve irrigation, livestock and water supply in the region.

1.2 Rationale for the Consultancy

The Kagera basin has a total area of 59,800 km^2 with rainfall less than 1,000 mm over most of the eastern half of the basin, which increases to over 1,800 mm in the western half, where most of the runoff is generated. Although the western half is partially forested, much of the basin has become intensively cultivated resulting in erosion and sediment loading of rivers in the high rainfall areas. The basin is characterized by low productive peasant agriculture, insufficient water for household use and grazing, and endemic poverty. There is continuing land degradation, deforestation and loss of soil fertility and soil erosion caused by population pressure and primitive farming methods. Wetlands are exploited and degraded, and there are unplanned migrations across borders of pastoralists with their cattle, causing friction in the border zones. The dense settlement, along with intensive and improper land management practices in the Kagera River catchments have resulted in heavy pollution loads in tributary rivers. The water quantity and quality available for various uses in the Kagera Basin is gradually dwindling and the water resources situation is already stressful in some parts of the basin.

There is a strong correlation between economic performance and water availability as a result of limited water storage infrastructure. Using the Falkenmark Water Stress Indicator, two of the four Kagera Basin riparian countries, i.e. Rwanda and Burundi, have a per capita water availability of 800 and 500m^3/capita/year respectively; which is far below the recommended threshold value of 1,700m^3/capita/year. The World Water Vision 2000, prepared by the International Water Management Institute (IWMI), classified all the four Kagera Basin Riparian countries as suffering from economic water scarcity. These countries face financial and capacity constraints in meeting their water needs. This situation is expected to get worse as the population increases, as impacts of climate change begin to manifest themselves gradually and as demands of different water use sectors out-match the existing supply. Water related conflicts are on the increase and will pose serious security risks in the catchments if the underlying issues are not adequately addressed. To address these challenges, there is a need to implement structural and non-structural approaches to improve water security through creation of water storage in the basin and promoting water demand management to minimize wastage of the scarce water resources among other solutions.

Agriculture is the economic mainstay of the Kagera river basin employing about 90% of the rural population and contributes about 40% of the GDP of the riparian countries. Despite its high importance in the region, agriculture records very low productivity levels owing to very inefficient traditional agricultural practices and high population pressure on the land. The current trend in developing irrigation is low, although opportunity for increased productivity through irrigation development and intensification is apparent with plains irrigation potential in the lower basin and marshlands irrigation potential in the upper basin catchments (Kagera Monograph, 2008).

There is potential to increase the otherwise very low livestock and aquaculture productivity and investment within the basin. The proposed dam have a potential to avail water for livestock watering, reservoir fisheries development or to avail water to off-reservoir fish ponds, which would improve the livelihood of the beneficiary communities and in some cases lead to adoption of new but economically rewarding activities in the project areas.

The basin has an average potable water coverage of 48% (Kagera Monograph, 2008), which implies that more than half of the population uses unsafe water.

2 Terms of Reference

As downstream work of the feasibility studies, the NELSAP and the Kagera RBM Project are procuring a consultancy to undertake the basic design for multipurpose dam sites. At this stage, a clear definition shall be defined for the different works previewed, including its lay-out design, construction methods and materials implicated in the construction.

It shall be provided every calculation notes using the most advanced methods and plans sufficiently detailed to allow:

- *Establishing an accurate bill of quantity and a good cost estimation;*
- *Writing tender files of civil works and supply of mechanical and electrical equipment.*

Once the Client has chosen the final dam design, the chosen Consultant will carry out the following tasks:

- *Detailed study of civil works;*
- *Determination of the characteristics of equipment;*
- *Study of the access road;*
- *Establishment of the work costs;*
- *Writing technical work specifications;*
- *Development of a construction management plan;*
- *Propose a general management structure;*
- *Preparation of tender dossiers.*

2.1 Detailed study of civil works

The Consultant shall provide all the necessary details on the technical and economical design of the dam and structures attached. These studies will be characterized by descriptive, calculation and checking notes and drawings as well.

These documents shall include:

- *Structural design of embankments, sealing, drainage and foundation grouting;*
- *Calculations of embankments slope stability;*
- *Filters and drains verification notices,*
- *Verification of hydraulic structures design (spillway, adduction system), as well the design of their sealing, drainage and special foundation works if any;*
- *Design of auscultation and monitoring works devices.*

2.2 Determination of the characteristics of the equipment

The basic design of electromechanical equipment shall determine types, specifications, operating principles and assembly and testing planning for all equipment with a sufficient degree of accuracy in a way to allow the preparation of appropriate technical specifications (working condition, main characteristics, construction data, tools and spare parts, etc.) and tender documents.

These facilities will include:

- *A fixe wheel gate;*
- *Hoisting equipment;*
- *Butterfly valve;*
- *Others service equipment, if any;*
- *The necessary spare parts.*

2.3 Study of the access road

The Consultant shall prepare:

- *Layout and longitudinal profile optimization;*
- *Cross section type definition and justification;*
- *Definition and justification of crossing structures (culverts, box culverts, bridges, etc.);*
- *Definition and justification of sewage disposal and drainage;*
- *Study of materials for the road embankment;*
- *Research of quarry for aggregates (for concrete and road layers);*
- *Research of borrow areas of materials for earthworks and concrete;*
- *Laboratory and in situ tests;*
- *Provision of protection layers;*
- *Study of protection and improvement of the environment, especially in woodlands.*

The Consultant will then prepares the technical study of works of the access road, evaluate the estimated cost of work and prepare the tender documents.

2.4 Establishment of the work costs

The Consultant will assess the estimated costs of the project as defined, distinguishing foreign expenditures and expenses in local currency. The assessment of costs will be based on bills of quantities before taking into account uncertainties, specifications relating to certain works conditions and the distance from the site.

2.5 Writing technical work specifications

The Consultant will provide:

- *The security coefficients assumed for the stability studies;*
- *The hypotheses to take into consideration, justifying his choice for the seismic design of structures;*
- *And the standards to which he intends to refer in the design of structures and equipment.*

2.6 Development of a construction management plan

All river diversion phases and work chronogram with key dates will be included in the general report of the project.

The Consultant will propose a general work organization scheme that shall include:

- *General schedule showing the logical construction sequence (including river diversion schemes), highlighting construction and procurement delays, as well as equipment order and installation deadlines;*
- *Procedures for impoundment;*
- *Operating instructions and maintenance works notices, etc.*

2.7 General management structure

The Consultant shall propose a plan with the human resources and equipment to be implemented to ensure the correct operation of the works. It will establish specifications for standard services responsible for the operation of civil engineering, electro-mechanical equipment, social management, etc.

The Consultant shall identify concerned actors and propose a structure for the creation of a Water User Association. This organization should be integrated as a major actor to group manager of the project water resources and also serve as a tool for conflict management and other related matters.

2.8 Reservoir operation plan

The Consultant will prepare an embankment management guidebook, based on hydrological information in its possession, allowing the operator to determine the mode of filling and emptying of the reservoir.

These are the Terms of Reference for the basic design of the Karazi small dam, where small dams are defined according to the World Bank Environmental and Social Safeguard Policy OP 4.37, i.e. with a height below 15m (but excluding dams between 10m and 15m that are complex).

Documents to be provided:
The Consultant shall prepare 10 copies of the provisional documents, concerning technical specifications for civil works and equipment supply and installation, to be submitted to the Client for approval.

Then proceed to the final edition of 20 copies and a digital reproducible medium (DVD-ROM).

3 Tender Documents

Once the basic design is approved by the Client, the tender documents for the civil works and for the supply and installation of electromechanical equipment should be prepared. The text of the Conditions of Contract universally recognized (and generally adopted by the international Development Banks) is the FIDIC (Federation Internationale Des Ingenieurs Conseils)'s appropriate "book".

The Tender documents shall include a provisional schedule, based on the Consultant experience, framing the aimed duration of the construction Works. Such program shall include key dates (usually related to meteorological constraints or delivery planning of equipment), and be based on reasonable productions of main items (excavations, filling, concrete, etc.).

Tender Documents shall include:
a) Instructions to Bidders
b) Convention
c) Special Papers of Technical Requirements for Civil Works:
- *Description of the structures and work*
- *Provenance, quality, preparation of materials,*
- *Mode works,*
- *Mode of assessment work,*
- *Special clauses.*

d) Special Technical Requirements Specification for equipment
- *Definition and consistency of work*
- *Specification of supplies,*
- *Conditions of contract, controls, fixtures.*

e) Frame price list
f) Estimated retail Framework
g) General Conditions of Contract
- *Bidding work,*
- *Execution of works*
- *Payment of expenses,*
- *Tax,*
- *Payments*
- *Various clauses,*
- *Submission template.*

REFERENCES

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[a] NELSAP: Rapid identification and assessment of potential sites for multi-purpose storage reservoirs; Eng. Dr. Henry K. Ntale; March 2011.

[b] Mc Allister Anderson Ian: Agricultural water in the Nile Basin – an overview

The socio economic survey used the following documents:

S/No	Report Titles
A	**GENERAL**
1	A Report on the Assessment of Stakeholder Involvement in the Nile Equatorial Lakes Subsidiary Action Program and Projects – 2011 by Lucy Daxbacher
2	Country assessments on Environmental and Social Policies in the Nile Equatorial Lakes Region – Draft Country Report January 2012 by Judy Obitre-Gama Consultant
B	**TANZANIA**
3	Tanzania Census 2002 Kagera Regional and District Projections – National Bureau of Statistics December 2006
4	The Tanzania Development Vision 2025 of 1999 for Mainland
5	The National Strategy for Growth and Reduction of Poverty (NSGRP or MKUKUTA) of 2005 also known as MKUKUTA I and MKUKUTA II launched in 2010
6	Household Budget Survey 2007 – Final Report by Ministry of Finance
7	Economic Survey 2008 by Ministry of Finance
8	District Agricultural Development Plans 2011 / 12 to 2013 / 2014 for Karagwe District Council
9	Karagwe DC CWIQ – Survey on Poverty, Welfare and Services in Karagwe DC – September 2006 by EDI and PMO – RALG
10	Agricultural and Livestock Policy of 1997 – Tanzania
11	Participatory Agricultural Development and Empowerment Project PADEP – ESMF and RPF 2003
12	National Fisheries Sector Policy and Strategy Statement of 1997
13	The Fisheries Act No. 6 of 1970 has been reviewed and replaced by the new Fisheries Act No. 22 of 2003 which is now operational
14	The Fisheries regulations of 2005 have been endorsed by the government and have been in force since October 2005
15	A National Water Policy – Tanzania 2002
16	National Water Sector Development Strategy 2004
17	The Energy Policy of Tanzania of 1992
18	The National Energy Policy for Tanzania of 2003
19	Efficient Water Use for Agricultural Production (EWUAP) Project, Agricultural Water in the Nile Basin – Tanzania Country Overview Annex H – April 2008
20	Forum Syd's draft Baseline Study Report for Districts of Karagwe, Ukerewe and Magu by Editrudith Lukanga July 2010
21	Socio-economic development and Benefit Sharing Project – The Impact of Regional Power trade on Poor Communities in the Nile Basin Countries – Tanzania - 2008
22	Socio-economic and Demographic Determinants of Infant and Child Mortality in Tanzania – A Case Study of Karagwe District, Kagera Region by Girson L. K. Ntimba and Maurice C. Y. Mbago 2005
	A 2011 Karagwe District Health Facilities Status Report

The water use and water demand assessment used the following documents:

- *Power Sector:*

S/No	Report Title
A	**GENERAL**
1A	Rapid Identification and Assessment of Potential Sites for Multi-purpose Storage Reservoirs – Final Assessment Report for NELSAP – Kagera River Basin Management Project - by Dr. Henry Ntale March 2011.
2A	Kagera River Basin Monogoraph – Basin Development report – Transboundary Integrated Water Resources Management and Development Project – Kagera River Basin – July 2008 for NELSAP by BRL Ingenieur – Socioeconomic (pg 63 – 85), Energy & hydropower (pg 191 to 207), pg 192, 193, 205,
3A	Strategic / Sectoral, Social and environmental Assessment of Power Development Options in the Nile Equatorial Lakes Region – Synopsis Report – Stage 1 – Burundi, Rwanda and Western Tanzania – Feb 2005 by SNC Lavalin for NBI NELSAP
4A	An Infrastructure Action plan for Burundi – Accelerating Regional Integration by African Development Bank – 2009 pg 46, 55, 59, 62, 77 – 79, 90 – 91, 134 – 139, 156,
5A	Hydropower Development – Small Scale Hydropower for Rural Development – Nile Basin Capacity Building Network - 2005
B	**TANZANIA**
6A	The Energy Policy of Tanzania of 1992
7A	The National Energy Policy for Tanzania of 2003 Section 3 and 4

- *Irrigation Sector:*

S/No	Report Title
A	**GENERAL**
1B	Rapid Identification and Assessment of Potential Sites for Multi-purpose Storage Reservoirs – Final Assessment Report for NELSAP – Kagera River Basin Management Project - by Dr. Henry Ntale March 2011.
2B	Kagera River Basin Monogoraph – Basin Development report – Transboundary Integrated Water Resources Management and Development Project – Kagera River Basin – July 2008 for NELSAP by BRL Ingenieur – Socioeconomic (pg 63 – 85), Agriculture Livestock and forestry (pg 121 – 167), pg 124, 126, 132, 138, 143, 145, 148 to 152
3B	Agriculture Water in the Nile Basin - Efficient Water Use for Agricultural Production (EWUAP) Project – for NBI by Ian McAllister Anderson – April 2008 Agriculture Water Use (pg 35 to 67) and Best Practices (pg 70 to 91)
4B	Large Scale Irrigation Practices in the Nile Basin - Efficient Water Use for Agricultural Production (EWUAP - NBI – Jan 2009 by Bastiaanssen and Perry pg 22, 25, 34, 44, 55 - 59, 71, 74, 76, 77, 136 – 140, Annex D, H, J and K.
5B	Handbook for the Assessment of Catchment Water Demand and Use – HR Wallingford and DFID for Zimbabwe and Zambia – 2003 Environmental Water Demand and Use (pg 20 to 41), Agricultural Water Demand and Use (pg 44 to 82),
	Farm Management Handbook of Kenya Vol II Natural conditions and Farm Management Information – Part A West Kenya
B	**TANZANIA**
6B	Annex H – Tanzania Country Overview - Efficient Water Use for Agricultural Production (EWUAP) Project, Agriculture Water in the Nile Basin April 2008 – pg 1,3, 4, 6 to 9
7B	Support to NEPAD – CAADP Implementation for Tanzania – Apr 2005 Vol IV – Crop and Livestock Private Sector Development

8B	The National Strategy for Growth and Reduction of Poverty (NSGRP or MKUKUTA) of 2005 also know as MKUKUTA I and MKUKUTA II launched in 2010
9B	District Agricultural Development Plans 2011 / 12 to 2013 / 2014 for Karagwe District Council Section 3 – Agriculture and livestock
10B	Agricultural and Livestock Policy of 1997 – Tanzania
11B	Ten Pillars of Kilimo Kwanza – Implementation Framework 2009

> *Livestock Development Sector:*

S/No	Report Title
A	**GENERAL**
1C	Rapid Identification and Assessment of Potential Sites for Multi-purpose Storage Reservoirs – Final Assessment Report for NELSAP – Kagera River Basin Management Project - by Dr. Henry Ntale March 2011.
2C	Kagera River Basin Monogoraph – Basin Development report – Transboundary Integrated Water Resources Management and Development Project – Kagera River Basin – July 2008 for NELSAP by BRL Ingenieur – Socioeconomic (pg 63 – 85), Agriculture Livestock and forestry (pg 121 – 167), pg 134, 135, 153,
3C	Handbook for the Assessment of Catchment Water Demand and Use – HR Wallingford and DFID for Zimbabwe and Zambia – 2003 Environmental Water Demand and Use (pg 20 to 41), Agricultural Water Demand and Use (pg 44 to 82),
B	**TANZANIA**
4C	Support to NEPAD – CAADP Implementation for Tanzania – Apr 2005 Vol IV – Crop and Livestock Private Sector Development
5C	National Census of Agriculture – Small holder Agriculture – Vol III – Livestock Sector – Mar 2012, Section 2 - Livestock
6C	District Agricultural Development Plans 2011 / 12 to 2013 / 2014 for Karagwe District Council pg 5 to 7,
7C	Agriculture and Livestock Report for Dec 2011 by Karagwe District Council
8C	National Livestock Policy – Dec 2006 – Ministry of Livestock Development
9C	Agricultural and Livestock Policy of 1997 – Tanzania

> *Fisheries and Aquaculture Sector:*

S/No	Report Title
A	**GENERAL**
1D	Rapid Identification and Assessment of Potential Sites for Multi-purpose Storage Reservoirs – Final Assessment Report for NELSAP – Kagera River Basin Management Project - by Dr. Henry Ntale March 2011.
2D	Kagera River Basin Monogoraph – Basin Development report – Transboundary Integrated Water Resources Management and Development Project – Kagera River Basin – July 2008 for NELSAP by BRL Ingenirie – Socioeconomic (pg 63 – 85), Fisheries and Aquaculture (pg 185 to 190), pg 188,
3D	Handbook for the Assessment of Catchment Water Demand and Use – HR Wallingford and DFID for Zimbabwe and Zambia – 2003 Environmental Water Demand and Use (pg 20 to 41), Agricultural Water Demand and Use (pg 44 to 82),
	Fingerponds – Seasonal Integrated Aquaculture in East African Freshwater Wetlands – PhD Thesis by Julius Kipkemboi 2006
	Guiding Principles for Promoting Aquaculture in Africa – benchmarks for sustainable development - FAO and Worldfish Paper No 28 – 2006 pg 91 Design Procedure
B	**TANZANIA**

4D	National Census of Agriculture – Small holder Agriculture – Vol III – Livestock Sector – Mar 2012, Section 2.6 – Fish Farming
5D	National Fisheries Sector Policy and Strategy Statement of 1997
6D	The Fisheries Act No. 6 of 1970 has been reviewed and replaced by the new Fisheries Act No. 22 of 2003 which is now operational
7D	The Fisheries regulations of 2005 have been endorsed by the government and have been in force since October 2005
8D	Overview of Fisheries and Aquaculture Resources, Fisheries Division, Tanzania 2006

> *Water Supply Sector:*

S/No	Report Title
A	**GENERAL**
1E	Rapid Identification and Assessment of Potential Sites for Multi-purpose Storage Reservoirs – Final Assessment Report for NELSAP – Kagera River Basin Management Project - by Dr. Henry Ntale March 2011.
2E	Kagera River Basin Monogoraph – Basin Development report – Transboundary Integrated Water Resources Management and Development Project – Kagera River Basin – July 2008 for NELSAP by BRL Ingenirie – Socioeconomic (pg 63 – 85), Potable water (pg 209 to 221), pg 210, 211, 213, 216, 218, 221,
3E	Handbook for the Assessment of Catchment Water Demand and Use – HR Wallingford and DFID for Zimbabwe and Zambia – 2003 Rural Domestic Water Demand and Use (pg 85 to 105), Industrial Water Demand and Use (pg 107 to 120), Urban Water Demand and Use (pg 121 to 156)
4E	Practice Manual for Water Supply Services in Kenya – Part A Water Supply Nov 2005 Chap 2 Water Demand – all sectors
B	**TANZANIA**
4E	A National Water Policy – Tanzania 2002 Section 2 – Water and Socio-economic Development, Section II – Rural WS, Section III – Urban WS
5E	National Water Sector Development Strategy 2004
6E	Design Manual for Water Supply and Wastewater Disposal - Third Edition March 2009 Chap 4 – water demand (domestic, livestock, industrial, institutional, commercial, fire fighting and losses)

> *Common Sectors:*

S/No	Report Title
A	**GENERAL**
1F	Rapid Identification and Assessment of Potential Sites for Multi-purpose Storage Reservoirs – Final Assessment Report for NELSAP – Kagera River Basin Management Project - by Dr. Henry Ntale March 2011.
2F	Kagera River Basin Monogoraph – Basin Development report – Transboundary Integrated Water Resources Management and Development Project – Kagera River Basin – July 2008 for NELSAP by BRL Ingenirie – Socioeconomic (pg 63 – 85), Agriculture Livestock and forestry (pg 121 – 167), Environmental use (pg 169 to 183), Fisheries and Aquaculture (pg 185 to 190), Energy & hydropower (pg 191 to 207), Potable water (pg 209 to 221), Transport & navigation (pg 223 to 230), Tourism (pg 231 to 238), Mining (pg 239 to 245),
3F	Development of Kagera Integrated River Basin Management and Development Strategy – Main Report – May 2010 by SWECO for NELSAP – Socioeconomic (pg 14-21), priority areas (pg 26), water use (pg 36-39), Water Demand (pg 54-59), pg 112, 117, Annex F,
4F	Country Assessments on Environmental and Social Policies in the Nile Equatorial Lake Regions – Draft Country Report – for NBI NELSAP by Judy Obitre-Gama Jan 2012. Sections 2.1 – Burundi, Sec 2.4 – Rwanda, Sec 2.5 – Tanzania, Sec 2.6 - Uganda

5F	Handbook for the Assessment of Catchment Water Demand and Use – HR Wallingford and DFID for Zimbabwe and Zambia – 2003 Environmental Water Demand and Use (pg 20 to 41), Agricultural Water Demand and Use (pg 44 to 82), Rural Domestic Water Demand and Use (pg 85 to 105), Industrial Water Demand and Use (pg 107 to 120), Urban Water Demand and Use (pg 121 to 156)
6F	Regional Transboundary Diagnostic Analysis of the Lake Victoria Basin – Lake Victoria Basin Commission – EAC March 2007
7F	Water and Agriculture in the Nile Basin – FAO 2000
8F	Environmental Water Requirements Rapid Assessment – by Tshimanga and Ndomba 2008
B	**TANZANIA**
9F	The Tanzania Development Vision 2025 of 1999 for Mainland
10F	The National Strategy for Growth and Reduction of Poverty (NSGRP or MKUKUTA) of 2005 also known as MKUKUTA I and MKUKUTA II launched in 2010
11F	District Agricultural Development Plans 2011 / 12 to 2013 / 2014 for Karagwe District Council