IRRIGATION FOR CLIMATE RESILIENCE PROJECT (ICRP)

Additional Surveys and Assessments for Kabuyanda Irrigation Scheme on

"Biodiversity and Ecological Flow Management Plan"

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRYNOMS

AAF	Average Annual Flow
BEFMP	Biodiversity and Ecological Flow Management Plan
CAIIP	Community Agricultural Infrastructure Improvement Programme
CFR	Central Forest Reserve
CIA	Cumulative Impact Assessment
DEM	Digital Elevation Model
DO	Dissolved oxygen
DRDIP	Development Response to Displacement Impact Project
EFR	Environmental Flow Requirement
EFCs	Environmental Flow Components
EFMP	Environmental Flow Management Plan
EMCs	Environmental Management Classes
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESS	Ecosystems Services Survey
FAO	Food and Agriculture Organization
FDCs	Flow Duration Curves
FGDs	Focus Group Discussions
FTEA	Flora of Tropical East Africa
GBV	Gender-Based Violence
GFS	Gravity Flow Scheme
GIS	Geographical Information System
GoU	Government of Uganda
GPS	Global Positioning System
HEC RAS	Hydrologic Engineering Center - River Analysis System
HEFR	Hydrology-based Environment Flow Regime Approach
HFPs	High Flow Pulses
HHs	Households
HIV/AIDS	Human Immuno-deficiency Virus/ Acquired Immuno-deficiency Syndrome
HSC	Habitat Suitability Criteria

ICRP	Irrigation for Climate Resilience Project
IFIM	Instream Flow Incremental Methodology
IHA	Indicators of Hydrologic Alteration
IUCN	International Union for the Conservation of Nature
LC	Local Council
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MAER	Mean Annual Environmental Runoff
MAR	Mean Annual Runoff
MBFIT	Modified Base Flow Index with Threshold
MoH	Ministry of Health
MWE	Ministry of Water and Environment
NDP	National Development Plan
NECOC	National Emergency Coordination and Operations Centre
NELSAP	Nile Equatorial Lakes Subsidiary Action Plan
NEMA	National Environment Management Authority
NFA	National Forestry Authority
NNL	No-Net Loss
NWSC	National Water and Sewerage Corporation
OVCs	Orphans and Vulnerable Children
OWC	Operation Wealth Creation
PHABSIM	Physical Habitat Simulation
PLA	Participatory Learning and Action
RAP	Resettlement Action Plan
RGS	River Gauging Station
RS	Remote sensing
RTK	Real Time Kinematic
RVA	Range of Variation
SDG	Sustainable Development Goal
SESs	Social - Ecological Systems
SPSS	Statistical Package for the Social Science
UBOS	Uganda Bureau of Statistics

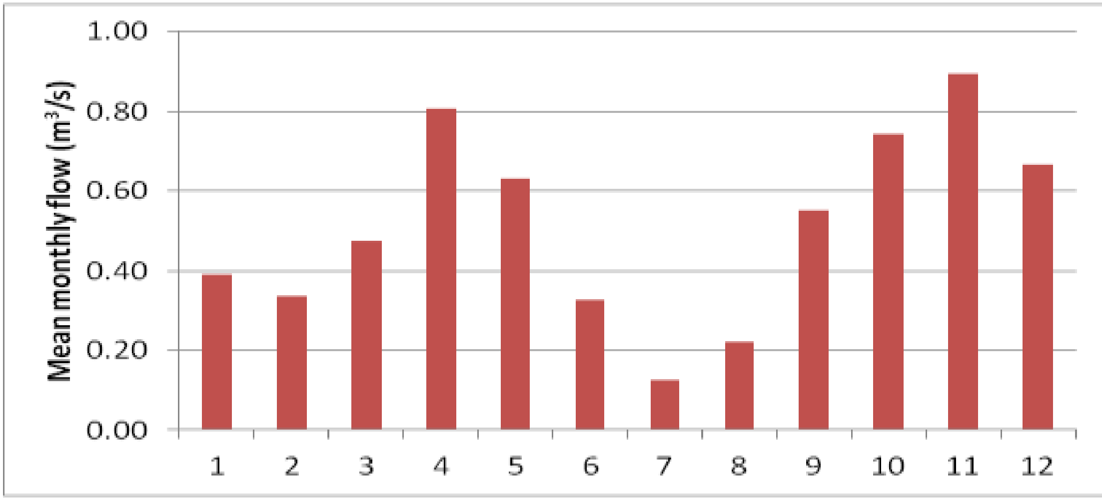
UNDP	United Nations Development Programme
UTM	Universal Transverse Mercator
VECs	Valued Ecosystem Components
VHT	Village Heath Team
WUA	Weighted Usable Area
YLF	Youth Livelihood Fund

EXECUTIVE SUMMARY

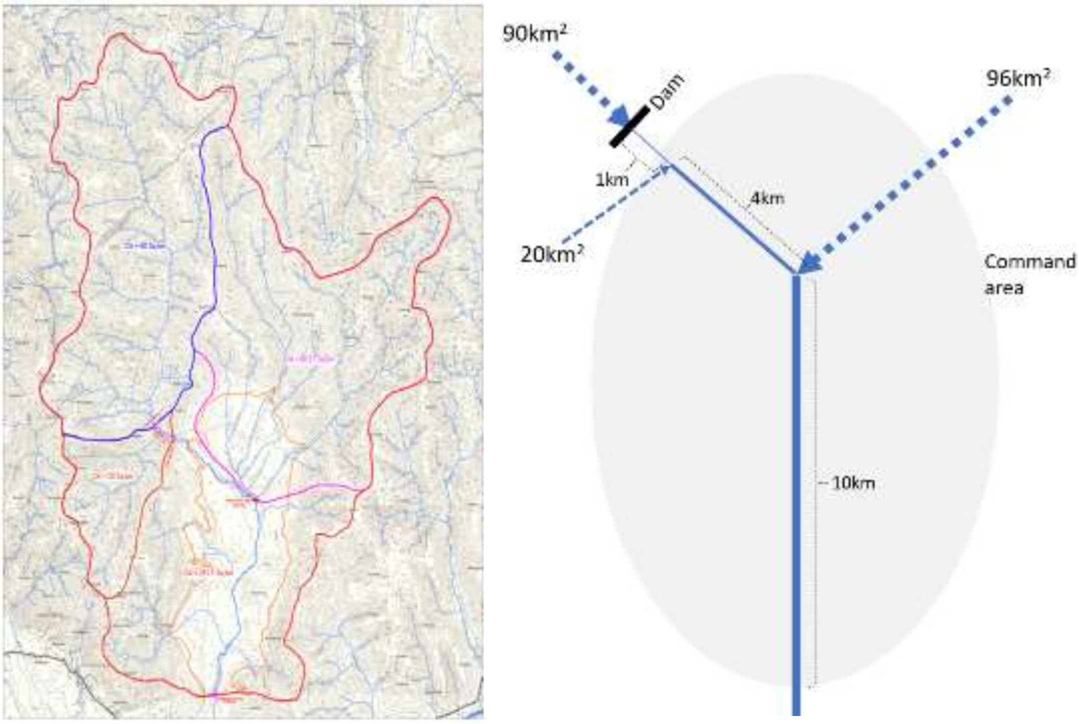
Background: The Government of Uganda (GoU) through the Ministry of Water and Environment (MWE) with support from the World Bank is implementing the Irrigation for Climate Resilience Project (ICRP). The project development objectives are to provide farmers in the project areas with access to irrigation and other agricultural services, and to establish management arrangements for irrigation service delivery. The project is implemented by the Ministry of Water and Environment (MWE), with the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) as technical implementation partner. The project comprises three components: Component 1 - Irrigation Services; Component 2 - Support services for agricultural production and value-chain development; Component 3 - Institutional Strengthening and Implementation Support.

Kabuyanda Irrigation Scheme: Kabuyanda Irrigation Scheme will be constructed under project component 1. The Scheme will be located in Isingiro District, in south-western Uganda. The scheme will contribute to improvement of farm incomes, rural livelihoods, food security, climate resilience, sustainable natural resources management in Kabuyanda. It is envisaged to develop 3,300 ha of irrigated agriculture extending southwards from the dam along the river banks. It consists of a 33m high zoned earth-fill dam, located on River Mishumba, with reservoir storage capacity of approximately 8.8Mm^3, draining an area of about 90 km^2. The proposed project will inundate 100 ha of Rwoho Central Forest Reserve (CFR). Rwoho CFR is a 9,000-ha plantation development forest that is largely degraded with bare hilltops with sparse woody plant cover, and partially restored with non-indigenous species (*Pinus caribaea*, *Pinus ocarpa* and *Eucalyptus sp*.).

The proposed Kabuyanda dam is designed for storage of streamflow, which will limit the water flow and may also possibly alter water quality in the R. Mishumba downstream of the dam. The estimated monthly runoff for R. Mishumba at the proposed dam location indicates a bi-modal variation with two peak flows in April and October of 0.8m^3/s and 0.89m^3/s, respectively, and a mean annual flow is 0.51m^3/s. Based on available data, the river sometimes dries up in the dry months of July and August, and February and September. Downstream of the Kabuyanda dam, the tributaries Rweibare (Kasharira) joins R. Mishumba downstream of the dam, and Rwemango and Kyabaganda join Mishumba about 5 km downstream of the dam. The Rweibare stream contributes about 18% of the 0.61m^3/s Average Annual Flow (AAF) of R. Mishumba at the confluence, and the combined flow of Rweibara and Rwemango Rivers is about 56% of the total flow at the confluence.



Mean Monthly flows of the River Mishumba the previous



Confluence and flow of the tributaries of river Mishumba below the dam.

Earlier study: In compliance with the National Environment Act 2019 requirements and the World Bank Environmental and Social Safeguards Policies, an Environmental and Social Impact Assessment (ESIA) was carried out to identify and assess the potential positive and negative environmental and social impacts of the Kabuyanda irrigation scheme prior to, during and after infrastructure construction, and to eliminate/minimize negative impacts, while enhancing the positive impacts. An Environmental and Social Management Plan (ESMP) with the mitigation measures was prepared.

The ESIA report (prepared by the MoWE, dated September 2019, disclosed in-country on October 2, 2019, and at the World Bank website on October 3, 2019) noted that additional biodiversity assessment and ecological flow analysis were needed. It was agreed that additional surveys and assessment will be undertaken by MoWE during project implementation and prior to dam construction to confirm some of the initial findings described in the ESIA, in particular, with respect to biodiversity surveys (with more focus on fish), cumulative impacts, underground water and environmental flow assessment and monitoring.

Current status: As of February 2022, the dam is at advanced stage of procurement, with signature expected in April 2022. The BEFMP – which represents a continuation of the ESIA and ESMP - has been incorporated into the tendering document. According to this additional study, the proposed release schedule does not deviate from the one proposed in the ESIA, and therefore there will not be any adjustments required in dam design and operations for this purpose to be introduced prior to dam construction.

Objectives: To assess the adequacy of the mitigation measures for project environmental and social impacts downstream of the proposed dam included in the Kabuyanda Irrigation Scheme ESIA to ensure compliance with the GoU Environmental requirements and the World Bank Environmental and Social Safeguards Policies. The study developed a proposed Biodiversity and Ecological Flow Management Plan to mitigate the downstream ecological impacts of the planned Kabuyanda Dam, providing guidance for monitoring the impacts and maintaining or improving the ecological condition of the downstream areas. The assignment built and expanded on information collected under the ESIA.

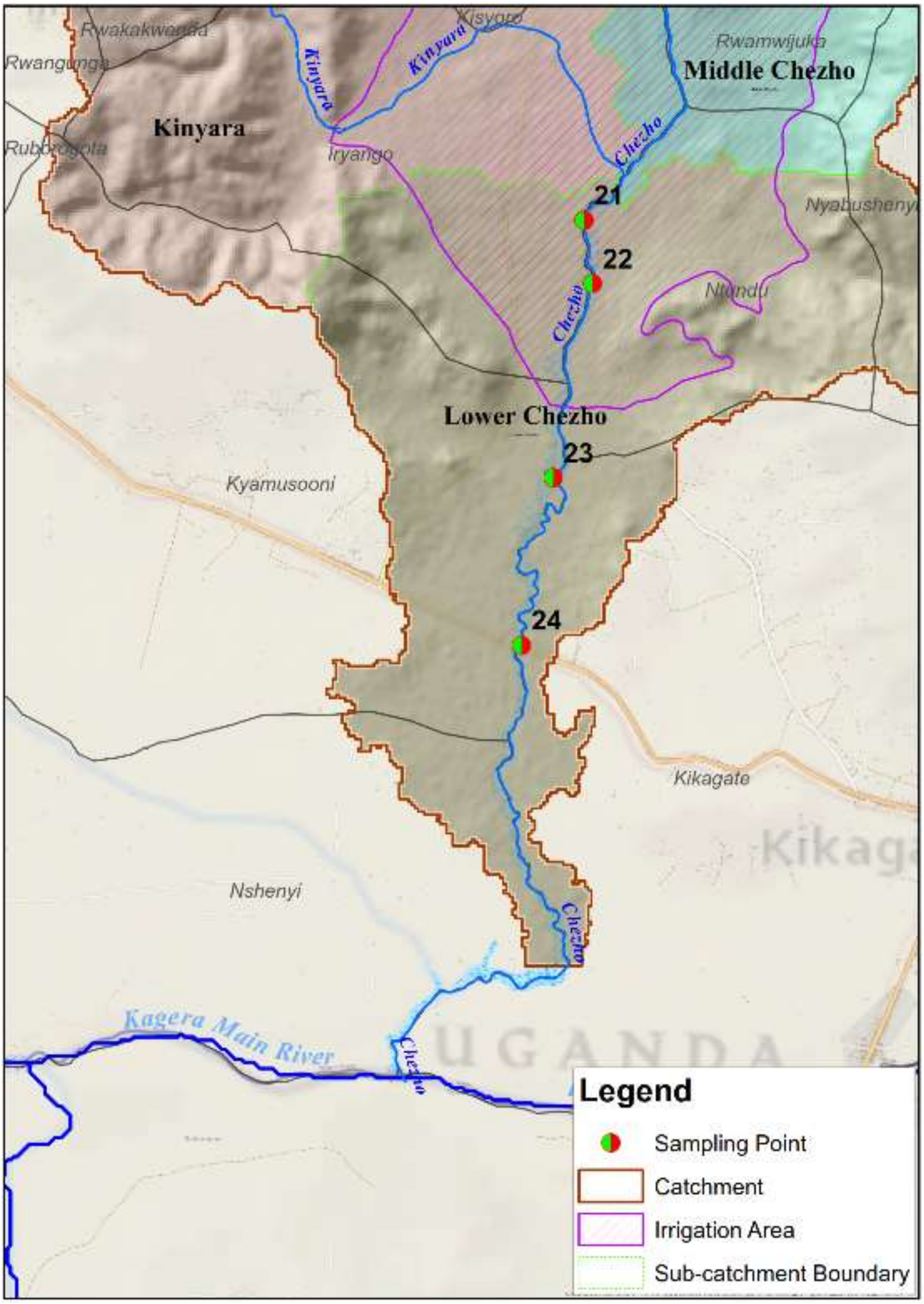
This study is aimed at:

a. better defining the magnitude and extent of the impacts (environmental, social and ecological) of the planned operation of the Kabuyanda Dam, with an emphasis on key ecosystem services, aquatic biodiversity (such as fish, amphibians and macro-invertebrate species), terrestrial biodiversity and the downstream users;
b. proposing/assessing measures to mitigate, as much as technically and economically feasible, any detrimental impact on key ecosystem services, aquatic biodiversity (such as fish, macro-invertebrate and amphibians' species) and the downstream users as a result of Dam construction and operation; and
c. confirming whether the currently proposed Environmental Flow Requirement (EFR) in the ESIA of 10% and 20% of Average Annual Flow (AAF) in the dry and wet seasons, respectively is adequate to ensure no-net loss (NNL) in aquatic and riparian ecosystem as well as to ensure safety and wellbeing for downstream communities and users with the findings of this study. If the proposed EFR is not appropriate, then identification and recommendation of an acceptable flow regime that will continue to allow the operation of the dam to supply the expected flow for the irrigation areas.

SURVEY APPROACH AND METHODOLOGY

The survey applied a number of methods not limited to literature and document review and field surveys but also stakeholder consultations and direct observations for the identification and collection of necessary data including views of the stakeholders (local and national), existing socioeconomic activities, social assessment of attendant communities, biodiversity, hydrology and water resources assessment, and limnological aspects and water quality assessment. This was conducted under the guidance of National Environmental requirements and World Bank Environmental and Social Safeguards policy requirements.

Sampling criteria: Using Geographical Information Systems (GIS) and Remote Sensing (RS) techniques, Mishumba catchment and the irrigable area were delineated with help of a 30m resolution DEM. This gave an insight about the initial hydrological and topographic characteristics of the whole catchment in Kabuyanda area. The catchment sampling strategy was designed to assess the main Mishumba River and take into account inputs from tributaries that can have significant ecological and socioeconomic impacts upon the different reaches of the river in the catchment especially downstream areas. Therefore, the catchment was divided into three (3) major zones or sections; (i) upstream, (ii) midstream and (iii) downstream. The upstream section covers the area upstream of the planned dam area, the dam area, immediately downstream of the dam area before R. Rweibare. The midstream section covers the area downstream of dam site including R. Rweibare, the entire irrigation area and tributaries that join the R. Mishumba within the irrigable command area. The downstream section includes the area immediately after the irrigation command area and before crossing the Kikagati – Ntungamo murram road. According to the GIS and Remote Sensing assessment, the study area was further subdivided into 9 sub-catchments based on the main river stem and its tributaries. This resulted in identification and use of a total of 24 sampling points that were surveyed during the wet (November, 2020) and dry (February, 2021) seasons. At point 24 the impact of the project is not expected to be significant as the change in hydrological streamflow as a result of dam development and operation is estimated to be less than 36% of the AAF (1.69 m^3/s of the dry season flow) and therefore the potential risk is deemed manageable through the other mitigation measures.



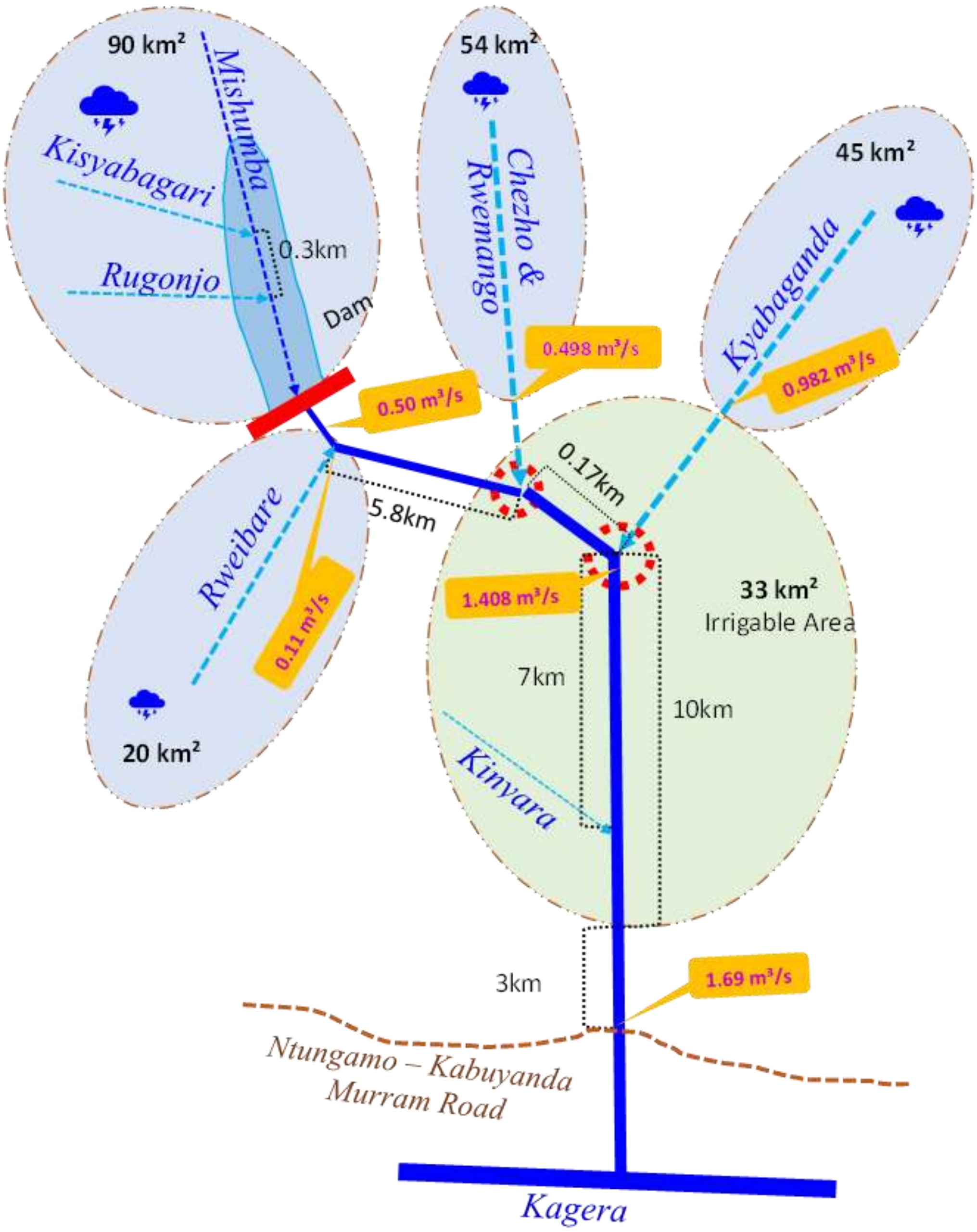
Location of the downstream sampling points 23 and 24 after the irrigable area

The assessment of the Environmental Flow Requirement (EFR) was based on the Building Block Methodology (BBM). The BBM is a methodology – a body of methods that together produces an output greater and more all-encompassing than the methods could produce individually. The BBM process is used both to guide on required form, and to organise the incoming data and knowledge to provide the required output. The output, or product, of applying the BBM is a modified flow regime, quantified in space and time. This is specific for the river, and for the desired future condition for that river." To determine and evaluate the 'building blocks' of the environmental flow, two (2) numerical models were used in addition to data collected, expert assessment, and impact assessment. The Modified Base Flow Index with Threshold (MBFIT) was applied to separate hydrographs into base flow and runoff components and the hydraulic model Hydrologic Engineering Center - River Analysis System (HEC RAS) model was used to estimate morphological changes and hydraulic properties in the stream.

SUMMARY OF FINDINGS OF SURVEYS

Hydrology: Analysis of the hydraulic and hydrological data for River Mishumba catchment using GIS and RS techniques and review of the Kabuyanda Design Report, showed that the planned impoundment of River Mishumba will only affect River Mishumba across which the dam will be constructed. The catchment area of the dam is calculated to be less than a quarter of the total catchment area (irrigable area) under study. Other streams and water sources in the wider catchment are after the planned dam on River Mishumba. Mishumba has its major confluences about 5.8 km and 6.0 km with River Chezho (combining Chezho and Rwemango) and River Kyabaganda respectively. These tributaries have catchment areas of 54 km^2 and 45 km^2 respectively. The mean average flow (MAF) for River Mishumba at the dam site is approximately 0.5 m^3/s whose catchment area size is about 90 km^2. The flows from the tributaries contribute significantly to satisfy the downstream water demands. The river has its first tributary as River Rweibare with a catchment area of 20 km^2 and flow of about 0.11 m^3/s whose confluence is just downstream of dam site i.e., Rweibara tributary contributes about 18.03% of the 0.61 m^3/s Average Annual Flow (AAF) of Mishumba River at the confluence. At 5 km downstream of the first confluence, the combined AAF of Mishumba, Chezho and Rwemango Rivers is 1.108 m^3/s, of which 45% passes the proposed dam location. The following downstream confluence (Kyabaganda junction) flows at a mean annual flow of 1.408 m^3/s, of which 36% passes the proposed dam location. The month with the lowest flow is July with a flow of 0.12 m^3/s. June, July and August record flows representing 24% of the MAF, of which 0.1 m^3/s is from the dam site. Consequently, the flow from the three tributaries (Chezho, Rwemango and Kyabaganda) and lateral inflow that joins the Mishumba river at Kyabaganda constitute 65% of the AAF at the confluence and is expected to be sufficient to sustain the ecosystem downstream of this main confluence (figure below).

At the outlet of the catchment (Sampling point 24), the flows combine to a mean annual flow of 1.69 m^3/s, of which less than 36% passes the proposed dam location. This implies that the area in the midstream (mainly the irrigable area) contribute about 0.28 m^3/s from baseflows to obtain the overall flow obtained at Kikagate – Ntungamo murram road point.



Schematic representation contribution of Mishumba and its tributaries

Hydrological flow data (discharges and hydrological sections for two field samplings; wet (high flow) and dry (low flow) periods) was collected from the field. The historical data comprised of annual flows from 1940 to 2010 (Final Design Report, 2019) and screening of this data showed non-significant trends or correlations hence considering the data to be fit for the study. The flow historical data statistics for Mishumba River indicated that the average flow was 0.516 m^3/s, Q90 was $0.1m^3/s$, Q50 was $0.5m^3/s$. Extreme discharge value analysis at different return periods was conducted using the Log Pearson III distribution which fitted the historical data the most. In a return period (T) of 2, 5, 10 and 25 years, flows of $1.81m^3/s$, $2.45m^3/s$, $2.98m^3/s$ and $3.72m^3/s$ were obtained, respectively.

Fisheries and Limnology: The aquatic ecology survey and fish sampling exercise during the wet (November, 2020) and dry (February, 2021) seasons (high flows and low flows) covered 24 sites encompassing adjoining streams (confluences) and River Mishumba established that seven (7) fish species belonging to five (5) genera (Haplochromine complex, Oreochromis, Tilapia, Clarias and Labeo) occur in River Mishumba catchment.

Most of fish caught were juvenile or small body sized individuals, a situation typical of generally upstream or primary and secondary rivers like River Mishumba. In terms of catch weight, the tilapiine species and African catfish (Clarias gariepinus) dominated while in terms of numbers the majority were Ningu (*Labeo victorianus*) followed by African catfish (*Clarias gariepinus*). In terms of the major river habitats, more fish were caught in vegetated areas with riffles than pools but majority of these were juveniles of Ningu (*Labeo victorianus*) and sub-adults of African catfish *(Clarias gariepinus*). The sizes of fish caught in pools and poddles in terms of length and weight were significantly bigger than those in riffles, a finding attributed to the fact that adult forms of those in riffles had already migrated downstream back to River Kagera or caught by fishermen on the way back after spawning.

The Ngege (*Oreochromis esculentus*), which is commonly known as Singida tilapia, was only found to occur in downstream reaches of River Mishumba at sampling point 24. Singida tilapia is on the red list of IUCN as a critically endangered fish species (Twongo *et al.,* 2006) and was previously the mainstay of Lake Victoria Region fisheries production (Mwanja *et al.,* 2013; Balirwa, 1990). The species although critically endangered is found in numerous other locations in Lake Victoria and Lake Kyoga basins as well as in River Kafu oxbow lakes with its major extant remnant stocks in Lake Kanyaboli in Kenya, Lake Kijanebalola and Lake Nakivale of the Kooki lakes complex in Uganda; lakes Kawi, Nyaguo, Gigatte, Lemwa, Nakuwa, Namumbya, and Nawampasa of the Kyoga lakes complex in Uganda (Mwanja *et al.,* 2013). In River Mishumba the species occurs only in relatively deeper waters of >0.5 m and extreme downstream reaches of River Mishumba. This makes the few individuals in the river more resilient and protected against water depth variations in upper reaches of River Mishumba. It is the expert view that changes in flow for irrigation purposes will not affect the continued existence of this species in River Mishumba.

The second fish species of conservation significance to be found in River Mishumba was the Ningu or as commonly known, the Victoria carp (*Labeo victorianus*). Most of the fish captured in the upper and middle portions of the basin were fingerlings and subadults of Victoria carp (Labeo victorianus) and African catfish (Clarias gariepinus). The stages of these two species are a reflection of use of the River Mishumba upper reaches for reproduction of current loving or rheophilic species, whose adult forms are likely to have migrated back downstream after spawning and breeding in the upper reaches of the river. These species therefore are responsive to changes in the flow regime that creates the conditions for upward migration for spawning and breeding, and downstream movement of first the spent adults and second the hatchlings and young forms of the two species. The variation in flow also creates habitats for spawning and breeding such increase in dissolved oxygen levels, and ease of mobility (Welcomme *et al.,* 1967). Although adult Victoria carp (Labeo victorianus) are considered lotic guild species, they are longitudinal migrants that are cued by rising water levels to travel upstream for spawning and breeding (Rutaisire & Booth, 2003). Sites found or associated with relatively median high-flow levels were assessed to enable upstream migration of adult Victoria carp and African catfish as indicated in the figure below. These migrant rheophilic species likely migrate between River Kagera, at lower reaches of River Mishumba, and upper reaches, which is also dependent on the timing of higher flows that make emergent vegetation, dissolved oxygen, and other channel conditions diverse and accessible habitats for a sufficient period of days to couple of weeks to enable spawning and breeding. Across all sites, gonadal maturation appears to be cued by first high flows, suggesting fish in River Mishumba time their spawning to coincide with rising flows and floods, as is common for many fish species in the tropics (Rutaisire *et al.,* 2005).

Whereas African catfish, in terms of conservation status, is of least concern, the Victoria carp (Labeo victorianus) is considered international as critically endangered (IUCN, 2015). These two species early stages were found to share the habitats and were found mostly in the fast-flowing sections of river channel. Figure below shows the sites at which the two forms were captured, that are considered to be breeding and nursing grounds/habitats of the two species. The mapping of these habitats was based on the flow–ecology relationships in the River Mishumba system, with the two species classified as rheophilic or lotic, emphasizing the importance of flow variability in sustaining and maintaining these species in the Mishumba River.

In terms of management implications in lieu of development of Kabuyanda Irrigation Scheme, the flows suggested here will maintain the diverse habitats and variations in flow spatially and temporally, allowing for high and low flows, which variation is critical in triggering upstream migration for spawning and breeding, and providing nursing grounds for the hatchlings. The ecological systems of the Mishumba River basin, though found to be highly disturbed with different socioeconomic activities, have evolved under a dynamic socio-hydrological regime, and the living aquatic resources have adapted to these alterations through changes in ecological behaviour such timing of breeding and spawning activities, use of different streams within the catchment for different ecological activities, and use of adjoining wetlands as refugee and feeding grounds. As such, the alterations in hydrological status of Mishumba River, if done according to the set e-flows, will not have any serious consequences for the flora and fauna communities of the Mishumba River. The suggested e-flows provide for occurrence of different flows at different times, that are similar to the natural hydrological variations albeit more rigorously managed flows which are required to support the channel and riparian vegetation with sufficient water, leading sustained growth and reproduction and growth.

Therefore, the set e-flows have taken in consideration the demands and needs of the respective biodiversity in Mishumba catchment, considering the seasonal variations in requirements of key biodiversity rtesources (fish, flora and fauna). The e-flows have also been set to mimic the natural variations in streaflow with the reservoir flow planned to capture the different set e-flows.

The reaches of the Mishumba River near Kagera River (downstream the proposed dam site location) were found to provide refuges to the seven species encountered, especially those known to been displaced out of or severely declined in Lake Victoria due to the introduction of non-native species, overfishing, and eutrophication. Thus, the fish species of the Mishumba River, like most of remnant stocks of these critically endangered fish species, although limited in number, have important conservation significance.

Summary of the fish species caught and their conservation status

Species	Age structure	No. fish caught	Indicative habitat/ location	Conservation status
African catfish (*Clarias gariepinus*)	Fingerlings	03	Ripples within channel	Least concern
	Sub-adults	16	Ripples within channel	
	Adults	05	Vegetated edges of channel	
Mudfish Clarias carsonii	Adult (gravid)	03	Shallow muddy vegetated edges of channel	Least concern
Victoria carp (*Labeo Victorianus*)	Fingerlings	08	Ripples within the channels	Critically Endangered
	Sub-adults	01		
Singida tilapia (*Oreochromis esculentus*)	Fingerlings	02	Pools and poddles within channel (relatively slow current)	Critically Endangered
	Sub-adults	03		
Redbelly tilapia Coptodon zilli	Sub-adults	01	Pools and poddles near vegetated edges of the river	Least concern
	Adults	01		
	Adults (processed)	36	Market	
Albert tilapia	Adults	01	Swampy edges of the river	Least concern
Haplochromines (Haplochromis spp)	Adults (processed)	>40	Different microhabitats and habitats	Threatened

Ecologically, the most appropriate habitats for the deep and slow water loving fishes such as the Ngege (Singida tilapia) and other tilapiines are in the lower parts of the catchment (downstream of irrigable area) towards R. Kagera.

The water current loving species encountered such as Ningu (*Victoria carp*) and the young forms of African catfish, require some level of current (at least above 0.2 m/s during the high flow periods) to be maintained in the different stretches of the river channel. This will allow for continued downstream migration of the juvenile fish following the hatching and nursing that comes with the reducing or weaning rains as dry season approaches. The deep slow water loving specie were captured about 12 km further downstream of the Mishumba and Chezho the biggest confluence towards the estuary of R. Mishumba and Kagera, with deeper waters that are outside of the dam and irrigable areas. As such they will not be directly affected by the planned irrigation scheme, and are unlikely to be affected by the operation of the dam.

It's further recorded and known that the home of Ningu (*Victoria carp*) is Lake Victoria as it is a lentic species. However, the Ningu migrates upstream and breeds in River Kagera and other Lake Victoria adjoining rivers including rivers Sio and Mara (Rutaisire, 2003; Rutaisire *et al.*, 2005). As such, the occurrence and breeding in tributaries of River Kagera, such as Mishumba River, is not what sustains the Ningu, and its occurrence and breeding of these species, given the small numbers encountered, may be more of a chance event river.

Key habitat requirement for the breeding of the critically endangered Ningu is basically current or upwelling conditions that allow the eggs to pick up air bubbles and to balloon. These keeps the fertilized eggs buoyant and able to float downstream i.e., a condition that triggers the hatching and nursing processes (Rutaisire, 2003). The other key condition, which is also provided by the relatively high-water current, is that of well oxygenated waters in open oxbow lagoons that allows for development of the eggs and their continued floating and ballooning so as to trigger the hatching and nursing processes. The implication therefore is that during the wet season, the set e-flows will allow for high-flows during the rains, and will provide for relatively higher currents between the dam and the confluence of Mishumba River and Chezho River, where water within the channel was found to be the fastest (over 0.8 m/s) so as to allow for the spawning and breeding of the Ningu, and hatching and nursing of its young. This will be followed by residual or base-flow as the rains wean so as to allow for downstream migration of young ones.

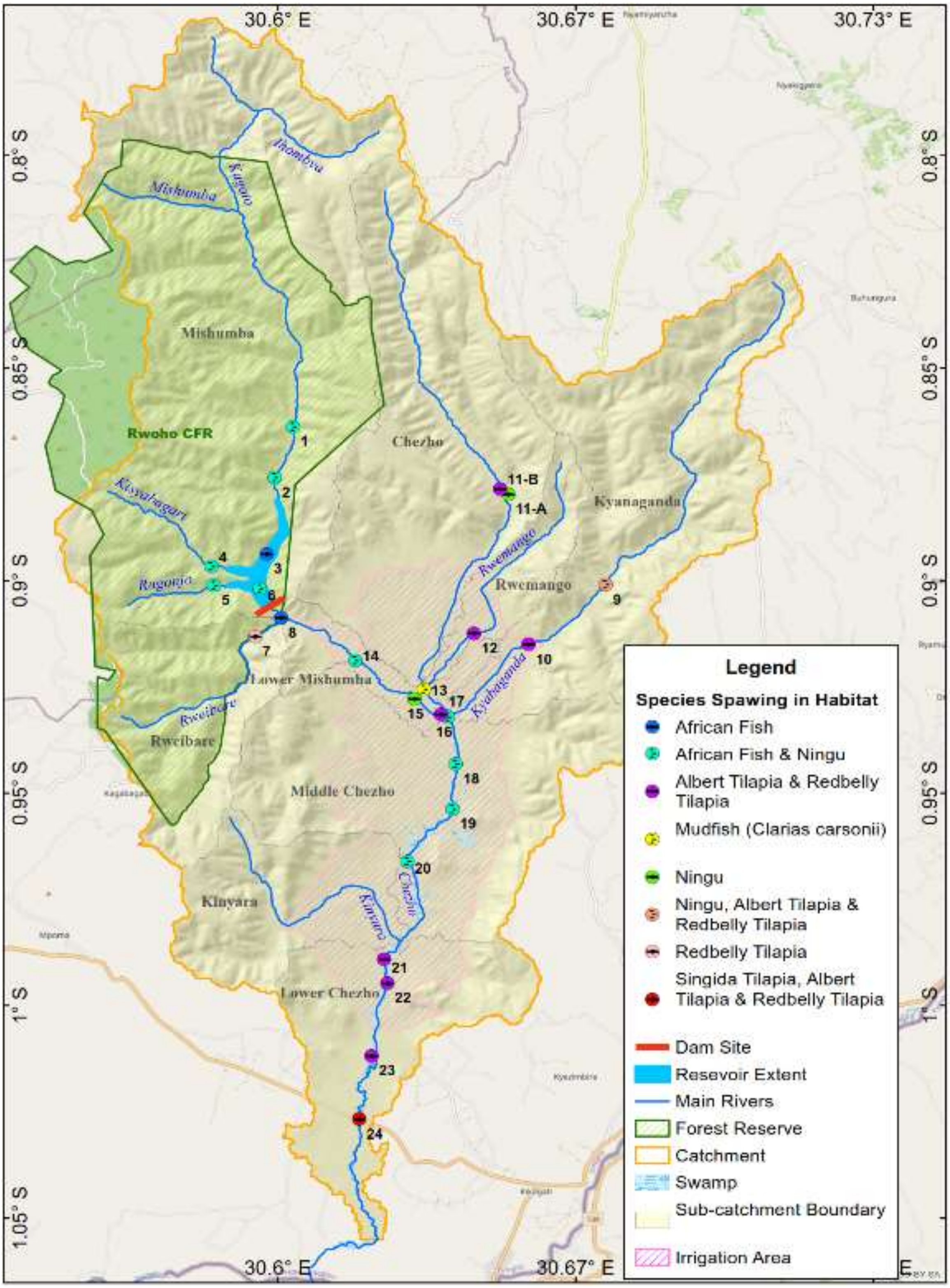
The African catfish (Clarias gariepinus) in Uganda is abundant and common (IUCN: Least Concern) in other water bodies throughout the country. The gravid adult forms are triggered to migrate enemas against the current for spawning. Once the eggs are fertilized, they become sticky and attached mainly to the submerged plants or rocks that are strategically located to allow for the water current to keep the eggs aerated. Once the young hatchery between 12 to 36 hours, they swim down or laterally into adjoining swamps for nursing and feeding purposes, hence the current loving nature of this species. In terms of conservation status, African catfish, once threatened by introduction and encroachment, is considered of least concern as they are found in nearly all waters in Uganda (both open and closed or wetlands systems). In Mishumba River, African catfish was encountered at different stages in all sampling points where fish was found. As such, given the set e-flows in lieu of the planned Kabuyanda Irrigation Scheme, there will be no or minimal effect on African catfish so long as basal flow is maintained and some areas with swampy nature, especially between the dam and Chezho and Mishumba rivers confluence are maintained with regular high flows and occasional flooding.

The findings of the survey and conclusions of the environmental flow assessment are as follows:

a) Mishumba catchment was assessed to be of conservation ecological importance due to the encountering of critically endangered Singida tilapia (Oreochromis esculentus) and Victoria carp (Labeo Victorianus). However, generally, catchment did not have any unique biodiversity that is known to occur only in River Mishumba and/or Mishumba catchment. Even the critically endangered species are found in several other places (water bodies) and in much larger numbers/stocks than what was found in Mishumba (Mwanja, 2000). The two nationally and IUCN Red listed critically endangered species identified in the River Mishumba have more viable populations and stocks elsewhere in other waters including River Kagera, River Sio, River Mara and other related water bodies (satellite lakes such as Kyoga Lake complex, Nabugabo lake complex, Kooki lakes and their adjoining rivers and streams) within Lake Victoria Region (Mwanja *et al.,* 2010; Rutaisire, 2003).

In this study, the e-flow assessment and requirements were set considering these two critically endangered species as representative indicators of critical aquatic biodiversity. It was determined that in order to maintain the populations of the indicator species, the low flow and hydrological variability was required to be maintained near current condition. Th Environmental Flow Assessment (EFA) aimed at maintaining these hydrological characteristics, incl. flow variability in the midstream and downstream reaches for rheophilic species during the wet season that is necessary to trigger their upstream migration, spawning, breeding, hatching and nursing at peak of the rains, as well as to support the downstream migration of the fertilized eggs and hatchlings as rains wean down. In addition, to sustain the deeper slow flowing waters for the sedentary water loving forms in the downstream stretch of the Mishumba River where they encountered.

The figure below shows the spawning and breeding habitats while the table gives the key characteristics of the breeding areas/habitats of these species. It is evident that whereas some spawning areas lie above the proposed dam site, there a number of alternative breeding areas just below the dam and in other tributaries (Chezho River) in the catchment, especially for the Ningu. This means the damming will not stop the breeding activities in the catchment for this critically endangered species. The remnant individuals in the area upstream of the proposed dam location may flourish in the lentic environment created by the reservoir.



Map showing the spawning and breeding habitats

Characteristics of the breeding areas and habitats of key indicator fish species encountered in the Mishumba Catchment.

Sampling point	Vegetation	Depth And Flow Rate	Sediment	Species Spawning in Habitat
1	highly vegetive this is the gauging point	deep and fast	mud and gravel from construction	African catfish and Ningu
2	little with cactus, but has forest with ferns	Deep and fast	Has rocks from	African catfish and Ningu
3	Highly vegetative	deep and fast	rocks with silt and plant debris	African catfish
4	highly vegetative	shallow and slow	Mud	African catfish and Ningu
5	highly vegetative	shallow and first	Mud	African catfish and Ningu
6	lititle vegetation with cactus, has ferns and papyrus brought by flood.	fast and deep	mud and silt from murram rocks	African catfish and Ningu
7	highly vegetative	shallow and slow	Mud	Redbelly tilapia
8	vegetative with a confluence	deep and fast	mud with silt	Ningu
9	Highly vegetative	deep and slow	clay and gavel	Albert tilapia & Redbelly tilapia
10	highly vegetative	deep and slow	silt, mud and pebbles	Albert tilapia & Redbelly tilapia
12	moderately vegetative with cultivated land	shallow and slow	mud with pebbles	Albert tilapia & Redbelly tilapia
13	modedrately vegetative with caltivated land	shollow and slow	mud with peeb les	Mudfish (Clarias carsonii)
14	Moderately vegetative	Shallow and fast	silt wth mad	African catfish and Ningu
15	highly vegetative	Deep and fast	silt with pebbles	Ningu
16	highly vegetative this forms aback pool of water	deep and fast	mud with a lot of plant debris at bottom	African catfish and Ningu

17	highly vegetative this forms aback pool of water	deep and slow	mud with silt	Albert tilapia & Redbelly tilapia
18	Highly vegetative	Deep and fast	gravel and silt	African catfish and Ningu
19	Highly vegetative	Deep and fast	mud, plant debris and marram pebbles	African catfish and Ningu
20	Highly vegetative	deep and fast	clay, plant debris and pebbles from the marram road	African catfish and Ningu
21	highly vegetative surrounded by gardens and within flood plain	shallow and slow	mud and plant debris	Singida tilapia, Albert tilapia and Redbelly tilapia
22	highly vegetative	deep and slow	mud	Singida tilapia, Albert tilapia and Redbelly tilapia
23	highly vegetative	deep and slow	mud	Singida tilapia, Albert tilapia and Redbelly tilapia
24	highly vegetive	deep and slow	mud	Singida tilapia, Albert tilapia and Redbelly tilapia
11-A	highly vegetative	shallow and fast	silt and pebbles	Ningu
11-B	highly vegetative	deep and slow	mud	Albert tilapia & Redbelly tilapia

a) None of the floral and terrestrial biodiversity was identified as endangered or vulnerable or unique to River Mishumba.
b) The fish species found at the different sampling points within the reference reach, have been found in the other areas of the catchment in bigger numbers.
c) The e-flow assessment and requirements have been made in a manner that mimics the natural hydrological variability so as to limit the impact on the biodiversity. It also noted that although there will be impact on the floral and faunal biodiversity in the catchment, this will be therefore be minimal, and the e-flow requirements have been set so as to allow tolerate the changes or be able to move, or be moved in case of fauna, or regenerate

and disperse easily in case of existing floral biodiversity affected by flow variation due to the Kabuyanda Irrigation Scheme development.

d) Maintaining flow variability will allow for creation of conditions that allow for affected mobile species to readily or easily migrate both upstream and laterally within and outside the River Mishumba channel through regular flow or overbank flows even in the dry season to allow connection between the Mishumba channel and destinations of the migrating fish (R. Kagera) for the rheophilic species, and adjoining swamps for limnophilic species. The damming will have limited impact on upstream migrating species as it relatively upstream above the main breeding area for the rheophilic species, that is, between the dam and the confluence of River Mishumba and River Chezho.
e) There were no special habitat sites or special areas of ecological significance found that are not generally available throughout the Mishumba River and Mishumba catchment, such as spawning or breeding grounds, migration routes identified in the affected river reach or upstream;
f) There are no significant differences in the climatic or water quality conditions within Mishumba catchment and along Mishumba River that would indicate the existence of special conditions in specific location not found elsewhere in the basin, say temperature, BOD, pH.

The survey also established which fish species belong to the same ecological and or environmental guilds in River Mishumba in terms of how they respond to changing hydrology and geomorphology of the river by comparing fish catches in the wet and dry seasons. The guilds range from fish that are moderately to highly sensitive to the flow timing and/or quantity, and these include all the tilapiine species and mudfish (*Clarias cassonii*), that were found only in the pools of water – pool guild; to those fish species which are sensitive to reductions in flow that altering the balance between riffles and pools in the river, or leave the pools anoxic, these include Ningu and to a lesser extent African catfish are fairly sensitive species representing the lotic guild. Ningu is typically an annual breeder whose breeding seasonality and migration patterns are highly dependent on the timing and quantity high flow events. Lotic guild members require fairly high levels of dissolved oxygen, necessitating high flow velocities. On the other hand, tilapiine species, encountered in large pool habitats (downstream), are in the riffle guild, generally considered to be a sensitive genus due to species group requirement for slow flowing water (velocity $\leqslant$ 0.3 m/sec) that is linked to their mode of reproduction and feeding ecology. On the basis of these fish guilds found in River Mishumba, it is recommended that in the dry season, base flows should maintain inundation of the riffles in the midstream and downstream to create the pools. Importantly, most of these sites are after the major confluence (sampling point 15) where the impact of flows from Mishumba stream to be dammed are very insignificant on the total flows discharging into River Kagera. In the wet seasons, base flows must inundate lower banks and benches, allowing the input of nutrients from the adjoining swamps and open farm fields that are regularly flooded by the river. High flows in the wet season must inundate the floodplains to recharge swamps as well as provide access to floodplain nursery grounds.

Vegetation and Flora

Kabuyanda irrigation scheme project area is covered by modified vegetation. The slopes and the hills are covered by fields of cultivation Plantations of Eucalyptus spp., Pinus spp. and Grevillia Robusta, entirely covering the section of the project area in Rwoho CFR while the rest of the land outside the CFR is covered by fields of cultivation under subsistence farming of food crops. Out of 247 species recorded, most of them are herbaceous plants (48.4%) with woody species constituting less than 30% mainly owing to cutting down of natural forests, replacing them with exotic plantations of Eucalyptus sp. and Pinus sp., including Rwoho CFR. Plant species with the highest spatial coverage were *Typha capensis* (22%), *Cyperus denudatus* (20.3%), *Cyperus dives* (16.6%), *Leersia hexandra* (11.5%), *Persicaria setosula* (9.6%), all of which are typical floodplain species. Only 34 species representing 13.8% have been assessed by IUCN (2021) and the rest are not yet assessed. All species recorded in the project area were of Least Concern (LC), thus, no plant species is considered as threatened, endemic, rare and/or require special conservation status in accordance with IUCN Red List. In addition, no critical habitats were found hence the dam impact will be minimal.

The main impacts identified are habitat loss, reduction in woody vegetation biomass and cover as a result of vegetation clearance, and possible proliferation of invasive species of plant. The overall impact is considered small-negative. These impacts may be mitigated through replanting indigenous tree species, restoration of disturbed areas immediately after operations, monitor invasive species of plants and mechanically remove them before flowering/fruiting stage, sensitisation of project workers, restriction of the activities to the areas that cannot be avoided, closely monitoring and supervising the operations to ensure compliance. In terms of water flow or environmental flow requirements, the plant species are a mixture of wetland species including those that are submerged, emergent, and those that occur to fringes of the water bodies on wet soil above the water. Therefore, to sustain the floral communities and biodiversity different flow requirements have been considered for the different groups of plants.

Fauna

Butterflies: 22 species comprised of 5 families and 15 genera of butterflies were recorded in Mishumba catchment during dry season. In abundancy, 3 species were relatively common during the dry season namely; *Forest Commodore Precis rauan*a, *African Migrant Catopsilia florella* and *Scalloped Sailer Neptidopsis ophione*. The Citrus Swallowtail Papilio Demodocus and *White-banded Swallowtail Papilio Echeriodes* were the least abundant relative of all registered species. No butterfly species were of conservation significance basing on the 2019 IUCN Red list during the additional surveys. The cycles of wet and dry seemingly play a critical role in presence or absence of many of these species. In setting and managing the e-flow requirements for butterflies therefore consideration of seasonal changes in water flow and supply is a key requirement captured in the biodiversity and e-flow management.

Dragonflies: 8 species out of the 231 species of dragonflies known in Uganda were recorded in the project area representing 2 families and 7 genera. In the dry season, the *Julia Skimmer Orthetrum Julia* registered the highest abundance with 50. *Painted Sprite Pseudagrion hageni* registered the second highest abundance. Other 35 individual species were registered where the *Eastern Blacktail Nesciothemis cf farinosa* and *Broad Scarlet Crocothemis erythraea* had the lowest abundance. All the 8 species are common and typically found around open waters and swamps hence, none is of conservation importance.

Amphibians: 9 species were recorded (all frogs) represent 4 families and 5 genera in both the wet and dry seasons. The *Hyperoliidae* and *Pyxicephalidae* families were the most and least represented with 4 and 1 species respectively. The main contributors were the *Mascarene Rocket Frog Ptychadena mascareniensis* with 108 individuals and *Dwarf Puddle Frog Phrynobatrachus mabebiensis* with 25 individuals in the wet season. Also, in the dry season, both the *Mascarene Rocket Frog Ptychadena mascareniensis* and *Anchieta's Rocket Frog Ptychadena anchietae* contributed 63 and 26 individuals respectively. Typically, the ecological and physiological requirements of frogs are very much dependent on presence of water, variation in water volume, and in some cases changes in water flow. This has been the basis for consideration of e-flow requirements for amphibians (all frogs) in the biodiversity and e-flow management plan.

Reptiles: A total of 11 individuals of reptilian groups were encountered in the wet season while only 5 individuals were encountered in the dry season where the skinks had the highest relative abundance compared to other species. None of the reptile species recorded in the project area is of ecological concern according to the IUCN red list 2017.

Avi-fauna: 84 species of birds representing 36 families and 69 genera were recorded during both wet and dry seasons indicating an 87% rise in the number of species recorded. This might be attributed to the additional sampling sites (scope) previously not sampled. The *African Wattled Lapwing Vanellus senegallus, Spur-Winged Lapwing Vanellus spinosus, Long-Toed Lapwing Vanellus crassirostris, Intermediate Egret Ardea intermedia* and *Sacred Ibis Threskiornis aethiopicus* (wetland specialists) were only recorded in the dry season and none was recorded in the wet season. The *Northern Red Bishop Euplectes franciscanus, Cattle Egret Bubulcus ibis* and *Pin-Tailed Whydah Vidua macroura* (purely grassland species) were only registered during the dry season. Like for most wetland associated biodiversity e-flow requirements set in this study, the avi-fauna here is dependent on presence and seasonal variation in water volumes.

Species Conservation Status of Avi-fauna in Mishumba Catchment: 10 species of conservation importance were recorded during the survey with 4 being recorded during the dry season, 2 in the wet season and 4 in both seasons. The birds were categorized as the IUCN Red List as Regionally Vulnerable at the African region, endangered by Uganda's National Red list, Near-Threatened at the Africa regional level, Vulnerable at the African regional level and also for Uganda and Vulnerable at the global level. These included the *Stephanoaetus coronatus Crowned Eagle* (dry season), *Martial Eagle Polemaetus bellicosus* (wet and dry season), *African Marsh Harrier Circus ranivorus* (wet and dry season), *African Darter Anhinga rufa, Grey Crowned Crane Balearica regulorum, Semi-Collared Flycatcher Ficedula semitorquata, Blue-Headed Sunbird Cyanomitra alinae, Red-Chested Sunbird Cinnyris erythrocercus, Cardinal Quelea cardinalis* and *Crex egregia African Crake. Most of these species were recorded in both the irrigable and wider catchments outside the irrigation command areas. It is however established that, the Grey Crowned Cranes are visitor species because there were no nests nor their roosting sites encountered.*

Social-Economic Assessment

Catchment Population: The catchment area has a total population of 138,870 people (66,185 male; 72,685 female) and 20,407 households with Kikagati Sub-County (downstream) with a population of 42,999 people (20,264 male; 22,735 female) and 8,766 households.

Poverty trends: During consultations with LC 1 committees (upstream, mid-stream, down-stream), it was revealed that the level of unemployment was high especially among the youth. However, coping mechanisms tend to diversify among people living near urban and peri-urban settlements. These areas include Kabuyanda Town Council, Rwamijuka-Kifumbira, Ruborogota trading centre. The differing levels of consumption in urban areas influences.

***Social services and infrastructure*:** The road network (both feeder and community access roads) within irrigable area stands at 259.84 km of which, Kikagate Sub-County (SC) has at 83.03 km; 75.99 km in Ruborogota SC; 56.6 km in Kabuyanda SC and 44.82 km in Kabuyanda Town Council (TC).

Education: In terms of education facilities, Kabuyanda Town Council has 6 primary and 2 secondary schools, Kabuyanda Sub-County has 7 primary and 1 secondary schools, Kikagate SC (Ntundu Parish) has 1 primary school located within irrigable area and Ruborogota SC (Kyamusooni parish) has 1 primary school.

Water and sanitation: Access to water stands at 69% in Kabuyanda SC and Kabuyanda TC respectively; 56% in Ruborogota SC and 33% in Kikagate SC (MWE/ Water Atlas, 2017). The water source functionality ranges between 95%-99%. Access to boreholes and piped water sources varies according to parishes. There are 3,003 households accessing piped water.

Toilet coverage is at 2% (279 out of 13,774 HHs) with the highest number of households with toilets in hilly area (upland of irrigable area) in Nyabishenyi parish (70 HHs) and Iryango parish (31 HHs).

Livelihoods: The major livelihoods are derived from agriculture (crop and livestock), employing about 88.5 HHs (16,131 out of 18,231) in Mishumba catchment. The upstream areas have the highest proportion of faring households at 56% (9,055 out of 16,131). Mid-stream has second highest at 245 (3,780 out of 16,131) and downstream has lowest at 20% (3,296 out of 16,131) as based on UBOS/SAP report 2019. The major source of domestic fuel (energy) is firewood and charcoal. Charcoal prices range between UGX 20,000-40,000/= per sack. Firewood prices range between UGX 1,000-10,000/= depending on size of bundle.

Ecosystems Services (social uses): By coverage, the ESS sampled 389 respondents (211 male; 178 female). It covered 17 villages surrounding 14 selected sampling sites. By distribution, 53.2% of respondents were located in irrigable area (mid-stream and downstream) namely 46 in Middle Chezho Sub-catchment, 69 in Kyabaganda & Middle Chezho Sub-catchments and 92 in Lower Chezho Sub-catchment. In Lower Mishumba Sub-catchment (downstream of dam site), 12% (45) respondents were sampled. People get services like water from the stream for household use, watering animals, fishing for income (21%), cultivation of food crops (93%) along the river, wild food (79%), wood fuel (99%), timber and wood fibre (97%). Others include; natural medicine (12%), recreation or leisure (e.g., swimming) (6%), spiritual and religious values (0.2%), brick making (4%) and sand mining (21%). Most of the downstream uses are after the major confluence (sampling point 16) where the impact of flows from Mishumba stream to be dammed are very insignificant on the total flows discharging into River Kagera. Therefore, the impact of the project on downstream uses and users is minimal. The communities living on the hillsides and 1 km downstream of the dam will benefit from the irrigation water in their fields and will be able to diversify their farming and production activities throughout most time of the year. This in turn will translate into improved food security and household income.

Assessment of the 10% and 20% of Average Annual Flow (AAF) EFR in the ESIA in the dry and wet seasons

Environmental Flow Requirement (EFR): The development of e-flow requirements for various species was based on species whose water requirements are more complex and/or restrictive. This is based on the understanding that by satisfying the requirements of those that require more water and/or variability, the requirements of others will automatically be met. Therefore, flow requirements concentrated on the requirement for fish, the papyrus for flora, fauna and communities downstream.

Minimum flow assessment: It should be understood that these flows were superimposed with the flow required for flushing or maintenance of the river reaches. The resultant minimum average flow at the dam site location for the fish requirements in the Mishumba River are as below (monthly). The determination of the minimum flow requirements for fish was based on the minimum flow requirement for movement, water level requirement, and maintenance of habitats.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow m^3/s	0.05	0.05	0.05	0.22	0.05	0.05	0.05	0.05	0.05	0.22	0.05	0.05

It was found that in 8 months out of the 12, the flow exceeds the requirement for 60% of the time. This provides an estimated flow of about 0.35 m^3/s. However, excluding the flow from the Rweibare tributary joining the river downstream of the reservoir, it implies that the reservoir release of about $0.24 m^3/s$ is expected for the 8 months from December to July. The resultant minimum flow requirement to maintain the fauna and flora in the downstream area are as in the table below. The implementation of these minimum flow requirements will lead to a No Net Loss (NNL) for fauna and flora.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow m^3/s	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.22	0.05	0.1

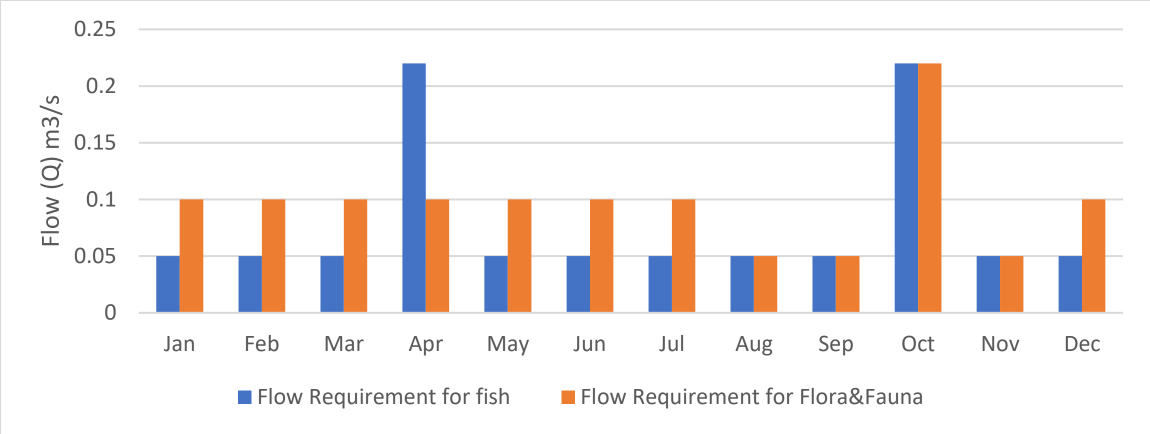


Figure #. *Flow requirement for fish.*

Structuring and Presentations of Scenarios: Three (3) main requirements for scenarios are the ability to: (i) provide a range of options of what a potential Environmental Flow Requirement (EFR) could be by illustrating the potential river changes and social impacts; (ii) provide simple summaries of each scenario of river change in a context that the decision makers can relate to; and (iii) express the social and environmental implications of each scenario in terms of both impacts and costs for compensation or mitigation purposes and benefits.

The scenarios are used to examine the trade-off between environmental and social impacts (while maintaining NNL), and abstraction of water for irrigation. The scenario development in this study aimed at the following two items: a) to meet a specific yield (requirement to abstract a specific volume of water) and to meet a specific condition (a certain river condition and ecosystem feature).

For quantitative predictions, five (5) severity levels of change were used to rate the scenarios including;

- 0 = None – No impact resulting from the change in the streamflow
- 1 = Negligible – Hardly noticeable impact resulting from change in the streamflow
- 2 = Low - Descernable but with limited effect resulting from change in the streamflow
- 3 = Moderate – Incident to minor effect resulting from change in the streamflow
- 4 = High – Intense effect of the damage resulting from change in the streamflow
- 5 = Very high – Critical level of damage resulting from change in the streamflow

Description of scenarios: The overall discharge in the river reaches under consideration are quite small, therefore, there is very limited room for manipulation of flows to provide meaningful variations. From this perspective and that the only investment using significant water in the catchment is the proposed irrigation scheme, only three (3) scenarios were studied. All scenarios include the maintenance of the high and low floods, i.e. allowing the 'pass-through' of key ecological flood events.

Scenario one (1) represents the water required for the e-flows including the maintenance of the high and low floods. Scenario two (2) comprises the proposed releases by the ESIA study (2019) report but with an addition of releasing low and high floods as in the previous scenario. Scenario three (3) is when the minimum flow releases are increased doubled as compared to Scenario 1 including the maintenance of the high and low floods. The table below gives the summary of the flows within each scenario.

Flow regime	Present situation m^3/s	Scenario 1 (EFR) m^3/s	Scenario 2 (Project) m^3/s	Scenario 3 (Increased Release) m^3/s
Dry season low flows, Dry Years	0.14	0.1	0.05-0.12	0.21
Wet season low flows, Dry Years	0.22	0.22	0.12-0.24	0.33
Dry season low flows, Wet Years	0.19	0.1	0.05-0.12	0.21
Wet season low flows, Wet Years	0.41	0.05-0.22	0.12-0.24	0.33
High flows lower	0.2	0	0	0
High flows upper	0.8	0	0	0
Small floods	1.8	1.8	1.8	1.8
Large floods	2.4	2.4	2.4	2.4

Impact of scenarios on irrigation potential: According to scenario analysis against the indicator list in table below. Scenarios 1 and 2 do not reduce on the amount of water required for irrigation and therefore it can be concluded that their impact on the proposed irrigation scheme is negligible. Scenario 3 allows a release that will reduce the amount of water required for irrigation by approximately 30% implying a possible reduction in the irrigated area in the same range.

Discipline	Indicator	Scenario 1	Scenario 2	Scenario 3
Irrigation	Irrigated Area	Negligible - Sufficient irrigation water available for planned irrigable area	Negligible - Sufficient irrigation water available for planned irrigable area	Significant - Sufficient water available - Reduced irriagable
Sedimentology	Deposition/erosion characteristics	Negligible - No change from the existing situation	Negligible - No change from the existing situation	Negligible - No change from the existing situation
Water quality	Nitrates	Negligible - Stable and no effect	Negligible - Stable and no effect	Negligible - Stable and no effect
Vegetation	Papyrus areas	Negligible	Negligible	Negligible

		- Stable and no effect	- Stable and no effect	- Stable and no effect
Fish	Spawning Areas	Negligible - Stable and no effect	Negligible - Stable and no effect	Negligible - Stable and no effect
Invertebrates	Species richness	Negligible - Stable and no effect	Negligible - Stable and no effect	Negligible - Stable and no effect
Socio-economic	Fishing	Negligible - Stable and no effect	Negligible - Stable and no effect	Negligible - Stable and no effect
Overall		Negligible - Meets the planned needs with minimum effect on the bidoversity and social economics	Negligible - Meets the planned needs with minimum effect on the bidoversity and social economics	Significant - Sufficient water for irrigation and negligible effect on biodiversity - No significant social economic alterations

Therefore, scenario 3 has a significant impact on the proposed irrigation scheme. Scenario 1 and scenario 2 do not have significant impacts on the scheme. The recommended minimum flows within the ESIA (Scenario 2) are sufficient to protect the fish, flora, fauna, and downstream demands.

Month	ESIA (m^3/s)	Fish (m^3/s)	Flora (m^3/s)
Jan	0.05	0.05	0.1
Feb	0.12	0.05	0.1
Mar	0.14	0.05	0.1
Apr	0.24	0.22	0.1
May	0.22	0.05	0.1
Jun	0.15	0.05	0.1
Jul	0.09	0.05	0.1
Aug	0.09	0.05	0.05
Sep	0.20	0.05	0.05
Oct	0.22	0.22	0.22
Nov	0.24	0.05	0.05

Dec	0.16	0.05	0.1

Therefore, the recommended water release schedule from the reservoir is as in the Table below is in agreement with the ESIA. For maintenance purposes, the floods with the return periods of 2 years and 5 years should be imposed on this flow.

Month	Baseflow	Final Minimum Flow Requirement (m^3/s)	Pulses	Small Floods	High floods
Jan	0	0.1	0		
Feb	0	0.12	0		
Mar	0	0.14	0		
Apr	0	0.24	0	1.8 m^3/s every after 2 years for 12 hrs.	2.4m^3/s every after 5 years for 12 hrs.
May	0	0.22	0		
Jun	0	0.15	0		
Jul	0	0.1	0		
Aug	0	0.09	0		
Sept	0	0.20	0		
Oct	0	0.22	0		
Nov	0	0.24	0		
Dec	0	0.16	0		

CONCLUSIONS AND RECOMMENDATIONS

The present study aimed at confirming some of the initial findings described in the ESIA, in particular, with respect to biodiversity surveys (with more focus on fish), cumulative impacts, underground water and environmental flow assessment and monitoring.

Eco-Hydraulics: The estimated monthly runoff for R. Mishumba at the proposed dam location indicates a bi-modal variation with two peak flows in April and October of 0.8m^3/s and 0.89m^3/s, respectively, and a MAF is 0.51m^3/s. The month with the lowest flow is July with a flow of 0.12 m^3/s. June, July and August record flows representing 24% of the MAF. Based on the data series, the river sometimes dries up in the dry months of July and August, and February and September. Flow in the months of September-November is more variable than during the other months. The maximum flows, that lead to flooding, are most likely to occur during the months of September - December. Rweibara (Kasharira) tributary joins R. Mishumba immediately downstream of the Kabuyanda dam while Chezho, Rwemango and Kyabaganda join Mishumba at about 5km. The Rweibara River contributes about 18% of the 0.61m^3/s AAF of R. Mishumba at the confluence, and the combined flow of Rweibara and Rwemango Rivers is about 43.3% of the total flow to the confluence. The contribution of 56.7% from the three tributaries of Chezho, Rwemango and Kyabaganda can fully sustain the ecosystem down of this main confluence.

Fish biodiversity: The additional surveys established existence of ecologically significant and critical fish biodiversity including relics of previous highlights of Lake Victoria fishery, Singida tilapia (*Oreochromis esculentus*) and Victoria carp (*Labeo victorianus*), both of which are currently considered as critically endangered and are Redlisted by IUCN. Other fish species found in Mishumba catchment are Zilli's tilapia (*Coptodon tilapia*); Albert tilapia (*Oreochromis leucostictus*); African catfish (*Clarias gariepinus*); Mudfish (*Clarias cassonii*); and Haplochromines (*haplochromis spp.*). In conclusion the additional survey and study found that the project will not have adverse effects on the aquatic biodiversity, and in many instances will instead provide a life line for this fish biodiversity by creating conditions to boost the numbers of fish such as the resultant reservoir and creation of special conservation areas recommended as part of the management options for aquatic biodiversity in BMP. Recommendations and guidelines have been given in here for sustenance and development of all the identified fish species for the different stages of the project development and operation. Key recommendations are as follows:

- Limnophilic fishes, especially the relatively large bodied fishes such as Singida tilapia, will required the e-flows to provide and maintain a minimum depths of >0.15m at the lower end of Mishumba River with water flow rates of not more than 1.4 m/s and seasonal overbank flow and inundation of adjoining areas so as to refresh and or create feeding, spawning and nursing grounds for such fish species found in the catchment.
- The rheophilic species in the catchment including Victoria tilapia, require seasonal flushes or pulses coupled with marked increase in water depths to stimulate spawning and creation of spawning, nursing and feeding grounds for such species. It is also recommended that selected sections of Mishumba River or sections of adjoining rivers with pockets of rheophilic species be maintained as relatively fast flowing (> 06 m/s) sections for purposes of sustaining the ecological requirements of such fishes.
- That two special conservation areas need to be created at specially selected sites on adjoining rivers Chezho and Kyabaganda for the preservation and breeding of the critically endangered Victoria carp (Ningu). This is meant to compensate for the interruption of the upstream migration on River Mishumba for Ningu's breeding and spawning by the damming of River Mishumba.

Flora and Fauna: The habitats were found to be greatly modified and non-critical for floral biodiversity. Large chunks of the area were under cultivation for subsistence, with farmlands, and pasturelands. Even the protected Rwoho CFR was had only the exotic tree species, notably Eucalyptus spp., Pinus spp. and Grevillia Robusta. All plant species were of Least Concern (in agreement with the ESIA). All habitats in Mishumba are non-critical for biodiversity, though it is home to some species of fauna and as such, caution be taken to ensure that, observance of minimal water flows and guided opening up of the areas should take into account, requirements set out in this study for sustaining the habitats. The additional survey established that there is less in-stream vegetation cover inform affecting water movement processes. However, it's projected that the impoundment/damming of Mishumba River will increase the resident time of the water which will allow for transformation of some of these chemical species. The chemical species input will be majorly anthropogenic, linked to the cottage industries and agricultural practices in the catchment. In terms of fauna, the additional surveys established that Mishumba catchment has no vulnerable, threatened or endangered fauan. The faunal species identified in the Mishumba catchment were common snakes, otters, water ducks and water insects including water skates, water bugs, dragon flies, earth worms.

Although the conclusion is that the Kabuyanda ICRP based on damming of River Mishumba will have no effect on existing fauna and floral since the area is already highly disturbed owing to the farming and mining activities in the area, cutting and clearing of the natural vegetation, and high level of siltation as shown by the level of turbidity and TDS at the different sampling sites, is likely to affect the provisional of ecological services by Mishumba River. It is therefore the recommendation of this study that:

- The water release schedule from the reservoir be $0.1m^3/s$ during the dry season (lowest) and $0.24\ m^3/s$ during the rainy season, and for maintenance purposes, and the floods be based on the return periods of 2 years and 5 years.
- Agricultural production and socioeconomic activities within Kabuyanda Irrigation Scheme be properly planned and controlled to significantly cut out the unnatural supply and entry of such chemical species in the water course.
- Water flow be set and regulated to maintain the existing flora and fauna, and limit the entry and establishment of invasive species.
- The Biodiversity and Ecological Flow Management Plan (BEFMP) has been developed in response to the identified potential impacts herein and those in the ESIA, and must funded and implemented as part of the Kabuyanda ICRP Project.

Social-economic: The catchment is an active site with planted forests in Rwoho CFR, extensive subsistence, pastoral livestock keeping, timber felling and chain sawing and cottage brewery. Change of purpose and use of water will certainly require transforming the communities into crop producers. There is a need to consider the cultural attachments, traditions and indigenous knowledge of these communities in the catchment plan as most households surveyed grow some bananas (matooke). This was not provided for in the agriculture development plan under the irrigable area, neither is the livestock production and existing cottage industries. Therefore, measures to allow for such communities to be transformed through training, exposure and demonstration have been captured as means of helping them adopt to the new plan for use of the area. In addition, suggestions to keep some of the traditional and cottage enterprises sustained is encouraged.

Underground water: The underground water level was assessed and found to be flacuate between rainy and dry seasons, and the variation to be also highly correlated to the level of water in the Mishumba River channel. Our conclusion is that the institution or change in hydrological regime for Mishumba Catchment to support the Kabuyanda ICRP project has to mimic the natural flow regime so as not to constrain the underground water sources and supply. Flooding or overbank releases will raise the water tables if not properly timed while over drawing in periods of low levels may result in drawing down the underground water resources. It is therefore the recommendation of the additional survey and study, that e-flows be done in a way that avoids excessive water supply or draw down so as to protect the underground water sources.

Environmental flow assessment and monitoring: The development of e-flow requirements for various species was based on species whose water requirements are dominated by others and would not require further analysis. This is based on the understanding that by satisfying the requirements of those that require more water, the requirements of other species will by ecological relation (shared habitats and effects) be realized. Therefore, flow requirements concentrated on the requirement for fish and for the papyrus for fauna and flora respectively. The e-flows were superimposed with the flow required for flushing or maintenance of the river reaches. It has already been indicated that the floods for the return period of 2 years and 5 years will be maintained for this purpose. In conclusion it was established that the overall discharge in the river reaches under consideration are quite small, therefore, there is very limited room for manipulation of flows to provide meaningful variations. From this perspective and the fact that the only investment using significant water in the catchment is the proposed irrigation scheme, only three (3) scenarios were studied. These include:

- Scenario one (1) represents the water required for the e-flows as deduced from the analysis of flows from sampling points 3, 6, 8, 14 and 15 including the maintenance of the high and low floods.
- Scenario two (2) comprises the proposed releases by the ESIA study report but with an addition of releasing low and high floods as in the previous scenario.
- Scenario three (3) is when the releases are increased in by twenty percent (20%) and forty percent (40%) of the Mean Annual Flow (MAF) during the dry and wet season respectively. It also includes the maintenance of the high and low floods.

Scenario 3 seemed the more appropriate scenario for the Mishumba Catchment based Kabuyanda ICRP project e-flow management.

Adjustments to the dam design and O&M plans: In the hydrolauic assessment it was established that Kabuyanda dam will impound and hold back a huge volume of water creating a reservoir. It was however concluded on analysis that the dam as designed and its operation and maintenance plan, are adequate and require no adjustments. As a point of emphasis however makes the following recommendations:

- The dam should undergo routine and scheduled inspections so as to enable discovery and attendance to any engineering and operational problem that may arise in a timely manner.
- Preventive maintenance programme for the components of Kabuyanda dam and its appurtenant structures be adopted and incorporated in the Kabuyanda ICRP project.

Cumulative Impacts: Kabuyanda ICRP project with its associated dam and irrigation infrastructure were found to have appropriately designed, and if operated as per design will have minimal and reversible cumulative impacts. It is a largely a positive project to both natural and the human environments. However key areas of concern leading to cumulative impacts are those regarding the impact of water reservoir and irrigation scheme on water quality, soil salinity, floral and faunal biodiversity, and underground water. To that effect the following conclusions are made concerning cumulative impact assessments carried out:

- Kabuyanda will transform the eixisting socioeconomic activities into organized irrigable crop production and associated downstream economic activities, and will have minimal or no resettlement of people as they ordinary do not reside in the catchment.
- Kabuyanda ICRP will involve land take for the dam and irrigation infrastructure as well as the irrigable area but this land is already under crop production and will not involve displacing peoples' other socioeconomic activities apart from a few cottage industries that in themselves related to agricultural production and products.
- The project is not in competition with other major socioeconomic or production activities as the site is majorly public land with a forest reserve based on planted trees with no prisitine vegetation.
- Does not significantly alter flows downstream apart from the period of daming and creation of the water reservoir.
- The resevior will allow for development a fishery to support the fishing livelihoods and perhaps act as a key conservation area for the limnophilic species and other aquatic bidoversity including water birds, terrestrial animals and aquatic plants.
- The project will have a moderate impact on habitat fragmentation and reduced connectivity of the rivers and habitats in the Mishumba catchment.
- There are no risks of opening and disturbing pristine areas, as the area is already highly disturbed and modified. However there will be additional cumulative impacts from clearing of vegetation for the dam and irrigation infrastructure construction as well establishment of a reservoir.

Key cumulative impacts were assessed and linked to issues of water quality, soil salinity, floral and faunal biodiversity, and underground water levels. However all the impacts if handled as per the project design are manageable and reversible.

Therefore, it is clear that save for the month of January, the recommended flows within the ESIA are sufficient to protect the fish and fauna. Therefore, the recommended water release schedule from the reservoir is $0.1 m^3/s$ during the dry season (lowest) and $0.24 m^3/s$ during the rainy season. For maintenance purposes, the floods with the return periods of 2 years and 5 years should be imposed on this flow.

The study also concludes that no hinderance in the environmental or social findings should stop the implementation of the Kabuyanda ICRP, hence recommending that the proposed mitigation/enhancement measures of identified impacts and several the proposed plans be implemented accordingly for the success of the project.

A planted forest that has replaced the natural forest in Mishumba catchment

1 INTRODUCTION

1.1 Background

The Government of Uganda (GoU) through the Ministry of Water and Environment (MoWE) with support from the World Bank is implementing the Irrigation for Climate Resilience Project (ICRP). The project development objectives are to provide farmers in the project areas with access to irrigation and other agricultural services, and to establish management arrangements for irrigation service delivery. The project is to be implemented by the Ministry of Water and Environment, with the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) as technical implementation partner.

1.2 Project components

The project comprises three components: Component 1 - Irrigation Services; Component 2 - Support services for agricultural production and value-chain development; Component 3 - Institutional Strengthening and Implementation Support.

1.2.1 Component 1. Irrigation Services

Access to irrigation is critical to allowing farmers cope with climate variability, to increase yield and intensification, and diversify towards higher value crops. Component 1 aims at providing farmers with irrigation water across various irrigation models, classified around the size of irrigation development as per the National Irrigation Policy, spanning across the country. Component 1 comprises three sub-components.

1.2.1.1 Sub-component 1.1 on Large and Medium-scale Irrigation

Large (>1,000ha) and Medium (100-1,000ha) scale irrigation schemes are established when an important water source is available in conjunction with a sizable irrigable area, offering the chance of developing economies of scale for marketing and value addition. As water might not be directly accessible across the whole irrigable area, and/or as the water source might be at a certain distance from the irrigable area and/or variable over the year, off-farm infrastructures (i.e., dams, diversion weirs, transmission pipes or canals, distribution networks) are required. The project will construct new irrigation schemes; support the development and strengthening of management model of irrigation schemes; and develop studies for future irrigation schemes. Kabuyanda Irrigation Scheme is being developed under Sub-Component 1.1.

1.2.1.2 Sub-component 1.2 on Small and Micro-Scale Irrigation.

Small (5-100ha) and micro (<5ha.) scale irrigation schemes are smaller in size, relying on a nearby water source mobilized with simple and relatively low-cost infrastructure, making it possible for farmers to take charge of irrigation development and management. The project will pilot public support for the construction of farmer-led small and micro scale irrigation schemes around the two new irrigation schemes and in areas close to Kampala characterized by high marketing potential, adopting a value chain approach.

1.2.1.3 Sub-component 1.3: Integrated Catchment management

It will develop and implement integrated catchment management interventions for the two new irrigation schemes, to improve the sustainability of the schemes, including the restoration /reforestation activity in Rwoho Central Forest Reserve (CFR).

1.2.2 Component 2: Support services for agricultural production and value-chain development

Component 2 aims to support farmers carrying out on-farm irrigation, accessing production and value addition knowledge and skills, and developing sustainable market access. It has two sub-components:

1.2.2.1 Sub-component 2.1: On-farm Production and Productivity

It will provide support to farmers and farmers' groups for production and productivity improvement at the farm level in the new irrigation schemes, in existing irrigation schemes, in small and micro irrigation schemes as well as in the area of the proposed future irrigation scheme.

1.2.2.2 Sub-component 2.2: Value Addition and Market Linkages

It will provide support to farmers' groups for value-chain development and strengthening and establishment of market linkages.

1.2.3 Component 3: Institutional Strengthening and Implementation Support

Component 3 will support institutional strengthening. Activities will include: (i) short-term studies on management models in irrigation, tariff structures, and prerequisites for financial sustainability; and (ii) capacity building, training and study tours.

1.3 Kabuyanda Irrigation Scheme

1.3.1 Kabuyanda Irrigation Scheme

One of the irrigation schemes to be constructed under component 1 is the Kabuyanda Irrigation scheme. It is between Isingiro and Ntungamo districts of South-Western Uganda (Figure 1-1) known as Uganda's "Cattle Corridor". This climatic region is part of a broad zone stretching diagonally from the south-west to the north-east of the country, and is characterized by high rainfall variability and dominated by pastoral rangelands.

The scheme is envisaged to develop 3,300 ha of irrigated agriculture extending southwards from the dam along the river banks. It consists of a 33m high zoned earth-fill dam, located on River Mishumba, with reservoir storage capacity of approximately 8.8Mm^3, draining an area of about 90 km^2 (Figure 1-3). The proposed project envisages to inundate 100 ha of Rwoho Central Forest Reserve (CFR). This CFR is a 9,000-ha plantation development forest that is largely degraded (modified habitat) with bare hilltops with sparse woody plant cover, and partially restored with non-indigenous species (*Pinus Caribaea*, *Pinus Oocarpa* and *Eucalyptus* sp.). The scheme will contribute to improvement of farm incomes, rural livelihoods, food security, climate resilience, sustainable natural resources management in Kabuyanda.

The proposed Kabuyanda dam on River Mishumba is designed for storage of stream flow, which will limit the water flow and may also possibly alter water quality in the downstream area of the dam. The estimated monthly runoff for R. Mishumba at the proposed dam location indicates a bi-modal variation with two peak flows in April and October of 0.8m^3/s and 0.89m^3/s, respectively, and a mean annual flow is 0.51m^3/s (Figure 1-2). Based on available data, the river sometimes dries up in the dry months of February, July, August and September. Downstream of the Kabuyanda dam, the tributaries Rweibara (Kasharira) join R. Mishumba while Chezho Rwemango and Kyabaganda join Mishumba about 5km. The Rweibara River contributes about 18% of the

0.61m³/s Average Annual Flow (AAF) of R. Mishumba at the confluence, and the combined flow of Rweibara and Rwemango Rivers is about 43.3% of the total flow to the confluence.

The Mishumba catchment is located between Isingiro and Ntungamo districts along the borders of three (3) sub-counties (Kabuyanda, Kikagati and Nyakitunda), one (1) Town Council (Kabuyanda) in Isingiro District and one (1) sub-county (Rukoni East) in Ntungamo District. It joins R. Chezho and then discharges into R. Kagera draining a total of 9 sub-catchments and their streams. The proposed dam and auxiliary works will be established at the borders of Katooma I, (Rwakakwenda Parish), Kyamazinga I & II (Kagara Parish) and Rwoho CFR (Rwoho Parish) along Mishumba stream (**Figure** 1-4).

Figure 1-1: Location of Kabuyanda Irrigation Scheme project area

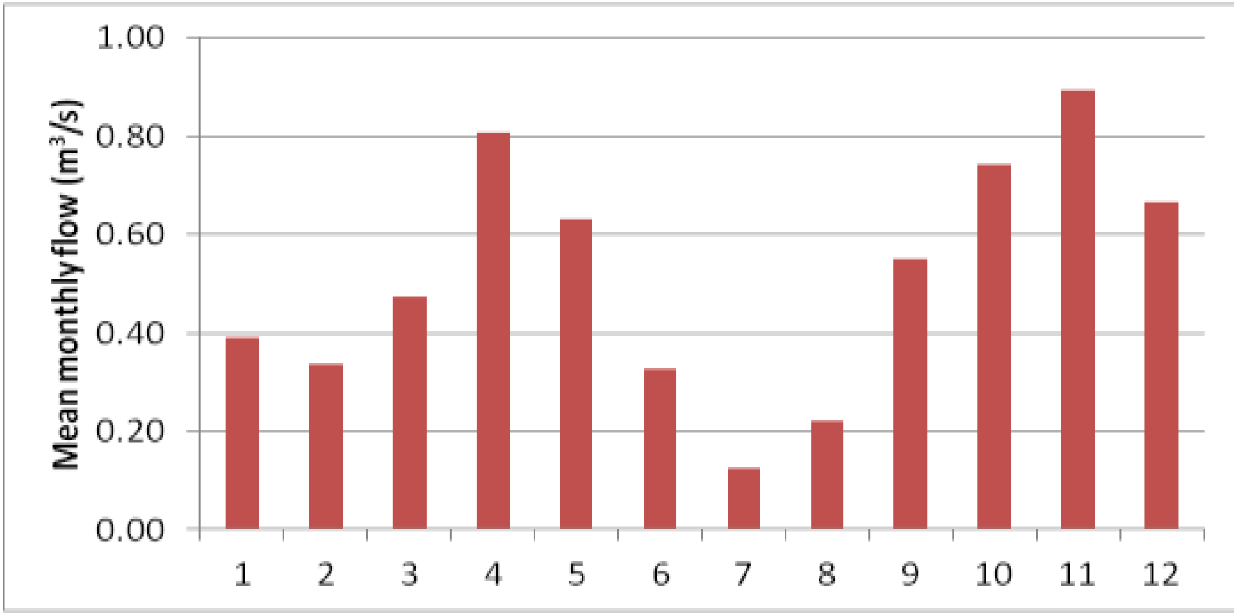


Figure 1-2: Mean Monthly flows of the River Mishumba

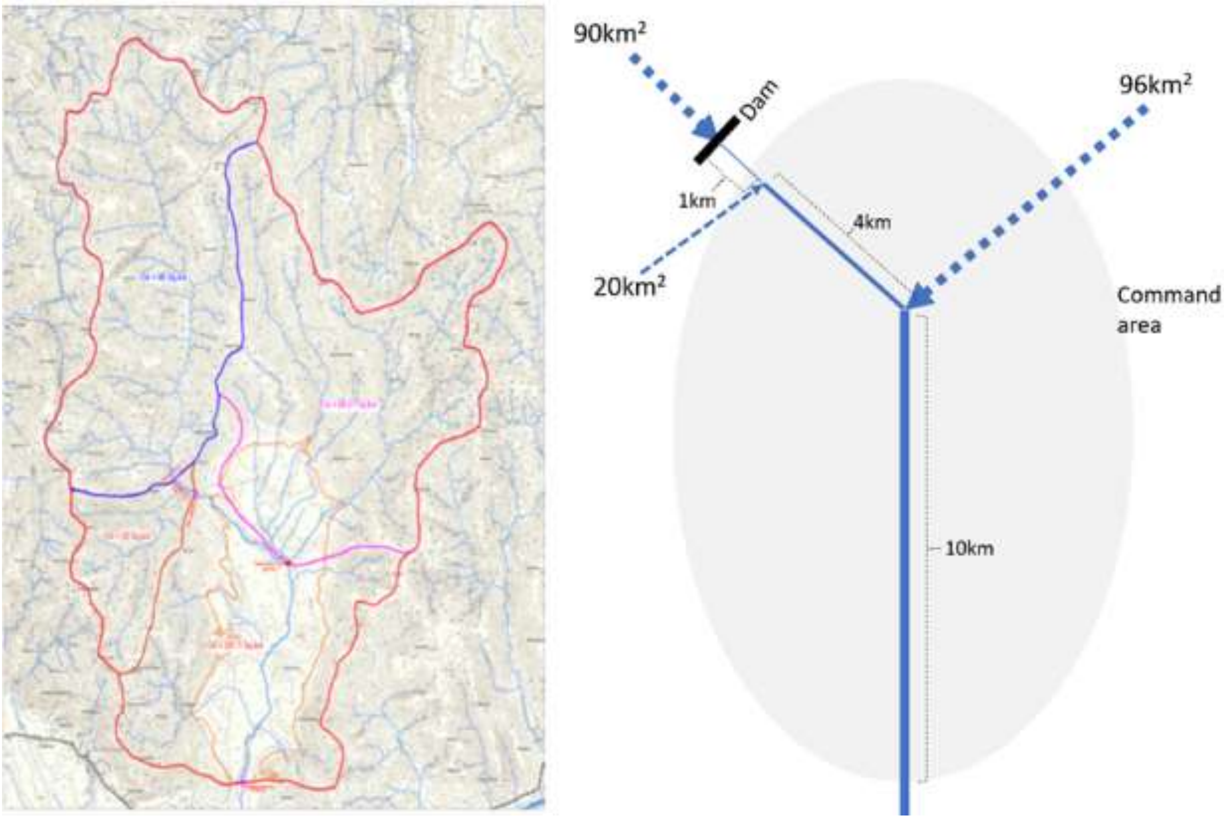


Figure 1-3: Confluence and flow of the tributaries of river Mishumba below the dam.

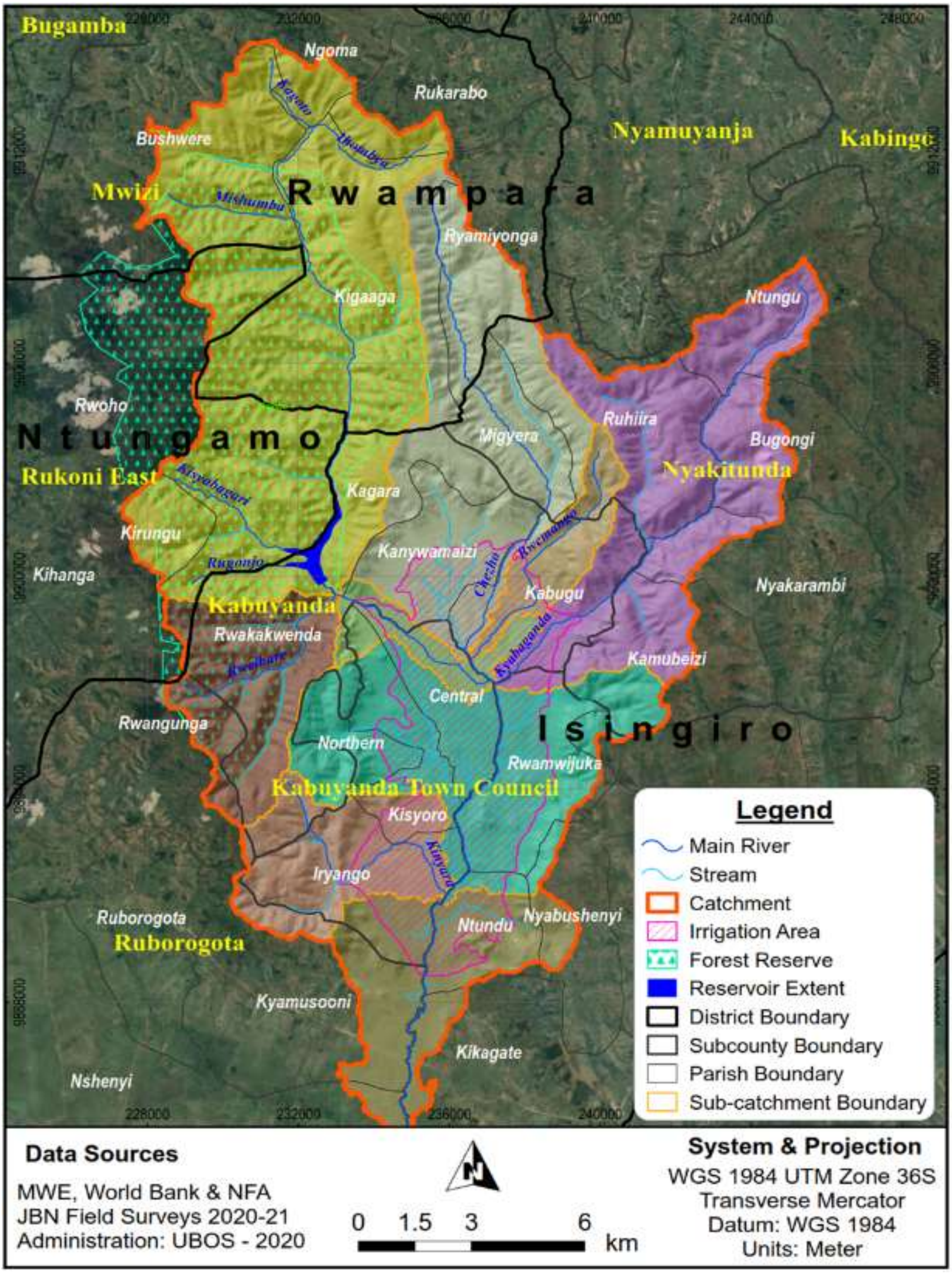


Figure 1-4: Administration of Kabuyanda ICRP area

Mid-section of River Mishumba immediately after the dam site (around gauging station) currently used for agricultural activities, forestry development, and other socioeconomic activities (towards the confluence of Rweibare)

1.4 The Assignment/study

1.4.1 Earlier study

In compliance with the National Environment Act 2019 as well as World Bank Environmental and Social Safeguards policies and standards, an Environmental and Social Impact Assessment (ESIA) was carried out to identify and assess the potential positive and negative environmental and social impacts of the project prior to, during and after infrastructure construction, and to eliminate/minimize negative impacts, while enhancing the positive impacts. An Environmental and Social Management Plan (ESMP) with the mitigation measures was also prepared.

The ESIA report (prepared by the MWE, dated September 2019, disclosed in-country on October 2, 2019, and at the World Bank website on October 3, 2019) noted that further assessment was needed. It was agreed that additional surveys and assessment will be undertaken by MWE during project implementation and prior to dam construction to confirm some of the initial findings described in the ESIA, in particular, with respect to biodiversity surveys (with more focus on fish), cumulative impacts, underground water and environmental flow assessment and monitoring. If needed, appropriate adjustments to dam design and/or operation will be introduced prior to dam construction in a manner satisfactory to the World Bank.

The project will alter the flow regime and limit the water quantity downstream the dam. Using a low-resolution hydrological methodology, the ESIA determines the environmental flow as 10% and 20% of Average Annual Flow (AAF) in the dry and wet seasons, respectively i.e., during the dry season was determined to $0.05 m^3/s$ and during the rainy season is $0.1 m^3/s$. The ESIA indicated that the proposed environmental flow requirement is adequate to satisfy the habitat and flow requirements of the few fish species that were recorded during the ESIA field work. It was proposed in the ESIA that the flows from downstream tributaries should contribute significantly to improve the downstream water flow for ecosystems demands.

1.4.2 Objectives

The objective of this consultancy is to assess the adequacy of the mitigation measures for project impacts downstream of the proposed dam included in the Kabuyanda Irrigation Scheme ESIA to ensure compliance with the GoU Environmental regulations and the World Bank Environmental and Social Safeguards Policies. The study developed a proposed Biodiversity and Ecological Flow Management Plan to mitigate the downstream ecological impacts of the planned Kabuyanda Dam, to monitor the impact and maintain or improve the ecological condition of the downstream areas. The assignment built and expanded on information collected under the ESIA.

This study is aimed at:

a. better defining the magnitude and extent of the impacts (environmental, social and ecological) of the planned operation of the Kabuyanda Dam, with an emphasis on key ecosystem services, aquatic and terrestrial biodiversity (such as fish, amphibians and macro-invertebrate species) and the downstream users;
b. proposing/assessing measures to mitigate, as much as technically and economically feasible, any detrimental impact on key ecosystem services, aquatic biodiversity (such as fish, macro-invertebrate and amphibians' species) and the downstream users as a result of Dam construction and operation; and

c. confirming whether the currently proposed Environmental Flow Requirement (EFR) in the ESIA of 10% and 20% of Average Annual Flow (AAF) in the dry and wet seasons, respectively is adequate to ensure no-net loss (NNL) in aquatic and riparian ecosystem as well as to ensure safety and wellbeing for downstream communities and users with the findings of this study. If the proposed EFR is not appropriate, then identification and recommendation will be made of an acceptable flow regime that will continue to allow the operation of the dam to supply the expected flow for the irrigation areas.

1.4.3 Scope

The scope of work shall include:

i. Data collection, review and study planning;
ii. Proposition of methodologies and conducting field surveys;
iii. Implementation of water flow and quality modelling;
iv. Assessment of risks and impacts, including assessment of the expected sedimentation, cumulative impact, and of the required environmental flow downstream the proposed Kabuyanda dam; and
v. Proposition of a Biodiversity and Ecological Flow Management Plan to improve conditions of downstream biodiversity and ensure proper actions implementation and monitoring.

1.5 Report Structure

Chapter 1. Introduction: gives a description of the project background, the project components, the scope of work, the project description and report structure.

Chapter 2. Policy, Legal and Institutional Framework: gives background of the Policy and institutional arrangements underwhich these Additional studies for Kabuyanda ICRP have been conducted including both the national and international legal framework requirements.

Chapter 3. Baseline Data Collection Methods: gives a detailed methodology on how the physical, biological and socio-economic baseline data collection was conduted. It further describes the project impact and risk assessmment including the cumulative impacts assessment methods.

Chapter 4. Environment and Social Baseline: describes the existing physical, biological and socio-economic baseline conditions.

Chapter 5. Environmental Flow Assessment (EFA) Methodology: decribes the process and methods used to get the recommended e-flows

Chapter 6. Environmental Flow Assessment (EFA): gives the details of the results, conclusdions and recommendations on the e-flows.

Chapter 7. Stakeholder Consultations and Concerns: provides an overview of consultation activities commenced in regard to additional studies and concerns raised.

Chapter 8. Impacts and Risk Assessment and Proposals For Mitigation Measures: gives a view of the potential environmental and social impacts according to their magnitude and presents the anticipated overall impacts of the Project. It as well points out the mitigation and enhancement measures.

Chapter 9. Biodiversity and Environmental Flow Management Plan: identifies the key biodiversity according to the conservation status, water flow requirement, and plan for ensuring such a environmental flows during the different phases of the project.

Chapter 10. Environmental Flow Requirement (EFR) Management System: provides an assessed (calculated) indication of the environmental flows required for the different purposes from sustaining the river to ensuring the river continues to provide the natural ecosystems services.

Chapter 11. Dam Operation and Maintenance Plan: outlines the operation and maintenance (O&M) requirements for the Kabuyanda dam and associated facilities to allow the users to define requirements in the context of their projects

Chapter 12. Monitoring Program: provides a review and assessment of the monitoring system and procedures for the Mishumba River, especially downstream the proposed dam, a gap analysis for improvements to the monitoring system and management and propose the team needed for effective monitoring plan, sites for installing flow monitoring stages, field equipment needed and local capacity needed for the implementing this monitoring plan, among others.

Chapter 13. Implementation Arrangements and Procedures: provides a detailed and costed plan for implementation of the mitigation activities set out in the Biodiversity and Environmental Flow Management Plan together with the responsible persons/agencies and location and period for implementation.

Chapter 14. Conclusions: provides concise details of the outcome of the additional surveys and assessment as to policies, strategies, plans, measures and activities needed to ensure that irrigation scheme development does not harm the socioeconomic, ecological, and abiotic functions of the river.

Mid-section of River Mishumba a highly ecologically disturbed area, currently used mainly for agricultural activities, forestry development, and other socioeconomic activities (dam site)

2 POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

Building on Chapter 3 of the ESIA, the present study expands on the review of the policy, legal and institutional framework for planning, implementation, operation and decommissioning of Kabuyanda irrigation scheme.

2.1 Uganda Policy Framework

2.1.1 The Uganda Vision 2040

Uganda Vision 2040 is anchored on the national shared vision which is attaining "A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years". However, it is clear, agriculture is the main stay of the Ugandan economy employing 65.6% (UBOS, 2017) of the labor force and contributing 21% to the GDP. Despite these, agricultural contribution to the GDP has been declining but remains very important to provide a basis for growth in other sectors. *For Uganda to shift from its current largely peasantry economy in most of the households to an industrialized and urban society, it must be propelled by multi-sectoral development interventions such as the project seeks to address electricity, water supply and agricultural production which therefore makes the project consistent with the GoU Vision 2040.*

2.1.2 Third National Development Plan (NDP III) 2020/21–2024/25

Amongst its programmes and in line with Uganda Vision 2040, NDP III aims to stop and reverse the degradation of water resources, environment, natural resources as well as the effects of climate change on economic growth and livelihood security. *According to the Plan, one of the key interventions identified that will spur growth is promotion of irrigation systems which is therefore consistent with the interventions lined in the proposed Kabuyanda irrigation scheme.*

2.1.3 The National Environment Management Policy, 1994

The key policy objectives include the enhancement of the health and quality of life of Ugandans and promotion of long-term, sustainable socio-economic development through sound environmental and natural resource management and use; and optimizing resource use and achieving a sustainable level of resource consumption. *On the planned Kabuyanda irrigation scheme, aspects of Environmental Assessment have been integrated into the project in line with the objective of ensuring sustainability in the project.*

2.1.4 National Water Policy, 1999

The policy objective of this instrument is to sustainably manage and develop the water resources of Uganda in a coordinated and integrated manner so as to secure/provide water of an acceptable quality for all social and economic needs.

2.1.5 MoWE Environment and Social Safeguards Policy 2018

This instrument provides a guide on how to effectively address the environmental and social issues for projects and programmes. Specifically, it aims to:

a. ensure integration of environmental and social concerns in all stages of project development and all levels including national, district and local levels, with full participation of the people as means of minimizing environmental and social impacts; identify key environmental and social issues or aspects that will affect or will be affected by the projects/programmes and ensuring that risks are screened against Adaptation Fund 15 principles;

b. specify appropriate roles and responsibilities, and outlining the necessary reporting procedures, for managing and monitoring environmental and social concerns including compliance; and
c. establish institutional capacity building requirements to successfully implement the ESS, with particular focus on monitoring framework for its implementation and compliance.

2.1.6 Uganda National Climate Change Policy-UNCCP, 2012

The UNCCP aims to ensure a harmonized and coordinated approach towards a climate resilient and low-carbon development path for sustainable development in Uganda. The overarching objective of the policy is to ensure that all stakeholders address climate change impacts and their causes through appropriate measures, while promoting sustainable development and a green economy. *It focuses on adaptation and mitigation actions across key sectors such as agriculture, environment, land use and land use change among others.*

2.1.7 The National Agriculture Policy, 2013

The policy outlines six (6) principles to guide the sector, which entail pursuance of a private sector led and market-oriented economy; zoning to promote the most suitable commodities per area and provision of government support for such commodities to enhance commercialization, development of value chains for these commodities and food security. The National Agricultural Policy provides the framework within which the sector expects to contribute towards achieving these targets. *To have a sustained positive impact on overall economic growth, poverty reduction and food security, the agricultural sector must grow at a rate of 5.6%.*

2.1.8 The National Fisheries and Aquaculture Policy, 2018

The fisheries and aquaculture policy seeks to highlight the contribution of fish as a commodity to agriculture sector. It recognizes the need for boosting production from both capture fisheries and aquaculture, and also puts emphasis on the ability of future generations to produce and ensure adequate supply of fish to Uganda. *It focuses and points to need for conservation of fisheries resources and identifies research as central in guiding fisheries and aquaculture management in Uganda.*

2.1.9 The National Land Use Policy, 2013

The overall policy goal is to achieve sustainable and equitable socio-economic development through optimal land management and utilization in Uganda.

2.1.10 The Occupational Health and Safety Policy

This policy will be especially relevant for Occupational Health and Safety (OHS) of the Project and associated irrigation dam construction crews and subsequently, maintenance personnel. *The policy will also have relevance in mitigation measures that protect the public from adverse health and safety impacts as a result of irrigation dam project construction and subsequent operation and maintenance activities.*

2.1.11 National Employment Policy 2011

It emphasizes adherence to guiding principles that include: Consistency with overall National Planning Framework; Social Dialogue; Private Sector-led Growth and Employment Generation; Employment creation as a key indicator for economic performance; Education, Skills

Development and Training; Compliance with labour standards; Affirmative action; Community participation; Addressing HIV/AIDS at the Work Place; Promotion of Gender Equality for all in employment. The same policy also prioritizes key action areas namely: employment-intensive growth; labour market information; labour productivity, skills development and training; promotion of agriculture and rural employment; improving informal sector, micro and small-scale enterprises; improving labour administration and labour standards; externalization of labour; employment of vulnerable groups and promotion of gender equality; promotion of youth employment.

2.1.12 Uganda Gender Policy 2017

The gender policy guides on aspects of addressing gender imbalances as well as a guide to all development practitioners. It guides all levels of planning, resource allocation and implementation of development programmes with a gender perspective. It gives a clear mandate to the MDAs to mainstream gender in all sectors. It offers overall indicators which can be used to assess the extent to which the purpose of the policy is achieved. *The policy also states four priority interventions and action areas namely livelihoods, rights, governance and macro-economic management.*

2.1.13 National Social Protection Policy 2015

The policy guides on how to promote effective social protection interventions as an integral part of the Uganda Vision 2040. The policy focuses on two pillars namely: social security and social care and support services. It emphasizes need to (a) expand provision of direct income support to vulnerable individuals and households and (b) to enhance provision of holistic social care and support services to individuals and families at the risk of social exclusion, neglect or abuse.

2.1.14 National OVC Policy 2004

It provides a framework for the enjoyment of rights and fulfillment of responsibilities of the orphans and other vulnerable children. The policy further ensures that (a) legal, policy, and institutional framework for child protection are developed and strengthened at all levels; (b) ensure that orphans, vulnerable children and their families access basic essential services package; (c) ensure that resources for interventions that benefit orphans and other vulnerable children are mobilized and efficiently utilized; (d) ensure that the capacity of duty-bearers for orphans and other vulnerable children to provide essential services is enhanced. It also ensures to prevent violation of the rights of children in relation to serious risks and hazards. It ensures improved child-friendly legal protection systems, procedures and facilities; strengthening family and community mechanisms that prevent the bereaved from inheriting property; and sensitizing communities about the rights and responsibilities of children. the NOP 2004 defines the target groups of OVC that include: Orphans and orphan households; Children affected by armed conflict; Children abused or neglected; Children in conflict with the law; Children affected by HIV/AIDS or other diseases; Children in need of alternative family care; Children affected by disability; Children in 'hard-to-reach' areas; Children living under the worst forms of labour; Children living on the streets.

2.1.15 The National Child Labour Policy, 2006

It provides a framework to mobilize all actors to take action to eliminate the practice. It explains the socio-economic context of child labour, the nature, extent and magnitude, the causes, consequences and effects.

2.1.16 Other relevant National Policies

There are relevant policies that include the following: National HIV/AIDS Policy; National Policy on Elimination of Gender Based Violence 2016; Social Development Policy; Uganda National Climate Change Communication Strategy 2016; Local Economic Development Policy 2014; National Local Government Capacity Building Policy 2013.

2.2 National Strategic Planning Framework

2.2.1 National Development Plan III

The NDP III provides a guiding framework on the development objectives and targets for Uganda. The NDP III prioritizes the development of agricultural production and productivity; construction of irrigation schemes (mini-micro; mechanized irrigation schemes; mega-irrigation) and multi-purpose surface storage facilities/ reservoirs; climate change adaptation and mitigation; environment and natural resource management in the NDP III period.

2.2.2 District Development Plans II and III

The respective district development plans of Isingiro, Ntungamo and Mbarara do prioritize environment management and natural resource management in relation to catchment protection among them Mishumba catchment.

2.2.3 Lower Local Government Development Plans

The respective lower local governments (LLGs) have development plans that are consistent with DDPs. They prioritize agricultural production, extension services and environmental protection at sub county, parish and village level. However, they have limited resources to implement the actions. These LLGs include Sub-Counties of Kikagate, Kabuyanda, Ruborogota, Nyakitunda and Kabuyanda Town Council.

2.2.4 Environment and Natural Resources Sub-Sector Gender Mainstreaming Strategy 2016-2021 (June 2016)

It offers a guide on how to attain gender equity and equality in delivery of environment & Natural Resources related services. It focuses on; a) improving access and control; b) promote equal opportunities for participation by men, women and vulnerable groups in planning and sustainable management of ENR at all levels; c) promote equitable sharing of environment and natural resource products and services; d) build and strengthen capacity for gender mainstreaming in Environment & Natural Resources sub-sector at all levels; e) integrate gender in ENR policies, legislation, planning, budgeting, implementation, monitoring and evaluation.

2.2.5 Water and Sanitation Gender Strategy 2018-2022 (WSGS III)

It guides on empowering men, women, boys, girls and vulnerable groups through ensuring equity in access to and control of resources in the water and sanitation sub-sector, contributing to poverty reduction. It aims at; a) Gender integration in policy, guidelines, plans and budgets; b) (ii) Capacity enhancement and promotion of a gender-sensitive work environment; c) Economic empowerment through equitable access to and control of water resources, supply, sanitation and hygiene; d) Gender documentation, reporting and monitoring; e) Gender coordination, partnership and networking.

2.2.6 National Irrigation Master Plan for Uganda (2010-2035)

The Overall Objective of irrigation development in Uganda is: “Poverty Alleviation and Economic Growth as a result of the sustainable realization of the country’s irrigation potential mitigating the effects of climate change and contributing to the transformation of Uganda society from a peasant to a modern and prosperous country”. *These objectives of the Irrigation Master Plan are in line with the aspirations of Kabuyanda irrigation scheme.*

2.2.7 Operation Wealth Creation

The GoU acknowledge that agriculture has, for a long time, been a core sector of the economy providing the basis for growth in other sectors and significantly contributing to GDP and employment. Under Operation Wealth Creation (OWC), it is the objective of GoU that national policies, interventions and programmes aim at transforming agriculture from subsistence to commercial agriculture with a target of raising household incomes to a minimum UGX20 million per household per year.

2.3 Uganda Legal Framework

2.3.1 Constitution of the Republic of Uganda, 1995

The right to a clean and healthy environment is enshrined in Article 39 of the Constitution of Uganda, 1995. *To ensure that the implementation of Kabuyanda Irrigation Project complies with the Constitutional obligations on environmental sustainability, this Biodiversity and Ecological Flow Management Plan has been prepared which amongst others, outlines anticipated environmental and social negative impacts of the project and outlines measures for addressing such concerns through its Environmental Flow Management Plan (EFMP).*

2.3.2 The National Environment Act, N°.5 of 2019

Part X of the Act in its Section 110 provides for preparation of environmental and social assessments whose purpose is to evaluate environmental and social impacts, risks or other concerns of a given project or activity, taking into account the environmental principles set out in its Section 5(2). *In this case, changes in land use with a construction of a dam envisaged under the project require ESIA to be conducted before project implementation.*

2.3.3 Water Act, 1995

This Act seeks to promote provision of orderly development and use of water resources for purposes other than domestic use, such as the watering of stock, irrigation and agriculture, industrial, commercial and mining uses, the generation of hydroelectric or geothermal energy, navigation, fishing, preservation of flora and fauna and recreation in ways which minimize harmful effects to the environment. The basic foundation of the Act’s provision is the reconciliation between protecting the environment and ensuring the availability to the population of water of sufficient quality and quantity. The project will largely use waters from the river system whose usage has a transboundary perspective. Therefore, to guarantee both equitable and optimal usage of the water, feasibility studies were undertaken to establish permissible abstraction levels which will ensure the project will be compliant with the relevant provisions in the Act.

2.3.4 Fish Act, 2002 and Fisheries and Aquaculture Bill 2019

The Fish Act seeks to implement the existing policy of producing enough fish for the current population needs without compromising the fish needs for future populations. With new fisheries and aquaculture policy, a fisheries and aquaculture bill were drafted, passed by Cabinet and is under consideration by the National Assembly. The bill seeks to improve management and conservation of wild fisheries resources, while promoting and supporting responsible and equitable fishing and fish production activities including aquaculture production. *Key for the bill is the emphasis on conservation and protection of key ecological and economic fisheries resources and biodiversity including associated habitats.*

2.3.5 National Forestry and Tree Planting Act, 2003

The National Forestry and Tree Planting Act 2003 is the main law that regulates and controls forest management in Uganda. Section 38 of this Act provides for an environment impact assessment to be undertaken for an activity that may have significant impact on a forest.

2.3.6 The Local Governments Act (Cap 243)

The Act creates a decentralized system of government based on the district as the main unit of administration. The Act allocates responsibility for service delivery of a number of functions to local government councils (districts, cities, municipalities or town councils) and to lower local government councils (sub-counties / divisions). *The design of Kabuyanda irrigation scheme is geared towards uplifting the livelihoods of the households, as such, its implementation is consistent with Isingiro District Development Plans and it is to be undertaken with technical guidance of the District technical staff supported by the political wing of the district.*

2.3.7 The Land Act, Cap 227

The Land Act vests land ownership in Uganda in the hands of Ugandans and that, whoever owns or occupies land shall manage and utilize the land in accordance with the Forest Act, Mining Act, National Environment Act, the Water Act, the Uganda Wildlife Act and any other law [section 43, Land Act]. *The Kabuyanda Irrigation Project has integrated Environmental Assessments into its feasibility study and design to ensure that, its implementation will be in compliance with the Act provisions.*

2.3.8 The Public Health Act, 1964

Section 7 of the Act provides local authorities with administrative powers to take all lawful, necessary and reasonable practical measures for preventing the occurrence of, or for dealing with any outbreak or prevalence of any infectious, communicable or preventable disease to safeguard and promote public health; and to exercise the powers and perform the duties in respect of public health conferred or imposed by this Act or other relevant laws. Public health and hygiene are key in the project with regard to management of a range of waste including agro-chemicals based types and the general health of the project and the communities in the vicinity.

2.3.9 The Children Act 1996

It provides a legal and institutional framework for child care and protection. It accords specific rights for children with disabilities to ensure equal opportunities, and obliges the parents or any person in custody over the child to maintain the child ensuring education, guidance, immunization, adequate diet, shelter and medical care.

2.3.10 Children Act (amended) 2016

It enhances the protection of Children; to strengthen the provision for guardianship of Children; to strengthen the conditions for inter-country adoption; to prohibit corporal punishments. It also establishes the National Children Authority (NCA).

2.3.11 Domestic Violence Act 2010

The act provides protection and relief of victims of domestic violence; to provide for the punishment of perpetrators of domestic violence; to provide for the procedure and guidelines to be followed by the court in relation to the protection and compensation of victims of domestic violence; to provide for the jurisdiction of court; to provide for the enforcement of orders made by the court; to empower the family and children court to handle cases of domestic violence and for related matters.

2.3.12 The Employment Act, 2006

It forbids contracts with persons under the age of eighteen, and the employment of children under the age of twelve years, except from light work defined by the Minister. It offers legal guidance on employment conditions and relationships such as contracts (verbal and written), prohibition of forced labour and child labour; discrimination in employment; labour management procedures, among others.

2.3.13 The Workers Compensation Act, 2000

The act provides for compensation to workers for injuries suffered and scheduled diseases incurred in the course of their employment.

2.3.14 National (Environmental and Social Assessment Regulations), 2000

The ESA Regulations gives outline in the conduct of an ESIA study, thus paving the way for an enabling environment for it to use as a tool for environmental protection. The Regulation provides for three levels of ESIA which in this case, a full ESIA has been prepared based on the nature and magnitude of the project.

2.3.15 The National Environment (Audit) Regulations, 2006

The Regulations reinforce the requirement to undertake Self-Environmental Audits as contained in the EIA Regulations. Normally, under approval conditions of NEMA, it is a requirement to undertake Audits for projects which comply with the EIA requirement as part of the conditions of EIA approval. With respect to this project will be the need for periodic Environmental Audit after 12-36 months of the project implementation in line with the Audit regulations.

2.3.16 The National Environment (Waste Management) Regulations, 1999

The National Environment (Waste Management) Regulations, 1999 apply to all categories of hazardous and non-hazardous waste and to the storage and disposal of hazardous waste and its movement into and out of Uganda. The regulations promote cleaner production methods and require a facility to minimize waste generation by eliminating use of toxic raw materials; reducing toxic emissions and wastes; and recovering and reuse of waste wherever possible. The Regulations oblige the Developer to put in place measures for proper management of waste.

2.3.17 National Environment (Wetlands, River Banks and Lake Shores Management) Regulations, No. 3/2000

The National Environment (Wetlands, River Banks and Lake Shores Management) Regulations, No. 3/2000 section 34 requires a developer to conduct Environmental impact assessment to a project which may have a significant impact on a wetland, river bank or lake shore. The project is aimed at protecting the environment and hence observes the protection zone. *In case the design and construction of project facilities will be within the protected zone then the permit will be requested from the National Environment Management Authority. However, for this project the dam site is inside the CFR, for which National Forestry's clearance will suffice, in accordance with the National Forestry and Tree Planting Act, 2003.*

2.3.18 The Water Abstraction Regulations, 1998

The Water Abstraction Regulation in Section 18 provides for the establishment of a controlled mechanism through issuance of permits to regulate the amount of water abstracted by users. The Regulation requires that a water abstraction permit either for ground or surface water abstraction are pre-requisites for motorized and/or abstracting of quantities above 400m^3/day for persons involved in construction (damming, diverting surface water). *Irrigation, hydropower and associated considerations will require abstraction permits from DWRM after detailed feasibility is conducted.*

2.3.19 Environmental Guidelines to Local Governments for Strengthening Compliance with Safeguards Requirements in Development Projects 2020

These provide a guiding framework to local governments on how to effectively address the environmental, climate change and social issues for all projects and programs (government or donor-funded) to minimize negative impacts on the environment and beneficiary communities during projects/programs implementation. Its objectives are to:

- ensure integration of environmental and climate change concerns in all stages of project development and at all levels including City, District or Municipal and Lower Local governments levels, with the full participation of the people as means of minimizing environmental and social risks and impacts;
- specify appropriate roles and responsibilities, and outlining the necessary reporting procedures, for managing and monitoring environmental concerns including compliance to the law for environment and climate change aspects in different Local Governments.

2.3.20 The Fish (Fishing) Rules, 2010 (Amended, 2020)

The regulation is a set of rules meant to guide fishing in all waters of Uganda. *Key in this set of rules is prohibition against destructive fishing, regulation of where fish is landed and traded, and ensuring safety of fisherfolk.*

2.4 Uganda Institutional Framework

2.4.1 Ministry of Water and Environment, (M0WE)

The Ministry has the national mandate to ensure provision of quality water and environmental protection services in the country and is charged with the management and sustainable utilization of water and environment resources for the betterment of the population of Uganda. With respect to this project, MoWE has dedicated a Project Coordination Office (PCO) headed by a National Project Coordinator (NPC), for the overall coordination of this project. The NPC is to be guided by a National Project Steering Committee (NPSC) chaired by the Permanent Secretary MWE.

2.4.2 MoWE Victoria Water Zone in South Western Region Mbarara

The Ministry has set up in its structure, four zonal regional water management zones which are charged with the sustainable use of its water resources and catchment areas, improving the catchment areas and setting up catchment management organizations, supporting sensitization of communities on sustainable management of water resources in the zones. The Zone Supports sustainable management of water resources, with a focus on benefiting the people within the catchment, economically and socially. The zone plays a role in catchment based integrated water resources management i.e., supporting the preparation of Catchment Management Plans (CMPs) and establishment of Catchment Management Organizations (CMOs) to promote coordination and collaboration among the various stakeholders. The Management Zone will be key in Sustainable Land Management (SLM) aspects in the project so that, the catchment is protected from degradation thus ensuring proper use and management of the river water.

2.4.3 Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)

Is mandated amongst others and specific relevance to this project, to support the development of infrastructure and use of water for agricultural production and to develop and promote collaborative mechanisms nationally, regionally and internationally on issues pertaining to the sector. With respect to irrigation aspects in Kabuyanda Irrigation, project issues of on-farm works will be the responsibility of the Ministry especially provision of technical assistance in the design and construction of on-farm irrigation systems. MAAIF will further be responsible for the provision of extension services and advice to farmers on irrigation systems and promotion of efficient water use. In addition, the Ministry will provide support in the supervision and monitoring of water use and management.

2.5 Statutory Agencies

2.5.1 The National Environment Management Authority-NEMA

NEMA is the principal agency for the management of the environment and coordinates, monitors and supervises all activities in the field of the environment in Uganda. Its Environmental Monitoring and Compliance division is responsible for the review and approval of ESIAs, post-implementation audits and monitoring of approved projects. NEMA will be responsible for reviewing the ESIA report and subsequent decision making in addition to monitoring of environmental compliance during project implementation and operation through the designated regional or district offices.

2.5.2 The Uganda Land Commission

The Uganda Land Commission (ULC), is an autonomous body that holds and manages any land in Uganda vested in or acquired by the Government of Uganda. The Uganda Land Commission holds and manages land in Uganda vested in or acquired by Government of Uganda. Once the land for common infrastructure facilities (dams, reservoirs, roads and offices amongst others) in the project is acquired, it will be vested with the ULC.

2.5.3 Isingiro Local Government

Through its bottom-up participatory planning process, the district prepares a 5-Year District Development Plan as a framework for its delivery of mandated services to its population. The District Development Plan is the single point for all development interventions and initiatives in the district. In view of this, to the extent possible, Kabuyanda irrigation scheme interventions are to be linked to the districts DDP in Uganda.

2.5.4 Local Governments (Isingiro, Mbarara & Ntungamo DLGs)

Through its bottom-up participatory planning process, the district prepares a 5-Year District Development Plan as a framework for its delivery of mandated services to its population. The District Development Plan is the single reference point for all development interventions and initiatives in the district. In view of this, to the extent possible, Kabuyanda irrigation scheme interventions are to be linked to the districts DDP in Uganda, as well respective developments plan of lower LGs (sub counties, town councils, parishes / wards, cells / villages).

2.5.5 Non-State Actors

There are non-state actors that are actively involved in promotion of agricultural production, water for production community development, environmental protection and natural resource management. These non-state actors include a) civil society organizations (CSOs) such as NGOs, CBOs, FBOs, activists, pressure groups, advocacy committees; b) media (TV, radio, print, online, social media); religious institutions among others.

2.6 International Conventions and Agreements to which Uganda is signatory

2.6.1 Convention on Protection and Use of Transboundary Watercourses and International Lakes 1992

Under Article 1, The Parties shall take all appropriate measures to prevent, control and reduce any transboundary impact on the watercourses and the Parties are obliged to: prevent, control and reduce pollution of waters causing or likely to cause transboundary impact; ensure that transboundary waters are used with the aim of ecologically sound and rational water management, conservation of water resources and environmental protection; ensure that transboundary waters are used in a reasonable and equitable way, taking into particular account their transboundary character, in the case of activities which cause or are likely to cause transboundary impact; ensure conservation and, where necessary, restoration of ecosystems; and Measures for the prevention, control and reduction of water pollution shall be taken, where possible, at source. In the implementation of the project, modalities for amicable involvement of the two States in the implementation of the project has been part of the ESIA process through joint workshops to discuss the deliverables as well as issues of design as in the feasibility study which ensured that, there is equitable availability of water for various users both up and downstream of the river.

2.6.2 Guidelines of the World Commission of Dams (WCD)

WCD was created by World Bank and IUCN in May 1998 in response to growing opposition to large dams. International Commission on Large Dams (ICOLD) defines a large dam as one with a height of 15 m or more from the foundation. If dams are between 5-15 m high and have a reservoir of more than 3 million cubic meters, they are also classified as large dams. *It is noted that, Kabuyanda Irrigation Scheme is a category A since, it will have a large dam and as such WCD, the WCD recommendations will be applicable in its implementation.*

2.6.3 Convention of Biological Diversity

The Convention on Biological Diversity (CBD), known informally as the Biodiversity Convention, is a multilateral treaty. The Convention has three main goals namely conservation of biological diversity (or biodiversity); sustainable use of its components; and fair and equitable sharing of benefits arising from genetic resources. In other words, its objective is to develop national strategies for the conservation and sustainable use of biological diversity. It is often seen as the key treaty document regarding sustainable development. Uganda is a signatory to this convention and when the ESIA is being undertaken for this project, there should be recommendations that the proponent will abide by in line with the convention requirements to carry out assessments for all projects likely to have significant adverse effects on biodiversity. *This project is in line with the spirit of the convention since it has integrated biodiversity in water resource planning as the environment has been considered a legitimate user of water. Thus, the project shall ensure that the volume of water abstracted leaves enough water for the existent ecosystems.*

2.6.4 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Uganda is a signatory to this treaty, which outlines the role of all parties to protect endangered plants and animals. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild, and it accords varying degrees of protection to more than 35,000 species of animals and plants. No animals will be traded in the course of the planned project implementation and all its phases. The workers will be briefed on risks of engaging in animal hunting and trade.

2.6.5 United Nations Convention to Combat Desertification (UNCCD)

Convention to combat desertification and mitigate the effects of drought through national action programs that incorporate long-term strategies supported by international cooperation and partnership arrangements. *The Kabuyanda irrigation scheme has direct impacts on the Rwoho CFR. As such, as provided by law, the CFR area taken up by the project will be subject to equivalent compensation which will address lost forest as well as lost climate change mitigation that would arise from the project.*

2.6.6 Convention on the Conservation of Migratory Species of Wild Animals

The convention aims to conserve terrestrial, aquatic and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. The project will in its implementation be cognizant of migratory aspects of wildlife some through its areas of implementation and such wildlife will not be hunted.

2.6.7 Ramsar Convention on Wetlands

Is an international treaty for the conservation and sustainable utilization of wetlands, to stem the progressive encroachment on and loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value. The implementation of the proposed project is to take into account, the need for sustainable use of wetlands. The project will ensure that the wetland areas within the project area are conserved.

2.6.8 Strategic Approach to International Chemicals Management (SAICM)

Uganda UNEP/UNDP Partnership initiative for the implementation of SAICM is intended to assist the Government, through the National Environment Management Authority (NEMA), to take up the strategic priorities of SAICM Quick Start Program (SQSP), namely: develop and strength national chemicals management institutions, plans, programs and activities to implement the Strategic Approach for chemicals management, building upon work conducted to implement international chemicals-related initiatives; and undertake analysis, interagency coordination, and public participation activities directed at enabling the implementation of Strategic Approach by integrating the sound management of chemicals in national development priorities and strategies. Provisions of SAICM will be considered in the project by developing PMP for the project to ensure information, capacity building and general safe handling of agrochemicals.

2.6.9 International Covenant on Economic, Social and Cultural Rights (ICESCR)

The ICESCR gives explicit guidance on the implementation of the Covenant in the context of indigenous peoples

2.7 World Bank Environmental and Social Policy Frameworks

The World Bank by policy requires that every development activity is assessed for compliance to the borrower's and the Bank's set environmental and social safeguards Operational Policies (OPs) and regulatory framework. These E&S Safeguards Policies standards are outlined below;

Safeguard Policies	Triggered?		Remarks
OP 4.01 Environmental Assessment	**Yes**		The project is about constructing *Irrigation Infrastructure Development* which are structures above 10m high which is considered Large Dam, entailing major infrastructure works necessitating detailed ESIA and ESMP to be developed. Typically, the irrigation infrastructure works of Kabuyanda scheme will include construction of a 33 m high dam and associated reservoir, and establishment of an irrigation system in the command area of about 3,300ha. This will lead to large scale environmental and social impacts, affecting a wider area, and resulting in significant health and safety impacts diuirng construction phase, including labor influx and associated socio-economic aspects. Kabuyanda dam will inundate 100ha of Rowho Central Forest Reserve. As such, the project is assigned E&S Category A. In addition, the project will have other auxiliary components which will equally necessitate to be subject to independent ESIAs. The additional Surveys and Assessments for Kabuyanda Irrigation scheme have been undertaken leading to development of "Biodiversity and

			Ecological Flow Management Plan". This assessment supplements the original project ESIA undertaken in 2019 and has assessed likely environmental and social impacts, including development of ESMP for addressing negative impacts during project implementation. The additional studies included extensive stakeholder consultations, which will continue during project implementation. The assessment demonstrates how the project will comply with all applicable rules and guidelines, including: (i) all triggered World Bank Safeguard Policies; (ii) relevant World Bank Group Environmental, Health and Safety Guidelines; and (iii) Uganda National Environment Management Authority's (NEMA) Guidelines for Environmental Impact Assessment and National Environment Act 2019.
OP 4.04 Natural Habitats	Yes		The project is designed to minimize any adverse impacts on natural habitats as a result of irrigation development while strengthening the management of vulnerable catchment areas. The project implementation will involve use of some ecosystem areas such wetlands and forests (parts of Rwoho CFR) thereby triggering this safeguards policy. The reservoir for Kabuyanda irrigation scheme will occupy 100 ha (1.1%) of Rwoho CFR, which is considered a modified non-critical habitat, largely degraded and under plantation production using exotic tree species of eucalyptus and pine. The project will mitigate this impact by undertaking restoration/reforestation on 500 ha in Rwoho CFR, under the technical leadership of National Forestry Authority (NFA). In consultation with the National Forestry Authority, the ESIA has identified an area of 1000 ha of degraded land within Rwoho Central Forest Reserve to be replanted under the project with indigenous tree species to mitigate and compensate for the loss of 100 ha reservoir area in the forest, through enrichment planting to promote natural regeneration. 10ha in the 1000ha covers a wetland area to compensate for the 5.6ha of the wetland to be taken up in the reservoir area. The project also has a catchment management sub-component through which natural habitats shall be conserved and/or managed and utilized sustainably, through the catchment management plans, while involving the host communities. Under this, more conservation measures shall be undertaken in and around the project catchment area. It is, therefore, expected that no critical habitats will be significantly converted under this project, rather environmental conservation will be encouraged at the project sites. In addition, a Biodiversity Action Plan has been developed (Appendix 12).
OP 4.09 Pest Management	Yes		The Kabuyanda Irrigation project is aimed at increasing agricultural production amidst evidently variable climatic conditions as such, there will likely be problems of pests and diseases which will necessitate use of agro-chemicals which

			triggers this safeguards policy and has necessitated inclusion of a generic Pest Management Plan prepared as part of the ESMF, which was disclosed.
OP 4.10 Indigenous People		No	This safeguard is not triggered and therefore not considered under the Kabuyanda Irrigation scheme since there are no Indigenous people in the project area.
OP 4.11 Physical Cultural Resources	Yes		This safeguard is triggered because project activities will involve excavations which is likely to occasion accidental discoveries of PCRs. Therefore, a Chance Finds Procedure has been prepared as part of project ESIA dated September 2019.
OP 4.12 Involuntary Resettlement	Yes		The project works involving construction of common project infrastructures such as roads, dam sites, irrigation channels irrigation infrastructures which will likely cause land-take thereby triggering this safeguards policy. A separate Resettlement Action Plan has been prepared as part of safeguards study in this project.
OP 7.50 Projects on International waters	Yes		The Kabuyanda Scheme located on parts of the broader R. Kagera system is a transboundary river feeding to the Lake Victoria and the R. Nile system which triggers this safeguards policy. Riparian notification has been undertaken by GoU through the Nile Basin Initiative on Nov. 13, 2018.
OP 4.36 Forests	Yes		The project activities will take up some areas of Rwoho CFR which therefore triggers this safeguards policy instrument. The reservoir for Kabuyanda irrigation scheme will occupy 100 ha (1.1%) of Rwoho CFR, which is considered a modified non-critical habitat, largely degraded and under production using exotic tree species of eucalyptus and pine. The project will mitigate this impact by undertaking restoration/reforestation activities on 500 ha in Rwoho CFR, under the technical leadership of National Forestry Authority (NFA). The project also has a catchment management sub-component through which natural habitats shall be conserved and/or managed and utilized sustainably, through the catchment management plans, while involving the host communities. Under this, more conservation measures shall be undertaken in and around the project catchment area.
OP 4.37 Safety of Dams	Yes		The policy is triggered because the project will finance construction of dams. In compliance with the triggered OP 4.37, a Dam Safety Panel has been constituted to provide the necessary oversight. The dam for Kabuyanda scheme, which is 33 m high, is designed by qualified engineers and dam safety measures will be incorporated in dam operations. Dam Safety Management and Emergency Plans have been prepared for Kabuyanda scheme alongside the ESIA (September 2019) to provide guidance on management of any dam failure that could result in loss of lives in the event of a failure. The following four dam safety reports were prepared, as required by OP4.37 were : 1. Plan for Construction Supervision and Quality Assurance;

			2. Instrumentation Plan; 3. Operation and Maintenance Plan; and 4. Emergency Preparedness Plan The above plans were reviewed by the Bank's dam safety specialist and found satisfactory in 2019.
OP/BP 7.60 Projects in Disputed Areas		**No**	The planned Kabuyanda Irrigation project will not be implemented in disputed areas; hence this safeguards policy is not triggered.

2.8 Relevant Environmental, Health and Safety (EHS) Guidelines (IFC/World)

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry specific examples of Good International Industry Practice (GIIP). The General EHS Guidelines contain information on cross-cutting environmental, health, and safety issues potentially applicable to all industry sectors. Applicable general guidelines include environmental, occupational health and safety, community health and safety and construction and decommissioning. These guidelines are used together with the relevant industry sector guideline(s). Application of the EHS Guidelines to the planned irrigation project may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The EHS Guidelines for Annual Crop Production include information relevant to large-scale, commercial production of the main annual crops, including cereals, pulses, roots and tubers, oil-bearing crops, fiber crops, vegetables, and fodder crops in tropical regions. Plantation crops are addressed in the EHS Guidelines for Plantation Crop Production. Information applicable to crop production is under the detailed General EHS Guidelines and Industry specific EHS Guidelines[1]

In line with these guidelines, MoWE will ensure that:

a. the project will provide safety of services without compromising the health and safety of project-affected communities;
b. the project's direct impacts on ecosystem services do not exacerbate climate change impacts and impacts on surface water courses;
c. the communities are not exposed to health issues, of particular importance are communicable diseases including COVID-19 (*details provided in next sub-section*) and HIV/AIDS from the project work force and risks from pesticides; and
d. emergency preparedness and response as well First Aid needs for the workers and the communities.

Also, due to the labor influx of project personnel, to undertake project works there could be increased risk of Gender Based Violence and Sexual Exploitation and Abuse in communities particularly towards the most vulnerable women and girls. Under this, the project management

[1] http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/our+approach/risk+management/ehsguidelines

will retain services a GBV expert to manage associated risks and impacts. The Ministry will be responsible for ensuring that the management and supervisions of all military and other security personnel engaged/employed in relation to the project conforms to these requirements.

The relevant General EHS Guidelines for the project are:

EHS Guidelines	Sector
Environmental	❖ Air Emissions and Ambient Air Quality ❖ Energy Conservation ❖ Wastewater and Ambient Water Quality ❖ Water Conservation ❖ Hazardous Materials Management ❖ Waste Management ❖ Noise ❖ Contaminated land
Occupational Health and Safety	❖ General Facility Design and Operation ❖ Communication and training ❖ Physical Hazards ❖ Chemical Hazards ❖ Biological Hazards ❖ Personal Protective Equipment (PPE) ❖ Special Hazard Environments ❖ Monitoring
Community Health and Safety	❖ Water Quality and Availability ❖ Structural Safety of Project Infrastructure ❖ Traffic Safety ❖ Transport of Hazardous Materials ❖ Disease Prevention ❖ Emergency Preparedness and Response.
Construction and Decommissioning	❖ Environment ❖ Occupational Health and Safety ❖ Community Health and Safety

Mainstreaming COVID-19 measures into the project

The Covid-19 pandemic threatens to overwhelm health systems globally, but especially in developing countries. With the spread in Uganda and its neighboring countries, the question is whether Uganda health system was resilient enough to respond to the pandemic and its short, medium term and long-term effects. Concerted action needed to be undertaken at national, regional and international levels to effectively contain this pandemic, underscoring the importance of cooperation, coordination and communication. Some of the COVID-19 control measures during the study involved a combination of Ministry of Health Guidelines for COVID-19, WHO Guidelines as well as World Bank COVID-19 guidelines (Technical Note: Public Consultations and Stakeholder Engagement in WB-supported operations when there are constraints on conducting public meetings March 20, 2020). The following key Covid-19 measures have been included in the ESMP and this additional BEFMP and contractors will be required to implement during construction:

a. Some of the project discussions with stakeholders were conducted via electronic media especially through zoom/teams' meetings, webinars, emails and tele-conferencing amongst others;
b. For meetings which were held by physical presence, the attendance was maintained below 20 individuals in line with Ministry of Health COVID-19 Standard Operating Procedures (SOPs) during the public consultations and effort was made to see that, a social distance of one meter between each other is observed in the meetings (Figure 2-1);
c. All individuals accessing the premises/places where the public consultations/meeting will be must undergo temperature screening at the entrance to such meetings facilities;
d. Ensure provision of adequate hand washing facilities with soap and water or alcohol-based hand rub. Everyone MUST wash and sanitize before entry to the meeting places and as frequently as possible;
e. Handwashing facilities and alcohol-based sanitizers were placed at strategic points accessible to the meeting venues;
f. Meeting venues were in open and well aeriated areas (Figure 2-1)
g. Chairs and tables were cleaned with alcohol-based sanitizers.
h. Arrangements had been made to have temperature guns in place as well as records for details of those participating in the meetings;
i. Displayed posters with information and key messages on COVID-19 preferably, in both English and area local languages such as *Runyakitara* in places that were easily visible;
j. Provided guidelines on the SOPs to individuals attending project public meetings and the SOPs such as:

- ❖ Covering your mouth and nose with tissue or a handkerchief when coughing and sneezing;
- ❖ The handkerchief must be washed and ironed by you daily. In case of use of disposable tissue, ensure it is disposed of in a waste bin or a designated area where it can be burnt on a daily basis. In this way, you protect others from any virus released through cough and sneezing;
- ❖ Wash your hands with soap and water or use an alcohol-based hand rub immediately after using the tissue or handkerchief;
- ❖ Maintain a distance of at least 1 meter from anyone who is coughing or sneezing and remind participants to have a face mask to avoid infecting others;
- ❖ Avoid touching your eyes, nose and mouth at all times. Hands touch many surfaces including money which can be contaminated with the virus and you can transfer the virus from the surface to yourself;
- ❖ AVOID hand-shakes and hugging at all times; and
- ❖ Emphasizing observance of NOT SPITTING in the public. Identify secluded places like pit latrines or toilets for purposes of spitting and wash your hands immediately with soap and water.

These were all done before and during the meetings and inconformity with Ministry of Health SOPs for mitigating the pandemic.

Figure 2-1: Stakeholder consultations on the project while observing COVID-19 SOPs during a meeting in February 2021

2.9 Africa Union Treaties, Conventions, Protocols and Charters

There are key African union instruments a, conventions and agreements that are relevant to ICRP and these include the following:

a. African Convention on the Conservation of Nature and Natural Resources, September 1968
b. Revised African Convention on the Conservation of Nature and Natural Resources, March 2017
c. Cultural Charter for Africa, July 1976
d. African Charter on Human and Peoples' Rights, June 1981
e. Convention for the Establishment of the African Centre for Fertilizer Development, July 1985
f. African Charter on the Rights and Welfare of the Child, July 1990
g. Protocol to the African Charter on Human and Peoples' Rights on the Rights of Women in Africa, July 2003
h. African Youth Charter, July 2006
i. African Charter on Values and Principles of Public Service and Administration, January 2011
j. Protocol to the African Charter on Human and Peoples' Rights on the Rights of Persons with Disabilities in Africa, January 2018

2.10 Regional Strategies, Plans, Protocols Conventions and Agreements

2.10.1 East Africa Community Protocol on Environment and Natural Resources Management, 2006

This protocol commits Member States to manage the environment and natural resources in their respective jurisdictions in accordance with regionally agreed principles, with the following objectives (a) promote sustainable development and sustainable utilization of the Partner States' environment and natural resources through prevention of activities that are detrimental thereto; (b) foster closer cooperation for judicious, sustainable and coordinated management, conservation, protection and utilization of the environment and natural resources; (c) promote capacity building and environmental awareness in environment and natural resources management; xiii (d) promote cooperation in the management of environment and natural resources including those that are transboundary in nature among Partner States; and (e) promote development and harmonization of policies, laws and strategies for environment and natural resources management to support sustainable development.


Part of the community access road in the irrigable area washed away by R. Mishumba during heavy rains in 2020

3 BASELINE DATA COLLECTION METHODS

3.1 General Approach

The Baseline data collection and study involved review and updating of information gathered in the ESIA, primarily based on additional surveys and assessments in the project area. This included an updated assessment of the current ecological and social status of the aquatic ecosystems (downstream of the dam), and description and interpreting of the pertinent physical conditions and processes including soils, geology, topography, climate, hydrological features, geomorphological features and processes, land use and biodiversity that will potentially be affected, following envisaged temporal and organizational scales at population, habitats and ecosystem levels of Mishumba catchment. The objective of updating of baseline information was to provide a basis for review and updating of the assessment of risks and impacts envisaged with implementation and operation of irrigation project and associated infrastructure. The Baseline Information has been used herein also to predict how conditions will change downstream of the Project, as well as provision of the data against which the progress of the project implementation will be monitored in terms of expected changes in ecological conditions with the construction and operation of the Project. The Baseline data update was also used herein to confirm the location and suitability of the identified EFA sites and provide relevant maps including survey and key identified areas along the Mishumba river.

3.2 Methodology

3.2.1 Review of the ESIA/ESMP

Different aspects of the baseline information are reported in the ESIA. These additional surveys and assessments were to confirm the recommendation, adequacy of mitigation measures for project impacts downstream of the proposed dam in the ESIA to ensure compliance with the GoU Environmental regulations and the World Bank Environmental and Social Safeguards Policies. Therefore, the data collection carried out as part of the additional environmental study complements the information collected in the ESIA by considering more sampling points to obtain primary information. This was to give more details on the water flow requirements, ecosystem services and water quality in the River Mishumba catchment. It also covered the fisheries biodiversity aspects of importance such as conservation status and impact of the planned development to this biodiversity. In terms of social assessment and socioeconomic survey, the study enhanced on coverage of different categories and groups of stakeholders in the Catchment.

3.2.2 Literature review

The study entailed extensive review of the background and secondary information including the ESIA covering various aspects of the planned project including the project area with its associated attendant communities, biodiversity, water flow network, and administrative and historical monuments. Analysis of the background information further entailed review of project documents provided by the Client, the current guidelines for Environmental Impact Assessment in Uganda as well as review of Environmental and Social Safeguards Policy requirements of the Bank, as well as other relevant international operating policies/safeguards, guidelines, standards, legislation and technical and scientific papers in as much as they concern or relate to the project.

Documents reviewed included the following:

a. Terms of Reference for the preparation of Additional surveys and assessments for Kabuyanda Irrigation Scheme on "Biodiversity and Ecological Flow Management Plan" from MoWE (2020);
b. Environmental and Social Impact Assessment (ESIA) Report for Kabuyanda Dam (2019). The ESIA provided a benchmark upon which further biodiversity surveys (with more focus on fish), cumulative impacts, underground water and environmental flow assessments;
c. Environmental and Social Management Plan for Kabuyanda Dam (2019). The ESMP provided the potential risks and impacts as identified in the ESIA. The Consultant therefore updated the ESMP to incorporate additional mitigation measures;
d. ESMF for Uganda-Irrigation for Climate Resilience Project (ICRP), MoWE 2019, Kampala. This provided general framework for expected Environmental and Social studies of the project during implementation covering various aspects and components.
e. Feasibility Report for the Kabuyanda ICRP including detailed designs and plans for Kabuyanda Dam and associated irrigation infrastructure (2018). This helped the consultant understand the initial identified impacts and projected environmental flow regimes for the scheme;
f. Catchment data including soils, geology, land use/cover, topography among others in regards to hydrology-based environmental flow regimes;
g. Technical and scientific papers on the occurrence, distribution and conservation status of specific biodiversity types;
h. World Bank Environmental and Social Safeguards Policies, and other policy and technical information on dams and irrigation development;
i. Brisbane Declaration on the need for environmental flow assessment for rivers;
j. Technical and Scientific papers on instream assessment of e-flow requirements; and
k. FAO, WorldFish, MAAIF, EPRC – Uganda and other information papers on status of fisheries resources in Mishumba catchment.

3.2.3 Field Sampling and Surveys

3.2.3.1 Sampling criteria for mapping the water flow network

Using Geographical Information Systems (GIS) and Remote sensing (RS) techniques, Mishumba catchment and the irrigable area were delineated using a 30m resolution Digital Elevation Model (DEM). This helped to analyse and determine the preliminary catchment characteristics including land surface features and drainage patterns through inlet, outlet and river/stream/tributary definition. It also gave an understanding of the initial hydrological and topographic characteristics of the whole catchment in Kabuyanda area.

The sampling strategy was designed in such a way to cover a wide range of determinants representing the catchment and accounting for inputs from tributaries that can have important impacts upon the downstream area. The catchment was divided into three (3) sections namely; (i) upstream (area before the reservoir and the reservoir), (ii) midstream (downstream of dam site, the entire irrigation area and tributaries that join the R. Mishumba within the irrigable area), and (iii) downstream (areas after irrigation command area and before crossing the Kikagati–Ntungamo murram road).

The catchment was further subdivided into 9 sub-catchments based on the main river stem and its tributaries. At this stage, a rapid assessment of instream values, which is an important part for selecting an ecological flow regime for a river, was taken into account. The assessment included the ecological or intrinsic values, amenity values and other values like landscape, scenic and natural characteristics of the river that can be affected. Therefore, each sub-catchment was assigned at least one sample point for better and detailed baseline data collection and naming of sub-catchments is based on the stream/tributary name. A total of 24 sampling points were assessed during the wet and dry seasons to address the variations and to substantiate results (Figure 3-1).

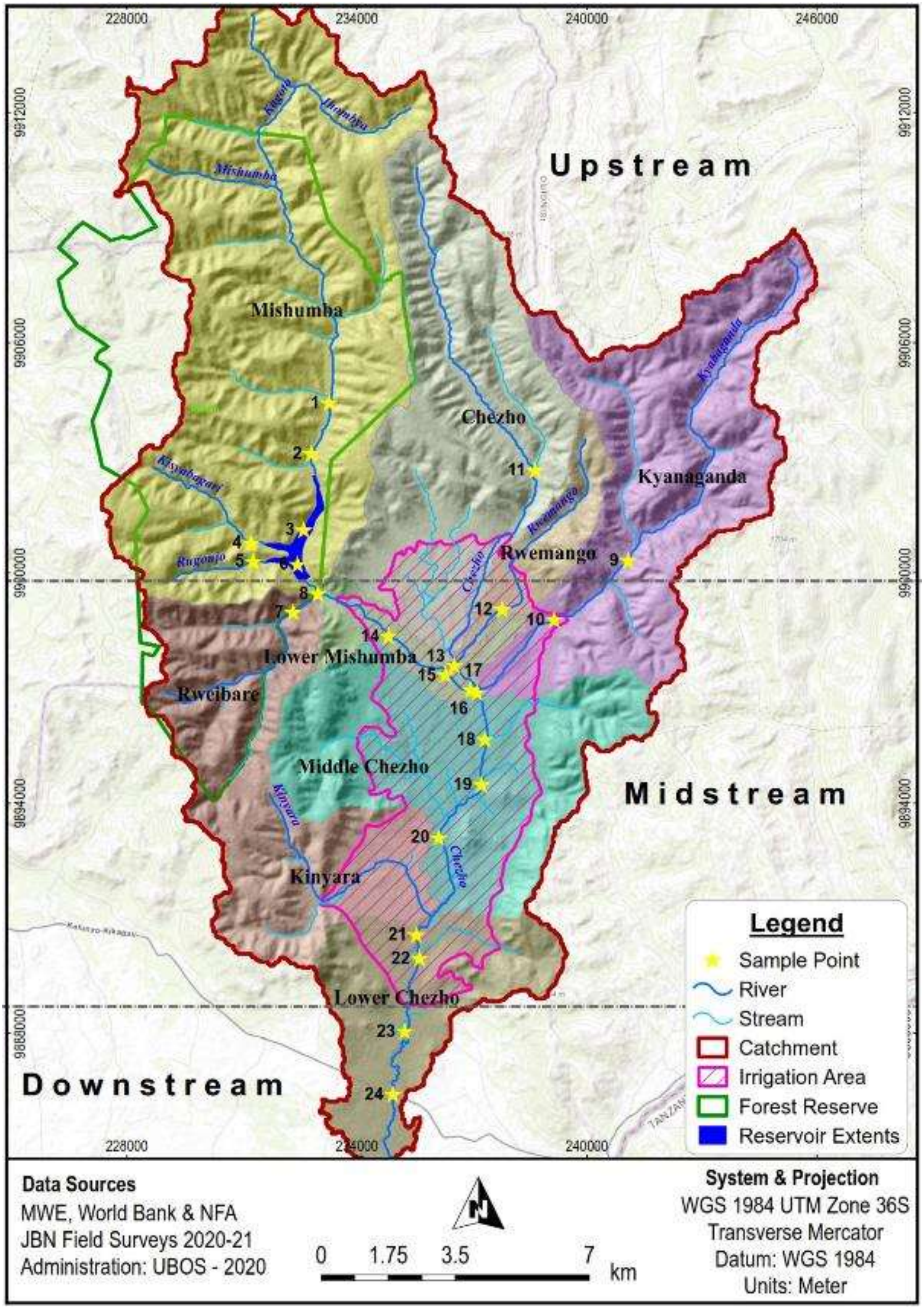


Figure 3-1: Overall map of sampled points in the upstream, midstream and downstream

Factors considered during selection of sites

The following factors were considered in determining sampling points:

- Confluence with the main river stem and any other confluence(s) or point(s) along the river/stream towards upstream to catch-up with flowing volumes. Inflows from tributaries below the dam area - perennial or seasonal;
- Good cross-section area with a dry profile (floodplain and riverbanks);
- Stability of both riverbanks and bed (nature of the river bed/banks- rocky, sandy muddy or any other status) showing levels of scouring and meandering;
- Longitudinal section along the river profile/gradient at an interval of 1-2km;
- Access to the sites (availability of roads, pathways or thickness of vegetation);
- Sub-catchment contributing to Mishumba Main River;
- Guidance from Locals and authorities well versed with project area (social, physical, biological, and chemical–water quality among others. For example, points affected by low and high flows based on seasons);
- Land use and land cover (sociological and other water uses -any irrigation/service/ commercial oriented water related works present in the stretch of the river/stream e.g., fish farming, cultivation etc.); and
- Presence of critical aquatic fauna and flora along the river.

3.2.3.2 Field baseline surveys

To ascertain the current status of the project site, the experts team including the Biologist/Ecologist, Hydrologist, Social Safeguards Specialist, Botanist, Zoologist/Fauna Specialist and GIS/Mapping Specialist undertook two detailed field visits to Kabuyanda in November 2020 (during the wet season) and February 2021 (during the dry season) following the bi-modal nature of the hydrology in the area. The survey focused at the selected 24 sampling sites along River Mishumba and its tributaries (Figure 3-1) covering the upstream, midstream and downstream areas (up to about 10 km downstream the dam along the river and tributaries confluences). The surveys focussed on vegetation and flora (land use/cover, vegetation, species richness, conservation status of species), fauna (butterflies, amphibians, reptiles, birds, other aquatic macro-invertebrates, riparian buffer zone utilization), fisheries and limnological aspects (different types of fish, soil samples from the river beds for sediment analysis). It also focussed on hydrological, hydraulic and fluvio-morphological characteristics of Mishumba and its tributaries (cross-section surveys, discharge measurements at different levels of flow, elevations, channel width, water depth, bed structure, runs, riffles and pools, infrastructure and obstructions for instance bridges, roads, channels). In addition, the socio-economic data was collected.

3.2.4 Hydrological Assessment

In this assessment compared to the ESIA (2019), more emphasis was put on hydrological features and processes to analyse their contribution to the catchment. The work involved consolidating baseline data from primary sources (field survey) used in the e-flow assessments in River Mishumba and determining the e-flow requirements for different aspects in the catchment.

3.2.4.1 Hydrological data acquisition and generation of discharge data for River Mishumba

Hydrological data was generated from both primary and secondary sources. The primary sources involved in-situ technical measurements and assessments, while the secondary data was based on historical records from established sources. Field investigations for two seasons were undertaken in both the wet (November 2020) and dry (February 2021) seasons to obtain hydrological data of Mishumba and its tributaries. This data included measured channel flows at different sampling sites, channel cross sections, floodplain and bank characteristics, among others. The gathered data was analysed in accordance to the following methods below:

3.2.4.1.1 Flow measurements

To estimate the channel flows at different sampling sites, the stream channel cross section was divided into numerous vertical subsections or segments (sometimes referred to as partial areas or panels), dependent on the width of river section **(Figure** 3-2**)**. In each subsection, the area was obtained by measuring the width and depth of the subsection, and the water velocity was determined using a current meter. Readings were recorded as the number of rotations of the current meter in a time period of 60 seconds. Two or three readings were taken for each registration point and an average was calculated. Velocity was measured at half depth below the water surface, and discharge in each subsection was computed by multiplying the subsection area by the measured velocity (based on current meter rating equation) **(Figure** 3-3**)**. The basic principle of the hydrometric current meter consists of counting the number of revolutions (N) of the propeller during a certain period (T).

The number of revolutions per second is calculated as;

$$n = \frac{N}{T}$$

Where n – rotation rate (rev/s)

And using the calibration expression of the apparatus

$$V = a * n + b$$

where V - velocity (m/s), one can determine the velocity of the flow; a is slope and b is intercept.

The total discharge for a current meter measurement is the summation of the products of the partial areas of the stream cross section and their respective average velocities. This computation is expressed by the following equation:

$$Q = \sum_{i=1}^{n} AV$$

where Q - Total discharge (m^3/s), A - cross-section area (m^2) and V - corresponding mean velocity (m/s) of the flow normal to the “i” segment or vertical. The measurement of discharge was done twice, once in the months of November 2020, and March 2021.

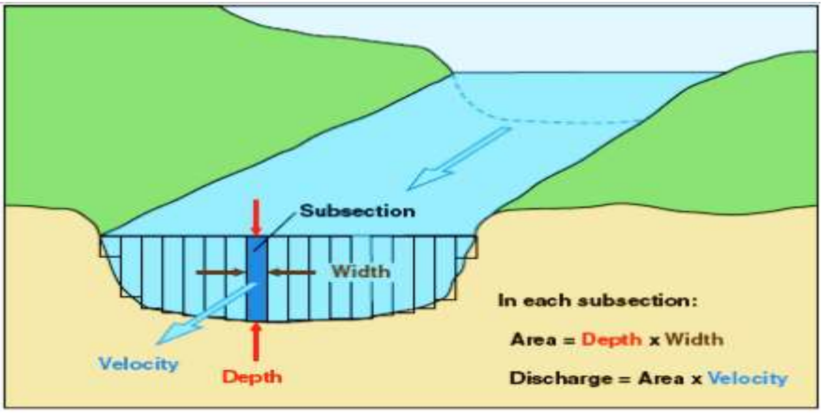


Figure 3-2: Schematic diagram of a chosen river cross-section for current-meter discharge measurements

The quality of the measured discharge is subjected to a number of errors as mentioned below:

a. the measurement of the width, b, of the cross section and water depth, along each vertical segment may be affected by errors and;
b. the spatial variability of the flow velocity may induce estimation errors for the area of the velocity curve along the vertical segments and the mean velocity per unit width. This error is strictly related to the number of vertical segments.
c. the river flow during the measurement may be unsteady;
d. the presence of wind may affect the reliability of the velocity measurement;
e. the velocity measurement by the current meter may be imprecise even in ideal conditions;

However, in this study, errors were minimized by continuous calibration of the current meter for every vertical section and the obtained flow data.

	
Upstream of the dam area (site 1)	Upstream of the dam area (site 2)
	
In the middle of the dam area (site 3)	Kisyabagari tributary (site 4) in the upstream

Rugonjo tributary (site 5) in the upstream

Dam area after the confluence of Rivers Mishumba, Kisyabagari and Rugonjo streams (site 6)

Confluence of River Mishumba and Rweibare tributary (site 8) – after the dam

Upstream of River Kyabaganda (site 9)

Midstream of River Kyabaganda (site 10)

Upstream of River Chezho (site 11)

After the confluence of Chezho and Rwemango streams (site 13)

Between the Mishumba - Rweibare confluence and Kabuyanda - Nyakitunda Road (site 14)

	
At the Kabuyanda - Nyakitunda Road culvert (site 15)	the main confluence of River Mishumba, Chezho and Kyabaganda (site 16)
	
Some of the hard cross-sections where discharge measurements were impossible due to floods along the river in November 2020 (site 19)	Main outlet of Mishumba catchment towards R. Kagera at Kikagati – Ntungamo Road culvert (site 24)

Figure 3-3: Field River/stream discharge measurement during the wet and dry season along River Mishumba and its tributaries.

3.2.4.1.2 Cross-section and profile measurements

Cross section measurements at the sampling sites were made using a dumpy level set and levelled at different instrument heights (**Figure** 3-4) during the first survey (in the wet season). However, during the second survey (in the dry season), a differential GPS (RTK) was used to capture a wider scope of the river profile (**Figure** 3-5). The coordinate system used was WGS 1984 UTM Zone 36S, Datum of WGS 1984 and Units in Meters (m). Both the left and right bank water surface elevations were captured and the relative heights of the proceeding dry sections at intervals of 4m and above were measured.

Figure 3-4: Picking the dry and wet profile cross-sections of Mishumba using a dump level set

Figure 3-5: Picking the dry and wet profile cross-sections of Mishumba using an RTK machine

3.2.4.1.3 Low flow assessment

Low-flows are an important part of the natural flow regime of rivers and streams. Ecologically, low flows maintain longitudinal connectivity in the stream channel, allowing fish migration and nutrient transport, as well as the preservation of aquatic, riparian, and hyporheic (below streambed) ecosystems.

To conduct low-flow measurements in the 24 additional sites selected jointly by Client and Consultant on the basis of several criteria, including the importance of the resource, accessibility, chosen sites were also being monitored for other purposes (for example, assessment of water quality), and whether a site represented combinations of basin attributes not represented by existing stream gauges. Sites with large diversions or return flows upstream of the stream gage, sites influenced by water from floodplains or storm water, and sites at which the stream was likely to go dry for extended periods during the low-flow season were avoided.

The overall strategy for the low-flow additional surveys and sampling was to make repeated measurements of flow at selected 24 sites to allow estimation of low-flow characteristics and incorporation of the results of low flow assessments at the 24 sites into the catchment analysis as partial-record stations. In the event that multiple measurements could not be made at a site, the individual measurements made under low-flow conditions were used to provide information used to project/model low-flow conditions over time and to evaluate errors in estimates of low flows from regression analyses.

The measurements were taken in-situ and included a listing of the meter type and an assessment of measurement quality. At all the 24 sites, measurements were repeated for verification of results and consistency in measurement procedures, and this was done during both the wet season sampling (November 2020) and in dry season sampling (February, 2021).

3.2.4.1.4 Flood assessment

Flood assessment was done with aim of determining flood-prone areas in Mishumba Catchment by using a hydrological model considering two wetness indexes; the topographical wetness index, and the SAGA (System for Automated Geoscientific Analyses) wetness index. The wetness indexes were obtained in the Quantum GIS (QGIS) software by using the Digital Elevation Model of the study area. Flood-prone areas were determined by considering the wetness index maps of the catchment. In the field a two-step process was used. The first step involved the detection and mapping of flood-prone areas by using GIS support and considering the topography of the watershed after which areas at risk were studied with more details by implementing the HEC-RAS hydraulic model to assess flooding parameters (Aksoy *et al.,* 2014). The first step was basically a flood susceptibility assessment process and was used to prioritize the flood-prone areas in terms of the importance of the assets at risk. The second step is the flood hazard assessment stage, leading to results needed in the selection of preventive measures.

3.2.4.1.5 Extreme Value Analysis

Extreme Value Analysis was based on data gathered from the field and that generated from simulation. In this study, the water flow data, flow duration and extreme value analysis were done using Mann-Kendell and Sen's slope analysis for data screening and checking the general trend, flow duration curves (FDCs) and different distributions including the Log Pearson (LP) III distribution respectively. The detailed method for modelling and Extreme Value Analysis is given in **Chapter 5 below** under e-flow assessment methodology**.**

3.2.4.1.6 Time series

Daily time series data for River Mishumba flow was generated based on methodology detailed in **Chapter 5 below** under e-flow assessment methodology.

3.2.5 Fisheries and Limnology

Ecological assessment involved determination of occurrence, the composition and abundance of aquatic flora, composition and abundance of benthic invertebrate, fauna and composition, occurrence, species composition and abundance and age structure of fish fauna. This also involved determination of river depth and width variation, structure and substrate of the riverbed and structure of the riparian zone.

3.2.5.1 Phytoplankton

Phytoplankton composition was studied by taking water samples (0.5- 1.0L) from the surface for chlorophyll a (chl a) analysis at a site along each set transect. The sample water would be filtered through special filters to which 1-2 mls of a saturated MgCO solution were added prior to the completion of filtration. The filters were stored as frozen in individual plexislides for laboratory analysis. Chlorophyll analysis followed the fluorometric procedure of Strickland and Parsons (1 972). In the laboratory, part of the water sample was analysed to establish the algal species composition wherever possible.

Figure 3-6: Sample collection and preparation to be frozen in individual plexislides for further laboratory analysis

3.2.5.2 Aquatic Macrophytes

These were assessed through direct observation on both shores of sites of sampling along the river. Photographs and estimation of the biomass by subjective score of dense, moderate, light and absent were taken for each type of major macrophyte in littoral zone or within the water along the respective transects.

3.2.5.3 Zooplankton and Macroinvertebrate Analysis

Zooplankton samples were corrected in triplicate vertical sampling of the water from mid-section of the river along set transects using a hand towed 0.2-m diameter, 153-p mesh, conical net in November 2020 for wet season, and in February 2021. The net was lifted through the water at a speed of about 1 m/s at a point along the transect of the sampling site; collected from the 24 sampling sites above the sediment surface. Samples were then further subjected to filtration through a 90-µm mesh plankton sieve (Sethi Standard Test Sieves, Ambala Cantt, India). Mishumba River. Zooplankton was analysed to species level wherever possible and counted for density estimations using triplicate I-ml subsamples taken with a Hansen-Stempel pipette in a I-ml Sedgewick-Rafter cell. Zooplankton body sizes were obtained by measuring the length to the nearest 0.01 mm of at least 10 individuals along a transect in each I -ml subsample (Koenings et al., 1987). Zooplankter biomass was estimated from an empirical regression between zooplankter body-length and dry weight, and weighted by organism density (Koenings et al., 1987). Macroinvertebrates were sampled with the aid of the Eckman's mad grabber sampler. The samples were taken across the River Mishumba channel at the different sampling points. The mad was washed and filtered with the organisms preserved in 4% formaldehyde solution and transported to the laboratory for further analysis.

Figure 3-7: Zooplankton sampling from the mid water column using a conical net

3.2.5.4 Fisheries biodiversity and habitat variability

The fish species were observed directly where the waters were clear and calm, and if necessary, for further identification collected using scoop nets. Where the waters were deep, a panel of gillnets ranging from 1 inch to 3.5 inches was set across for river and checked every one (1) hour for a period of 24 hours for any fish caught. If required for further analysis specimens were caught and prepared following National Fisheries Resources Research Institute (NaFIRRI) and or Lake Victoria Fisheries Organizations (LVFO) protocols/SOPs. Photographs of each specimen were taken. Biometrics including weight, length, body width (depth), scales along the lateral line, operculum width and others as may be necessary were also taken and recorded. In addition, fullness of stomach and gut content was analysed after gutting the fish. Where the species of the fish caught required further laboratory analysis, the specimen was preserved in 10% formalin solution. The habitat description was made by describing the vegetation, bottom substrate, water depth, water flow rates, texture of the benthos and in-situ measurement of key physicochemical parameters at each of the surveyed sites.

Figure 3-8: Setting a gillnet at the catchment outlet along Kikagati – Ntungamo road (E234935, N9886429)

3.2.6 Water Quality and Mass (Sediment) Transport

3.2.6.1 Water Quality

Water samples were taken for parameters that can be determined within allocated time and collected from water column using a non-metallic, opaque Van Dorn sampler. The water samples were collected from 24 sites, stored (<24 hr) in pre-cleaned polyethylene carboys, transported to the laboratory for processing and further analysis. The target parameters were measured according to Koenings et al. (1 987) including conductivity (pmhos cm-l) using a conductance meter, alkalinity levels (mg L-') using the acid titration (0.02 N H,SO,) to pH 4.5, using a Corning model-399A specific ion meter, calcium and magnesium (mg L-') using separate EDTA (0.0 I N) titrations after Golterman (1 969), turbidity (NTU) using a turbidimeter, colour of water using a spectrophotometer, and total iron (pg L-') by reduction of ferric iron with hydroxylamine during hydrochloric acid digestion after Strickland and Parsons (1972). Both insitu and ex-situ measurements were done. Key physico-chemical elements that were assessed are prescribed in **Annex 1**, but in general, it included the thermal conditions, oxygenation conditions, salinity acidification status, and nutrient conditions of the river at its different tributaries. Specifically, the assessment included measure of the specific pollutants, key elements set out in the **Annex 1** that includes substances identified during ESIA as being discharged into the river, and any other substances that was identified during field assessment as being discharged in significant quantities.

Figure 3-9: Insitu water quality parameter measurements along River Chezho in Nyakitunda (E238425, N9902839)

Figure 3-10: *In situ* water quality measurements using Horiba U-53 water quality meter along Mishumba at E232809, N9903119.

3.2.6.2 Sediment transport and flush flows

Established flush flows are released for either channel maintenance, fish habitat improvement, and recreation, among others. Evaluation was undertaken to establish whether sedimentation problems were likely to occur in the drainage below the dam and irrigation scheme. Specific areas considered included

(i) physical location of the reservoir (i.e., above or below major sediment sources);
(ii) topography and geology of the project area;
(iii) susceptibility of the drainage to catastrophic events (e.g., landslides),
(iv) sensitivity of important fish species and their life history stages to sediment;
(v) extent of man-induced activities within the drainage which may increase sediment recruitment (mining, logging, etc.), and
(vi) operational characteristics of the project (storage, or multipurpose).

This was important in determining whether the systems were susceptible to upstream sediment recruitment. From a biological perspective, it can be generalized that flushing flows are needed when sediment concentrations exceed historic levels and begin to affect important aquatic habitats and life history functions. Flows for channel maintenance are needed when vegetative encroachment begins to affect flow transport capacity and channel shape, thus predisposing the reach to further encroachment and sedimentation.

The best time for releasing flush flows was determined based on the species of fish present in the system, the life-history requirements of the important species, the historical run-off period, and perhaps most important, flow availability. A review of historical flow records was used in determining the timing of releases. This was based on the understanding that flow releases scheduled during normal peak-flow periods would provide the most benefits. To the extent possible, the economics of the flow release was factored into the timing determination based on flow availability and competing water use.

For channel maintenance, a sequence of natural flow events determines the shape of a river reach. Although the process is dynamic, many reaches maintain a stable shape. The dominant discharge, defined as the equivalent steady discharge to produce the same dimensions as the sequence of natural events, has been found to be approximately the same as the bank-full discharge for many natural channels. In addition, the bank-full discharge appears to be approximately the same as the frequency of occurrence of the flow which transports the most sediment ("effective discharge"). For this study, a 2-year flood was chosen to represent the bank-full discharge and together with the 5-year flood events were selected as the flow maintenance discharges.

3.2.6.3 Nutrients

Nutrient samples were analysed following Koenings *et al.* (1987). In general, filterable reactive phosphorus (FRP) was analysed by the molybdate- blue/ascorbic-acid method of Murphy and Riley (1962), as modified by Eisenreich et al. (1975). Total phosphorus was determined using the FRP procedure, after persulfate digestion. Nitrate and nitrite (NO, + NO,) was determined as nitrite following cadmium reduction of nitrate, and total ammonia (NH, + NH,)' was determined using the phenolhypochlorite methodology after Stainton et al. (1977). Total Kjeldahl nitrogen (TKN) was assessed as total ammonia following sulfuric acid block digestion (Crowther et al. 1980). Total nitrogen was calculated as the sum of TKN and NO3 + NO. Reactive silicon was determined using the method of ascorbic acid reduction to molybdenum-blue after Stainton et al. (1977). Estimation of the yearly phosphorus loading in was calculated following Vollenweider (1976).

3.2.7 Vegetation and Flora

3.2.7.1 Literature review

Literature relevant to the site and proposed activities was reviewed prior to field surveys to get a picture about the vegetation and flora that is found in the project area from previous studies. This information was sought from available published reports and other resources. The Forest Department biodiversity report of Rwoho CFR was also reviewed for additional information.

3.2.7.2 Field surveys

To collect site specific data, a field visit was conducted in the month of November 2020. The vegetation and flora survey focused on the 24 sampling sites identified by the project. Each of the sampling sites was surveyed independently for description and assessment of the vegetation and flora.

At each site, the vegetation of the general area was described from the dominant and more common species of plant. Observations were made of land use practices and any activities that could cause disturbance to the ecological integrity of the ecosystem and the flora. Photographic representation of the vegetation and condition of the sites was made and coordinates taken for such pictures. Photographs of species encountered were taken. For illustration of different plant cover types and valued ecosystem components (VECs), pictures were taken and coordinates of location marked with GPS "Garmin 64s" in World Geodetic System 1984 (WGS 84). The coordinates for pictorial illustrations were displayed in Universal Transverse Mercator (UTM).

At each site, the site coordinate was taken to estimate a quadrat measuring 100 x 100 m around it within which to assess the flora. Within this plot, all species of plants observed were identified and recorded. The abundance of each species was assessed as a percentage cover over the total plot size. The plants' growth habit was recorded as Tree, Shrub, Herb, Climber or Grass. Invasive species of plants within the project area of interest were recorded and coordinates of the actual areas of their occurrence as well as their photographs taken. Those recorded from the quadrats had their relative abundance assessed from their percentage cover.

Additional inventory sampling was done along the tributaries of rivers and other habitats to capture species that may not have been observed within the plot sampling procedure. This helped to maximise accumulation of species richness. The Flora of Tropical East Africa (FTEA) was the principal resource for such determination, together with the preserved collection at Makerere University Herbarium. Voucher specimens were collected for species which could not easily be identified in the field. These were taken to Makerere University Herbarium for determination.

Species richness: Species checklists were compiled, on a site-by-site basis, the total richness obtained the species lists of the 24 sites maintaining the richness for each site. Their percentage cover was also analysed from their distribution through the growth habits.

The global conservation status of each species was obtained from the published IUCN red list of threatened species (IUCN 2021). The national red list of Uganda's threatened species (Wildlife Conservation Society 2016) was used for identification of species that are nationally threatened.

3.2.8 Fauna

3.2.8.1 Literature Review

Literature was consulted to establish known fauna that is found in the project area and the role of fauna in the ecosystem. This was done by reviewing publication and various websites dedicated to avi-fauna conservation and research. Also consulted were the previous baseline survey reports conducted under the project ESIA and biodiversity survey report for Rwoho CFR published by the Forest Department (current National Forest Authority).

3.2.8.2 Informal community consultations

During the field visit and field sampling, the consultant informally consulted the community members especially those found working in the field. The purpose was to document information on fauna which the consultant may not be able to get during the field sampling, especially regarding which faunal groups / species occur in the area.

3.2.8.3 Field Sampling

Field sampling was conducted using known scientific methods and international best practices. Fauna species found or living within a riparian buffer zone width of 40m strip (20m buffer strip at each side of the river/stream) along the river/tributaries at each sampling sites or found depending on this zone for feeding, reproduction, resting, etc. or for any key activity of their life cycle, were registered or recorded.

Twenty-four sampling sites were established as follows:

a. Eight sampling sites were established upstream–four before the dam site, one at the proposed dam site, and three immediately after the proposed dam site;
b. Within the irrigation command area nine sites were established downstream along R. Mishumba at 2km interval;

c. Four sampling sites were established on tributaries that pour/contribute water into the R. Mishumba but within the irrigation command area, and;
d. Three sites were established downstream outside the irrigation command area.

The following methods were used during field sampling

3.2.8.3.1 Butterflies

3.2.8.3.1.1 Sampling Method

Pallard's sweep net method (Gall, 1985; New, 1991; Warren, 1992; De Vries 1997) was employed to sample butterflies along transects that were established at the agreed sampling sites along the river or its tributaries. The method was used to document the fauna species richness, as well as estimate their relative abundance. The method was chosen because it is time-efficient. The method was also chosen because the negative effects that may be brought about by catching and handling of individuals or those that may be brought about through habitat destruction by intense trampling are avoided (Nowicki, P *et al.,* 2008). The method can also be widely applied in extensive large-scale and / or long-term monitoring programs. For example, the method has been used in the well-known British Butterfly Monitoring Scheme (Pollard and Yates, 1993) and the European Grassland Butterfly Indicator (van Swaay and van Strien, 2005).

Estimating species richness was assessed based on recorded species presence or absence at the different sites that were be sampled. The observer recorded the species encountered as he moved through transects sited in the 20m buffer on either side of the river or its tributaries. A species list was then compiled from the records of the survey. Abundance estimation was assessed by counting and recorded the number of individuals of the different butterfly species that were encountered while sampling the established transects along the river and its tributaries at the selected sites.

3.2.8.3.1.2 Sampling design

At each of the identified sites, two transects of 10m wide and 100m long were established in the 20m buffer area on either side of the river or its tributaries. The observer or data collector moved through the transect along a fixed route with 5m stretch on either side of the observers left and right hand. The observer moved at a slow and uniform / even pace of approximately 1 km/h (Pellet 2007) through the transect, recording individuals sighted within an imaginary 5 x 5 x 5m box of the observers left and right hand. Sampling was conducted when weather warmed up or in sunny weather (13-17°C) and between 9am - 5pm.

On spotting an individual butterfly, the observer swept the net back and forth to capture the seen butterfly. On anticipation of a capture, the net was flipped over, with the bag hanging over the rim, trapping the individual fly. Trapped butterflies were gently removed from the net and identified. Once identified, the individuals were released. In case of encounter with an individual butterfly whose identity is not known, the butterfly was photographed and placed in collection envelops, with details of GPS coordinates, Time and the photograph number written on the labels and taken to Makerere University Museum for identity determination. All trapped butterflies were identified to species level.

3.2.8.3.1.3 Use of sites for butterfly breeding

Use of sites for breeding by butterflies was investigated by sampling for existence or presence of butterfly caterpillars. Search for butterfly larvae (Caterpillars) within vegetation was conducted during sampling within the recommended 20m buffer and any presence of caterpillars was documented.

3.2.8.3.1.4 Data analysis

Species Richness: The number of species present in a given sample is a measure of Species richness (Hellmann and Fowler 1999). Species checklists of butterflies encountered at each sampling site were compiled. Standard guide by Larsen (1991) was used as basis of identification. Unidentified specimens were matched with Makerere University Museum collections. The species were arranged into families *Hesperiidae, Lycaenidae, Nymphalidae, Paeridae* and *Papilionidae* and their corresponding sub families and genera. Bar graphs were used to compare the results. The total number of individuals recorded per species was taken as the relative abundance of the butterfly population at the sampling sites.

3.2.8.3.2 Dragonflies

3.2.8.3.2.1 Sampling methods

Pallard's sweep net method (Gall, 1985; New, 1991; Warren, 1992; De Vries 1997) was employed to sample dragonflies at the selected sites along the river or its tributaries. Estimating species richness was assessed based on recorded species presence or absence at the different sites that were sampled. The observer recorded the dragonfly species encountered as he walked through transects sited at the selected sampling sites. A species list which forms a measure of species richness was compiled from the records done during the transect walks. Abundance estimation was assessed by counting and recording the number of individuals of the different dragonfly species that were encountered while sampling the established transects at the selected sites.

3.2.8.3.2.2 Sampling design

Two transects of 10m wide and 100m long, oriented parallel to the river or its tributary were established and used to sample dragonflies. The two transects lay within the 20m buffer of the river or its tributaries. The transects were placed one on each side of the river or tributary. The transects were stationed 1m off the river edge, on either side of the river. A single observer or data collector moved through the transect along a fixed route with 5m stretch on either side of the observers left and right hand. The observer moved at a uniform pace through the transect, recording individual dragonflies sighted within the transect width and length. Dragonflies need sunny warm weather to fly; the temperature below 25˚C slowed the activity whereas an optimal temperature above 30 °C increased activity. If it is too cold or wet, they usually hide in vegetation. Sampling was therefore conducted when weather warms up. Each sampling event was conducted between 09:00h to 17:00h time and lasted about 1hour. All dragonflies that were flying or be perched within 5m of transect routes were recorded. All flying species were easily detected within the search area and an aerial net was swept through the vegetation to elicit a flight response from less conspicuous, resting individuals.

Same amount of sampling effort (time given to searches) was applied at each site. Sampling events were conducted during the wet season as well as during the dry season.

3.2.8.3.2.3 Assessing Dragonfly use of buffer for breeding

Dragonfly larvae are aquatic and are most commonly found in ponds, marshes, lake margins, shallow areas of streams and the slower reaches of rivers and streams, or in water-filled hollows within trees. Use of sites for breeding by dragonflies was investigated by sampling for existence or presence of dragonfly larvae. Larvae was collected by sweep-netting in water or amongst aquatic vegetation.

Pools within the 20m buffer along the river or its tributaries and the river itself, were sampled for dragonfly larvae by using of a dip-net (or a large sized Kitchen sieve). The dip-net was also used to sample among aquatic vegetation and underneath woody or leafy debris (Bright 1999). Kick sampling was also employed to sample for dragonfly larvae. In kick-sampling, a net was placed about 30cm downstream and the river or tributary substrate was disturbed using the feet. Organisms that are dislodged were collected by the net as they are washed downstream. The nets were emptied into a pan or screen to sort the larvae.

3.2.8.3.2.4 Data Analysis

The data collected were analyzed as follows:

Species Richness: The number of species present in a given sample is a measure of Species richness (Hellmann and Fowler 1999). Species checklists of dragonflies encountered at each sampling site was compiled. Standard guide by Klaas-Douwe B Dijkstra (2006) was used as basis of identification. Unidentified specimens were matched with Makerere University Museum collections. The species were arranged into families, sub families and genera.

Species composition was computed for the dragonfly samples that were collected during sampling. Species Composition = (Total no. of individuals in each species/Total no. of individuals in all species) x 100 (Bisht *et al*., 2004)

Relative abundance of each species was computed for the collected sample.
Relative Abundance = No. of individuals of a species/Total no. of individuals of all species
The average relative abundance was categorized as follows:
Uncommon (uC) = having relative abundance less than 0.0100.
Common (C) = having relative abundance of 0.0100 and above but less than 0.0500.
Very common (vC) = having relative abundance of 0.0500 and above (Bisht *et al*., 2004)
Bar graphs were used to compare the results.

3.2.8.3.3 Herpetofauna (Amphibians and Reptiles)

3.2.8.3.3.1 Sampling Methods

A combination of scientifically tested methods was used to collect information on herpetofauna as described by Heyer *et al*., (1994); Fellers and Freel, (1995); Halliday, (1996); and Olson, *et al.,* (1997).

The methods included the following:

a. ***Visual Encounter Surveys (VES):*** The method involved moving through a habitat watching out for, and recording surface-active herpetofauna species. VES were complimented by visual searches, by examining under logs, leaf litter, in vegetation, and crevices. Species encountered and their numbers were recorded and where possible photographed;

b. ***Audio Encounter Surveys (AES):*** This method uses the species-specific calls / sounds / advertising calls made by breeding males. The identity of the amphibian species heard calling and their numbers were counted and recorded;
c. ***Dip netting:*** Using a dip net, ponds, pools, and streams and other water collection points were dip netted. Adult amphibians and tadpoles encountered were also recorded; and
d. ***Opportunistic Encounters:*** Herpeto-fauna species encountered opportunistically while moving in the project area were recorded in order to accumulate a complete species checklist for each site.

3.2.8.3.3.2 Sampling Design

Two transects of 10m wide and 200m long, were established parallel to the river or its tributary were sampled for herpetofauna. The two transects lay within the 20m buffer on either side of the river or its tributaries. The transects were placed parallel to the river or tributary, one on each side. The transects width run from the river or tributary edge, on either side of the river. A single observer walked through the transect for a period of 1hour (1-man hour), at a uniform pace, systematically searching for amphibians and reptiles. Each sampling event was conducted between 09:00h to 17:00h time and lasted about 1hour. Same amount of sampling effort (time given to searches) was applied at each site. Many species of amphibians and reptiles (herpetofauna) tend to be nocturnal. Sampling was done during day time (07:00am-06:00 pm) as well as at night (07:00-08:30pm). The sampling was done during the wet-season (which coincide with their breeding period) and the dry season. Herpetofauna were sampled using the above combined methods with sampling effort standardized by area (Jaeger and Inger 1994, Bailey *et al.*, 2004) or a time constraint (Crump and Scott 1994).

3.2.8.3.3.3 Assessing Herpetofauna use of sampling site for breeding

Herpetofauna especially Amphibians have a double life, aquatic life as larvae and terrestrial life as adults. Use of sites for breeding by Amphibians was investigated by sampling for existence or presence of amphibian larvae and or young adults within the 20m buffer area at the sampling sites. Searches was conducted for amphibian larvae (tadpoles) in the water bodies encountered at each site (ponds, marshes, shallow areas of the river / streams) during sampling. Amphibian larvae (tadpoles) were collected by dip-netting in water or amongst aquatic vegetation. For reptiles, the observer was on the lookout for young hatchlings and or juveniles.

3.2.8.3.3.4 Data analysis

Species Richness: Species checklist was compiled; which list gives a measure of herpetofauna species richness at each sampling site. Standard identification guides by Spawls *et al*. (2008) and Branch B (2005) was used. Unidentified specimen were taken to Makerere University Museum for identification. Bar graphs were used to compare the results. Relative abundance was computed from the total number of individuals recorded per species within the herpetofauna population for the sampling sites.

3.2.8.3.4 Avi-fauna (Birds)

3.2.8.3.4.1 Sampling Method

Line transect method was used to sample birds at the identified sites along the river and its tributaries. The method was chosen because of the advantages it provides, generic and encompasses most species and can be used to survey a number of bird species together. With this method, multiple counts can be obtained by counting in the same study site repeatedly in the same season or by counting multiple study sites once. Therefore, by this method, temporal variations at sites within season, and spatial variation across the sites can be captured. The method was also chosen because of the time given for fieldwork was limited.

It is highly adaptive and can be used in terrestrial, freshwater, and marine systems. The method can be used to survey individual species, or groups of species. The method is also efficient in terms of the quantity of data collected per unit of effort expended, can be used to examine bird-habitat relationships and can be used to derive relative and absolute measures of bird abundance. It is also the best method for sampling diurnal species in grasslands, marshes or other rather uniform vegetation conditions (Ribic and Sample, 2001).

3.2.8.3.4.2 Sampling design

During the sampling, the observer walked a predetermined route and recording birds on either side of the observer. Birds identified by sight or sound 50m (estimated by eye from the line) perpendicular to the transect line was recorded when first detected. Fauna and especially birds are non-stationary objects and can be mobile. The observer recorded birds continually within a fixed distance of 200m length. The sampling lasted a period of one hour. Two transects were sampled one on either side of the river or tributary and the transects were oriented parallel to the river and or tributaries. Birds seen flying over the survey area (aerial species) were recorded separately and their numbers estimated at each site. Birds flying away from the site during the sampling process were counted and recorded. Double recording of the same individual of birds within a transect was avoided by use of careful observations. A few additional records were made of species found present in the area outside the time of the count. Bird observations were aided by a 10x40 binocular.

Many bird species are highly seasonal, either moving between seasons to follow suitable habitat, or as part of larger migratory movement. This is especially true in the case of many wetland birds. Sampling for Avi-fauna was conducted during the wet and dry season.

3.2.8.3.4.3 Assessing the use of sampling site by Birds

Observations were made on the use of the selected sites by birds. Observation was also made on the availability of active bird nests at the selected sites. Signs of use of selected sampling sites by birds for roosting, refugia, breeding, foraging was also documented. The use of selected sites as migration routes was also investigated and noted through observations of migrant species.

3.2.8.3.4.4 Data Analysis

Species Richness: Species checklist was compiled; which list gives a measure of the bird species richness at each sampling site. Standard identification guide by Stevenson and Fanshawe (2002), supported by the Uganda Bird checklist (Nature Uganda 2016) was used.

Bar graphs were used to compare the collected data. Relative abundance was computed from the total number of individuals recorded per species within the herpetofauna population within the sampling sites.

3.2.8.3.5 Mammals

During the survey, the following were investigated and assessed; 1) species richness (number of small mammal species detected in each sample), 2) sample size (number of individual small mammals in a sample), and 3) their relative abundance (number of individuals of a species in each sample).

3.2.8.3.5.1 Sampling Method

Mammals were sampled using four main methods:

a. ***Direct observation/opportunistic encounters:*** All mammals seen or opportunistically sighted while moving in the project area were identified, counted and recorded;
b. ***Use of signs*** e.g., footprints and/or dung or calls: Mammal species whose footprints and dung was seen and is recognizable were recorded for their presence;
c. ***Use of Sherman Live traps****;* The method uses baited traps, set and left in place over night before they are moved to a different sampling site. This method was meant to be used to sample small mammals. However, the phenomenon that affected the study area couldn't permit use of this method. Locals say that a flash flood happened that swept through the study area in May 2020. The flash flood left the area of interest bare of vegetation. The vegetation where the researcher could hide traps was not there and risked traps being stolen.
d. ***Local consultations:*** The fauna specialist also held informal discussions with community members who were found working in the project area, about the availability of mammal species in and around the proposed sites. The project area has been degraded and chances of finding or recording large mammals are small. The aim was to put emphasis on small mammals. Trapping is the most common method used to study small mammals (Gurnell and Flowerdew 1990) and it was hoped that it would be employed for this survey but it was not possible due to the flash flood which swept through the study area. Live traps have been successfully used to detect patterns of richness, composition, and abundance of small mammal communities (Kelt 1996; Patterson et al. 1989; Yu1994).

3.2.8.3.5.2 Sampling design

The large mammals seen through direct observation and indirectly through use of signs, were recorded. For small mammals, two trap lines would be established, one on each side of the river or tributary in the 20m buffer. Each trap line consisted of a total of 10 traps spaced at distance of 20m apart. The traps were left open for one night. Traps were baited with a piece of casava smeared with a mixture of peanut butter, ghee and yellow banana and set under cover of shrubs or dense vegetation to conceal them and to provide some thermal insulation. Traps were checked twice daily, immediately after sunrise (0630-07030-hrs) and in late afternoon (1730-1830-hrs). Traps were baited daily in late afternoon with fresh bait. Small mammals caught were identified to species level, sexed and marked on-tails using a waterproof marker pen; before being released back into the field at the point of capture (Gurnell and Flowerdew 1990).

3.2.8.3.5.3 Data analysis

Species Richness: the number of species caught at each site were used as a measure of species richness (Hellmann and Fowler 1999). The simplest measure of species richness is the number of species present in a sample (Hellmann and Fowler 1999). Species richness was compiled from the list of caught animals, or those casually encountered and from those whose signs were spotted in the field and could be identified. S"rensen Coefficient (CCs) was computed and used to determine the similarity of animal species between wet and dry seasons based on binary (present-absent) data (Wolda 1981, Brower et al. 1990). The coefficient was calculated as follows:

$$CC_2 = \frac{2C}{S_1 + S_2}$$

where S1 and S2 = the number of species caught in dry and wet seasons, respectively and C = the number of species common to both seasons. The value of CCs ranges from 0 (when no species are found in both seasons) to 1.0 (when all species are found in both seasons).

Relative Abundance: The number of individuals caught was used as an index of abundance of small mammal species at each survey site (Slade and Blair 2000). Bar graphs were used to compare the data.

3.2.8.4 Fauna Species Conservation status

The conservation status of each fauna species encountered was ascertained using the 2019 version of the published IUCN red data list and the National red list of Uganda's threatened species (Wildlife Conservation Society 2016). Through examining published distribution records and literature, assessment of distribution range limits of the different species, new records, lack of records of expected species, and determining how typical/representative/distinctive the species/communities are in the area was conducted. Mammal identifications were based on Field guides by Kingdon (1974), Delany (1975) and Kingdon *et al.* (2013).

3.2.8.5 Surveying of other parameters

The ToRs indicated some of the parameters that were expected to be surveyed and analyzed. The parameters mentioned include 1) taking note of fauna species or communities that are of limited distribution range, new records, lack of records of expected species, how typical / representative / distinctive are the species / communities, 2) determine the diets and preferred habitat of key fauna species to be agreed; 3) quantity and quality of habitats available for fauna life cycle, and 4) issues affecting the riparian areas e.g. fires, agriculture, water extraction, hunting, pollution, etc. These parameters were considered.

3.2.8.6 Distribution status of faunal species

Through examining published distribution records and literature, assessment of the limits of distribution range of the different mammal species was undertaken, new mammal records were reviewed, lack of records of expected mammal species was noted, and determining how typical/representative/distinctive the species/communities are in the area was done.

3.2.9 Social-Economic Survey

3.2.9.1 General Approach

The consultant conducted social assessment using a Social Ecological Systems (SES) approach. The SES took into multiple flow - related objectives that reflect both biophysical sustainability and societal preferences of the project area communities (David et al1, 2014). The consultant assessed the freshwater social-ecological system along and within river stretches. The socio-economic uses and concerns were identified and assessed using mixed methods more so Ecosystems Services Survey. The consultant assessed socio-ecological concerns in relation to farming (crop, livestock, aquaculture), ecosystem services, resource user rights, institutions, property rights, behaviours, cultural heritage, vulnerabilities, among others. The consultant also assessed anticipated scenarios vis-à-vis flow related vulnerabilities. The vulnerability assessment identified the likely vulnerable groups, anticipated social risks, and enhancement and mitigation measures. The identified vulnerabilities were related to age, sex/ gender, education, GBV, OVC, livelihoods, land ownership, resource use, Pathology based (disability, immobility), public health, sanitation & hygiene, socio-ecological imbalances, climate changes, rural-urban migration and urbanization.

3.2.9.2 Data collection methods

The consultant applied mixed method approach that involved quantitative, qualitative and participatory learning and action (PLA) methods.

1. **Quantitative method;** The consultant used an ***Ecosystems Services Survey* (ESS)** aimed at assessing the socio-economic uses of river streams and biodiversity upstream, mid-stream and downstream of dam areas of Mishumba Catchment.
   a. **Sample size: A sample size of** 374 respondents was considered in the catchment where 22 respondents were considered per selected sampled site) along river stretches. A 95% confidence level and margin of errors of 5% were considered for accuracy.
   b. **Sample Frame:** The consultant targeted local communities within and surrounding areas of the sampled sites, micro and sub catchments. The key characteristics used to identify respondents were a) proximity to river; b) users of ecosystem services; c) community roles e.g., leadership and management; d) gender (women, children, men, disabled persons); e) occupation (farmer, hunter, fish farmers, brick makers, etc.); f) employment status (unemployed).
   c. **Data Collection Tools:** The Ecosystems Service Survey questionnaire was converted into digital form using Kobo Collect. The form was loaded and aggregated on mobile device (tablets) that were used to collect data (Fig. below). It should be noted that the use of digital tools increased efficiency, minimise errors and ensures timely analysis of data.
   d. **Analytical Methods:** The consultant used Statistical Analysis (Ms Excel and SPSS), Thematic Analysis of qualitative information; gender assessment and photographic interpretation. Data visualisation (graphs, charts) was done.
2. **Qualitative methods** included Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), Direct Observations and Photography and Document Review.
3. **Participatory Learning & Action (PLA) methods** included Transect Walks / Drives, Seasonal Calendar, Trend Analysis, Systematic Farm Model, Preference Ranking. Institutional arrangements were also assessed using SWOT & PESTLE Analysis.
4. **Stakeholder and public consultations;** through meetings at village, Sub County, Town Council and District levels. Others include; Ministry of Water and Environment officials and National Forestry Authority (NFA).

3.2.9.3 Sampling Sites

The study areas encompassed the core and influence zone of the 13 out of 24 selected sampled sites within the sub catchments and micro catchments along the river stretches (down-stream, mid-stream and upper stream) as shown in Figure 3-1 and Table 3-1 below.

Table 3-1: Sample sites (villages) and their respective sub-catchments

Sub County	Sample sites (villages)	Sub Catchment
Kabuyanda	Kanywamaizi I, II, III, Nyamiyaga	Chezho
Kabuyanda	Kabugu II, Kabugu I	Kyabaganda
Kabuyanda	Kagoto I, Kagoto II,	Lower Mishumba & Chezho
Kabuyanda	Kyamazinga II, Katooma II	Mishumba & Chezho
Kabuyanda	Katooma I	Mishumba & Rweibare
Kabuyanda	Kyamazinga I	Mishumba
Kabuyanda	Rutooma, Katooma	Rweibare
Kabuyanda TC	Rutooma	Lower Mishumba
Kabuyanda TC	Nyamiyaga	Kyabaganda & Middle Chezho
Kikagate	Kabumba, Ruzinga, Rukuraijo, Bugarika	Lower Chezho
Ruborogota	Kabumba	Lower Chezho Sub-catchment
Ruborogota	Ruzinga	Lower Chezho Sub-catchment

3.2.9.4 Data Collection

Data collection was through administering Ecosystems Services Survey Questionnaires using mobile devices (**Figure** 3-11), FGDs, KIIs, Village meeting, direct observation, semi-structured interviews.

Figure 3-11: Administering ESS Questionnaire using mobile device at Nombe village (downstream)

3.2.10 Stakeholder and public consultations

Consultations with different stakeholders on the study was carried out accordingly including meetings at Village, Sub County, Town Council and District levels.

a. Ministry of Water and Environment (MWE);
b. Directorate of Fisheries Resources at Ministry of Agriculture Animal Industry and Fisheries (MAAIF);
c. National Fisheries Resources Research Institute (NAFIRRI);
d. Isingiro District Fisheries Office;
e. Biodiversity Specialists and/or Civil Society Organizations (through Environmental Alert – Lead Environmental CSO);
f. Academia (Makerere University); and
g. Civil Society and NGOs (working in biodiversity like WCS, Nature Uganda, others and through Environmental Alert, coordinator of environmental NGOs in Uganda).

Figure 3-12: Meeting users of ecosystems services near below Dam site in Kagoto 2 village

Figure 3-13: Meeting Village Leader at Kagoto 2 village

Figure 3-14: Meeting parish Chiefs of Kanywamizi and Kagara parishes (upstream)

Figure 3-15: Meeting Upstream communities of Kyamazinga 1 and 2

Figure 3-16: Community consultation in Kagoto 1 and 2

Figure 3-17: Consultations with 4 villages (Kagoto 1 and 2, Kaaro 3 and Katoma)

Figure 3-18: Meeting Kabuyanda Town Council Technical and Political Team

Figure 3-19: Meeting Ruborogota Sub County Technical Head (SAS)

Figure 3-20: Consultations with smallholder farmers in downstream (Kabumba)

Figure 3-21: Consultations with smallholder farmers in Mid-stream

Figure 3-22: Consultations with community leaders in Rwakijuma Parish

3.2.11 Project Impacts and Risks Assessment

The construction and implementation of the Kabuyanda Irrigation Scheme will have potential impacts and risks on the biophysical environment as well as the human and socio-economic environment in the area. These impacts and risks will occur during all phases of the project, including the construction, operation and maintenance phases. Accordingly, this assessment presents the anticipated impacts (both positive and negative) of the project that were not covered in the ESIA report (2019) and but also expands on (where necessary) or gives more information on some of the potential impacts ascertained. Key activities included the following:

a. Identification of key indicators of the aquatic ecosystems;
b. Identification of scenarios for evaluation in the assessment;
c. Effect of flow releases on sediment flows;
d. Undertaking of Cumulative Impact Assessment (CIA); and
e. Review and confirm the mitigation measures/plan proposed in the ESIA.

The description of a potential impact involved an appraisal of its characteristics, together with the attributes of the receiving environment. Therefore, relevant impact characteristics included whether the impact is: a) adverse or beneficial; b) direct or indirect; c) short, medium, or long-term in duration; and permanent or temporary; cumulative (such an impact results from the aggregated effect of more than one project occurring at the same time, or the aggregated effect of sequential projects); among others. A cumulative impact is “the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions”).

To provide a relative illustration of impact significance, numerical or relative descriptors were assigned to the impact intensity and receptor sensitivity for each potential impact. Each is assigned a numerical descriptor of 1, 2, 3, or 4, equivalent to very low, low, medium or high. The significance of impact was then indicated by the product of the two numerical descriptors, with significance being described as negligible, minor, moderate or major, as illustrated in **Table** 3-2 below. This is a qualitative method designed to provide a broad ranking of the different impacts of a project.

The likelihood of each impact occurring was also analyzed and presented as very low, low, medium or high and their significance determined as to whether they are acceptable, require mitigation or are unacceptable as too risky to the environment and for the socio-economic human setting i.e., negligible, minor, moderate or major.

Table 3-2: Determination of impact significance

Significance			**Sensitivity**			
			Very low	**Low**	**Medium**	**High**
			1	**2**	**3**	**4**
Magnitude	**Very low**	1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low	2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium	3	3 Minor	6 Moderate	9 Moderate	12 Major
	High	4	4 Minor	8 Moderate	12 Major	16 Major

3.2.12 Cumulative Impact Assessment (CIA)

Cumulative impacts are impacts on key biodiversity features (valued ecosystem components related to biodiversity) generated by the combined effects of all past, present, and reasonably foreseeable projects. This was undertaken as follows[2]:

Step 1: the team identified the incremental effects of ICRP on the identified VECs within the environs of Kabuyanda Irrigation scheme. The VECs were selected based on information related to current or anticipated future degraded or stressed conditions, the occurrence of protected species or habitats, and the presence or anticipated presence of other human activities that would (adversely) affect the same VEC.

Step 2: Identified other past, present, and reasonably foreseeable future actions within the spatial and time boundaries that have been, are, or could contribute to cumulative effects (stresses) on the VECs or their indicators as identified. Cumulative impacts occur when two or more developments are located sufficiently close and with relatively similar implications, such that their combined impact needs to be considered. Therefore, this involved identification of the sources of stress i.e. past developments whose impacts persist, existing developments and foreseeable future developments, as well as any other relevant external social and/or environmental drivers including wildfires, droughts, floods, predator interactions and human migration

Step 3: For the selected VECs, the experts compiled appropriate information on their indicators, and describe and assess their historical to current conditions where possible. Depending upon the availability of information, the identified trends in the conditions of the VECs and their indicators were determined and analysed.

Step 4: The team further linked the Kabuyanda Project to other actions like the upcoming South Western Cluster - Development of Water & Sanitation Infrastructure for the Mbarara - Masaka Areas; Kagera Water Works (Isingiro water supply project), DRDIP in the study area to the selected VECs and their indicators.

Step 5: Assessment of the significance of the cumulative effects on each VEC over the time and the incremental effects (the direct and indirect effects) on specific VECs were also included.

Step 6: For VECs or their indicators that were identified, they were subjected to negative incremental impacts from the Kabuyanda Project and for which, the cumulative effects are

[2] Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets (2013) was jointly prepared by the Environmental, Social, and Governance Department of the International Finance Corporation (IFC) and ESSA Technologies Ltd., Vancouver, BC, Canada. http://documents.worldbank.org/curated/en/946301468309844309/pdf/769980WP0P1292440Box374382B00PUBLIC0.pdf
Sample Guidelines: Cumulative Environmental Impact Assessment for Hydropower Projects in Turkey (2012). http://documents.worldbank.org/curated/en/787161468178468723/pdf/864920WP0IFC0G0IC00Department0CESPQ.pdf
Ministry of Water and Environment (2019). Environmental and Social Impact Assessment for Kabuyanda Irrigation Scheme, under Irrigation for Climate Resilience Project - P163836. Kampala, Uganda.

significant, develop appropriate action-specific "mitigation measures" for such impacts. The mitigation measures were mainly based on those identified in the ESIA study.

3.2.12.1 Reference Sources used in CIA

As a source of information in the conduct of the CIA following the above steps, a list of documents was collected and reviewed. These documents are as listed below:

1) Final Design Report. 2019. *Final Design for Kabuyanda Irrigation Scheme in Isingiro District*.

2) MWE. 2014. "Directorate of Water Resources Management - National Water Resources Strategy." (August).

3) MWE. 2019. "Environmental and Social Impact Assessment for Irrigation for Climate Resilience Project - Kabuyanda Irrigation Scheme." (September).

4) The Brisbane Declaration. 2007. "Environmental Flows Are Essential for Freshwater Ecosystem Health and Human Well-Being"." *10th International River Symposium and International Environmental Flows Conference* 1–7.

5) Forest Department (2002). Uganda Forestry Nature Conservation Master Plan. Report No. 32.

6) IUCN (2021). *Red List of Threatened Species, Version 2020-2*. www.iucnredlist.org, accessed January 2021.

7) Langdale-Brown I, Osmaston HA, Wilson JG (1964). The vegetation of Uganda and its bearing on land uses, Uganda Government Printer, Entebbe, Uganda.

8) MAAIF (2019). The National Fisheries and Aquaculture Policy, 2018. Ministry of Agriculture, Animal Industry and Fisheries, Entebbe.

9) Greenwood, Peter Humphry. Fishes of Uganda. Kampala : Uganda Society.

10) Mwanja, W.W., Fuerst. P. and Kaufman L. (2012). The collapse of the ngege, Oreochromis esculentus (Teleostei: Cichlidae) populations, and resultant population genetic status in the Lake Victoria Region. Uganda Journal of Agricultural Sciences 13 (2), 65-82.

11) Rutaisire, J. (2003). The reproductive biology and artificial breeding of ningu *labeo victorianus* (pisces: cyprinidae). Thesis, Rhodes University, South Africa.

Field hydrological and hydraulics technical assessment (Kikagate – Ntungamo Murram road in the downstream).

4 BASELINE CONDITIONS

The Figure 3-1 in **Chapter 3** shows the 24 sampling points specifically selected for additional surveys and sampling for determination of biodiversity and socio-economic data. Each of the 24 sampling points was surveyed and sampled for hydrological, hydraulics and geomorphological parameters aimed at generating data for water flow analysis, environmental flow assessment, extreme value analysis, water audit, and review of findings for these parameters as indicated in the ESIA Report. The conditions in each section of river stretch (upstream, mid-stream and downstream) and sub-catchments are provided. More beneficiary LGs have been included such as Ruborogota and Mwiizi Sub counties (previously omitted by earlier ESIA).

4.1 Physical Environment

The entire catchment area does not have unique physical characteristics. The area has a fairly extended shape with an average length and width of 34 km and 19 km respectively. The rivers and streams/tributaries have their headwaters in the Parishes of Ngoma, Rukarabo, Bushwere, Rwoho, Ryamiyonga, Ruhiira and Ntungu in Mwizi, Rukoni East and Nyakitunda Sub-Counties in Rwampara, Ntungamo and Isingiro Districts. Rwampara covers about 22.8%, Isingiro about 67.6% whereas Ntungamo about 9.6% of the entire catchment (**Figure** 4-1). The river then flows in a generally southern direction through Rwoho CFR and is fed by several tributaries that flow in from the east and west towards the river.

Figure 4-1: Map of Districts and their area contribution to Mishumba Catchment's area

4.1.1 Topography

The catchment is characterised by hilly to mountainous terrain with steep fluted slopes and high hilltops. Catchment elevations vary from 1,354 m.a.s.l at the dam site to over 1,853 m.a.s.l at the upper reaches (**Figure** 4-3). The hillsides are steep with average slopes of more than 30%, but which can be as high as 80%. The valley bottoms have milder slopes of less than 5%. As a result, fast flowing slope-side stream flows are significantly attenuated in the valleys and flow in the mean river is expected to show a significantly lower degree of peakedness. Elevations in the irrigation area vary over a lower range of 1,272-1,350 m. Slopes are mild and average 7% but rarely reach 20%. Over 80% of the area has slopes less than 10%. Therefore, the terrain in the irrigation area can be classified as flat to undulating with a few areas having rolling terrain[3].

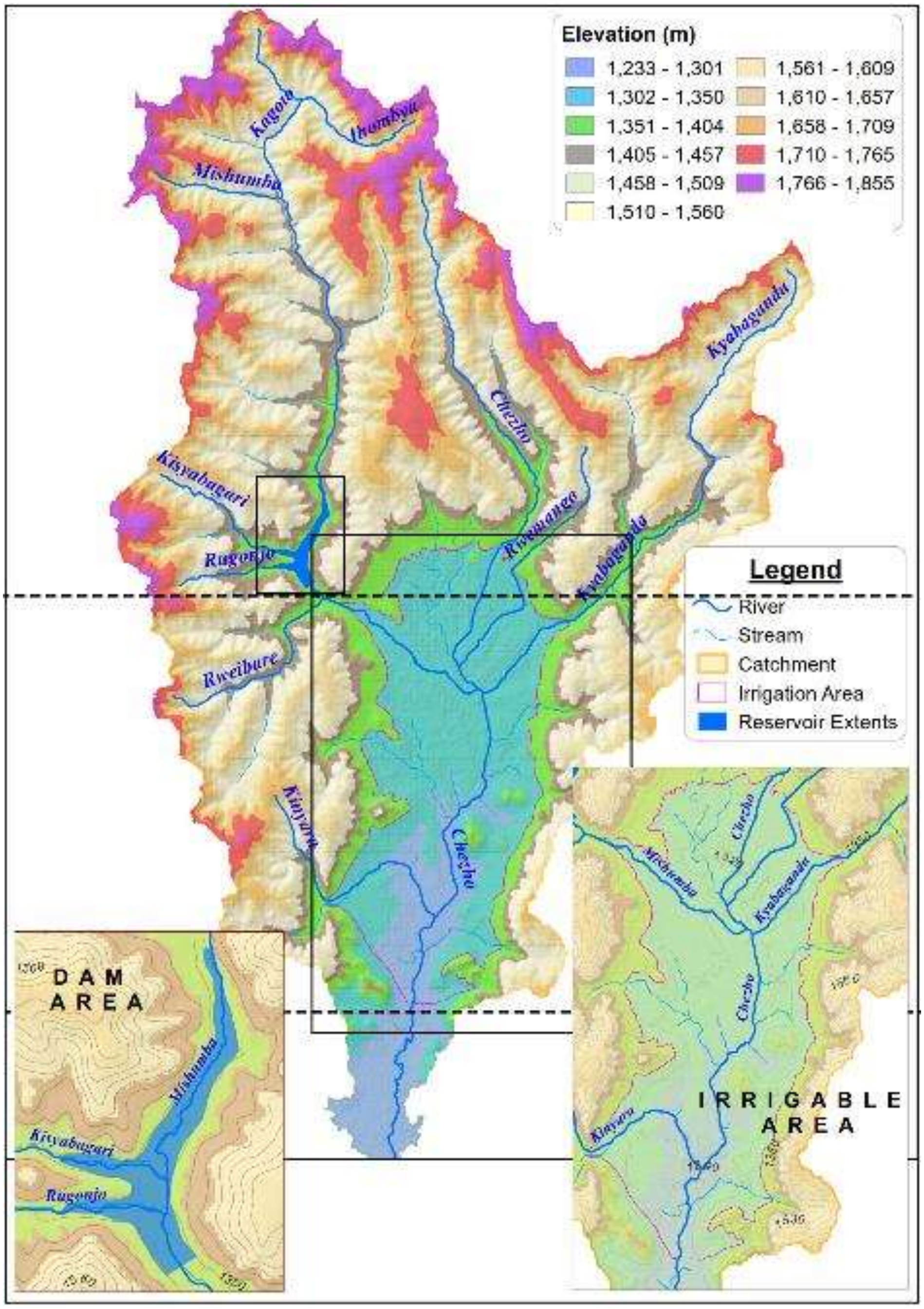


Figure 4-2: Topographic characteristics of Mishumba catchment

4.1.2 Climate

Most areas in the southern western part of Uganda exhibit bi-modal patterns with long rains occurring from March to May and the short rains from October to December. The "short rains" are strongly affected by interactions between the Indian and Pacific oceans (MWE, 2013) and the heavy rainfall during this season being associated with El Niño events. The Mishumba catchment is located in this climatic zone which receives an average of 1,120 mm of rainfall annually with about 330 mm of rainfall received during the first long rainy season which lasts from March-May, whilst the second rainy season receives more rainfall on average, i.e., 450 mm but it is more variable, starting as early as September or even August and sometimes continuing until December.

Temperatures average 19°C but ranges between 13°C and 26°C. Evaporation averages around 1,350 mm per annum but may be a factor of 3-4 times the rainfall amount during the dry season.

Generally, most of south-western part of Uganda exhibits bi-modal pattern of rainfall with long rains occurring from March to May and the short rains from October to December. The "short rains" are strongly affected by interactions between the Indian and Pacific oceans (MoWE, 2013) and the heavy rainfall during this season being associated with El Niño events. The Mishumba project is located in Climatic Zone which receives average of 1,120 mm of rainfall annually with about 330 mm of rainfall is received during the first long rainy season which lasts from March-May, whilst the second rainy season receives more rainfall on average, i.e., 450 mm but it is more variable, starting as early as September or even August and sometimes continuing until December. Temperature averages 19oC but ranges between 13°C and 26°C. Evaporation averages around 1,350 mm per annum but may be a factor of 3 to 4 times the rainfall amount during the dry season. **Figure** 4-3 shows the annual rainfall pattern for Mishumba catchment (MoWE 2019).

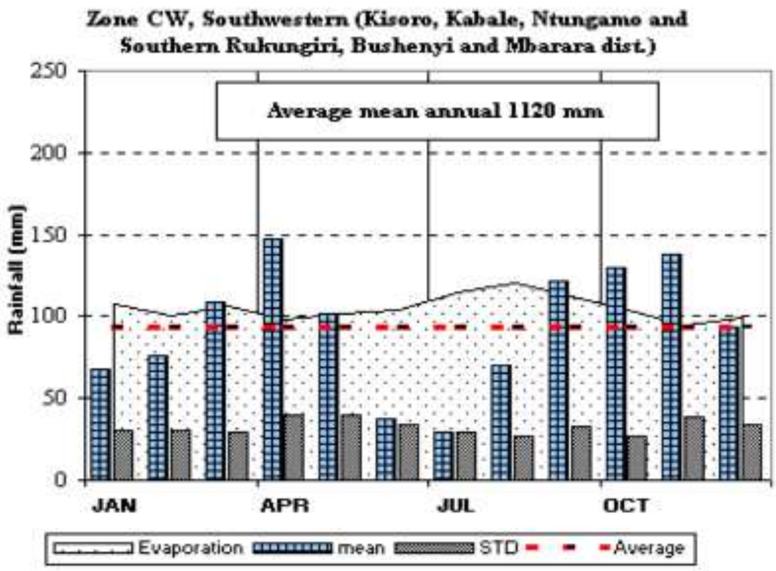


Figure 4-3: Average monthly rainfall for the project area[3]

4.1.3 Geology (Lithology)

The catchment area is underlain by the both the Karagwe-Ankolean system of Cambrian origin and Basement Complex system. The dominant rocks include Argillites and Arenites which are mainly sedimentary rocks composed of indurated clay particles and varying sizes of silt particles. There are occasional occurrences of some basal metacalcarous rocks (including shales, slates and sandstones), and undifferentiated gneisses including elements of P(B) and, in the north, granulite facies rocks. Therefore, all the three major divisions of rocks i.e., Sedimentary, Igneous and Metamorphic are represented in the area (**Figure** 4-4).

[3] Source: Irrigation for Climate Resilience Project - Kabuyanda Irrigation Scheme Environmental and Social Impact Assessment (ESIA, 2019)

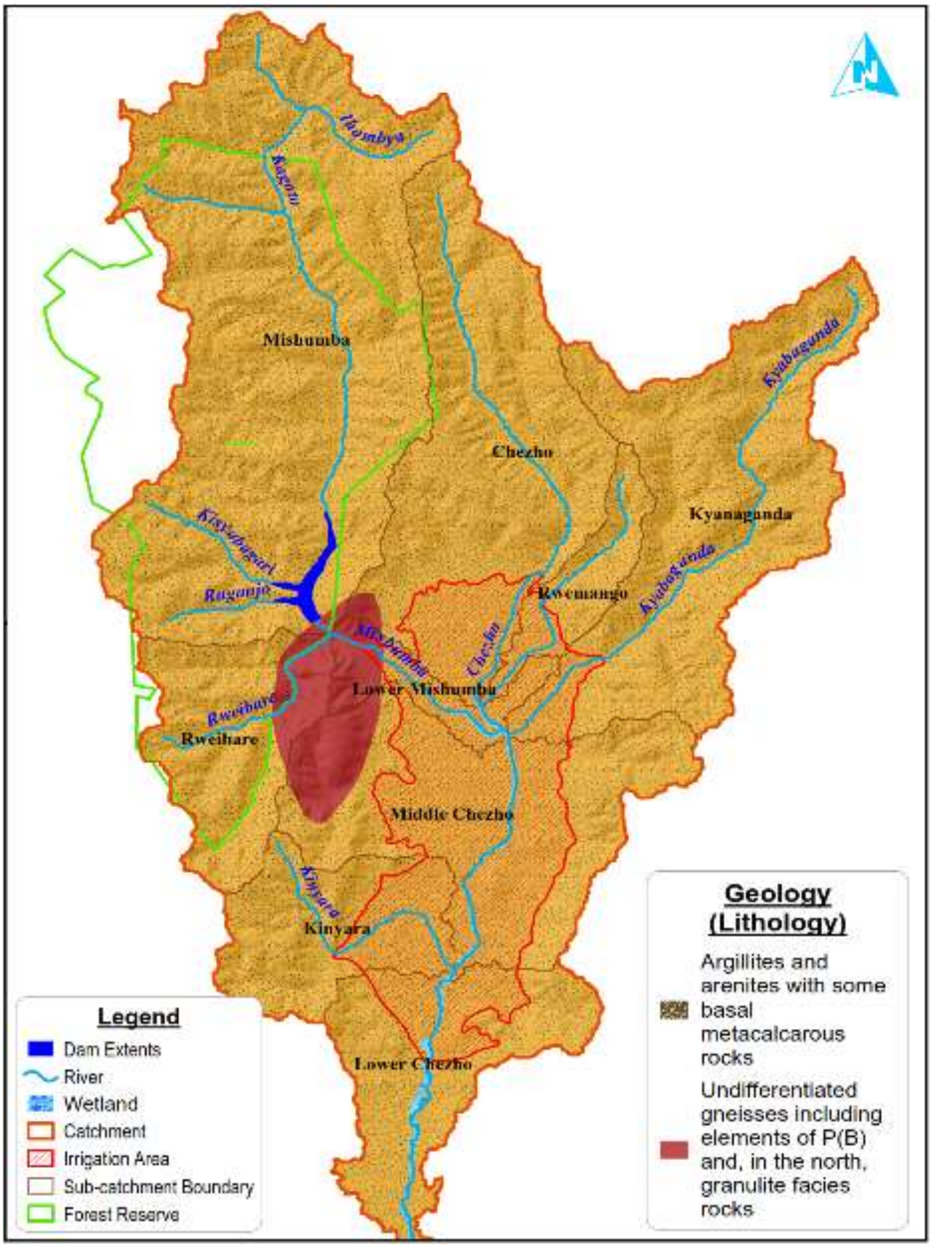


Figure 4-4: Geological formation of the project area

4.1.4 Soils

The dominant soils within the catchment area are Dystric Rego sols that range from shallow, medium- to fine-textured, unconsolidated parent material that may be of alluvial origin and by the lack of a significant soil horizon (layer) formation because of dry or cold climatic conditions. There are Lixic Ferralsols which include very shallow soil over hard rock or highly calcareous material, or deeper soils that is extremely gravelly and/or stony. The dominant soils within the irrigation area are Lixic Ferralsols which cover extensive areas on the flat, generally well drained area. They are strongly weathered, and tend to be associated with old geomorphic surfaces. Many Ferralsols have stable micro-aggregates which explain the excellent porosity, good permeability and favorable infiltration rates. A small but long stretch along the river is formed by the Gleysols under waterlogged conditions produced by rising groundwater (**Figure** 4-5**).** Therefore, the general area is formed of yellowish red clay loams, red sandy clay loams, yellowish red loams and sandy loams with occasional soft laterite and finally the dark brown sandy loams over dark grey clays which fall under the Bugamba Catena, Rugaga Series, Mbarara Catena and Partly Bukora Series.

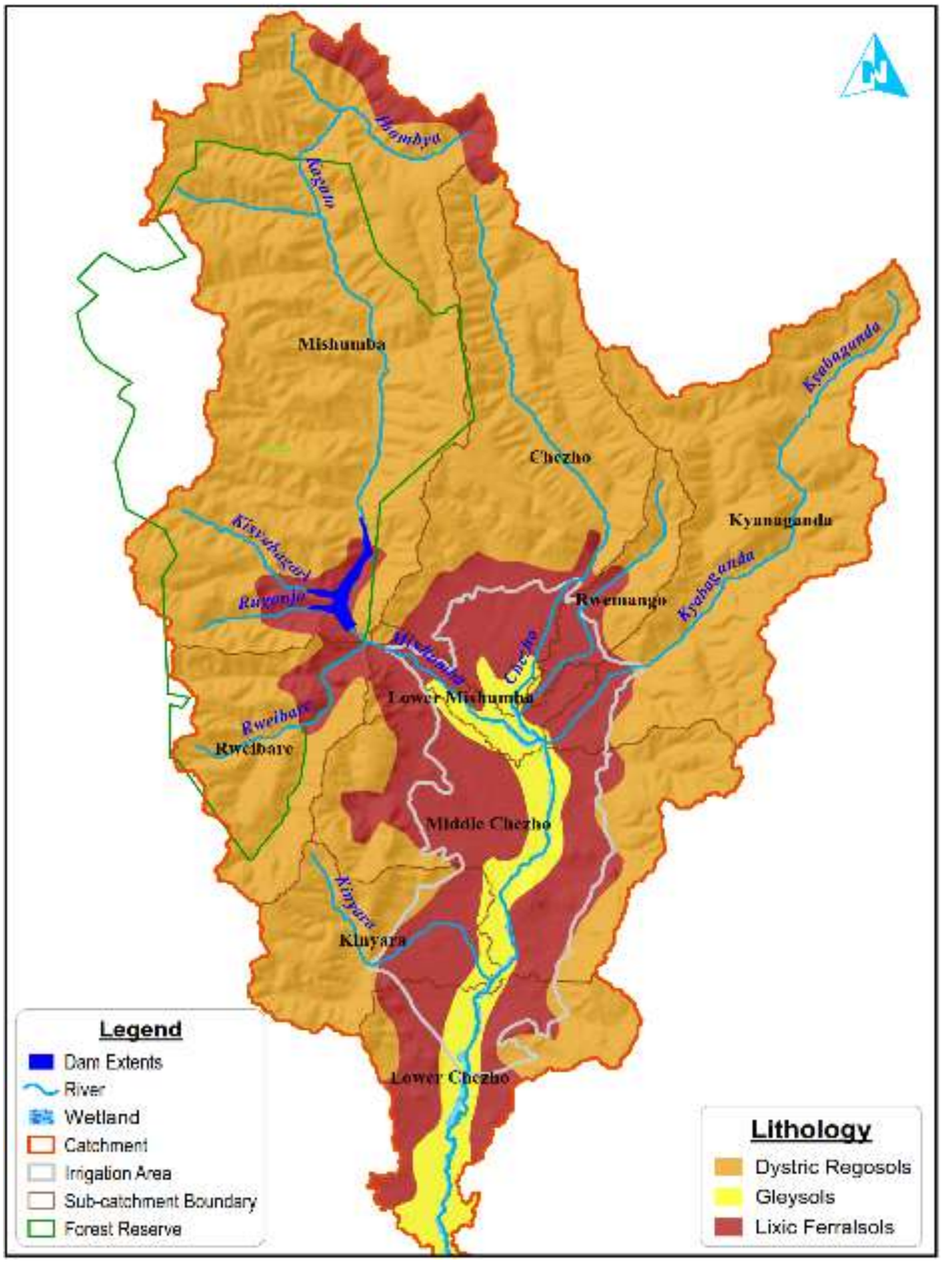


Figure 4-5: Soil formation and classification of the project area

4.1.5 Hydrology

4.1.5.1 Overview of Mishumba Catchment Hydrology

Mishumba catchment has three major sections including the upstream (area before the reservoir and the reservoir); midstream (downstream of dam site, the entire irrigation area and tributaries that join the R. Mishumba within the irrigable area); and downstream (areas after irrigation command area and before crossing the Kikagati-Ntungamo murram road). The catchment was subdivided into 9 sub-catchments based on the main river stem and its tributaries Table 4-1 and Figure 4-8

Table 4-1: Sub-catchments, Rivers and Streams in Mishumba Catchment

SN	Sub-catchment	Contributing Rivers/Streams	Catchment Area (km^2)	Rivers or Streams Length (km)
1	Mishumba	Mishumba, Kisyabagari and Rugonjo	90	45.94
2	Kyabaganda	Kyabaganda	45	23.82
3	Rwemango	Rwemango	7.1	6.30
4	Chezho	Chezho	45.1	30.71
5	Rweibare	Rweibare	19.1	10.07
6	Lower Mishumba	Mishumba and Chezho	6.5	6.28
7	Middle Chezho	Chezho	38.7	21.42
8	Kinyara	Kinyara	18	9.67
9	Lower Chezho	Chezho	23.5	16.38

The monthly runoff records for R. Mishumba at the proposed dam location exhibit a bimodal variation with two peak flows in April and October of 0.8m^3/s and 0.89 m^3/s, respectively. The Mean Annual Flow (MAF) is 0.51 m^3/s whose catchment area size is about 90 km^2 (Figure 4-6). The month with the lowest flow is July with a flow of 0.12 m^3/s. June, July and August record flows representing 24% of the MAF. Based on the data series, the river sometimes dries up in the dry months of July and August, and February and September. Flow in the months of September-November is more variable than during the other months. The maximum flows, that lead to flooding, are most likely to occur during the months of September - December.

Mishumba River has its first tributary as River Rweibare with a catchment area of 20km^2 and flow of about 0.11 m^3/s whose confluence is just downstream of dam site i.e., Rweibara tributary which contributes about 18.03% of the 0.61 m^3/s Average Annual Flow (AAF) of Mishumba River at the confluence. This means that Mishumba and Rweibare contribute about 36% of the total flow at main outlet (at sampling point 24). It has it's major confluences about 5.8 km and 6.0km with River Chezho (combining Chezho and Rwemango) and River Kyabaganda respectively. These tributaries have catchment areas of 54km^2 and 45km^2 respectively. The combined flow of Mishumba, Chezho and Rwemango Rivers is about 56.7% of the total flow at the confluence. Kyabaganda junction flows at a MAF of 0.66 m^3/s and the total downflow downstream of this junction is about 1.408 m^3/s. The flows from these tributaries contribute significantly to satisfy the downstream water demands. Figure 4-7 is a schematic representation of Mishumba Catchment, River Mishumba and its tributaries.

Consequently, the flow that joins the river at Kyabaganda is much more than the flow from River Mishumba. This flow all together combines to provide a MAF of 1.69 m^3/s at the outlet of the catchment (Site 24). This implies that the area in the midstream (mainly the irrigable area) contribute about 0.28 m^3/s of the MAF from baseflows to obtain the overall flow obtained at Kikagate – Ntungamo murram road point (Figure 4-8).

It can therefore be safely stated that, the influence of the dam on the environmental and low flows becomes insignificant downstream of the Kyabaganda junction. Therefore, the hydrological study on the e-flows concentrated on the river stretch between the dam site and the Kyabaganda junction where flow is significantly impacted upon by the operations of the reservoir.

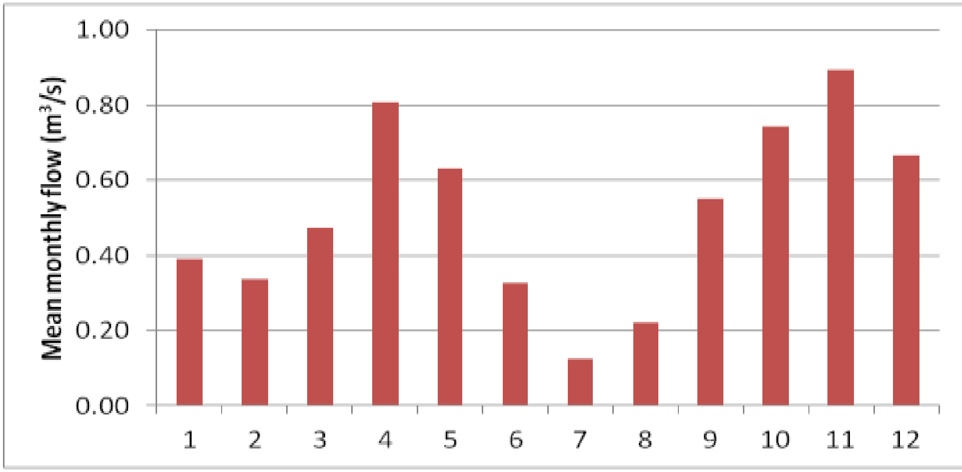


Figure 4-6: Mean Monthly flows of the River Mishumba

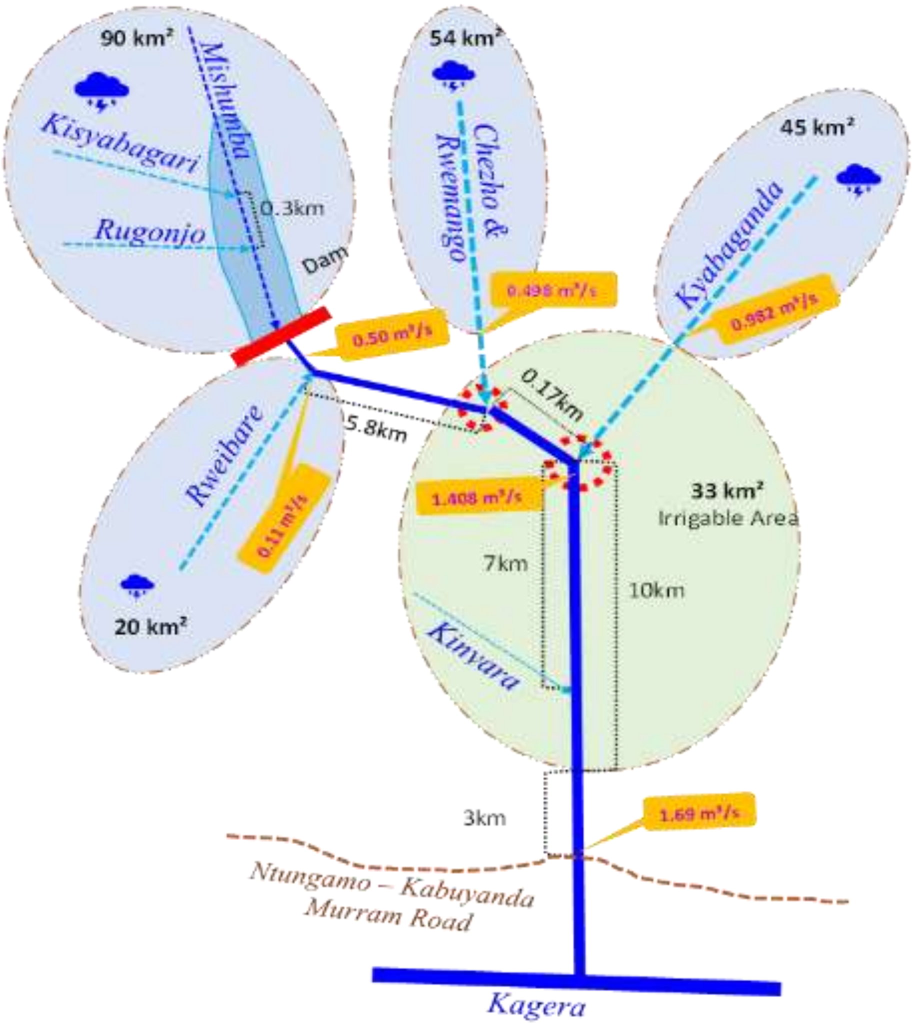


Figure 4-7: Schematic representation of Mishumba Catchment, River Mishumba and its tributaries.

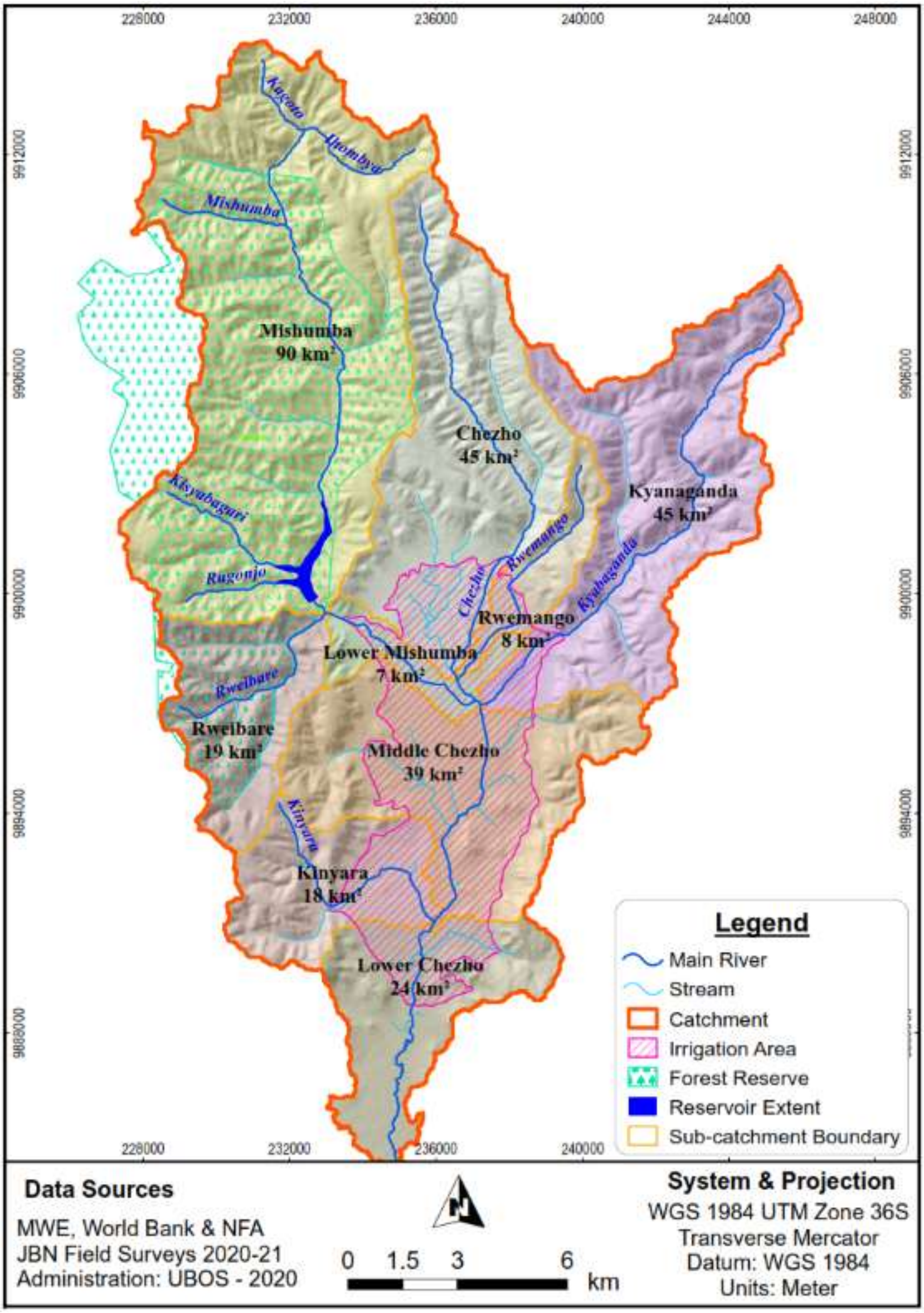


Figure 4-8: Mishumba Catchment and its Sub-catchments

4.1.5.2 Hydrological stream flows River Mishumba

Satisfactory discharge data of Mishumba river stream gauging station (UTM, WGS84: E 232641, N 9899764) i.e., just downstream of the dam site was not available necessitating outsourcing data from existing sources to assess the river flows. Therefore, the input data for the hydrological assessment were acquired from discharge records of the hydrological report (Final Design Report, MoWE 2019). This historical annual flow data from 1950 to 1995 for Mishumba was used as the basis for the flow timeseries (**Table 7-1**). **Figure** 4-9 shows the historical trend of mean annual flows for Mishumba obtained. The overall mean discharge of Mishumba between 1950 and 1995 is 0.516 m^3/s. The lowest and maximum flows were 0.365 m^3/s and 0.738 m^3/s with a standard deviation of 0.0973. **Figure** 4-10 shows the temporary gauge downstream of the proposed dam site on River Mishumba.

Table 4-2: Mean annual flows for Mishumba River

Year	Mean		Year	Mean		Year	Mean		Year	Mean
1950	0.4		1962	0.61		1974	0.54		1986	0.48
1951	0.74		1963	0.66		1975	0.54		1987	0.37
1952	0.39		1964	0.52		1976	0.51		1988	0.63
1953	0.56		1965	0.38		1977	0.63		1989	0.47
1954	0.4		1966	0.48		1978	0.41		1990	0.45
1955	0.61		1967	0.42		1979	0.51		1991	0.46
1956	0.43		1968	0.5		1980	0.41		1992	0.37
1957	0.64		1969	0.52		1981	0.54		1993	0.71
1958	0.58		1970	0.55		1982	0.45		1994	0.69
1959	0.48		1971	0.5		1983	0.48		1995	0.59
1960	0.49		1972	0.58		1984	0.38			
1961	0.6		1973	0.59		1985	0.39			

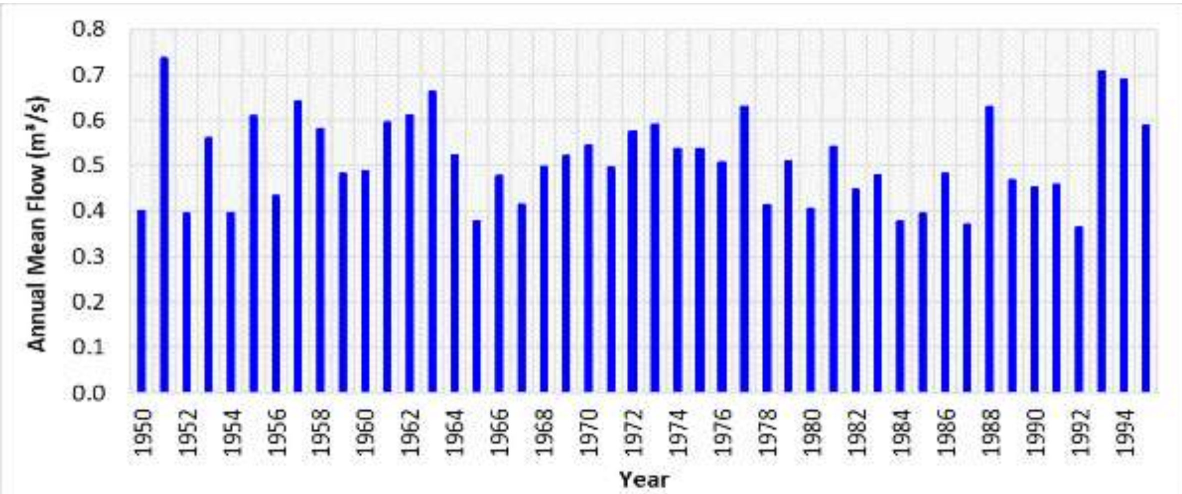


Figure 4-9: Trend of annual mean flow for River Mishumba[4]

[4] Final Design for Kabuyanda Irrigation scheme in Isingiro District 2019

Figure 4-10: Temporary gauging station along R. Mishumba (36 M E 232879, N 9899582) downstream of the dam site and its current status

4.1.5.2.1 Stream flow data analysis

During the data screening and checking processes for the general trend using Mann-Kendell and Sen's slope analysis **(Figure** 4-11**)**, obtained flow data did not indicate any significant trends (**Table** 4-3 and **Table** 4-4). This could be confidently used in the timeseries analysis of the field measured data. Therefore, the hydrological flow data from the main study and data collected from the field was used in the analysis of the e-flows in **Chapter 5**.

Table 4-3:Mann-Kendall trend test analysis results showing no significant trend

Mann-Kendall trend test (S)		
n	Test Z	Significance
46	0.41	No

n – number of data points and Z - quantile of the standard normal distribution

Table 4-4: Sens slope estimate showing a slope of zero

Sen's Slope estimate				
m	m (min 99)	m (max 99)	C (min 99)	C (max 99)
0.00	-0.015	0.025	2.07	1.3

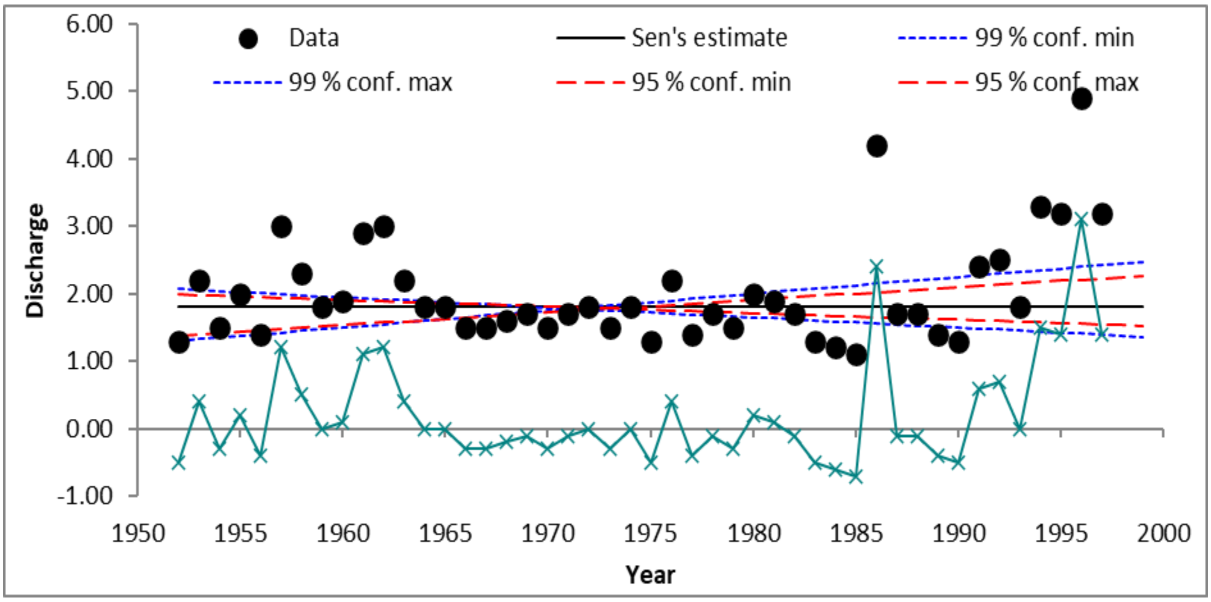


Figure 4-11: Graph showing the estimated fitting of the Sen's slope and the 99% and 95% confidence intervals

4.1.5.2.2 Flow Duration Analysis (FDC)

Figure 4-12 below is a graph of the flow duration curve (FDC) for the data at the proposed dam site. This shows the discharge versus percent of time that a particular discharge is equaled or exceeded a specified value of interest. Therefore, important values derived from the flow duration curves are as follows: that a particular discharge was equaled or exceeded

Percentage Time	99%	90%	50%	25%	15%	10%	5%
Flow Rate (m³/s)	0.0	0.1	0.5	0.8	1.0	1.1	1.4

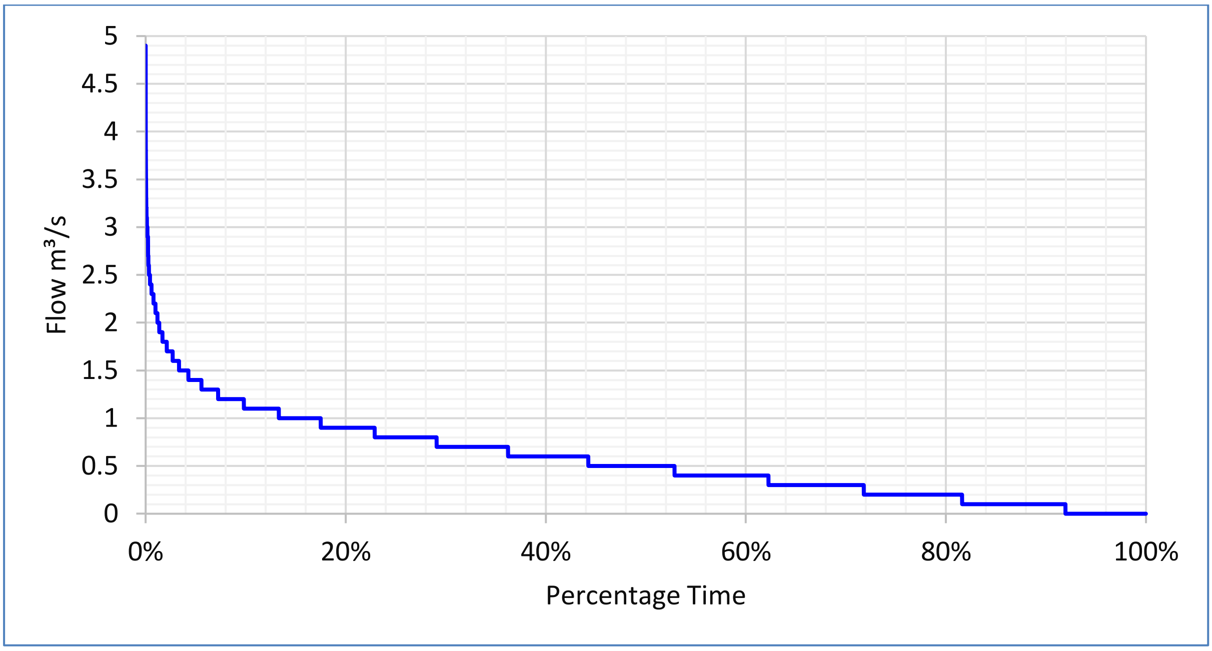


Figure 4-12: Flow duration curve of the Dam site data

4.1.5.2.3 Extreme value analysis

The analysis of extreme value analysis was undertaken by fitting the data to different distributions. The estimation of discharges at different return periods was estimated using the LP III distribution which fitted the data the most. The results from the estimations are in **Table** 4-5 below.

Table 4-5: Discharges at different return periods estimated using the LP III distribution

T (yrs.)	K	S	$\bar{X}$ [m³/s]	X [m³/s]	Y [m³/s]
2	-0.148	0.1452	0.278	0.25651	1.81
5	0.769	0.1452	0.278	0.389659	2.45
10	1.339	0.1452	0.278	0.472423	2.98
25	2.018	0.1452	0.278	0.571014	3.72

T – Return Period (yrs.), K - Frequency Factor (a function of return period and skew coefficient), S – Standard deviation of annual peak discharge, $\bar{X}$ *- Average of annual peak discharge, and Y – Predicted discharge at return period*

4.1.5.3 Discharge or flow measurements

Stage discharge measurements were carried in both wet and dry seasons at the same selected sites. The records included all hydrological statistics to information on local hydraulic conditions of every site/section that allows river scientists to understand why river features and species occur where they do. Several cross-sections were surveyed at each site, and stage discharge data recorded over a range of flows as summarized in the **Table** 4-6. These were used to calibrate a hydraulic model, which was in turn used to derive statistics of depths, velocities and other relevant parameters for each cross-section, at any discharge within a named range. **Figure** 4-13 shows pictures of the activities perform while carrying out stage discharge measurement at different cross-sections in the same catchment. **Figure** 4-14 shows the stage discharge measurement points for the wet (Nov. 2020) and dry (Feb. 2021) season carried out along River Mishumba. This data was further used for catchment hydraulic modelling.

Figure 4-13: Stage discharge measurement at different sampling sites in Mishumba catchment

Table 4-6: Summary of stage discharge at hydrological sampling points

DISCHARGE SUMMARY – NOVEMBER, 2020										
Cross Section	River/tributary /Stream Name	Date	Coordinates		Total Q (m^3/s)	Mean Velocity (m/s)	Width (m)	Area (m^2)	Mean Depth (m)	Cross-Section
			Lat	Lon						
Point 1	Mishumba	18/11/2020	-0.8636	30.6037	0.221	0.380	1.30	0.58	0.45	Mid-point (upstream of dam)
Point-1-1	Mishumba	18/11/2020	-0.8638	30.6039	0.023	0.048	1.90	0.48	0.25	Mid-point (upstream of dam with no flow, ponding water)
Point-2	Mishumba	18/11/2020	-0.8783	30.5989	0.332	0.945	1.15	0.35	0.31	Mid-point (upstream of point 3)
Point-3	Mishumba	18/11/2020	-0.8945	30.5970	0.301	0.518	2.20	0.58	0.26	Mid-point (upstream of point 6)
Point-4	Kisyabagari	19/11/2020	-0.8966	30.5851	0.042	0.359	0.80	0.12	0.15	Upstream of point 6
Point-5	Rugonjo	19/11/2020	-0.9014	30.5882	0.011	0.160	0.90	0.07	0.08	Upstream of point 6
Point-6	Mishumba	19/11/2020	-0.9009	30.5964	0.500	0.525	3.68	0.81	0.22	Mid-point (upstream of point 8)
Point-7	Rweibare	19/11/2020	-0.9131	30.5950	0.110	0.338	1.30	0.16	0.12	Upstream of point 8
Point-8	Mishumba	19/11/2020	-0.9088	30.6007	0.475	0.743	1.40	0.64	0.46	Downstream of point 6 (after confluence with Rweibare)
Point-9	Kyabaganda	24/11/2020	-0.9009	30.6734	0.965	1.038	2.00	0.95	0.47	Upstream of point 10
Point-10	Kyabaganda	24/11/2020	-0.9142	30.6577	0.982	1.473	1.45	0.66	0.45	Mid-point (upstream of point 16)
Point-11	Chezho	20/11/2020	-0.8899	30.6492	0.281	0.871	1.10	0.32	0.29	Upstream of point 13
Point-12	Rwemango	20/11/2020	-0.9124	30.6439	0.061	0.658	0.80	0.09	0.12	Upstream of point 13
Point-13	Chezho -2	20/11/2020	-0.9255	30.6327	0.498	0.115	10.30	4.32	0.42	Upstream of point 16 (after confluence with Rwemango)
Point-14	Mishumba	20/11/2020	-0.9186	30.6173	0.351	0.730	2.50	0.48	0.19	Mid-point (upstream of point 15)
Point-15	Mishumba	21/11/2020	-0.9278	30.6306	0.604	0.756	2.70	0.53	0.20	Upstream of point 16
Point-16	Chezho-3	21/11/2020	-0.9321	30.6380	1.408	0.363	8.00	3.88	0.49	Downstream of point 15 (Confluent of all tributary)
Point-24	Chezho-3 Out flow	22/11/2020	-1.0267	30.6183	1.688	0.399	7.30	4.23	0.58	Out flow to Kagera

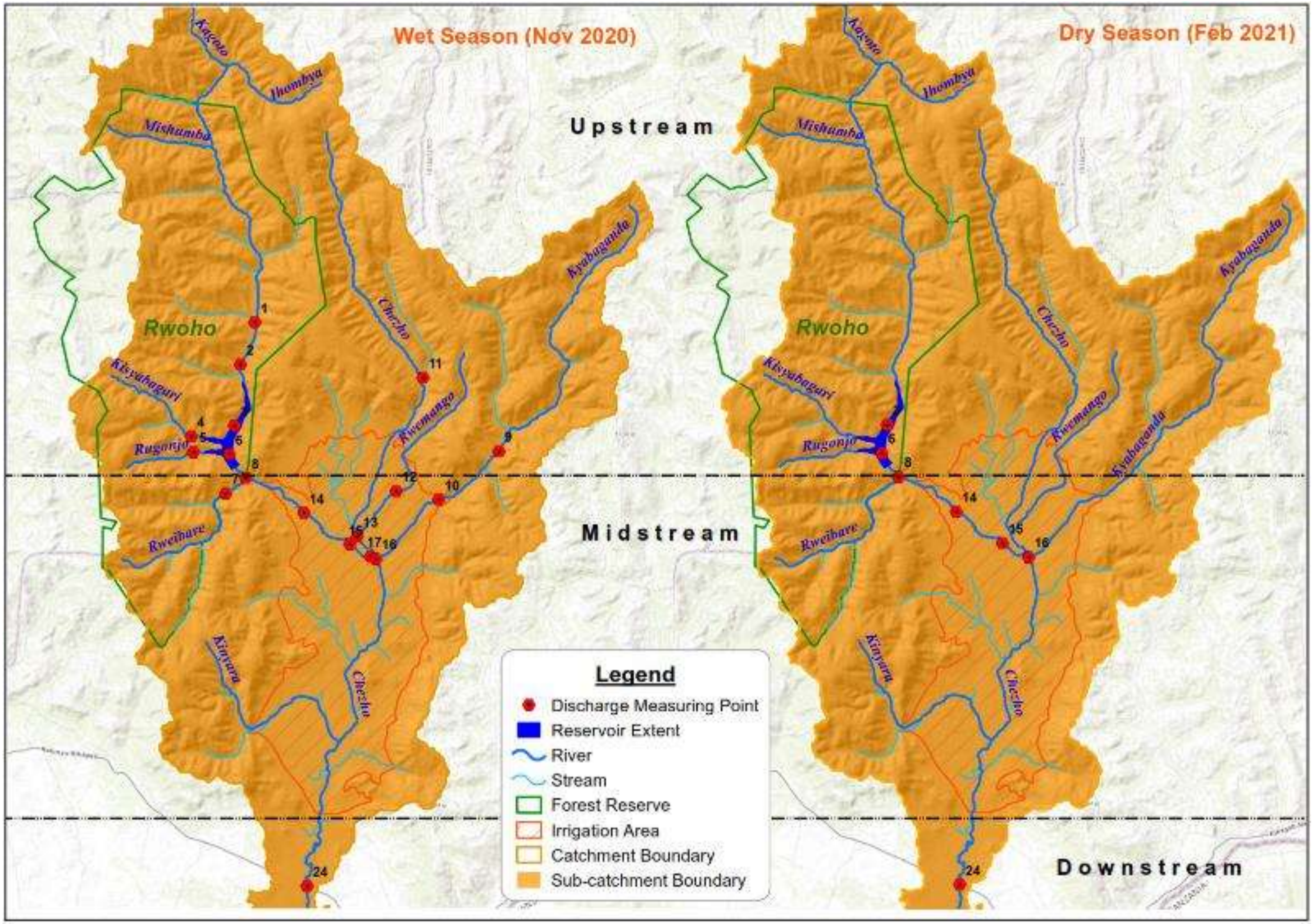
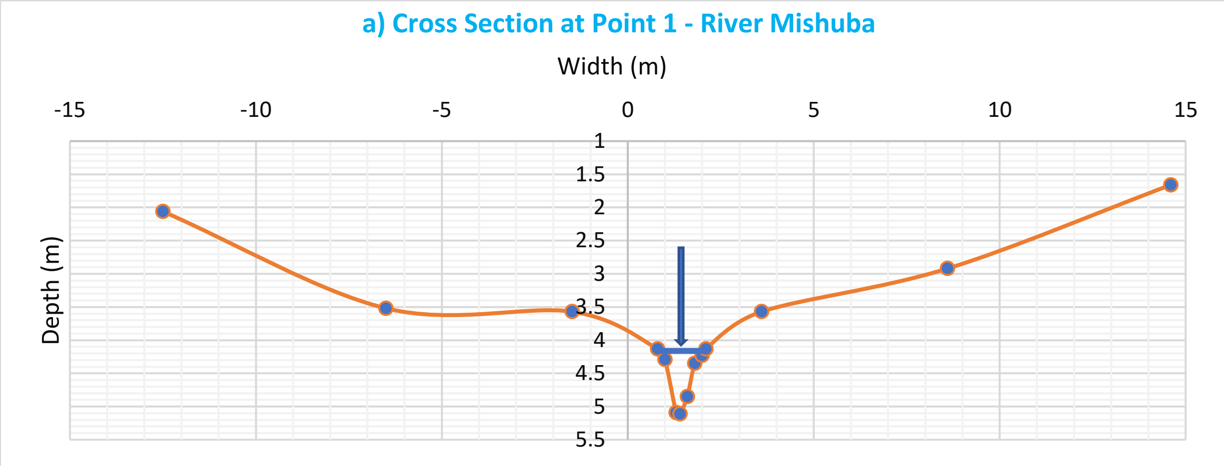
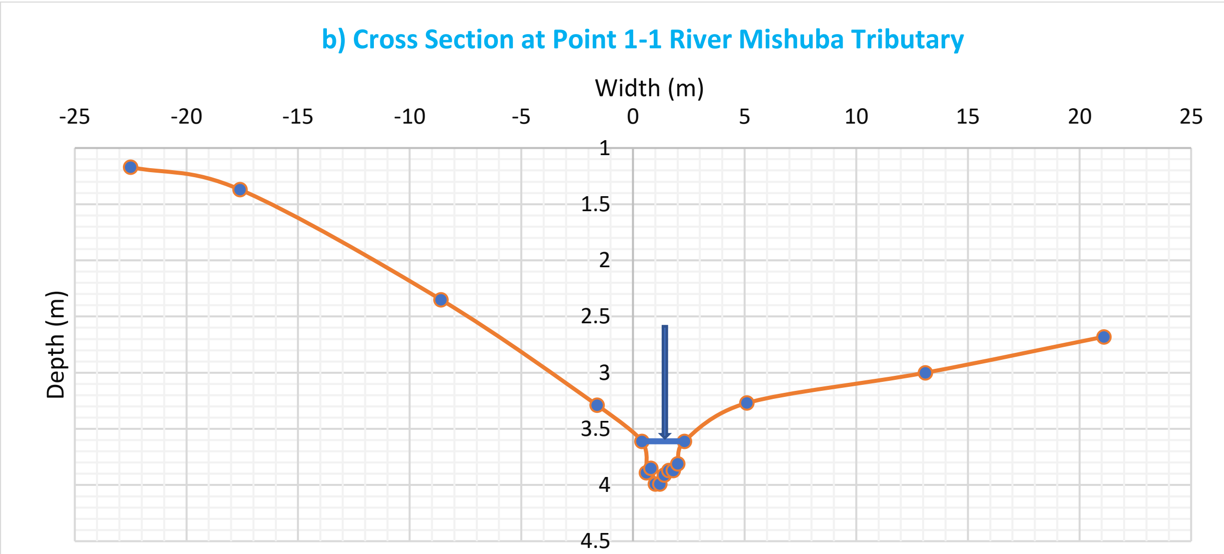


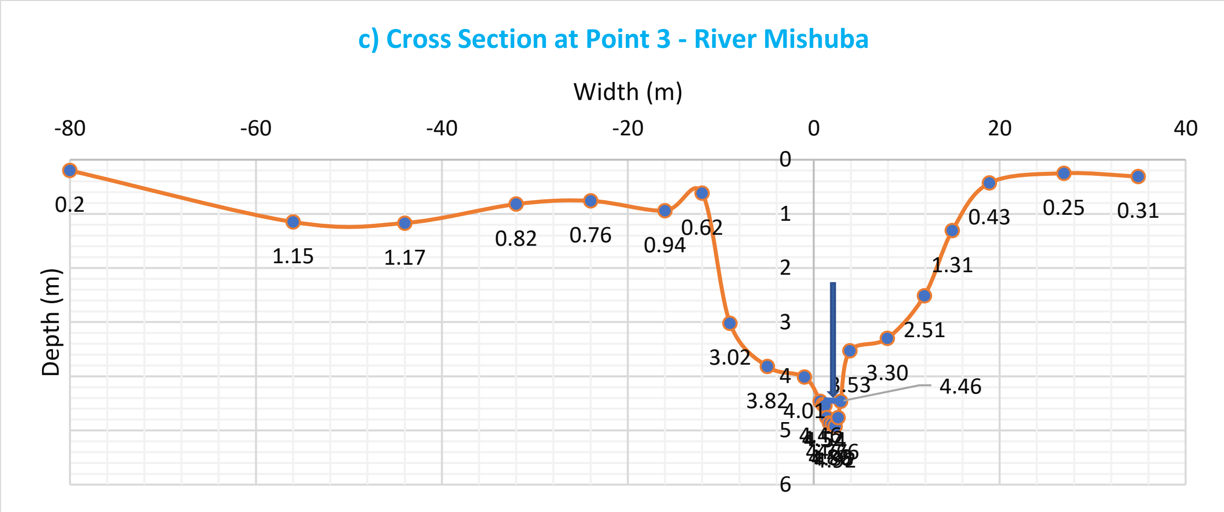
Figure 4-14: Hydrological sampled points of stage discharge in the wet (Nov 202) and dry (Feb 2021) seasons

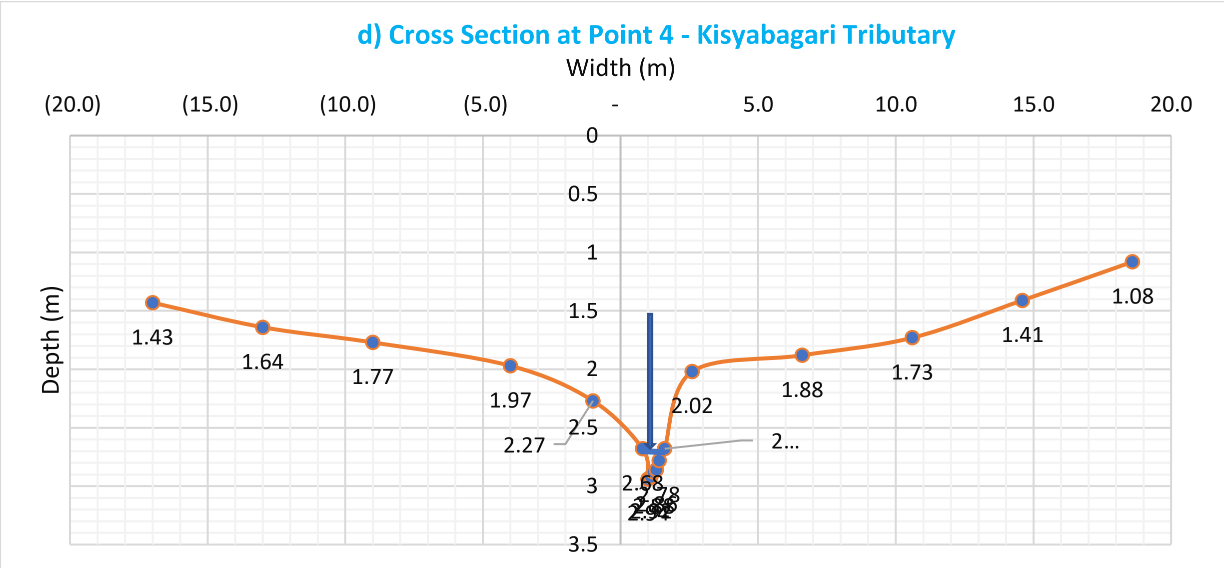
4.1.5.4 Cross-section and profile measurements

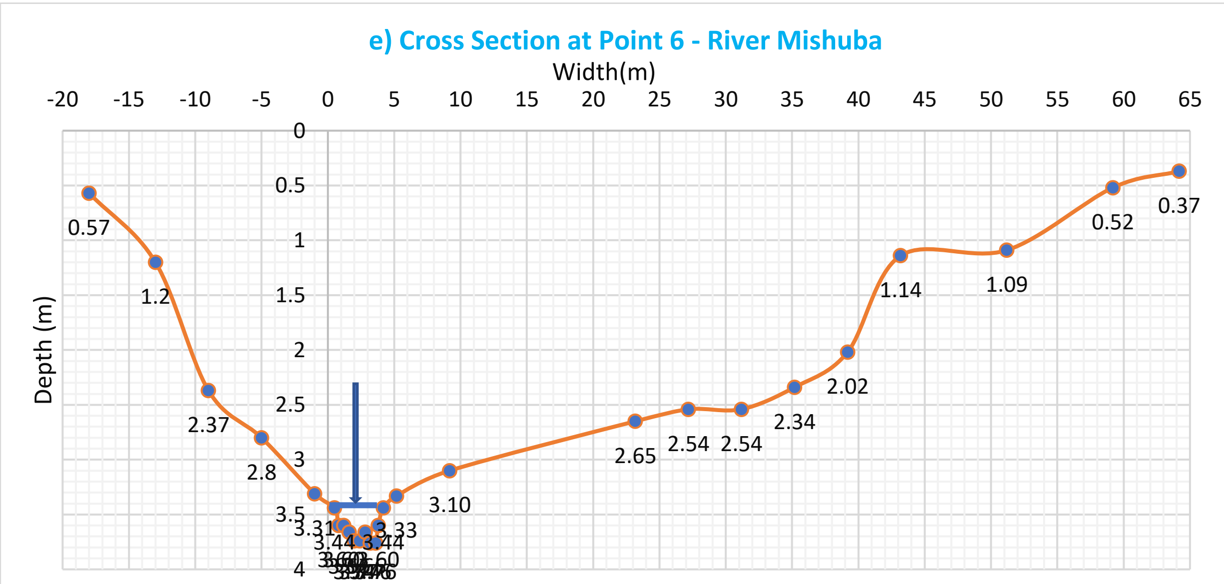
In addition to stage discharge measurement, a site cross-section was obtained covering both the wet and dry profiles **(Figure** 4-14**)**. They show the extent of each vertical zone, as well as any other features of interest. The range of inundated areas in the two low-flow seasons on either banks, and the levels reached by the size of flood. **Figure** 4-15 **(a – p)** show different cross-section results at selected sampling points.

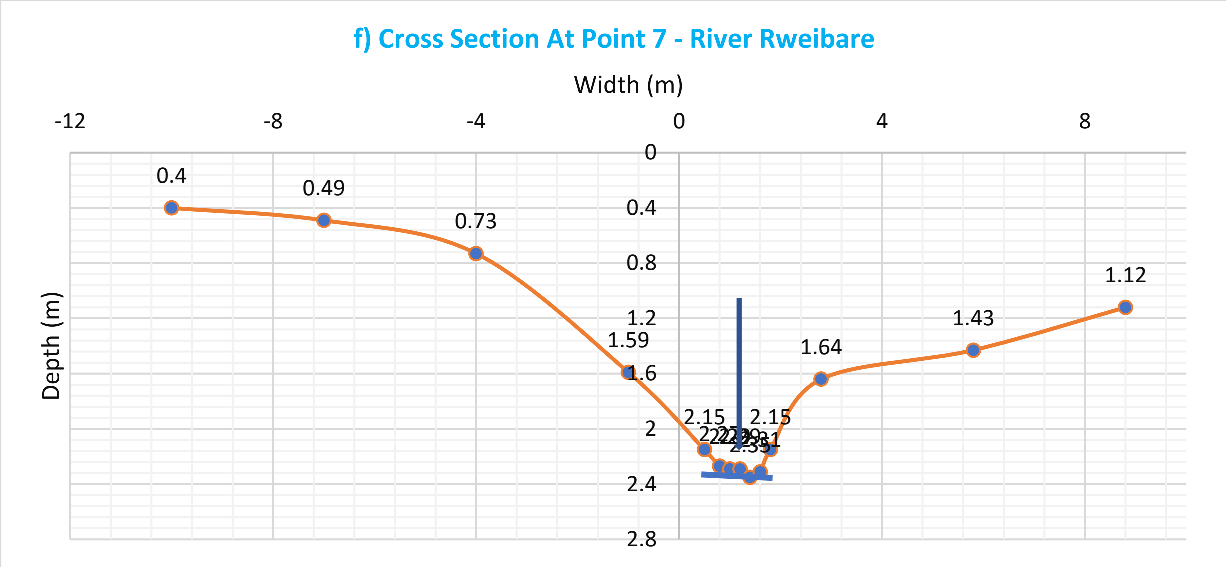


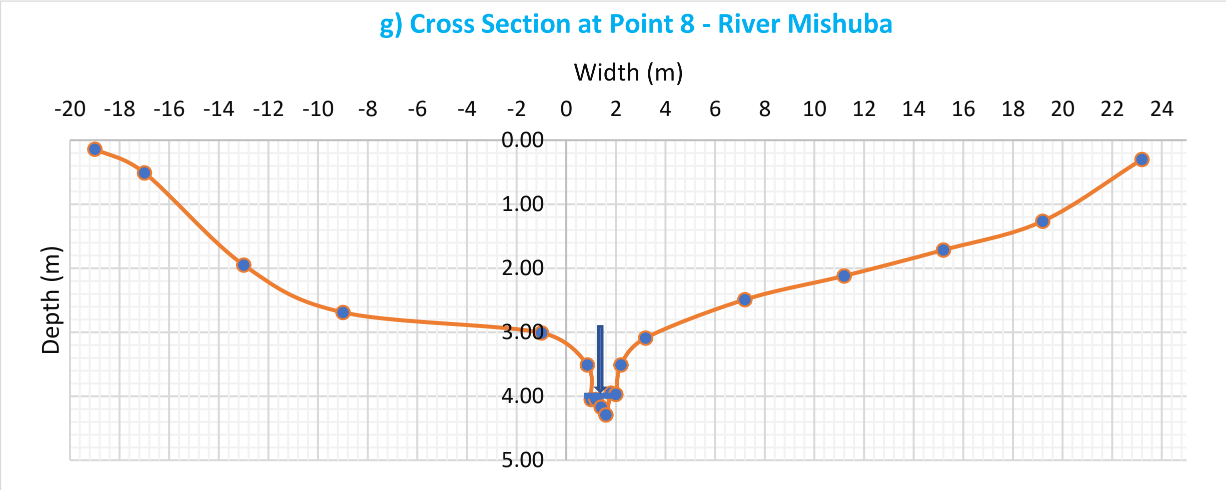


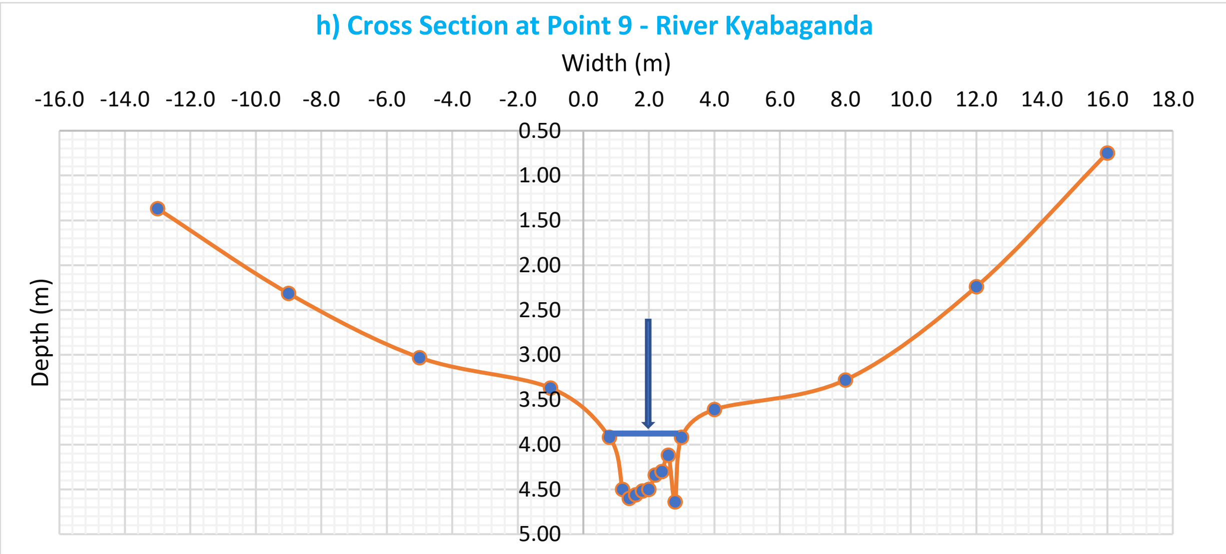

c) Cross Section at Point 3 - River Mishuba
Width (m)
-80
-60
-40
-20
0
20
40
Depth (m)
0
1
2
3
4
5
6
0.2
1.15
1.17
0.82
0.76
0.94
0.62
3.02
3.82
4.01
3.53
3.30
2.51
1.31
0.43
0.25
0.31
4.46

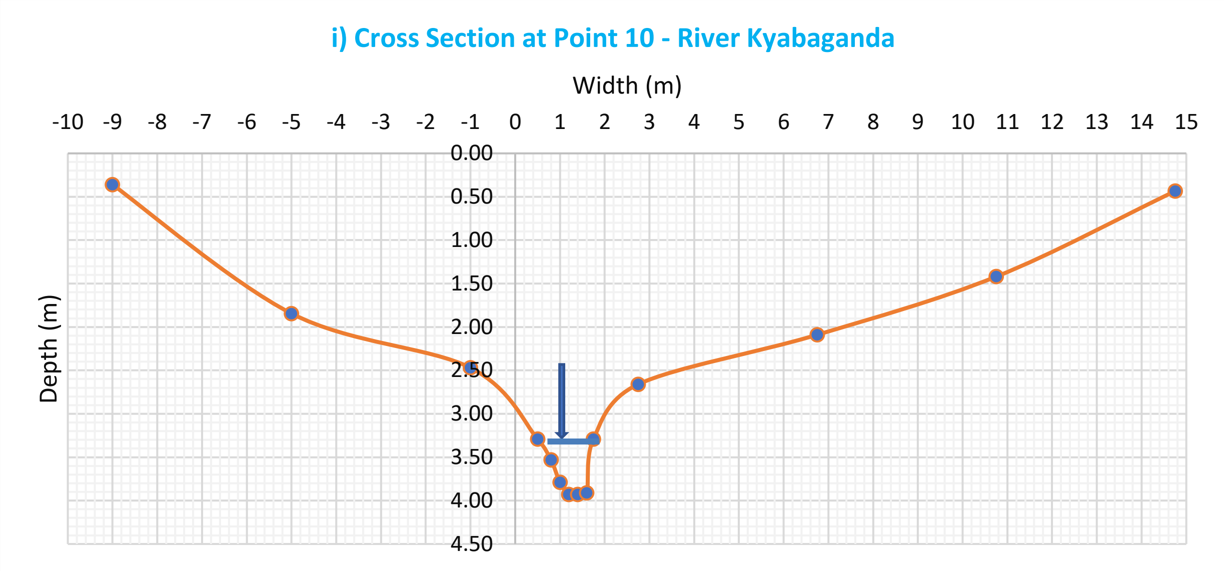

d) Cross Section at Point 4 - Kisyabagari Tributary
Width (m)
(20.0)
(15.0)
(10.0)
(5.0)
-
5.0
10.0
15.0
20.0
Depth (m)
0
0.5
1
1.5
2
2.5
3
3.5
1.43
1.64
1.77
1.97
2.27
2.68
2.02
1.88
1.73
1.41
1.08
2...

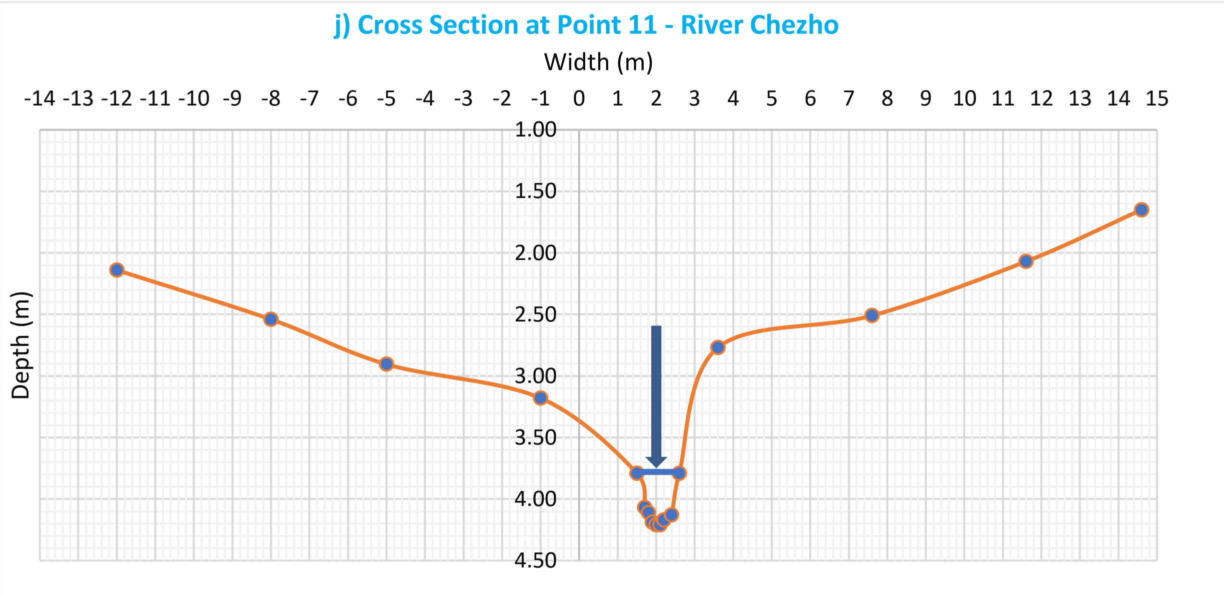

e) Cross Section at Point 6 - River Mishuba
Width(m)
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Depth (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
0.57
1.2
2.37
2.8
3.31
3.44
3.44
3.33
3.60
3.10
2.65
2.54
2.54
2.34
2.02
1.14
1.09
0.52
0.37

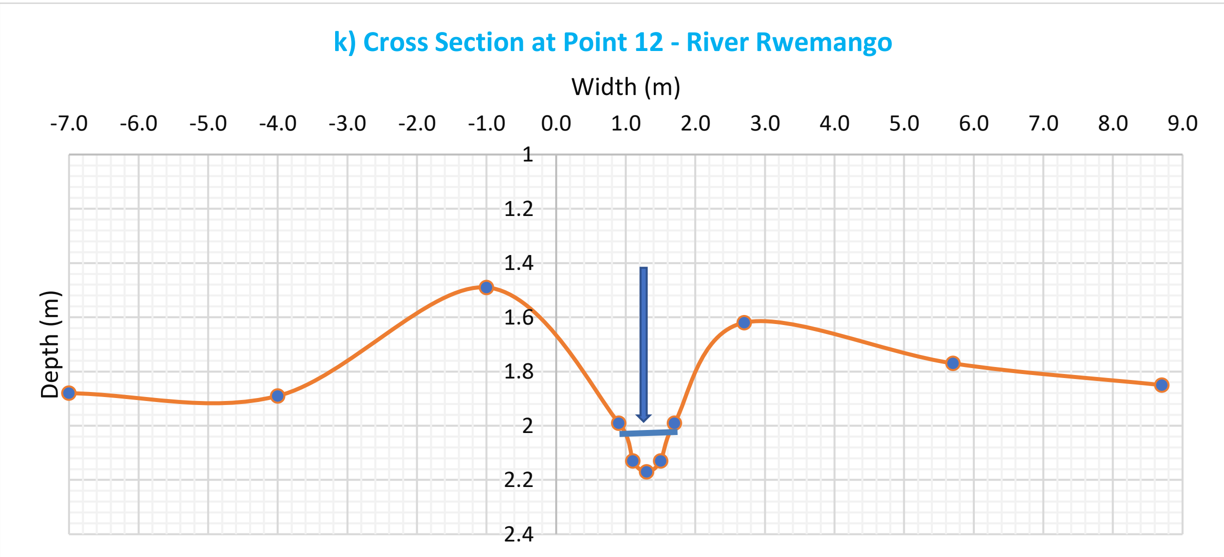

f) Cross Section At Point 7 - River Rweibare
Width (m)
Depth (m)
0.4
0.49
0.73
1.59
2.15
2.15
1.64
1.43
1.12

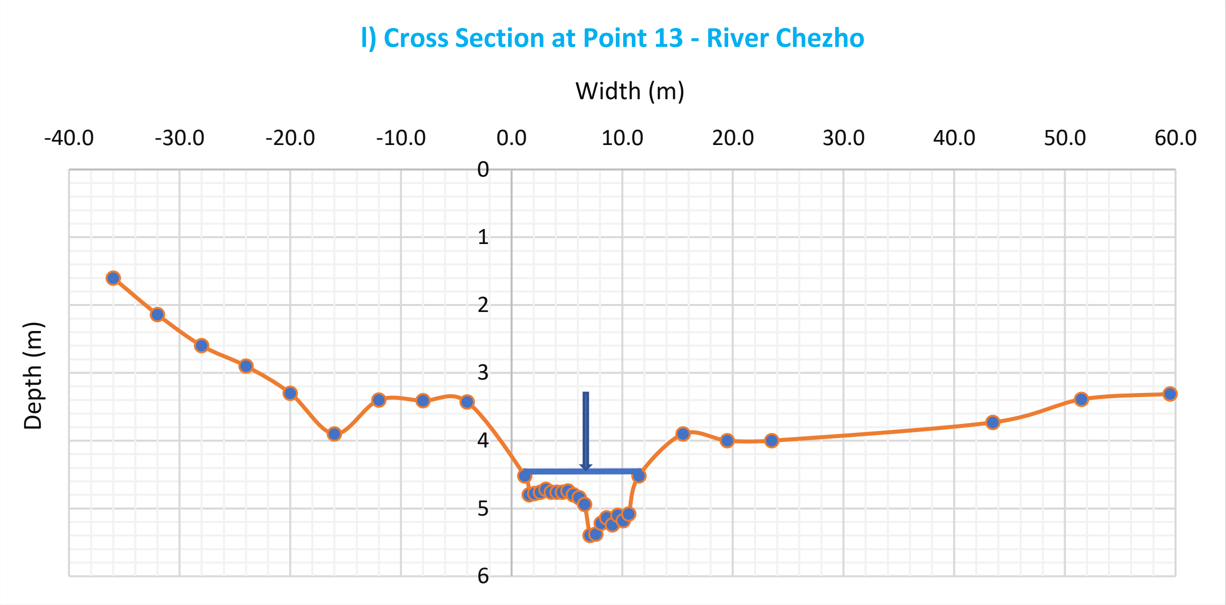

g) Cross Section at Point 8 - River Mishuba
Width (m)
Depth (m)

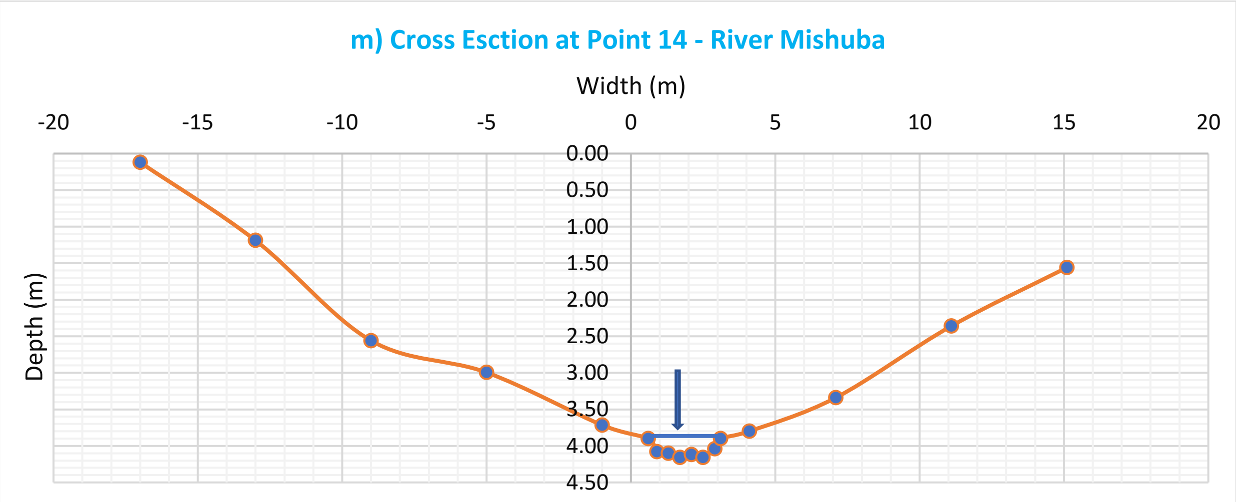

h) Cross Section at Point 9 - River Kyabaganda
Width (m)
Depth (m)

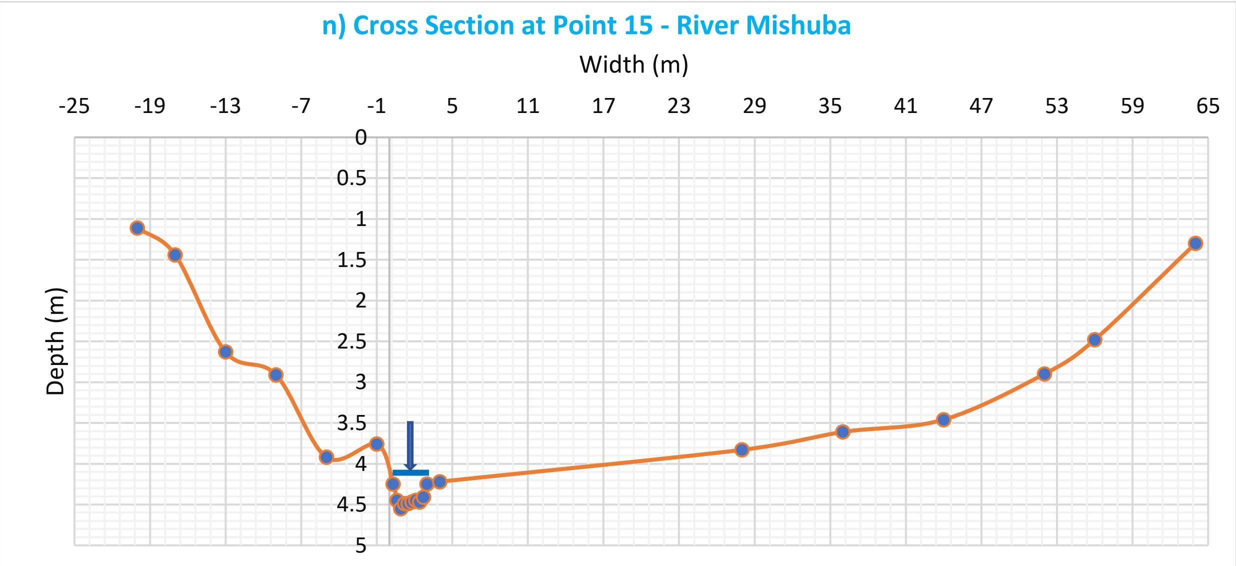

i) Cross Section at Point 10 - River Kyabaganda
Width (m)
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
Depth (m)

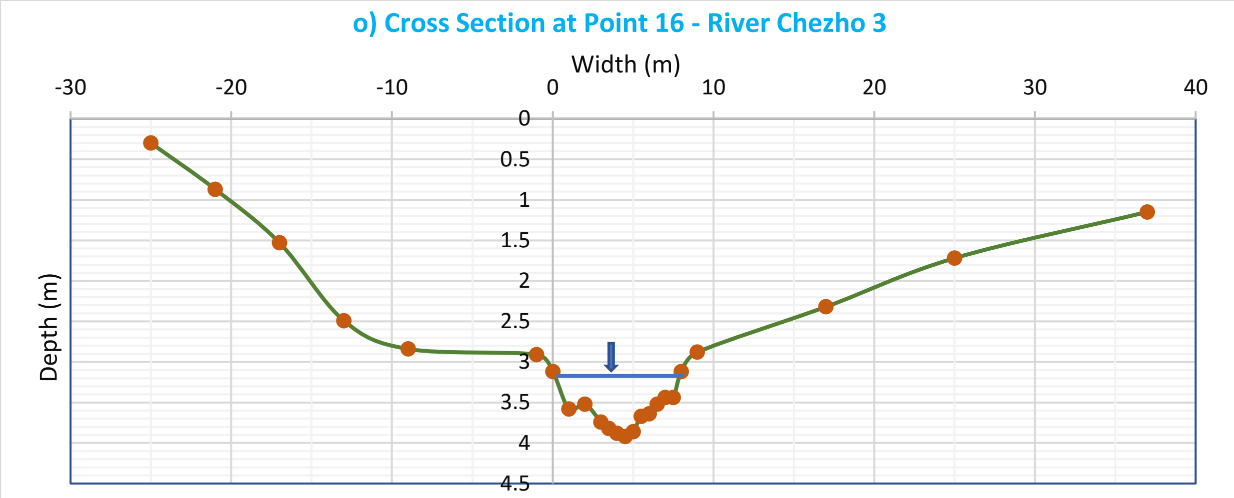

j) Cross Section at Point 11 - River Chezho
Width (m)
-14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
Depth (m)


k) Cross Section at Point 12 - River Rwemango
Width (m)
-7.0 -6.0 -5.0 -4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
1
1.2
1.4
1.6
1.8
2
2.2
2.4
Depth (m)


l) Cross Section at Point 13 - River Chezho
Width (m)
-40.0
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Depth (m)
0
1
2
3
4
5
6


m) Cross Esction at Point 14 - River Mishuba
Width (m)
-20
-15
-10
-5
0
5
10
15
20
Depth (m)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50


n) Cross Section at Point 15 - River Mishuba
Width (m)
-25
-19
-13
-7
-1
5
11
17
23
29
35
41
47
53
59
65
Depth (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5



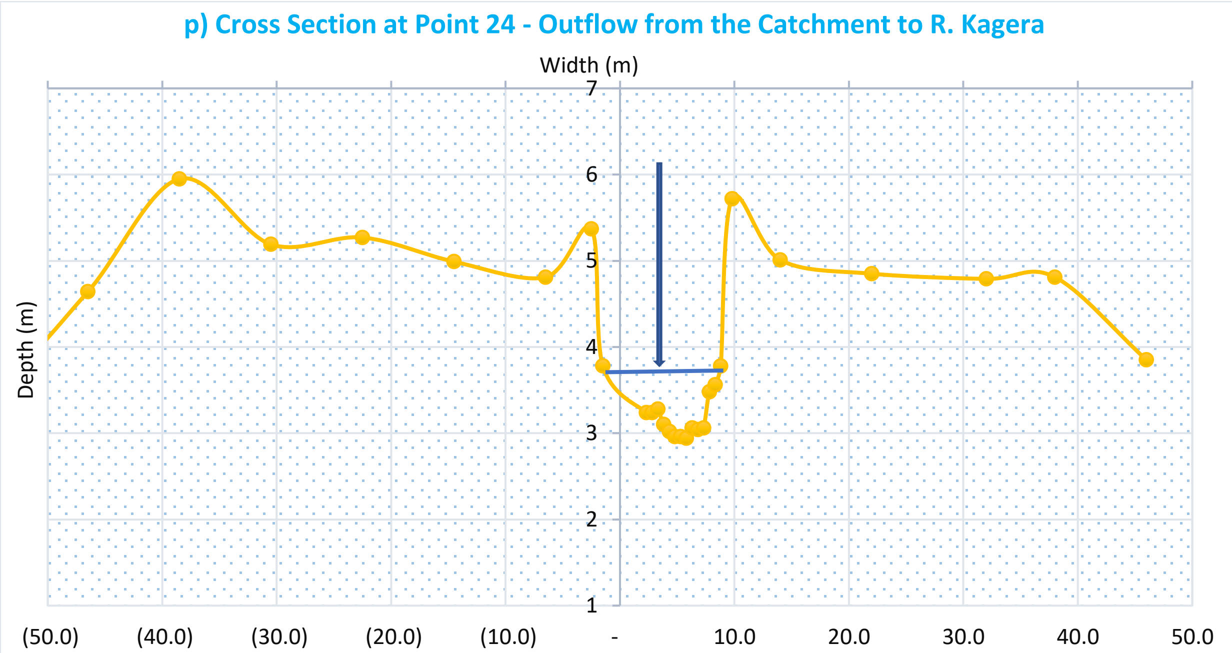


Figure 4-15: Cross-sections at different points measured along River Mishumba and its tributaries

4.1.5.5 Low and High flows along River Mishumba

The Mishumba catchment experiences both low and high flows during dry and wet seasons in a year due to the bi-modal pattern experienced in south western Uganda. During field surveys in the wet season (November 2020), it was found that most parts after the major confluence areas (in the command areas and downstream) is where high flows occur. This does not spare the murram roads and access roads hence, complicating the connection (access) between either side of the river due to raised water levels. However, during the dry season (February 2021), it was observed that flows reduce below the road surface levels at the same points of survey **(Figure** 4-16**).**

During the community consultations, it was noted that in May 2020, a severe flash flood hit Mishumba River which uprooted and washed away all the riverine vegetation cover (both instream and bank vegetation) leaving the ground bare and degraded. This exposed the shallow water levels and river banks due to washed away soils implying more sediment accumulation in the midstream and downstream. Most infrastructure at river crossing points e.g., bridges and culverts were washed away during the flood and temporary structures are now being used for crossing except at points 13, 15 and 25 (**Figure** 4-17**).**

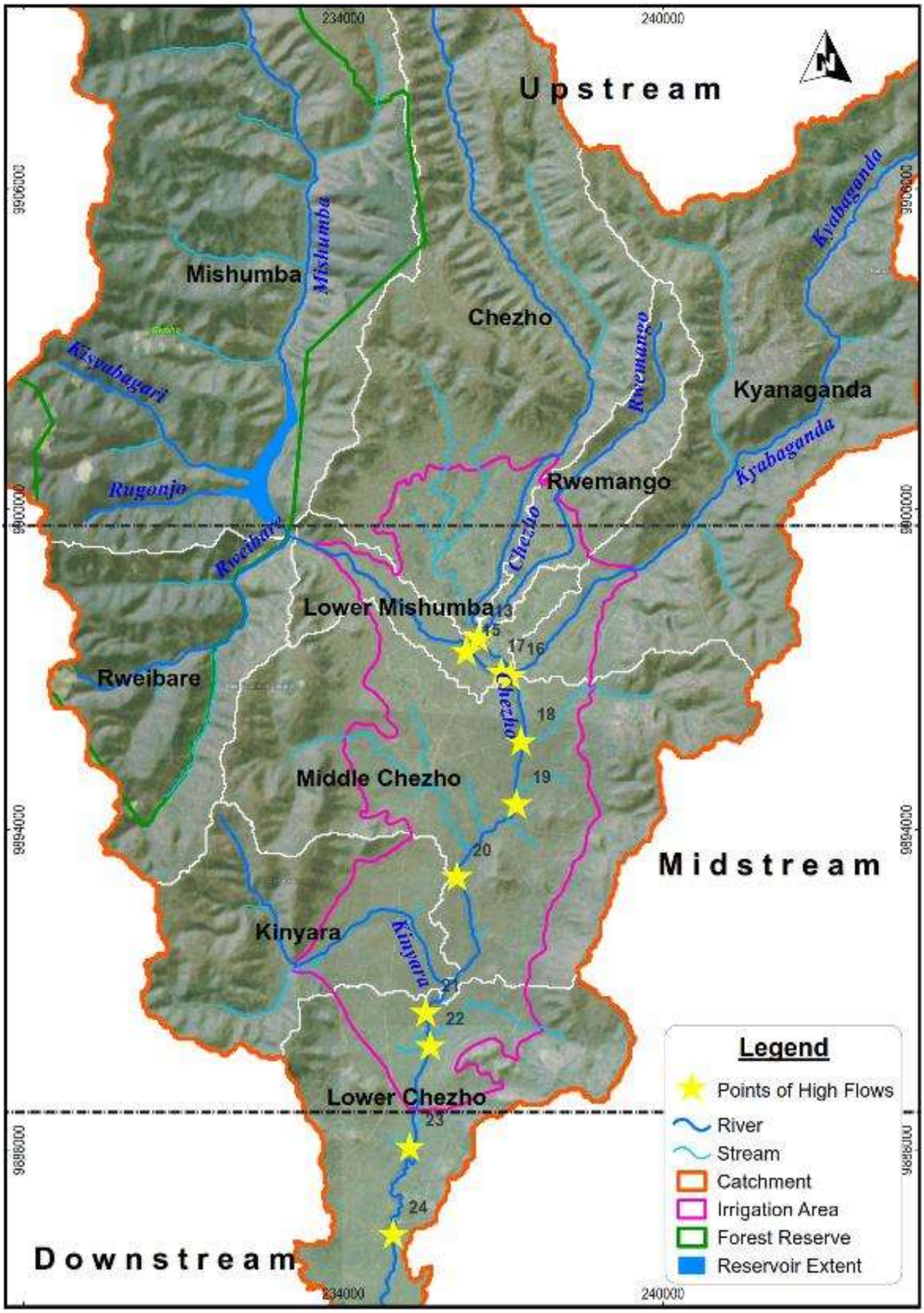


Figure 4-16: Map showing points where high and low flows are experienced along Mishumba in the midstream and downstream

	
High flow pulses and overbank flows at E237334, N9895669 (site 18)	Low flow pulses in the midstream at E237334, N9895669 (site 18)
	
High flow pulses and overbank flows at E237249, N9894498 (Site 19)	Low flow pulses in the midstream at E237249, N9894498 (Site 19)
	
High flow pulses and overbank flows at E236134, N9893128 (site 20)	Low flow pulses (dry season in Feb - Mar) at E236134, N9893128 (site 20)
	
Effects of high flows and overbank flows in the project area due to washing away of culverts (site 21)	Overbank flows along the Mishumba floodplains in the downstream leaving the banks bare (along site 19)

<table>
<tr><td></td><td></td></tr>
<tr><td>Figure 4-17: High flow pulses and overbank flows (wet season in Nov.) and low flows (dry season in Feb.-Mar.) in the downstream midstream and downstream areas. Upstream of the dam area along Mishumba</td><td>Upstream of the dam area along Mishumba</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Dam area (upstream) along Mishumba</td><td>Middle of the dam area along R. Mishumba</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Middle of the dam area along Mishumba</td><td>Middle of the dam area along Mishumba</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Towards the end of the dam area (after major confluence of Mishumba and Kisyabagari stream</td><td>Dam towards the confluence of Mishumba and Rugonjo stream</td></tr>
</table>

	
After the dam area and before the confluence of Mishumba and Rweibare stream	After the dam area at the temporary River Gaging Station (RGS)
	
At the confluence of Mishumba and Rweibare stream (after the temporary RGS)	After the confluence of Mishumba and Rweibare but before the Kanuyanda murram road
	
Culvert washed away by the floods (before the Kabuyanda murram road (irrigable area)	Floodplains nearby homes that were almost taken by May 2020 floods (irrigable area)
	
Floods cut -off the road during the rainy season and people cannot cross the river (midstream)	Floods cut -off the road during the rainy season and people cannot cross the river (midstream)

	
Floods cut -off the road during the rainy season and people cannot cross the river (midstream)	Part of the banana plantation washed away by the floods during rainy seasons (November) along Kyabaganda stream in the upstream.

Figure 4-18: Evidence of effects of high flows in Mishumba catchment

Section of River Mishumba in middle of the reservoir area

4.2 Biological environment

4.2.1 Limnology of Mishumba Catchment

4.2.1.1 Physical environment characterization

Table 4-7 gives the basic physical characteristics of River Mishumba at the different sampling sites surveyed **(Figure** 4-19**).** The River Mishumba waters had a temperature ranging from 20.4 °C in the upper reaches to 25.3 °C in the lower reaches in the dry season, and between 18.7 °C and 24.2 °C in the wet season. In the dry season, the water was found to be generally clearer than in the wet season, and of lower flow rate, while the conductivity at all sampling sites registered slight increase during the wet season. The salinity levels for a freshwater body remained significantly high, and this was attributed to presence of some rocks from which the river water flows and picking up salts which makes the water saline and hard. This was assessed at sampling points 9,10 and 12. The common fauna in this area are snakes, otters, water ducks and water insects including water skates, water bugs, dragon flies, earth worms. The River Mishumba can generally be said to be highly disturbed owing to the farming and mining activities in the area, cutting and clearing of the natural vegetation, and high level of siltation as shown by the level of turbidity and TDS at the different sampling sites.

Table 4-7: Summary of river habitat description of sampling sites along reaches of River Mishumba catchment.

Site ID [Name at river reach]	GPS Location (WGS 84)	Description of fish sampling sites according to the Building Block Methodology (BBM) following Jowett *et al.,* (2008)
Upper reaches (Upstream of the dam site)		
Nyakagoto Sampling site 1	S 0.863717 E 30.6034 Elev: 1391 m	• Sampling point 1 was approx. 2 km upstream of the proposed dam area; and sampling point 2 is about 0.5 km upstream of dam area. • Low flow conditions (shallow average 30 cm depth) and completely wadable across the channel by members of sampling team. • River zone: Runs through planted and managed forests. • Channel/substrate type: Single thread channel with mixed sand/silt and alluvium substrate. • Biotopes present: mainly riffles and runs (consisting largely of sand/silt/mud). • Vegetation: Largely unnatural vegetation (planted forests about 10 to 20 m from the channel on either side, with limited canopy cover and no invasive aquatic vegetation. • Land use: Forestry. Water abstraction for domestic use and as cattle watering point.
Kagara Sampling sites 2	S 0.87574 E 30.5993 Elev: 1385 m	
Proposed Dam site area and adjoining streams		
Kyamazinga Sampling site 3	S 0.893667 E 30.5975 Elev: 1366 m	• Areas has a confluence of the two streams, Rugonjo and Kisyabagari meeting with River Mishumba, a point considered to be the centre of the proposed dam site while.
Kisyabagari Sampling site 4	S 0.896624 E 30.5851	

	Elev: 1383 m	• 1000 m below this site the river has been impounded to create a dam and a fall for hydropower generation. • High flow conditions (r) and completely wadable across the channel by members of sampling team. • River zone: Upper foothill in a typical mountain torrent zone. • Channel/substrate type: Largely single thread channel but braided with typical exposed bars that are vegetated near the Bridge. Bedrock and large boulders characterize the river substrate at this section. • Biotopes present: Predominantly riffles and runs but with few isolated pools. • Vegetation: Stable riparian vegetation, higher canopy cover that provide appreciable shading to the Banks. No invasive aquatic vegetation. • Land use: Agriculture-livestock & crops, rural residential.
Rugonzo Sampling site 5	S0.901084 E 30.5857 Elev: 1388 m	
Sampling site 6	S 0.901783 E 30.596 Elev: 1356 m	
Lower reaches – immediate downstream of dam site)		
Rweibare Sampling site 7	S 0.913113 E 30.5949 Elev: 1373 m	• Areas has a confluence of Mishumba and Rweibare, a point considered to be downstream of the proposed dam site. • Fast flowing conditions and safely wadable across channel but with few deep pools of a more than meter deep. • River zone: Lower foothill with flat raised banks (0.3m to 0.8m) with evidence of erosion during high/bank full flows. • Channel/substrate type: Split thread of channels that collapse back into a single channel with predominantly silt substrate. • Biotopes present: combination of riffles, pools and run. • Vegetation: Disturbed riparian papyrus vegetation. No invasive aquatic vegetation. • Land use: Crop farming (matooke/banana plantations, beans). • Water abstraction for domestic use and watering animals. • Small rural residential area approximately 2 km from this site.
Sampling site 8	S 0.908733 E 30.6007 Elev: 1354 m	
Sampling site 14	S 0.91875 E 30.6173 Elev: 1330 m	
Kaaro Sampling site 15	S 0.927831 E 30.6306 Elev: 1315 m	
Rutooma Sampling site 16	S 0.932039 E 30.6381 Elev: 1308 m	
Rutooma Sampling site 17	S 0.931401 E 30.6365 Elev: 1310 m	
Migyera Sampling site 11-A	S 0.8783 E 30.6497 Elev: 1373 m	

Kagonji Sampling site 11-B	S 0.879622 E 30.6516 Elev: 1374 m	
Kigabagaba Sampling site 12	S 0.9124 E 30.6439 Elev: 1327 m	
Akatesani Sampling site 13	S 0.925533 E 30.6327 Elev: 1315 m	
Kyabaganda Sampling site 9	S0.900901 E 30.6734 Elev: 1362 m	
Rwemango Sampling site 10	S0.914934 E30.6561 Elev: 1335 m	
Lowest reaches (irrigable areas)		
Rwamwijuka Sampling site 18	S 0.943112 E 30.6398 Elev: 1305 m	• Sampled sites here lie approximately 1,500 to 12,000m downstream of the dam site. • River zone: This is socioeconomically most active area with agriculture, forestry, alcohol brewing, livestock grazing and water supply. • Relatively highly settled with houses about 500 m from either side. • Channel/substrate type: Mostly a single thread channel but with a few areas where the river is split by the thick vegetation patches and by disposition with adjoining streams with its substrate mainly as mud, silt and pebbles. • Biotopes present: combination of riffles, pools and runs (with isolated pockets of silt and sand. • Vegetation: Poorly developed riparian vegetation which provides no shading to the river water. No invasive aquatic vegetation. • Land use: A mixture of crop, livestock and fisheries activities.
Kaburara Sampling site 19	S 0.953695 E 30.6391 Elev: 1302 m	
Nyampikye Sampling site 20	S 0.966067 E 30.629 Elev: 1293 m	
Nyampikye Sampling site 21	S 0.989027 E 30.6238 Elev: 1289 m	
Kagunga Sampling site 22	S 0.994633 E 30.6245 Elev: 1282 m	
Kabumba Sampling site 23	S 1.01181 E 30.621 Elev: 1273 m	

Bwentare/Rukuraijo Sampling site 24	S 1.02662 E 30.6182 Elev: 1271 m	

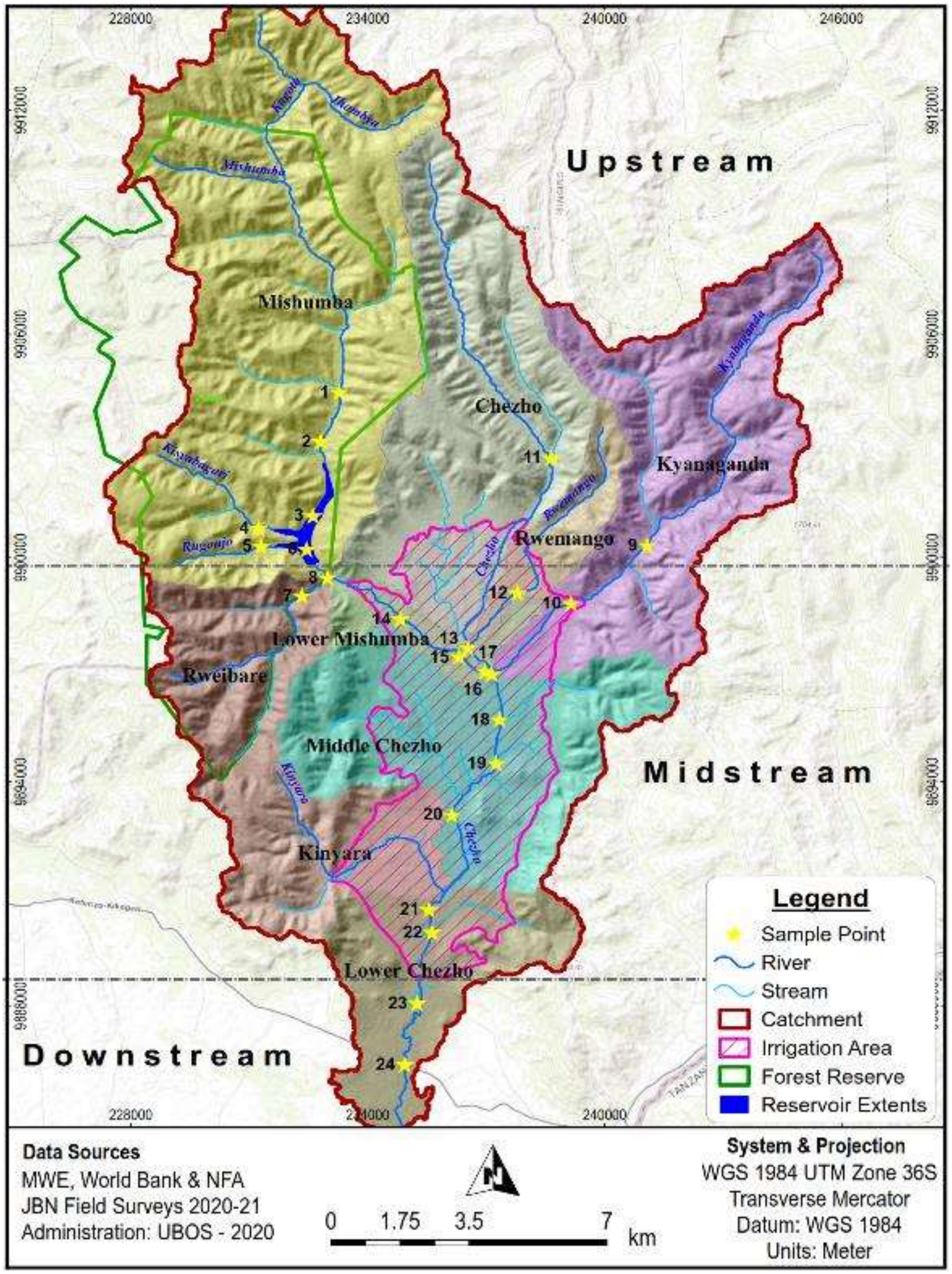


Figure 4-19: Map of sampled points for limnology and fish

4.2.1.2 Water Quality Parametric Analysis

Table 4-8 provides *in-situ* measurements of the basic water quality parameters of River Mishumba in the dry season while **Table** 4-9 *ex-situ* or laboratory detailed analysis of the water. In general, the water chemistry and limnological measurements reflect a typical low level significantly disturbed tropical river due to agricultural, extractive and mining activities. The Mishumba catchment and river is associated with significantly low buffering capacity or alkalinity; significantly high levels of TDS and electrical conductivity levels; and significantly high levels of total hardness, calcium and magnesium hardness in all reaches of the river. This is attributed to the highly disturbed nature of the river, and the fact that it is only about 5 km from upstream to lower reaches, and typically a shallow river that does not provide time for chemical constituents to breakdown or transform along its course. There is less in-stream vegetation cover inform affecting water movement processes. However, in case of the impoundment/damming, it will increase resident time to allow for transformation of some of these chemical species. It should also be noted that many of the sources are anthropogenic linked to the cottage industries and agricultural practices in the basin. Properly planned agriculture and socioeconomic activities will have the effect of cutting out the unnatural supply and entry of those chemical species in the water course.

Table 4-8[5]: *In situ* measurements of basic physiochemical parameters taken during the dry season (February 2021)

Point	Temp (°C)	DO (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)	Depth (m)	Flow rate (m/s)
Natural water standard	22-30°C	>2.00	6.5-8.4	0.5	25.0	N/A	N/A
Upstream of proposed dam site							
Site 1	21.2	8.63	8.55	0.5	20.8	0.4	0.43
Site 1-1	20.4	5.75	7.84	0.4	12.6	0.25	0.45
Site 2	23.1	10.2	6.96	0.4	28.1	0.45	0.31
Dam area and contributing tributaries							
Site 3	23.5	10.2	7.25	0.4	28.6	0.25	0.59
Site 4	20.7	6.57	7.26	0.4	12.3	0.35	0.48
Site 5	20.3	8.79	7.63	0.4	19	0.7	0.37
Site 6	22.6	9.56	6.76	0.4	25.6	0.35	0.63
Downstream of proposed dam site and other contributing tributaries							
Site 7	24.2	7.31	7.14	0.6	20.4	0.35	0.33
Site 8	23.5	7.87	7.66	0.65	13.2	0.8	0.66
Site 9	24.3	6.4	7.74	1	23.5	0.57	0.68
Site 10	20.68	6.76	7.35	0.7	11	0.2	0.54
Site 11	20.68	6.3	7.12	0.8	7.9	0.25	0.59
Site 12	20.93	6.76	7.35	0.8	7.1	0.84	0.83

[5] According to the natural water standards, the orange and green colours indicate values of parameters at sites that were above and below the recommended levels respectively

Site 13	23.1	6.6	7.5	0.7	8.7	0.52	1.87
Site 14	21.54	6.5	6.98	0.7	15.4	0.65	0.73
Site 15	25.3	6.9	6.37	0.7	15.1	0.3	0.83
Site 16	21.69	5.5	7.25	0.8	8.5	0.4	2.1
Site 17	22.4	6.9	7.21	0.9	20.2	0.3	0.71
Site 18	22.6	6.6	7.26	0.4	15.8	0.25	0.52
Site 19	23.2	5.7	6.08	0.7	12.8	0.3	0.35
Site 20	24.3	5.2	8.92	0.7	30.5	0.46	0.35
Site 21	23.2	5.3	6.5	0.5	20.9	0.67	0.66
Site 22	24.5	8.5	6.93	0.7	28.2	0.15	0.48
Site 23	22.7	6.4	7.58	0.7	13.5	0.15	0.27
Site 24	22.4	5.6	7.02	0.9	10.6	0.25	0.66

In conformity to National Standard   Slightly Non-Compliant

Severely non-compliant

Table 4-9: Water quality parameters for different sections and reaches of River Mishumba and associated watershed.

	COD (mg/L)	Electrical Conductivity (µS/m)	TDS (mg/L)	Turbidity (NTU)	Iron (mg/L)	Aluminum (mg/L)	Total Alkalinity (mg/L)	Total hardness (mg/L)	Calcium hardness (mg/L)	Magnesium Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	E. coli (CFU/ 100 ml)	Total coliforms/100 ml	Manganese (mg/L)	Soluble Phosphates (mg/L)	Chlorides (mg/L)	NO_3 (mg/L)	-NH_3/ NH_4 as N in mg/L
Standard of Irrigational water (FAO)	100	0.7 to 3.0	450 to 1,500	25	1	5	20 - 200	180	180	180	150	100	1,000	1,000	0.2	0.7	250	10	0.5
National Natural water standard	**100**	**1.5 - 2.5**	**1,200**	**25**	**2**	**0.5**	**200**	**180**	**180**	**180**	**100**	**100**	**50**	**1,000**	**1.0**	**5.0**	**500**	**20**	**0.5**
Upstream of proposed dam site																			
Site 1 (Nyakatojo)																			
Site 2 (Kagara)	63.67	0.98	686	2.91	0.3	2.97	2	355.33	166.67	188.67	66.67	45.33	9	200	4.93	0.04	77	0.35	1.38
Dam site																			
Site 3 (Kyamazinga)	55	127.27	89,086	6.53	0.02	3.64	2	474.67	231	243.67	92.33	58.67	1	200	0.01	0.01	34.67	0.01	0.01
Site 4 (Kisyabagari & Rugonjo)	69.67	122.1	85,470	4	0.01	0.71	2	461.33	333	128.33	133.33	30.67	1	200	0.01	0.01	25.67	0.18	0.05
Site 5 (Rugonjo)	54.67	90.23	63,163	4.27	3.86	0.92	2	500	116	268	92.67	64.33	1	200	0.64	0.07	36.33	1.8	0.01
Site 6 (Confluence)	48	120.37	84,256	18.34	0.12	0.21	2	500.67	207	293.67	83	70.33	1	200	0.01	0.11	71.33	3.6	0.01
Lower reaches (immediate downstream of dam site)																			
Site 7 (Rweibare)	80	47.79	33,450	3.15	0.76	0.58	2	449.67	121.67	328	48.67	78.67	6.67	200	0.01	0.58	38.67	1.32	0.54
Site 8 (Confluence)	39.67	95.3	66,710	40.83	1.92	0.97	2	468.33	199	269.33	79.67	64.67	1	200	0.01	0.24	24	1.57	0.38
Site 9 (Kyabaganda)	66.67	117.63	82,343	12.97	0.56	20.67	2	472.67	246.67	226	98.67	54.33	1	200	0.01	0.01	53	2.8	0.01
Site 10 (Kyabaganda)	36.67	160.63	112,443	75.57	0.54	0.29	2	544	235.33	308.67	94	74	1	200	0.01	0.31	37	2.13	0.01
Site 11-A (Kagongi)	60.33	127.13	88,993	36.47	0.16	2.29	2	504.33	337.67	166.67	135	40	1	200	0.01	0.13	66	7.67	0.01
Site 11-B (Migyera)	61	129.67	90,766	3.12	0.22	2.95	2	506	285.67	220.33	114	52.67	1	200	0.01	0.01	52.67	2.67	0.01
Site 12 (Kigaragara)	51	122.6	85,820	210	0.34	0.38	2	486	246.67	239.33	96.67	57.33	1	200	0.01	0.19	42.67	5.23	0.62
Site 13 (Akatesani)	106	122.07	85,446	4.84	0.01	0.89	2	478.33	338	140.33	135.33	34	1	200	0.04	0.02	64.33	3.73	0.23
Site 14 (Kaaro)	71.33	184.4	129,080	133.33	5.25	0.63	2	582.67	279	303.67	111.67	73	1	200	0.03	0.78	16.33	0.01	0.01
Site 15 (Rutooma)	52.67	117.33	81,923	138	4.96	3.9	2	501.67	244.67	257	98	61.33	1	200	0.01	0.46	24.67	3.43	0.03
Site 16 (Rutooma)	119.33	125.57	87,896	12.67	0.42	4.76	2	469.33	255.67	213.67	102.33	51.33	1	200	0.01	0.01	44.67	1.8	0.01
Site 17 (Rutooma)	81	137.27	96,086	30.67	5.58	3.42	2	531	169.67	361.33	68	86.67	1	200	0.01	0.26	37.33	0.01	0.56
Lowest reaches (irrigable areas)																			
Site 18 (Kamwosya)	120.67	108.57	75,997	12.7	1.71	2	2	483.33	213.33	270	85.33	64.67	1	200	0.01	0.12	43.33	1.5	0.71
Site 19 (Kaburara)	189.33	161.97	113,376	3.38	0.01	0.66	2	488.33	220	268.33	88	64.33	1	200	0.01	0.03	44.67	0.01	0.01
Site 20 (Nyampikye)	32	127.83	89,483	2.03	0.01	7.18	2	444	215.67	228.33	86	54.67	1	200	0.01	0.08	56	2.17	0.01
Site 21 (Nyampikye)	38.67	112.36	76,648	8.96	0.13	2.7	2	596.67	314	282.67	125.33	67.67	1.67	200	4.44	0.01	94.67	0.38	0.01
Site 22 (Kagunga)	103	1.61	1,124	1	0.01	0.08	11.6	609	282	327	113	78	5	200	5	0.01	214	0.2	0.07
Site 23 (Kabumba)	51	70.4	49,280	1.72	0.09	2.45	2	722	258	464	103	111	1	200	7.8	0.01	113	1.54	0.88
Site 24 (Bwentare or Rukuraijo)	37	141.13	98,793	3.37	0.04	2.26	2	522.33	258	264.33	103.33	63.67	1	200	0.01	0.01	59.67	1.13	0.01

In conformity to National Standard | Slightly Non-Compliant | Severely non-compliant

Table 4-10: River Mishumba bed sediment description and key socioeconomic activities (landuse)

Point	Sediment description	Usage
1	Mud and silt	Forest, watering animals
2	Silt and mud, boulders from bridge	Forest, watering animal
3	Silt and mud	Forest, watering animals
4	Silt and mud	Agriculture with forest
5	Silt, mud	Fishing, water for home use
6	Silt, with pebbles of 4-20 mm	Agriculture, waragi/alcohol distilling
7	Mad, silt /most times turbid all season	Agriculture
8	Silt, mud with material	Agriculture, common swimming spot
9	Silt, mud and some pebbles of 2-20 mm	Agriculture
10	Silt, pebbles of 2-4 mm / turbid most times	Water for all use at home, agriculture
11	Silt and gravel of 2-64 mm	Human consumption, agriculture
12	Silt and gravel of 2-64 mm	Human consumption, agriculture
13	Mud, silt / times turbid all season	Human consumption, agriculture
14	Swamp/ farm	Agriculture
15	mad and silt	agriculture, fishing
16	Silt and gravel of 2-64 mm	Human consumption, agriculture
17	Clay bottom	watering animal, human consumption
18	Mud, silt and pebbles of 2-4 mm	Agriculture, forest
19	Silt and pebbles of 4-20 mm	Forest, water for human consumption
20	Silt and mud	Water alcohol distilling
21	Mud and pebbles of 4-20 mm	Water for agriculture, animal raring
22	Silt and mud	Forest, agriculture
23	Mud with iron thus brown colour of water	Fishing, water for home use
24	Mad with silt	Agriculture, watering animals

Figure 4-20: Site 14 (E234824, N9898362) with rooted emergent vegetation

Figure 4-21: Middle reaches of River Mishumba after point 14 at E234896, N9898285

Figure 4-22: Emergent and rooted vegetation between site 14 and 15

Figure 4-23: Vegetated pool of water created at site 24 (E234935, N9886429)

Figure 4-24: Collecting sediment samples at site 20 from the river bed at E236134, N9893128

Figure 4-25: Some of the regenerating and surviving vegetation at site 24 in the downstream at E234935, N9886429

Figure 4-26: Riparian vegetation in the downstream areas of the catchment at site 23

4.2.2 Plankton and Macroinvertebrates

4.2.2.1 Phytoplankton occurrence and abundance

Cyanophyta dominated the three (3) commonly encountered phyla in almost all sampling points in all reaches of the catchment during both sampling periods (Table 4-11). The total abundance of phytoplankton species was significantly higher (U = 117; p = 0.009) during the wet season (November) sampling than in the February (dry season). Among the Cyanophyta, the Microcystis spp., Planktolyngbya spp. and Anabaena spp. were the most dominant species throughout the catchment. The diatoms were the least abundant and were dominated by Nitzschia acicularis. There were no particularly significant patterns in the vertical or lateral distribution of phytoplankton but there was increasing abundance and dominance of Cyanophyta from upstream to downstream reaches of the catchment.

A higher numerical abundance of phytoplankton was observed in wet season sampling, when the abundance reached 1,005.29 cells/ml while in the dry season sampling the abundance was 919.33 cells/ml. Among the six-phytoplankton phyla found, Cyanophyta was the most abundant group in all the reaches of the catchment, followed by Chlorophyta and Bacillariophyta. The occurrence of Euglenophyta and Dinophyta was low and Chrysophyta had no representative species during both seasons in the samples for abundance data.

Table 4-11: The algal phyla encountered and unidentified in the Mishumba catchment during both wet and dry sampling periods

WET Season	**Upstream above dam site**	**At and around the dam site**	**Immediate after the downstream**	**Downstream of the dam site**
Cyanophyta	28.57	44.07	68.75	69.23
Bacillariophyta	09.52	16.23	0.00	07.69
Chlorophyta	18.10	32.51	25.00	23.08
Dinophyta	03.81	03.24	0.00	0.00
Euglenophyta	07.62	02.22	0.00	0.00
Others (unidentified)	0.00	01.73	6.25	0.00
DRY Season	**Upstream above dam site**	**At and around the dam site**	**Immediate after the downstream**	**Downstream of the dam site**
Cyanophyta	44.75	57.77	55.42	59.77
Bacillariophyta	18.70	05.48	16.01	06.48
Chlorophyta	30.23	35.05	28.57	33.05
Others (unidentified)	06.32	01.70	0.00	00.70

Species diversity of phytoplankton

In the rainy season, the Cyanophyta (mainly Microcystis spp. and Planktolyngbya spp.) was the most abundant group. However, a Chlorophyta, Spirogyra sp., was also fairly well represented. Chlorophyta was the most diverse group in both seasons and it was represented by a great number of species (8) followed by Bacillariophyta (3). There was no significant difference between the diversity indices in the two seasons ($U = 11.3$; $p = 0.713$).

4.2.2.2 Zooplankton and macro-invertebrate occurrence and abundance

Both wet and dry season samplings were dominated by rotifers followed by crustaceans, comprising mainly of cladocerans and cyclopoid and calanoid copepods. Also found within samplings for both wet and dry seasons were insect larvae. In total 11 species were identified; seven were rotifers; 2 were crustaceans; and two insect species. The most abundance of the zooplankton was during the wet season. In general, the zooplankton community of Mishumba catchment is dominated by rotifers and copepods. Among the copepods, cyclopoid copepods (adults, copepodites and nauplius larvae) were the most common group throughout the study period. The identified rotifers were *Polyathra sp., Keratella sp., Brachionus sp, Proales sp., Euclanis sp., Ascomopha sp.,* and *Lecane sp.* in decreasing order of occurrence. Among crustaceans the two species identified were Cyclops oithonoides and Bosmina longirostris; and the insecta group was comprised of chaoborid species and *Odonata sp.* (Dragonflies) nymphs. A total of 3 species of molluscs were recorded in the Mishumba catchment; *Melanoides sp.; Bellamya asp.;* and *Gabbia sp.* The results on species richness, density and the distribution of molluscs increased from upstream reaches to downstream of the planned dam site. The benthic macro-invertebrates' abundance was composed mainly of Oligochaeta and Mollusca. Insecta groups contributed a very small portion but with increasing densities downstream.

4.2.2.3 Fisheries Ecology

The Baseline Study established that there are two categories of fishes, the limnophilic ones (those which prefer to live in lakes, ponds, marshes, pools or other slow moving, still or stagnant waters), which include tilapias, haplochromine species and mudfish (*Clarias carsonii*); and those that are rheophilic (prefers to live in fast-moving water), represented by African catfish (*Clarias gariepinus*) and Victoria carp (*Labeo victorianus*). The rheophilic were found mainly occupying runs and ripples in the main channel of the river and were associated with the breeding and nursing processing, whereas the limnophilic occupied mainly the pool waters and closer to the adjoining vegetation and or swamps, and were apparently associated with feeding and nursing ecological processes. In case of *Victoria carp* and *African catfish*, they were found mainly in points that were upstream, while for tilapias and haplochromines were found close to the flooded sandy and vegetated plains (downstream). In the limnophilic specie habitats, the flow was moderate to low; while in the rheophilic species habitats the river flow was relatively moderate to fast.

Resident fish species in the study area: The fish fauna of River Mishumba basin has hardly been studied previously, and this is among the few attempts known at describing and understanding the fish resources of this river catchment. The findings of this study show that the area has fishes that are typical of Lake Victoria basin with both native and introduced fish species. The studies have identified 7 species belonging to 5 genera with the fifth being the complex haplochromine group (**Table** 4-12). Upstream sites had on average 10 cm of water depth in the dry season and 30 cm in the wet season. Fish were seen and captured both in riffles and runs, especially those that were vegetated with rooted emergent aquatic plants. This probably due to the need for shelter or break of the water currents for fish to feed and carry out other life processes.

Most importantly, River Mishumba was found to contain species such as Singida tilapia and Ningu and also species of the haplochromines complex, all of which are relics of Lake Victoria basin.

These species were mainly found in the lower parts of the catchment (downstream of irriagable area) towards R. Kagera. They were captured at about 12 km further downstream of the Mishumba and Chezho biggest confluence towards the estuary of R. Mishumba and Kagera which are deeper water areas (after both the dam and irrigable areas). The existence of Ningu in Uganda is common also in other water bodies. It is also important to note that the resultant planned management of the flow regimes allows for the fast flow during the onset of wet season for the breeding of the rheophilic species especially Victoria carp that may venture from River Kagera into lower sections of River Mishumba.

The juveniles of Ningu and African catfish were found in all reaches occupying mainly the riffles and runs, while tilapiine species were found in the pools far after the dam site and lower reaches. Other fishes recorded include *Tilapia zillii* known locally as Zilli or Kadugara; *Oreochromis leucostictus*, Nile tilapia (*O. niloticus*) that together with Kadugara were introduced from Lake Albert together. During the present fish survey 129 fish specimens belonging to 5 genera and representing 7 different species were collected from only 6 sampling sites out of 24 sites in the River Mishumba catchment (**Table** 4-12). This is because most of the river sections in the upstream are shallow and have no vegetation cover to favour the stay of fish. The other 18 sites were all sampled but no fish was caught in these sites for various reasons especially the level of human disturbance, water quality, low level water flow (volume and or current) and physical make-up of the channel. The more fish caught during the November 2020 survey is attributed to high water levels and probably breeding activity compared to the February 2021 survey. A panel of gillnets of 1'', 1.5'', 2.5'' and 3" mesh sizes as well as local basket traps were used. Records of length-weight measurements of fish taken at all sampling sites are presented in **Table** 4-12, and photographs of voucher specimens of representative species are in **Figure** 4-27 to **Figure** 4-32. The catches were dominated by clariids, followed Ningu then tilapiines. There are non-known previous records of fisheries resources. The affinity for fast flowing water for juveniles of Ningu and African catfish means they will be central in setting and monitoring of the e-flows.

Figure 4-27: Subadults of African catfish (*Clarias gariepinus*) and fingerlings of Ningu (*Labeo victorianus*) caught at sampling site 14

Figure 4-28: A mixture of tilapiine species fish from R. Mishumba in a market at Kyabaganda (salted, sun dried and smoked)

Figure 4-29: *Oreochromis leucostictus* or Mbiru introduced from Lake Albert in the 1930s

Figure 4-30: Juveniles of African catfish (*Clarias gariepinus*) captured at Site 11.

Figure 4-31: A fingerling of African catfish (*Clarias gariepinus*)

Figure 4-32: African catfish (*Clarias carsonii*) found with eggs

Table 4-12: Fishes of River Mishumba catchment

Site	Species	Genera	Local name	Age status	Conservation status	TL (cm)	SL (cm)	Body depth (cm)	No. fish caught	Temp	Water flow rate (m/s)
3	Victoria carp (Labeo victorianus)	Labeo	Ningu	Fingerling	Critically Endangered	2.8	2.3	0.6	06	20.0°C	0.56
				Fingerling		2.5	2.0	0.6			
				Fingerling		1.8	1.6	0.5			
				Fingerling		2.3	2.0	0.8			
				Fingerling		2.1	1.9	0.8			
				Fingerling		2.0	1.8	0.8			
6	African catfish (*Clarias gariepinus*)	Clarias	Mmale	Fingerling	Least Concern	8.9	8.0	0.8	07	22.7 °C	
				Sub-adult		10.2	9.3	1.1			
				Sub-adult		10.0	8.9	1.1			
				Sub-adult		9.7	8.9	0.8			
				Sub-adult		10.3	9.2	1.2			
				Sub-adult		10.8	9.7	1.1			
				Sub-adult		11.0	9.3	1.4			
8	African catfish (Clarias gariepinus)	Clarias	Mmale	Sub-adult	Least concern	10.0	9.0	1.5	05	20.0°C	0.57

	African catfish			Sub-adult		10.0	9.0	1.3			
	(Clarias gariepinus)	Clarias	Mmale	Sub-adult	Least concern	10.0	9.0	1.4			
	Albert tilapia (*Oreochromis leucostictus*)	Oreochromis	Mbiru	Sub-adult	Least concern	8.0	7.0	1.0	05 01		
				Sub-adult		8.0	7.0	1.1			
				Fingerling		4.0	3.5	0.1			
	African catfish (*Clarias gariepinus*)	Clarias	Mmale	Adult	Least concern	18.0	17.0	2.3	03		
10	African catfish (*Clarias gariepinus*)	Clarias	Mmale	Sub-adult	Least concern	9.1	8.1	1.1	03	22.3 °C	0.26
	African catfish (*Clarias gariepinus*)	Clarias	Mmale	Sub-adult	Least concern	9.0	8.0	1.1			
				Adult		33.4	27.5	4.5	04		
11	African catfish (*Clarias gariepinus*)	Clarias	Mmale	Adult	Least concern	31.6	27.3	3.8	04 01	22.6 °C	
	Tilapia zilli (*Coptodon zilli*)	Tilapia (Coptodon)	Kadugara	Adult	Least concern	33.8	28.2	4.2			
				Adult		33.5	28.1	3.3			
				Adult		12.0	8.9	3.2			
13	African catfish (*Clarias gariepinus*)	Clarias	Mmale	Sub-adult	Least concern	11.3	10.1	1.2	03	23.2 °C	0.78
15	African catfish (*Clarias gariepinus*)	Clarias	Mmale	Sub-adult	Least concern	9.2	8.3	1.1	03 01	23.2 °C	0.66
	Mudfish (*Clarias carsonii*)	Clarias	Nsonzi		Least concern						
				Sub-adult		9.1	8.0	1.0			

				Adult		15.0	12.0	3.0			
	Tilapia zilli (*Coptodon zilli*)	Tilapia (Coptodon)	Kadugara	Adult	Least concern	16.0					
	Redbelly tilapia (*Coptodon zilli*)	Coptodon	Kadugara	Adult	Least concern	18.0	17.0	8.0	01		
24	Singida tilapia (*Oreochromis esculentus*)	Oreochromis	Ngege	Sub-adult	Endangered	4.5	4.0	1.3	06	24.0°C	0.26
	Singida tilapia (*Oreochromis esculentus*) Tilapia zilli (*Coptodon zilli*)	Oreochromis	Ngege Kadugara	Sub-adult	Endangered Least concern	4.5	4.0	1.3	06 36		
				Sub-adult		5.2	4.8	1.7			
				Fingerling		4.0	3.5	1.1			
				Fingerling		3.5	3.0	0.1			
						4.0	3.5	1.1			
		Tilapia (Coptodon)		Adult							

4.2.2.3.1 Conservation and ecological status of endangered and threatened species

According to **Table** 4-12 above**,** this study also found the occurrence of Victoria carp (*Labeo victorianus*) locally known as Ningu, and Singida tilapia (*Oreochromis esculentus*) formally locally known as Ngege, a name taken over by its "sister" species that is ecologically more versatile (can inhabit a range of habitats), *Oreochromis niloticus* commonly known as Nile tilapia. The Victoria carp seasonally migrates from L. Victoria and its estuary with R. Kagera to upstream areas of Kagera. These include the nearby swamps e.g., the downstream flood plains area of Mishumba i.e., sampling point 24 (after irrigable area) and its estuary with R. Kagera to breed at times of high rains. The fish then goes back for feeding via R. Kagera to L. Victoria at times of low rains.

The young follow after but a number a left behind due to late hatching and the decreasing water flow and levels in the upstream channels. This species is still found in nearly all adjoining inflowing rivers to Lake Victoria but with River Kagera being the major conduit between Lake Victoria and breeding sites which are spread throughout number of adjoin streams and rivers to the Kagera system. Singida tilapia, once the mainstay of fisheries in Lake Victoria Region, economically collapsed in the 1970s in Lake Victoria region and was relegated mainly to minor water bodies and rivers in the basin. *The finding in River Mishumba was limited to very few individuals occupying mainly poddles and pools of water close to naturally vegetated swampy areas further downstream towards river Kagera (after sampling point 24) where project activities will not be implemented.*

There were no significant stocks or populations or numbers of these species in the catchment. This is linked especially to the high disturbed nature of the catchment with a lot of unnatural socio-economic activities in the catchment, especially agricultural, forestry and mining activities. Indeed again, the chance of continued existence of Singida tilapia in Mishumba catchment will be enhanced and assured with a managed water and agricultural production system, especially if certain areas close to swamps that allow for deep water that can stay through dry season can be designated as special conservation areas for this species in River Mishumba.

4.2.3 Vegetation and Flora

4.2.3.1 Vegetation and Land use/cover

Kabuyanda irrigation scheme project area is largely covered by modified vegetation. Some of the valleys are traversed by rivers for example river Mishumba and some tributaries while others are seasonal swamps with no water flowing in the dry seasons. These swamps are covered with typical wetland plant species mainly of the genera *Cyperus* and *Typha*. Within swamps are patches of bogs and bare ground which resulted from the after effects of the flush floods which washed away vegetation when the water levels considerably rose in the upstream of river Mishumba. However, the slopes and the hills were covered by fields of cultivation. The entire section of the project area in Rwoho CFR is covered by plantations of *Eucalyptus* spp., *Pinus* spp. and *Grevillia Robusta*. The rest of the project area is in fields of cultivation under subsistence farming of food crops mainly *Coffea* sp. (coffee), *Musa* spp. (bananas), *Zea mays* (maize), among others. **Table** 4-13 shows the state of all the terrestrial and aquatic points that were provided for survey as of November 2020 in form of vegetation type, dominant species and total species richness.

Table 4-13: Terrestrial and aquatic survey points with vegetation description, dominant flora and species richness

Way point	Coordinates	Altitude (m)	Vegetation description	Dominant flora	Species richness
1	S0 51.769 E30 36.200	1388	*Cyperus-Persicaria* riverine vegetation with *Eucalyptus* spp. woodland on the hill slopes of Rwoho CFR	*Cyperus denudatus* *Cyperus exaltatus* *Persicaria setosula*	46
2	S0 52.685 E30 35.923	1376	*Cyperus-Persicaria-Phoenix* riverine vegetation in Rwoho CFR	*Cyperus denudatus* *Persicaria setosula* *Cyperus difformis*	61
3	S0 53.620 E30 35.849	1372	*Cyperus riverine vegetation and bushed fallow in valley with Eucalyptus sp and Pinus sp on hill slopes in Rwoho CFR*	*Eucalyptus sp.* *Cyperus papyrus*	46
4	S0 53.797 E30 35.057	1399	*Lepistemone-Commelina* wetland fallow derived from *Cyperus-Typha-Ludwigia* riverine vegetation; This is in the middle of *Eucalyptus* sp woodland of Rwoho CFR	*Lepistemon owariense* *Acanthus polystachius* *Acalypha ornata*	49
5	S0 54.065 E30 35.140	1377	*Eucalyptus* sp woodland in a swamp	*Eucalyptus* sp. *Oxalis corniculata* *Neonotonia wightii*	49
6	S0 54.098 E30 35.771	1348	*Cyperus* riverine vegetation and bushed fallow in valley with *Eucalyptus* sp and Pinus sp on hill slopes in Rwoho CFR	*Cyperus denudatus* *Cyperus papyrus* *Persicaria setosula*	84
7	S0 54.816 E30 35.622	1374	*Cyperus – Bridelia - Melanthera* riverine vegetation with patch of Eucalyptus woodland	*Bridelia micrantha* *Eucalyptus* sp. *Neonotonia wightii*	49
8	S0 54.511 E30 36.040	1340	*Cyperus* wetland in valley with *Musa-Coffea*-gardens contiguous with *Eucalyptus* sp woodland in Rwoho CFR	*Cyperus denudatus* *Cyperus papyrus* *Leersia hexandra*	39
9		1369		*Typha capensis*	

	S0 54.033 E30 40.408		*Typha-Cyperus-Melanthera* streamline vegetation with moderately bushed grassland patch	*Melanthera scandens*	42
				Cyperus dives	
10	S0 54.882 E30 39.362	1328	*Cyperus-Melanthera-Ludwigia* riverine vegetation with *Eucalyptus*-Caffea Garden on hill slopes	*Cyperus dives*	60
				Melanthera scandens	
				Ludwigia abyssinica	
11 - PM	S0 52.783 E30 39.097	1377	*Cyperus-Typha* riverine vegetation	*Cyperus dives*	27
				Typha capensis	
				Persicaria senegalensis	
11 - PK	S0 52.680 E30 38.972	1376	*Cyperus-Typha* streamline vegetation in valley with *Musa-Coffea* gardens on hill slopes	*Cyperus denudatus*	37
				Typha capensis	
				Leersia hexandra	
12	S0 54.742 E30 38.630	1323	*Eucalyptus* sp woodland with patches of *Sorghum-Ipomoea* gardens through which passes a stream	*Eucalyptus* sp	70
				Commelina benghalensis	
				Leersia hexandra	
13	S0 55.395 E30 37.864	1291	*Typha-Cyclosorus-Cyperus* riverine vegetation fringed by *Eucalyptus* sp plantation	*Typha capensis*	61
				Cyclosorus interraptus	
				Cyperus exaltatus	
14	S0 54.886 E30 36.823	1334	*Cyperus* riverine vegetation with *Eucalyptus* sp woodland on hill slopes	*Cyperus dives*	25
				Cyperus denudatus	
				Cyperus difformis	
15	S0 55.605 E30 37.669	1322	*Cyperus* riverine vegetation with patches of bare ground and short bushes	*Cyperus dives*	58
				Persicaria setosula	
				Senna dedymobotria	
16	S0 55.923 E30 38.287	1313	*Cyperus-Typha-Persicaria* riverine vegetation with patches of cultivated *Eucalyptus* sp and *Zea mays*	*Cyperus denudatus*	37
				Typha capensis	
				Cyperus exaltatus	
17	S0 55.897 E30 38.187	1307	*Cyperus* community surrounding open water patch	*Cyperus denudatus*	58
				Cyperus exaltatus	
				Cyperus dives	
18	S0 56.575 E30 38.373	1314	*Cyperus* riverine vegetation	*Cyperus exaltatus*	46
				Cyperus dives	
				Cyperus denudatus	
19		1307		*Cyperus denudatus*	42

	S0 57.205 E30 38.322		Cyperus-Typha-Leersia–Cynodon riverine vegetation	*Typha capensis*	
				Leersia hexandra	
20	S0 57.959 E30 37.734	1300	*Typha – Leersia - Cyperus* riverine vegetation with patches of *Eucalyptus* sp. and a grassland	*Typha capensis*	91
				Leersia hexandra	
				Cyperus dives	
21	S0 59.338 E30 37.407	1286	*Typha* riverine vegetation with patches of *Eucalyptus* sp. woodlots	*Typha capensis*	63
				Eucalyptus sp.	
				Cynodon dactylon	
22	S0 59.681 E30 37.467	1272	*Typha* riverine vegetation; There are fish ponds surrounded by *Cynodon dactylon*	*Typha capensis*	41
				Cyclosorus interraptus	
				Cynodon dactylon	
23	S1 00.716 E30 37.241	1268	Typha-Cyclosorus-Leersia riverine vegetation	*Typha capensis*	40
				Cyclosorus interraptus	
				Leersia hexandra	
24	S1 01.589 E30 37.088	1263	*Typha – Leersia - Persicaria* riverine vegetation with fields of cultivation	*Typha capensis*	84
				Leersia hexandra	
				Persicaria decipiens	

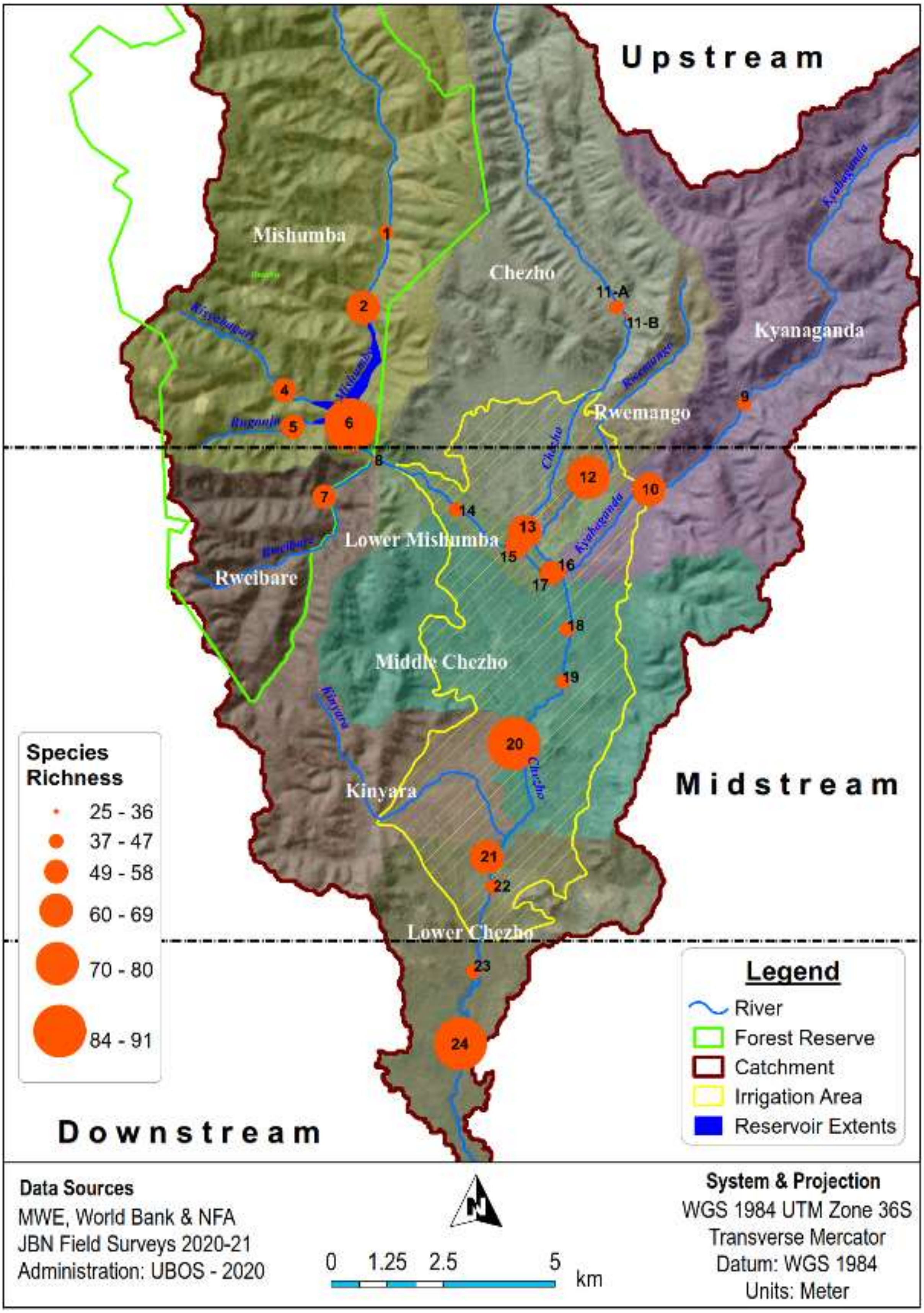


Figure 4-33: Location of terrestrial and aquatic survey points with flora species richness

4.2.3.2 Conservation areas

Rwoho Central Forest Reserve (CFR), covering 9,000 ha, is managed by the National Forestry Authority (NFA), on behalf of the Government of Uganda (GoU) according to the National Forestry and Tree Planting Act 8/2003. The reserve lies on top of a large flat-topped ridge whose external boundary runs 50 km of about 9 km follow streams while 41 km is maintained as a planted cutline of the exotic trees and crops under subsistence agriculture. The reserve is classified as a plantation development forest as per the Forest Management Plan for Bugamba and Rwoho Central Forest Reserves (2012-2022). Rwoho CFR is largely degraded and partially restored with non-indigenous species (*Pinus caribaea, Pinus ocarpa* and *Eucalyptus* sp.). Planting of conifer species started in 1964. In the area under reforestation, NFA had a *taungya* farming arrangement, where licensed tree farmers were also allowed to grow crops (mainly beans, maize, Irish potatoes, millet) during tree project establishment.

Langdale-Brown *et al*. (1964) reported that Rwoho was characterised by two vegetation communities: i) the D3 medium-altitude *Albizia-Markhamia* forest covering 45 km^2 (50%) and ii) the Q4 *Themeda-Chloris* grass savanna constituting the other half (45 km$^{2)}$. The Rwoho and Kijanabolola Forest Reserves Biodiversity Report prepared in 1993 described the vegetation of the forest reserve as grass savanna together with original native vegetation characterized by medium altitude moist semi-deciduous *Markamia* forest. However, the 2006 Forest Management Plan reported that “all trees in the valleys were highly degraded and surviving ones were small and of poor quality and that natural regeneration would be hard”. Degradation was attributed to its close proximity to communities and easy access by people from all sides.

4.2.3.3 Land use and disturbances

Upstream of the project area and a section covered by Rwoho CFR was generally covered by agricultural landscapes existing as plantations of trees mainly *Eucalyptus* spp which were in some areas mixed with *Pinus* spp. Outside Rwoho CFR, the points were in subsistence agriculture areas with crops such as coffee, bananas and maize being cultivated on a larger scale than others. There were some sections with pasture lands which had indication of trampling by grazers and in some of these cattle and goats were sighted grazing on the *Cynodon dactylon* and *Brachiaria* spp which dominated cover in such areas. Thus, agriculture was the major form of land use but also disturbance in Kabuyanda irrigation scheme project area. Additionally, apiculture, distillation of local brew, tree felling and charcoal burning were other forms of disturbance recorded in the project area. **Table** 4-14 gives the different forms of disturbance that were recorded at each survey point and **Figure** 4-34 provides pictorial views of the different forms of disturbance.

Table 4-14: Disturbances and their location

Point	Plantation	Form of disturbance							
		Subsistence cultivation	Fish farming	Grazing	Timber extraction	Charcoal burning	Apiculture	Local brew distillation	Settlement
1	+	-	-	-	+	+	+	-	-
2	+	-	-	-	+	-	-	-	-
3	+				+		+		

4	+	+	-	-	-	-	+	-	-
5	+	+	-	-	-	-	-	-	-
6	+	-	-	-	+	-	+	-	-
7	-	+	-	-	-	-	-	-	-
8	+	+	-	-	+	-	-	-	-
9	-	+	-	+	-	-	-	-	-
10	-	+	-	-	-	-	-	-	-
11 - A	-	+	-	+	-	-	-	-	+
11 - B	-	+	-	-	-	-	-	-	+
12	-	+	-	-	-	-	-	-	-
13	-	+	-	+	-	-	-	-	-
14	+	-	-	-	+	-	-	+	-
15	+	+	-	-	+	-	-	+	-
16	+	+	-	-	+	-	-	-	-
17	+	+	-	-	+	-	-	-	-
18	-	+	-	+	-	-	-	-	-
19	-	+	-	-	-	-	-	-	-
20	-	+	-	-	-	-	-	-	-
21	-	+	-	-	-	-	-	-	-
22	-	+	+	-	-	-	-	-	-
23	-	+	-	-	-	-	-	-	-
24	-	+	-	-	-	-	-	-	-

Key: + Present; - Absent

Eucalyptus sp. plantation at 36M 233261 9904548 in Rwoho CFR

Banana cultivation at 36M 238640 9902685


Fish farming at 36M 235607 9890283


Local brew distillation at 36M 235685 9897553


Apiculture at 36M 233261 9904548


Grazing at 36 M 241255 9900725

Figure 4-34: Some of the land uses and disturbances that were recorded in the project area

4.2.3.4 Species richness and percentage cover

A total of 247 plant species from 122 genera belonging to 51 families were recorded from all the surveyed areas. Although heavily impacted with cultivation activities, the general area was diverse with a Shannon diversity index of 4.41. In terms of growth habit, most of the species recorded were herbaceous plants with 48.4% followed by shrubs 20.8% and trees were the least with 7.6% (**Figure** 4-35). The low percentage of trees and shrubs was probably due to cutting down of natural forests that were replaced with exotic plantations of *Eucalyptus* sp*.* and *Pinus* sp.

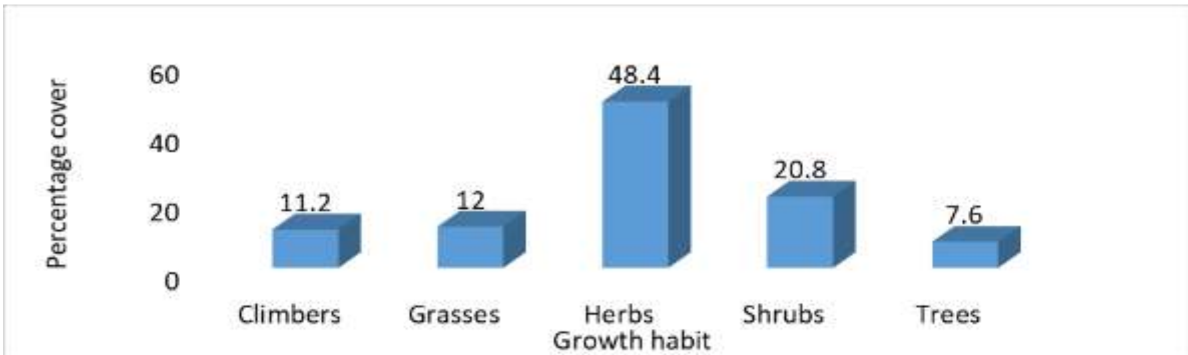


Figure 4-35: Species richness by growth habit

Plant species with the highest spatial coverage were *Typha capensis* (22%), *Cyperus denudatus* (20.3%), *Cyperus dives* (16.6%), *Leersia hexandra* (11.5%), *Persicaria setosula* (9.6%), *Cynodon dactylon* (9.5%) and *Cyperus exaltatus* (9.4%). With the exception of *C. dactylon*, all the rest were typical wetland species and this emphasized the dominance of wetland species cover in the valleys of the project area although the general land cover is dominated by fields of cultivation. Plant species that were most frequently encountered and were recorded from at least 15 of the 24 study points were *Persicaria setosula* (27.5%), *Commelina benghalensis* (79.2%), *Cyperus dives* (75%), *Ludwigia abyssinica* (75%), *Ageratum conyzoides* (75%), *Bidens pilosa* (70.8%), *Cyperus denudatus* (66.7%), *Leersia hexandra* (66.7%), *Cynodon dactylon* (66.7%), *Achyranthes aspera* (66.7%) and *Clerodendrum johnstonii* (62.5%). From this list, *Achyranthes aspera, Ageratum conyzoides*, *Bidens pilosa* and *Commelina benghalensis* were weeds of cultivation, an indicator of cultivation extending into swamps.

4.2.3.5 Invasive plant species

Two invasive species of plants, *Lantana camara (Plate B)* and *Mimosa pigra (A)*, were encountered at several points in the proposed project area (**Figure** 4-36**)**. *Lantana camara* is an invasive species of terrestrial ecosystems and had already established flowering individuals at some of the points that were surveyed. *Mimosa pigra* is an invasive species of permanent swamps and because of this, these species have potential to invade different in the project area although *M*. *pigra* was recorded at fewer points compared to *Lantana camara*. In the proposed project area, native flora in terrestrial areas is threatened by *L. camara* while the wetland sections are threatened by *M. pigra*.

Mimosa pigra encountered at 36M 235685 9897553 at point 6

Plate A

Lantana camara encountered at 36M 232465 9900262 at point 4

Plate B

Figure 4-36: Invasive species that were encountered in the project area

Invasive species become a menace after introduction from their native range to new areas where conditions favour them to flourish and take over the natives (Davis 2009). They also flourish due to disturbances that alter plants cover in a particular area (Klinger & Brooks 2009) and they significantly change the ground cover. After establishment the area now has novel species and consequently habitats. Due to their great dispersal characteristics, high tolerance to unsuitable conditions, large reproductive capacities and high growth rates, invasive species easily overtake the natives. Changes at individual and at ecosystem level render native species and habitats unsuitable for many species thus altering population growth, disturbance regimes and geomorphology (Davis 2009).

In the ESIA Report, 22 species are reported as invasive species. This wide variation is due to the fact that during the ESIA, nearly all weeds of cultivation such as *Bidens pilosa, Tagetes minuta,* *Melinis repens* and many others, were listed as "invasive species". In this study, the focus was on the Alien Invasive Species.

4.2.3.6 Conservation status of plant species

Of the 247 plant species recorded, only 34 species representing 13.8% have been assessed by (IUCN 2021) and the rest are not yet assessed. All the assessed species were considered globally Least Concern (LC). Thus, no plant species considered as threatened, endemic or rare and would require special conservation concern according to IUCN was recorded within the project area.

4.2.3.7 Monitoring indicators

Monitoring will have to be done covering all survey points and particularly the actual footprint of the project. The parameters recommended for monitoring are:

a. Species richness and diversity
b. Species abundance (cover and density)
c. Changes in the dominance patterns of permanent survey plots (Table 30)
d. Invasive species presence, abundance and impact
e. Ecosystem health of the reserved habitats
f. Habitat recovery after restoration

4.2.3.8 Comparison of findings with the earlier ESIA study

The 2019 ESIA described the vegetation as being largely modified, as also revealed by the present study. The mainly subsistence cultivation reported in the earlier ESIA was still evident at the time of this study as most of the area was covered by agricultural landscapes. The present study also reports grazing, timber extraction, charcoal burning and settlements, indicating worse levels of degradation than was the case in 2019.

As reported, in the project ESIA (2019), there still was only one protected area, Rwoho Central Forest Reserve. Though a protected area, this reserve was by far degraded, with the indigenous species replaced by the exotic *Eucalyptus*, *Pinus* and *Grevillia*, consistent with the 2019 ESIA findings.

The plant species reported in 2019 is 91 as compared to 247 recorded during the present study. Consistent with the 2019 findings, no species of conservation concern were revealed during this study. No globally or nationally threatened or range-restricted species of plant were recorded from the project area.

A total of 22 species of plants in the 2019 ESIA Report were reported as having been invasive species, as opposed to only two from the present study. This wide variation is due to the fact that during the ESIA, nearly all weeds of cultivation such as *Bidens pilosa*, *Tagetes minuta*, *Melinis repens* and many others, were listed as "invasive species". In this study, the focus was on the Alien Invasive Species which are not disputable, and hence raises no contention and confusion.

4.2.4 Fauna

4.2.4.1 Literature review

Review of the project documents and other publications shows that the first survey of the project area was conducted in November 2017 when the detailed ESIA survey was being conducted. The survey focused on the entire project area, namely; the proposed dam sites, the area to be inundated by the dam, downstream of river Mishumba and the general irrigation command area. For fauna the survey focused on Amphibians, Reptiles, Birds and Mammals. Butterflies and dragon flies were not included in the survey. During the survey twelve (12) Amphibian species were recorded in the project area. Eleven (11) were frogs while one was a toad. Eight (8) reptile species were recorded; two (2) skinks, one (1) lizard, one (1) gecko, one (1) chameleon and three (3) snakes. A total of 53 bird species were recorded in six (6) general areas where the surveys were conducted.

During the ESIA surveys, interviews with members of the local community revealed that large mammals reportedly used to occur in the area. Those that used to occur included the Hyrax, Olive Baboon and Side-Stripped Jackals. The report also indicates that lions, stripped jackals and leopards used to roam the areas up to early 1980s. However, due to increased conflicts with mainly cattle keepers in the area, the large carnivorous mammal groups (especially leopards and lions) were reportedly killed by the cattle keepers and do not exist in the project area today. The common species of mammals are largely small mammals and only five (5) small mammal species were recorded.

The second survey was done in March 2018 and in the survey, the research teams undertook additional survey of biota (herptiles, fish and other aquatic biota, mammals and birds) and hydrological surveys for environmental flow (amount of water to be left flowing in river for sustenance of biota life). The survey focused on sampling for biota within stretch downstream of the proposed dam site on River Mishumba. Crawling creatures (amphibians and reptiles that could be affected by reduced water flow were assessed. Eight (8) Amphibian species and one reptile species (Striped Skink *Trachylepis striata*) were recorded in the stretch.

No new species record for amphibians and reptiles were documented.

The third survey which took place in 2019, focused on surveying for fauna in the area to be inundated by the dam and area to be restored as an off-set for the project. The survey looked at butterflies, amphibians, reptiles, birds and mammals. During the third survey, 4 butterfly, 9 amphibian, 6 reptiles, 45 bird and 10 mammal species were recorded.

Species recorded during the 3rd survey not previously recorded in earlier surveys include; 1 reptile (a snake; Puff Adder *Bitis arietans*) and 5 mammals (White Tailed Mongoose *Ichneumia albicauda*, African Civet *Civettictis civetta*, Blue Monkey *Cercopithecus mitis*, Red Tailed Monkey *Cercopithecus ascanius* and Vervet Monkey *Chlorocebus pygerythrus*).

Overall, the following information is known on the fauna groups in the project area:

4.2.4.1.1 Butterflies

A total of 103 butterfly species were recorded for Rwoho CFR during the biodiversity inventory surveys that were carried out by then Forest Department with support from European Union. Some of the species known to occur in the project area include; Scalloped Sailer *(Neptidopsis ophine)*, Soldier Commodore Junonia Tereo, Common Joker *(Byblia ilithyia)* and small whites Dixeia orbona.

4.2.4.1.2 Amphibians

Document review reveals that twelve (12) amphibian species are known to occur in the project area, they include Striped Leaf-folding Frog *Afrixalus quadrivittatus,* Cinnamon-bellied Reed Frog *Hyperolius cinnamomeoventris,* Kivu Reed Frog *Hyperolius kivuensis,* Common Reed Frog *Hyperolius viridiflavus,* Dwarf Puddle Frog *Phrynobatrachus mababiensis,* Natal Puddle Frog *Phrynobatrachus natalensis,* Lake Victoria Clawed Frog *Xenopus victorianus,* Anchieta's Rocket Frog Ptychadena anchietae, Mascarene Rocket Frog *Ptychadena mascareniensis,* Senegal Kassina *senegalensis,* Flat-backed Toad *Bufo maculatus* and Angola River Frog *Amietia angolensis.*

4.2.4.1.3 Reptiles

Document review indicate that ten reptile species are known to occur in the project area. They include Montane Side-striped Chameleon *Chamaeleo ellioti*, Olive House Snake *Lamprophis olivaceus,* Forest Cobra *Naja melanoleuca,* Tropical House Gecko *Hemidactylus mabouia*, Olive Marsh Snake *Natriciteres olivacea*, Central African python *sebae*, Speckled-lipped Skink *Trachylepis maculilabris*, Striped Skink *Trachylepis striata*, Nile Monitor *Varanus niloticus*, and Puff Adder *Bitis arietans.*

4.2.4.1.4 Birds

The 2019 ESIA survey report provides a list of bird species (45 in number) encountered during the survey. The Rwoho Central Forest Reserve Biodiversity inventory reports a total of sixty-three (63) bird species encountered during the biodiversity inventory for the reserve.

4.2.4.1.5 Mammals

Ten mammal species have been documented to occur in the project area and include; African Civet *Civettictis civetta,* White Tailed Mongoose *Ichneumia albicauda,* Short-snouted Elephant shrew *Elephantulus brachyrhynchus,* Red Tailed Monkey *Cercopithecus Ascanius,* Blue Monkey *Cercopithecus mitis,* Olive Baboon *Papio Anubis,* Vervet Monkey *Chlorocebus pygerythrus,* Hinde's Rock Rat *Aethomys hindei,* Striped Grass Mouse *Lemniscomys striatus and* House Rat *Rattus rattus.* The survey team worked to further enrich the survey findings for the butterflies, amphibians, reptiles, avifauna and mammal fauna; as well as undertake a survey for dragonflies.

4.2.4.2 Field Sampling Survey Results

4.2.4.2.1 Butterflies

4.2.4.2.1.1 Species Richness

In Uganda, some 1245 species of butterflies have been recorded (Davenport, 1993) from a variety of habitats. Twenty-two (22) species of butterflies were recorded in Mishumba catchment during dry season visit (**Table** 4-15). The species comprise five (5) families and fifteen (15) genera (**Figure** 4-37). During the wet season survey, the butterfly taxa was not considered and there is no wet season data to compare with. The only available butterfly data surveyed specifically for this project around the dam area and areas to be inundated by the dam in the upstream recorded four (4) butterfly species. Those recorded include Scalloped Sailer *Neptidopsis ophine*, Soldier commodore Junonia tereo, Common Joker *Byblia ilithyia* and small whites *Dixeia orbona*. Butterflies appear at certain times during the year, some at the on-set of the wet season.

Table 4-15: List of butterfly species encountered during Dry Season

Families	**Species recorded**	**No. counted dry season**	**IUCN Red List status**
Hesperiidae	*Borbo fatuellus* Foolish Swift	5	Least Concern
Lycaenidae	*Zizula hylax* Tiny Grass Blue	8	Least Concern
Nymphalidae	Acraea uvui Tiny Acraea	3	Least Concern
Nymphalidae	Danaus chrysippus African Queen	12	Least Concern
Nymphalidae	Hypolimnas misippus Diadem	2	Least Concern
Nymphalidae	Junonia oenone Blue Pansy	8	Least Concern
Nymphalidae	Junonia Sophia Little Commodore	14	Least Concern
Nymphalidae	Junonia stygia Brown Pansy	2	Least Concern
Nymphalidae	Neptidopsis ophione Scalloped Sailer	23	Least Concern
Nymphalidae	Precis archesia Garden Inspector	8	Least Concern
Nymphalidae	Precis octavia Gaudy Commodore	3	Least Concern
Nymphalidae	*Precis rauana* Forest Commodore	34	Least Concern
Nymphalidae	Pseudacraea Lucretia False Diadem	8	Least Concern
Nymphalidae	Vanessa cardui Painted Lady	2	Least Concern
Papilionidae	Papilio demodocus Citrus Swallowtail	1	Least Concern
Papilionidae	Papilio echeriodes White-banded Swallowtail	1	Least Concern
Papilionidae	Papilio nireus Narrow Blue-banded Swallow tail	4	Least Concern
Pieridae	*Belenois aurota* Brown Veined White	5	Least Concern
Pieridae	Belenois creona Common White	3	Least Concern
Pieridae	Catopsilia florella African Migrant	27	Least Concern
Pieridae	Eronia leda Orange-and-lemon	10	Least Concern
Pieridae	*Eurema desjaridinsi* Angled Grass Yellow	16	Least Concern

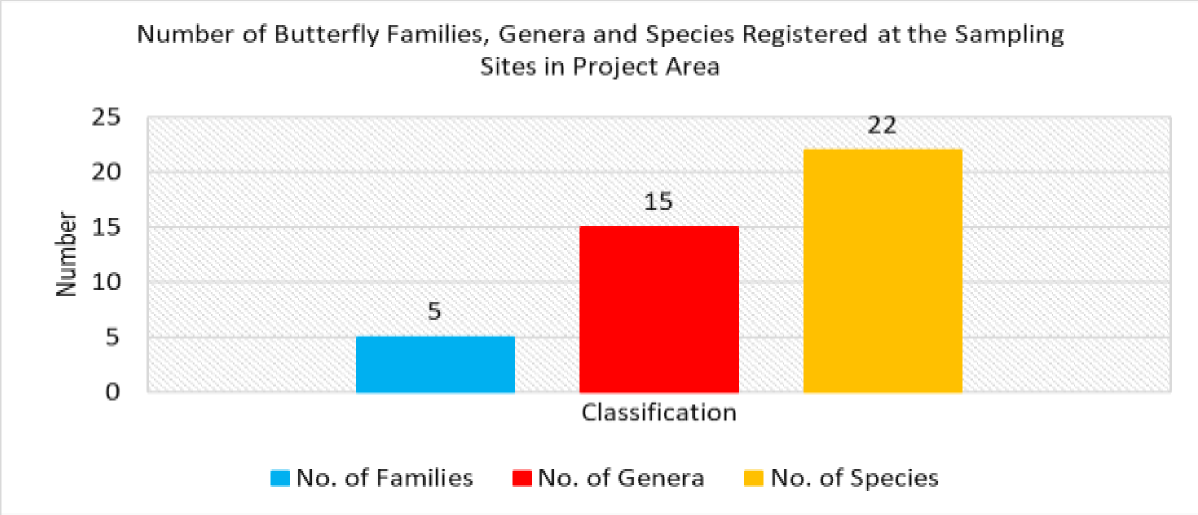


Figure 4-37: Diversity of Butterfly species in the study area

4.2.4.2.1.2 Species Relative abundance

Three (3) species of butterflies were relatively common during the dry season sampling. They included Forest Commodore *Precis rauana*, African Migrant *Catopsilia florella* and Scalloped Sailer *Neptidopsis ophione* for which 34, 27 and 23 individuals respectively were counted. Citrus Swallowtail *Papilio demodocus* and White-banded Swallowtail *Papilio echeriodes* were the least abundant relative to all the species registered. One individual for each species was counted during the dry season sampling.

4.2.4.2.1.3 Species conservation status

None of the butterfly species recorded during the additional survey were of conservation significance basing on the 2019 IUCN Red list of threatened species. The species are categorized as Least Concern.

	
Scalloped Sailer Neptidopsis ophione	Foolish Swift Borbo fatuellus

Little Commodore *Junonia Sophia*

Figure 4-38: some Butterfly species encountered during the additional survey

4.2.4.2.2 Dragonflies

4.2.4.2.2.1 Species Richness

Scientists consider dragonflies reliable bioindicators of the health of an ecosystem. This is because dragonflies require stable oxygen levels and clean water. Uganda lies between two important biogeographical regions. This combined with its extensive swamps and forest areas, has a high number of dragonfly species. Uganda has 231 species of dragonflies. Eight (8) species were recorded in the project area (**Table** 4-16).

Southern Banded Groundling *Brachythemis leucosticta* is one of Africa's most familiar odonates species. Red-veined Dropwing Trithemis *arteriosa*, is one of Africa's most widespread dragonfly and Julia Skimmer *Orthetrum Julia* is one of the commonest dragonflies. The species that were encountered represent two families and seven genera (**Figure** 4-39). However, no dragonfly data was collected in the wet season. Only the dry season data set was collected. An earlier survey of the damming area and areas to be inundated by the dam, recorded a total of five dragonflies.

Table 4-16: Dragonflies recorded in the project area during the survey

Families	Species Recorded	No. Counted Dry Season	IUCN Red List Status
Coenagrionidae	Pseudagrion hageni Painted Sprite	35	Least Concern
Libellulidae	*Brachythemis leucosticta* Southern Banded Groundling	5	Least Concern
Libellulidae	Crocothemis erythraea Broad Scarlet	4	Least Concern
Libellulidae	Nesciothemis cf farinosa Eastern Blacktail	4	Least Concern
Libellulidae	Orthetrum Julia Julia Skimmer	50	Least Concern
Libellulidae	Palpopleura lucia Lucia Widow-	12	Least Concern
Libellulidae	Palpopleura portia Portia Widow	6	Least Concern
Libellulidae	*Trithemis arteriosa* Red-veined Dropwing	6	Least Concern

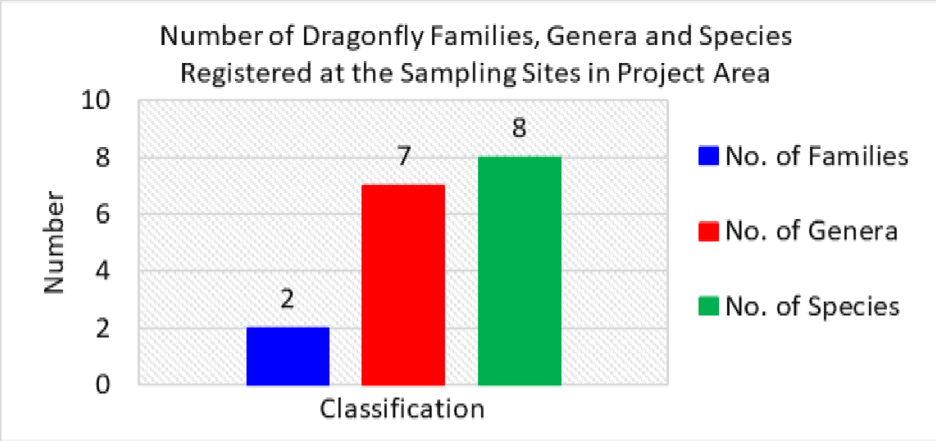


Figure 4-39: Diversity of dragonfly species in the project area

4.2.4.2.2.2 Species Relative abundance

In the dry season the Julia Skimmer *Orthetrum Julia* registered the highest abundance relative to other dragonfly species. Fifty (50) individuals of the Julia Skimmer were encountered during the dry season survey. The Painted Sprite *Pseudagrion hageni* registered the second highest abundance relative to other species with thirty-five (35) individuals registered (**Table** 4-16). The Eastern Blacktail *Nesciothemis cf farinosa* and the Broad Scarlet *Crocothemis erythraea* had the lowest abundance relative to other species with one individual each recorded. Dragonflies were mainly recorded around rivers / streams, swamps, wet culverts, and seasonal floodplains.

4.2.4.2.2.3 Species conservation status

None of the dragonfly species recorded during the survey are of conservation importance. The species are listed as least concern (LC) by IUCN 2019 Red list of threatened species. Modification of the natural landscape through settlement and agricultural encroachment, and the subsequent alteration of water bodies by erosion and siltation, are some of the main threats to Odonata (a group of dragonflies) in Africa. Measures that avoid or minimize landscape transformation will go a long way in promoting dragonfly conservation (Dijkstra *et al*., 2011).

	
Male Julia Skimmer *Orthetrum Julia*	Male Southern Banded Groundling *Brachythemis*

Male Lucia Widow-*Palpopleura lucia*	Male *Broad Scarlet Crocothemis erythraea*

Figure 4-40: Catalogue of some of the Dragon flies recorded in the project area

4.2.4.2.3 Amphibians

4.2.4.2.3.1 Species Richness

A total of Nine (9) amphibian species were recorded in the project area (**Table** 4-17). Recorded were all frogs. The recorded species represent 4 families and 5 genera (**Figure** 4-41). In terms of species richness, Family *Hyperoliidae* was the most represented with four species. Families Ptychadenidae and Phrynobatrachidae were represented with two species each. Family Pyxicephalidae was the least represented with one species. Amphibians were mainly recorded in areas that are moist especially around wetland areas and streams and wet culvert points.

All the four (4) families and all the five (5) genera were represented in the wet and dry seasons. This may be attributed to the fact that the project area is wet throughout the year due to the permanent rivers. However, only eight (8) species of amphibians were recorded during the wet season and seven (7) species of amphibians recorded during the dry season. The difference in species number between wet and dry season may be attributed to their activity time.

Table 4-17: Amphibian species recorded in the project area during the survey

Family	Species Recorded	No. Counted Wet season	No. Counted Dry Season	IUCN Red List Status
Hyperoliidae	Hyperolius cinnamomeoventris Cinnamon-bellied Reed Frog	2		Least Concern
Hyperoliidae	Hyperolius kivuensis Kivu Reed Frog	1	1	Least Concern
Hyperoliidae	Hyperolius viridiflavus Common Reed Frog	1	1	Least Concern
Hyperoliidae	Kassina senegalensis Senegal Kassina	2		Least Concern
Phrynobatrachidae	Phrynobatrachus mabebiensis Dwarf Puddle Frog	25	11	Least Concern
Phrynobatrachidae	Phrynobatrachus natalensis Natal Puddle Frog	1	15	Least Concern

Ptychadenidae	Ptychadena mascareniensis Mascarene Rocket Frog	108	63	Least Concern / Data Deficient
Ptychadenidae	*Ptychadena anchietae* Anchieta's Rocket Frog		26	Least Concern
Pyxicephalidae	Amietia angolensis Angola River Frog	1	1	Least Concern / Data Deficient
Total		141	118	

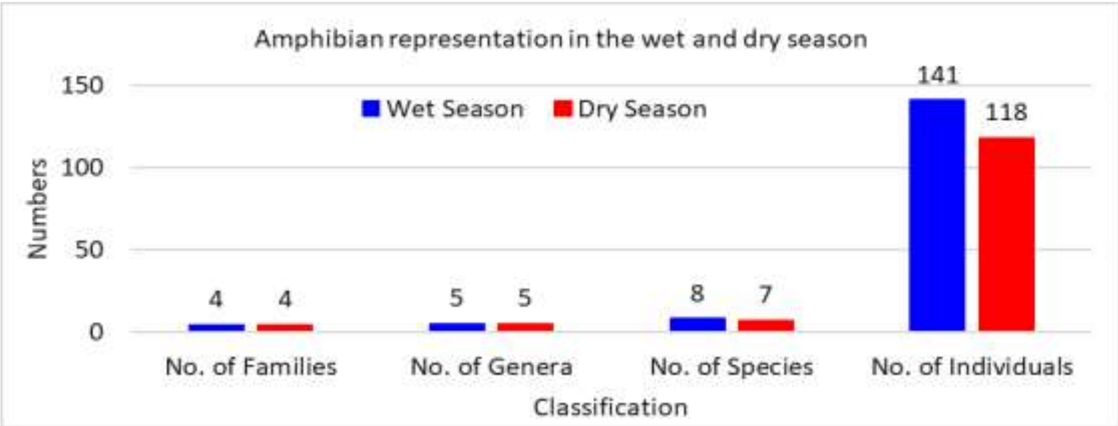


Figure 4-41: Diversity of Amphibian Species encountered in the project area

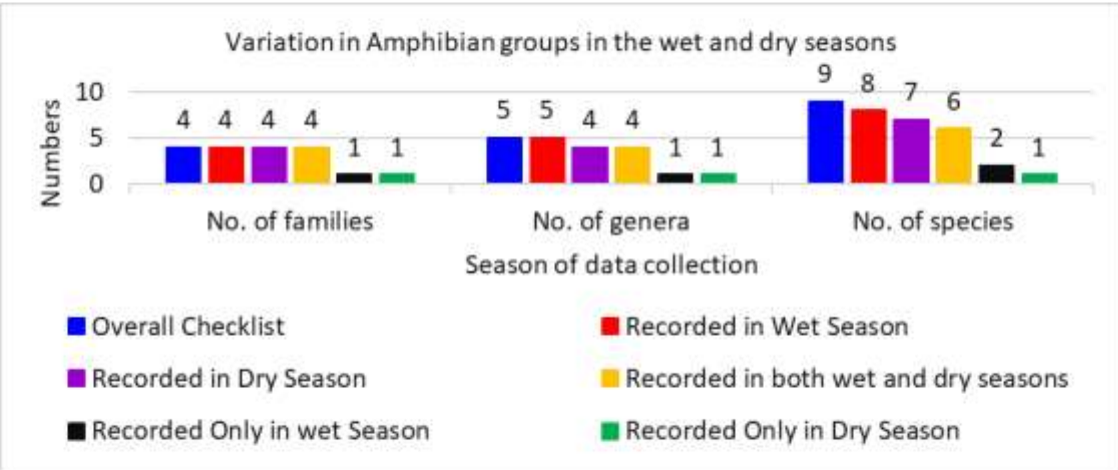


Figure 4-42: Amphibian diversity representation in the wet and dry seasons

Six (6) species belonging to four families and four genera were recorded in both the wet and dry season (**Figure** 4-42). Two (2) species were recorded only in the wet season, while one (1) species was recorded only in the dry season. As already pointed out, the difference in species number between wet and dry season or registering presence of species in wet or dry season, may be attributed to their activity time.

Earlier studies in the project area, recorded five (5) amphibian species which were not encountered during the survey. The species include Kisolo Toad *Sclerophrys Kisoloensis*, Flat-backed Toad *Sclerophrys maculatus*, Sharp-nosed Ridged Frog *Ptychadena oxyrhynchus*, Striped Leaf-folding Frog *Afrixalus quadrivittatus* and *Xenopus victorianus* Lake Victoria Clawed Frog.

4.2.4.2.3.2 Species relative abundance

More individuals of amphibians were recorded during the wet season than during the dry season. One Hundred Forty-One (141) individuals were encountered during the wet season and only One Hundred Eighteen (118) individuals were encountered during the dry season.

The biggest contributor to the relative abundance in the wet season were Mascarene Rocket Frog *Ptychadena mascareniensis* contributing 108 individuals and Dwarf Puddle Frog *Phrynobatrachus mabebiensis* contributing twenty-five (25) individuals. The biggest contributor to the relative abundance in the dry season were Mascarene Rocket Frog *Ptychadena mascareniensis* and Anchieta's Rocket Frog *Ptychadena anchietae*. They contributed Sixty-three (63) and Twenty-six (26) individuals respectively. Species of genus *Ptychadena* are well known for their adaptive capacities and are therefore resilient to effects of degradation. This probably accounts for their high relative abundance during the dry season.

4.2.4.2.3.3 Species conservation status

Based on the IUCN Red List of threatened species 2019, none of the Amphibian species recorded during the survey and those earlier recorded are of conservation concern, all the species are globally listed as Least Concern (LC). Three species, the Mascarene Ridged Frog *Ptychadena mascareniensis*, Angola River Frog *Amietia angolensis* and the Striped Leaf-folding Frog *Afrixalus quadrivittatus* (recorded in earlier studies) are listed as Data Deficient (DD) by the National Red List for Uganda (WCS, 2016).

	
Mascarene Rocket Frog *Ptychadena mascareniensis* one of the most common species in project area	Dwarf Puddle Frog *Phrynobatrachus mabebiensis*

Figure 4-43: Catalogue of some of the Amphibians in the project area

4.2.4.2.4 Reptiles

4.2.4.2.4.1 Species richness

Four (4) reptile species were recorded during the additional field survey related to seasons (**Table** 4-18). They include One snake, two skinks and one Chameleon. The species represent three families and three genera (**Figure** 4-44). All the species were recorded during the wet season and only two (2) species recorded during the dry season. Two species were recorded both in the wet and dry season and include Speckled-lipped Skink *Trachylepis maculilabris* and Striped Skink *Trachylepis striata*.

From literature review, five reptile species exist in the area but were not encountered during the survey. The species include Olive Marsh Snake *Natriciteres olivacea*, Olive House Snake *Lamprophis olivaceus*, Puff Adder *Bitis arietans,* Nile Monitor *Varanus niloticus and* Speke's Hinged Tortoise *Kinixys spekii*.

Table 4-18: Reptile species recorded during the survey

Family	Species Present	No. Counted Wet season	No. Counted Dry Season	IUCN Red List Status
Chamaeleonidae	*Chamaeleo ellioti* Montane Side-striped Chameleon	2		LC
Elapidae	Naja melanoleuca Forest Cobra	1		LC
Scincidae	Trachylepis maculilabris Speckled-lipped Skink	3	2	LC
Scincidae	Trachylepis striata Striped Skink	5	3	LC

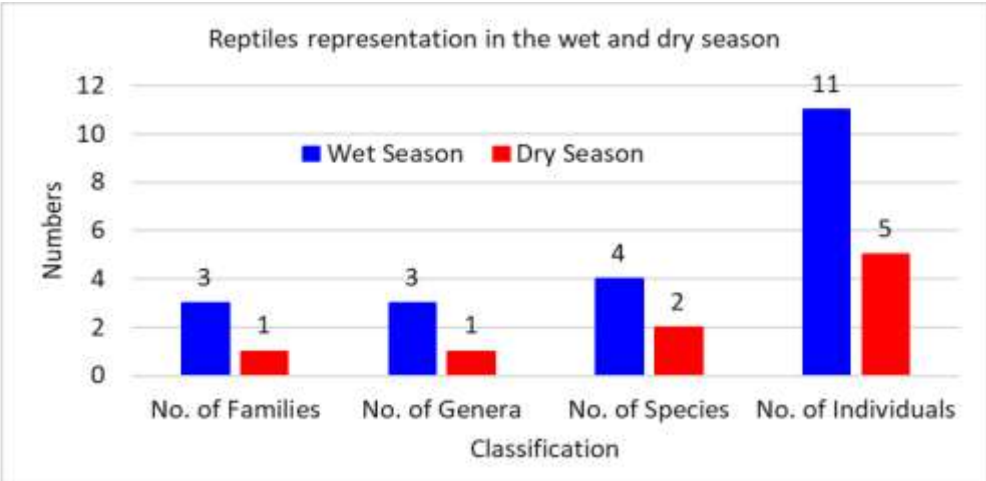


Figure 4-44: Diversity of reptile Species encountered in the project area

4.2.4.2.4.2 Species relative abundance

More individuals of reptiles were recorded during the wet season than during the dry season. Eleven (11) individuals were encountered during the wet season while only five (5) individuals were encountered during the dry season. The skinks had the highest relative abundance compared to other species. The *Trachylepis striata* Striped Skink registered five (5) individuals and the *Trachylepis maculilabris* Speckled-lipped Skink registered three individuals. Two individuals of the *Chamaeleo ellioti* Montane Side-striped Chameleon and one individual of the *Naja melanoleuca* Forest Cobra were encountered. Estimation of reptile species abundance requires an extended period of time which was not feasible with the time allocated to the consultant for the additional studies.

4.2.4.2.4.3 Species Conservation Status

Globally, IUCN Red List of threatened species 2019 categorizes the species recorded during the studies and those recorded in earlier surveys as Least Concern. The species are listed under CITES Appendix II (Branch, 1998***). In Uganda, the species were down listed from Appendix II because***

the species are still abundant and wide spread in the countryside. In addition, the Crested Crane is a resilient bird and can still be found in abundance in some areas though its habitat is slowly being depleted[6].

Figure 4-45: Catalogue of some of the Reptiles recorded in the project area

	
Montane Side-striped Chameleon *Chamaeleo ellioti*	Two Montane Side-striped Chameleon *Chamaeleo ellioti* fighting

4.2.4.2.5 Avi-fauna (Birds)

4.2.4.2.5.1 Species Richness

Eighty-four (84) species of birds were recorded during the survey in both the wet and dry season (**Table** 4-19 and **Figure** 4-46). These represent 36 families and 69 genera. This is an increase of 87% in the number of species recorded in the project area. The increase might be attributed to the additional sampling sites which were not previously sampled. The increase could also be a result of sampling during both the wet and dry season. During the wet season, sixty-two (62) species were recorded and sixty-seven (67) species recorded during the dry season. More species being recorded during the dry season may be attributed to the fact that there is a lot of movement of birds in search for food. Forty-five (45) species were recorded in both the wet and dry season. Seventeen (17) species were recorded only in the wet season and twenty-two (22) species were recorded only in the dry season.

African Wattled Lapwing *Vanellus senegallus*, Spur-Winged Lapwing *Vanellus spinosus*, Long-Toed Lapwing *Vanellus crassirostris*, Intermediate Egret *Ardea intermedia* and Sacred Ibis *Threskiornis aethiopicus* are wetland specialists. These were only recorded in the dry season visit in March 2021. During the wet season none was recorded. Northern Red Bishop *Euplectes franciscanus*, Cattle Egret *Bubulcus ibis* and Pin-Tailed Whydah *Vidua macroura* are purely grassland species which were only registered during the dry season. The appearance of the Semi-Collared Flycatcher *Ficedula semitorquata,* Ross's Turaco *Musophaga rossae,* Eastern Grey Plantain Eater *Crinifer zonurus,* Blue-Headed Sunbird *Cyanomitra alinae* and Scarlet-Chested Sunbird

[6] Brayan Haines 2020: 16 Facts about Crested Crane of Uganda, Africa: Balearica regulorum gibbericeps. Storyteller.Travel

Chalcomitra senegalensis was noted. In the dry season, food scarcity may result in conspicuous species moving in search for food.

Table 4-19: Summary of recorded bird species in both wet and dry seasons in the study area

Season	N°. of families	N°. of genera	No. of species
Overall Checklist	36	69	84
Recorded in Wet Season	34	55	62
Recorded in Dry Season	32	54	67
Recorded in both wet and dry seasons	28	39	45
Only recorded in wet Season	15	17	17
Species Only recorded in Dry Season	15	19	22

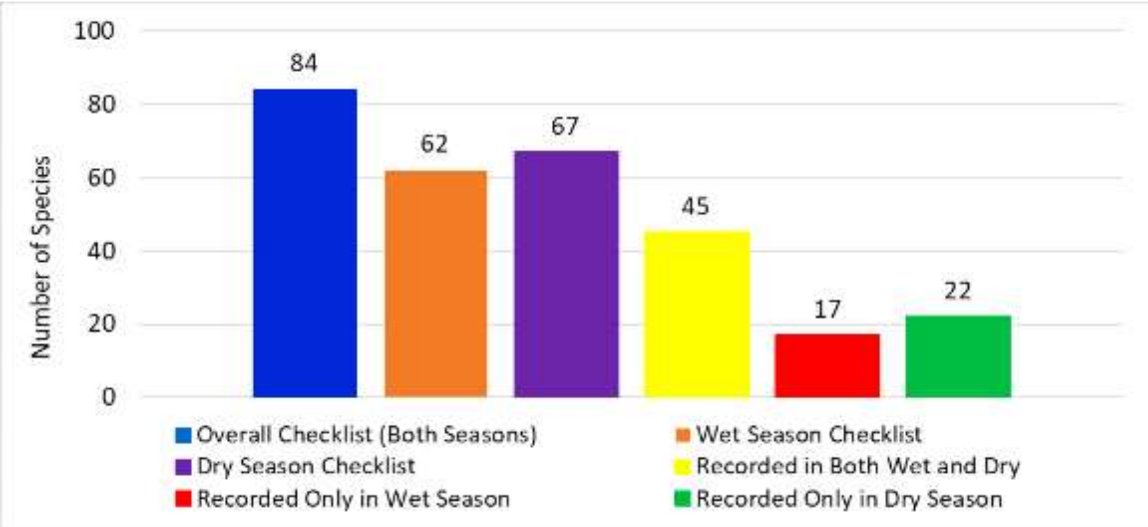


Figure 4-46: Number of recorded species in both wet and dry seasons in the study area

4.2.4.2.5.2 Species Relative abundance

Wet and dry seasons combined, the Lesser Masked Weaver *Ploceus intermedius*, Black-Headed Weaver *Ploceus cucullatus* and Common Bulbul *Pycnonotus barbatus* were the most abundant relative to other species with 226, 209 and 115 individuals recorded respectively. Seven species had one individual each recorded during the survey. During the wet season, the Lesser Masked Weaver *Ploceus intermedius*, Black-Headed Weaver *Ploceus cucullatus* and Common Bulbul *Pycnonotus barbatus* were the most abundant relative to other species with 223, 75 and 41 individuals recorded respectively. During the dry season, the Black-Headed Weaver *Ploceus cucullatus*, Yellow-Backed Weaver *Ploceus melanocephalus*, Common Bulbul *Pycnonotus barbatus*, African Mourning Dove Streptopelia decipiens, and Grey Crowned Crane *Balearica regulorum*–were among the most abundant relative to other species. During the survey, 134, 76, 74, 58 and 57 individuals were recorded respectively.

4.2.4.2.5.3 Species Conservation status

Ten (10) species of conservation importance were recorded during the survey. Four (4) of them were recorded during the dry season, two (2) were recorded during the wet season while four (4) were recorded during both seasons. The *Stephanoaetus coronatus* Crowned Eagle is categorized by IUCN Red List as Regionally Vulnerable at the African region and endangered by Uganda's National Red List. The species was recorded during the dry season. The Martial Eagle *Polemaetus bellicosus* is categorized as Near-Threatened and it is regionally vulnerable. This was recorded during both the wet and dry season. African Marsh Harrier *Circus ranivorus* is categorized as Near-Threatened at the Africa regional level. It was also recorded in both the wet and dry season. African Darter *Anhinga rufa* is categorized as Vulnerable at the African regional level and also for Uganda. **Table** 4-20 and **Figure** 4-47 shows sampling sites where the Grey Crowned Cranes were recorded during the study in both wet and dry deasons.

It is important to note that, the areas where most of these birds were recorded happen to be flat open areas used for livestock grazing and cultivation by the communities. In addition, according to the surveys conducted during this study (including consultations with the local communities in the vicinity), there were no nests nor roosting points for these birds implying the bird groups a visitor category to the area.

Table 4-20: List of Sites and numbers of Grey Crowned Cranes encountered during the study

Sampling Site	GPS Coordinates (UTM 36 M)		Number of Cranes Recorded at site
	Easting (m)	Northing (m)	
Wet Season			
11	238427	9902841	3
17	237018	9897007	3
19	237243	9894503	2
20	236139	9893131	6
21	235513	9890533	2
22	235620	9889958	3
24	234940	9886432	2
Total			**21**
Dry Season			
5	231266	9900330	2
9	241266	9900833	4
11	238425	9902835	5
11	238667	9902707	6
12	237776	9899070	7
16	237208	9896881	2
17	237024	9897006	9
18	237310	9895631	4
19	237207	9894511	2
20	236136	9893131	2
21	235506	9890587	2
22	235622	9889966	10
24	234932	9886423	2
Total			**57**

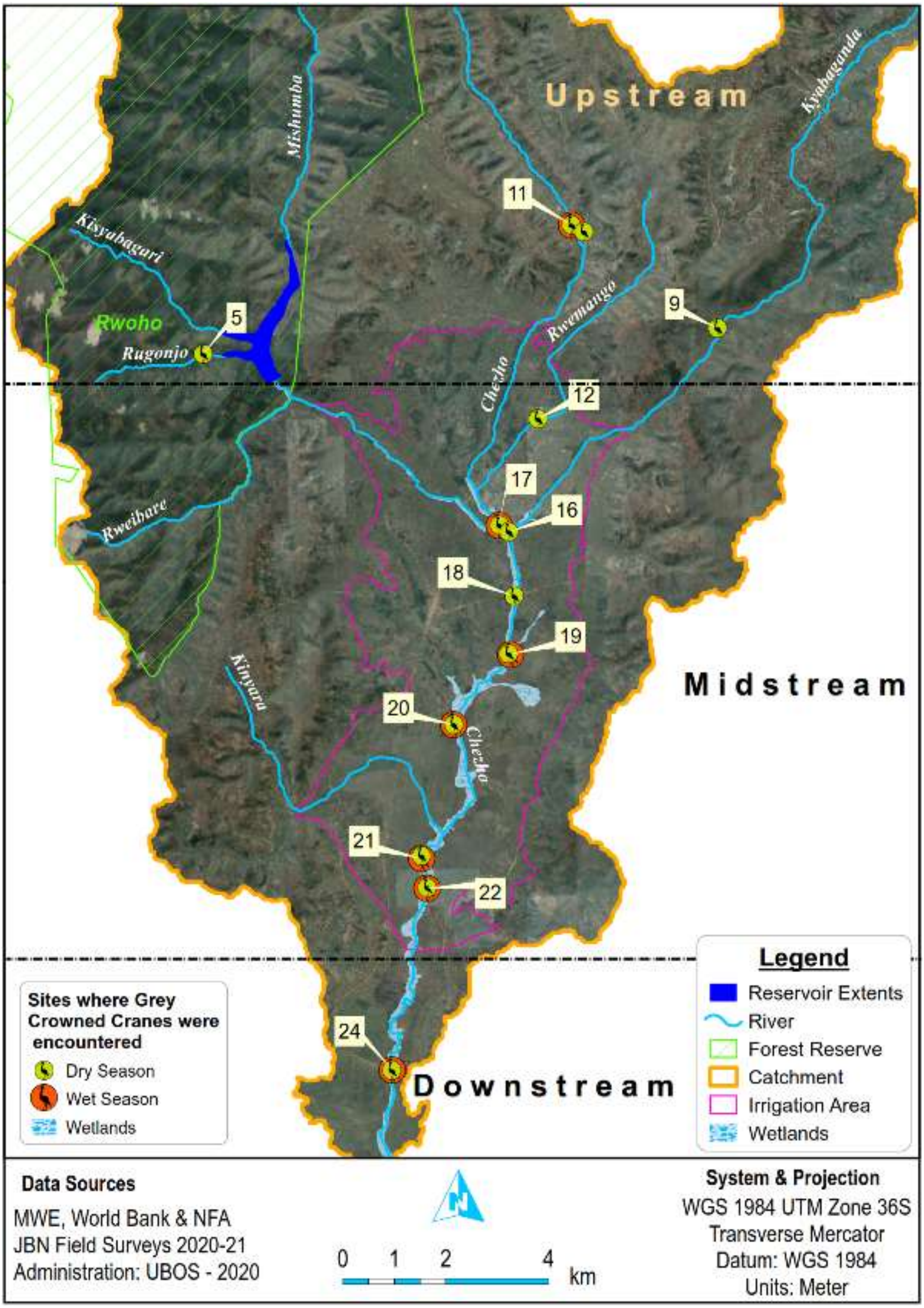


Figure 4-47: Sites where Grey Crowned Cranes were encountered during the dry and wet seasons.

The grey crowned crane remains common over most of its range, although it faces threats from continued habitat degradation, drainage/reclamation, overgrazing and pesticide pollution from agricultural practices. Their global population is estimated to be between 58,000 and 77,000 individuals. Those that live far north in the arid Sahara Desert often migrate south for portions of the year to escape the hottest and driest months in the desert. They join their more sedentary cousins in Uganda and Kenya which live near rivers and lakes.

The project area has been greatly modified by the local community who harvest papyrus for crafts e.g., for mats and baskets and for mulching banana gardens. Because of the level of human influence on the ecosystem, local people reported, they have never encountered any breeding sites for the Crested Cranes in the proposed project areas. Even during all the surveys in this study neither were nests nor roosting sites encountered implying the project will not have impact on its breeding or related habitat functions. African Crake Crex egregia is categorized as Near-Threatened at the African region and in Uganda, this bird is regarded as of least conservation concern because of its occurance in many parts of the country and its habitats not limited.

4.2.4.2.6 Mammals

Four (4) studies have been conducted on fauna in the project area. The first was during the detailed ESIA in 2017 and this focused on the entire project area. The second survey was conducted in March 2018 and this focused-on sampling amphibians and reptiles that could be affected by reduced water flow downstream of the proposed dam site. The third survey which took place in 2019 focused on surveying for fauna in the area to be inundated by the dam and area to be restored as an off-set for the project. The fourth and latest additional studies took place in November 2020 and February 2021 within the catchment but different sub-catchments that contribute to the irrigation area.

During the additional studies no mammal species were recorded but about ten species have been recorded from previous studies related to the project. From interviews conducted by the ESIA team in 2017 with members of the local community, large mammals reportedly used to occur in the area ranging from Hyrax, Olive Baboon, Side-stripped Jackals and lions and leopards used to roam the areas up to early 1980s. However, due to increased conflicts between mainly cattle keepers in the area and some of the large carnivorous groups of mammals in the area especially leopards, stripped jackals and lions were reportedly killed by the cattle keepers so, none of those animals exist in the project site anymore. **Table** 4-21 shows the list of species and areas where they have been recorded in previous studies. However, there is no information is available on the species relative abundance.

Table 4-21: Consolidated list of mammal species recorded in the project area

Order	Scientific Name	English Name	Remarks	IUCN Red List Status	National Red List Status
Rodentia	*Aethomys hindei*	Hinde's Rock Rat	Recorded upstream of the dam including the areas to be inundated by the dam	LC	
Rodentia	*Lemniscomys striatus*	Striped Grass Mouse	Recorded in the restoration/reforestation area	LC	
Macroscelidea	*Elephantulus brachyrhynchus*	Short-snouted Elephant shrew	One dead individual encountered in the grassland patches in Rwoho Forest Reserve	LC	
Rodentia	*Rattus rattus*	House Rat	Recorded by ESIA team in general project area	LC	LC
Carnivora	*Ichneumia albicauda*	White Tailed Mongoose	Dung / Faecal material observed in the grassland patch of Rwoho FR restoration/reforestation area	LC	
Carnivora	*Civettictis civetta*	African Civet	Dung / Faecal material observed in the grassland patch of Rwoho FR restoration/reforestation area	LC	
Primate	*Cercopithecus mitis*	Blue Monkey	Seen in the western side of Rwoho FR restoration/reforestation area	LC	
Primate	*Cercopithecus ascanius*	Red Tailed Monkey	Reported by NFA staff in the western side of Rwoho FR restoration/reforestation area	LC	
Primates	*Chlorocebus pygerythrus*	Vervet Monkey	Reported in western side of Rwoho FR the restoration/reforestation area Also reported by community in the far side of upstream areas of the dam.	LC	LC
Primate	*Papio anubis*	Olive Baboon	Reported by NFA staff in the western side of Rwoho FR the restoration/reforestation area Also reported by community in the far side of upstream areas of the dam.	LC	

4.2.4.3 Fauna species of limited distribution range

The fauna lists for all the taxa were cross examined against their known distribution. It was established that none of the taxa (Butterfly, Dragonfly, Amphibians, Reptiles, Birds and Mammals) have a limited distribution range. Also, no new bird records were registered neither mentioned in the literature reviewed.

4.2.4.4 Use of the Riverine System by Fauna and its implications

4.2.4.4.1 Nesting

Four species of birds were observed building nests during the wet season field visit. For some, there was an indication that nests have been around for some time. Some of the birds with or which were constructing nests include: Grosbeak Weaver *Amblyospiza albifrons,* Lesser Masked Weaver *Ploceus intermedius*, and Hamerkop *Scopus umbretta*. The Black Crake *Zapornia flavirostra* is also known to construct nests in thick riverine vegetation. To breed successfully, wetland birds require suitable places in which to build their nests. Some bird species were observed to build their nests on and from wetland vegetation.

Grosbeak Weaver *Amblyospiza albifrons* nest which are built on riverine vegetation

Lesser Masked Weaver *Ploceus intermedius* nests also are visible on papyrus vegetation

Hamerkop Scopus umbretta nest

Figure 4-48: Birds using the riverine vegetation for nesting

4.2.4.4.2 Feeding

Sixteen (16) wetland birds were recorded. Eight were wetland specialists and seven are wetland visitors. Wetland birds depend on wetland for feeding and breeding. However, wetland birds feed on a wide range of invertebrates, small fish, frogs and wetland vegetation seeds. The seasonal increase in water volumes (wetting) during the wet season and the associated receding (drying cycles) of the river to its normal flow brings about provision of different foods at different times therefore should be maintained. Amphibians and reptiles also feed on a number of insects which occur in the project area. Type and taxa may vary with species.

4.2.4.4.3 Breeding

The presence of the numerous young individuals of amphibians is a sign that the project area is used for breeding. A few tadpoles were seen. The increase in water volumes and associated pools within the project area are vital for amphibian breeding success. Enough volumes of water should be maintained in the project area to maintain the breeding success.

4.2.4.5 Issues affecting the riparian areas

As already pointed out, a phenomenon happened in the study area which impacted the project area. According to the local community, a heavy down pour which happened on 2nd May 2020 caused a flash flood impacting negatively on the ecosystem along the river. All the vegetation was swept downstream by the big force of water that came from upstream leaving the river banks bare. The riverine vegetation was destroyed and negatively impacted the biodiversity utilizing the habitat along the river. The river was left bare as evidenced by photographic catalogue below:

Before	**After**
	
Section of R. Mishumba upstream of the bridge (culvert) in 2019 (site 2)	Section of R. Mishumba upstream of the bridge in November 2020 (site 2)
	
Shows presence of bridge (culvert) in 2019 (site 3)	Bridge swept by the Flash flood in 2020 (site 3)

Figure 4-49: Comparison of the previous and current status of upstream of dam (E232820, N9903147)

Before	After
	
Left hand side of bridge before flash flood in 2019 (site 3)	Left hand side after flash flood in November 2020 (site 3)
	
Righthand side of bridge before flash flood in 2019 (site 3)	Righthand side after flash flood in November 2020 (site 3)

Figure 4-50: Comparison of the previous and current status of upstream (middle of dam) (E232583, N9901041)

Before	After
	
Dam site was fully grown with thick papyrus vegetation along the river in 2019 (site 6)	Dam site papyrus swept by the flash flood in November 2020 (site 6)

Figure 4-51: Comparison of the previous and current status of dam (confluence at E232533, N9900100)

The impacts of the May 2020 flash flood on the river biodiversity, ecology and morphology are evident for almost 5-km downstream. The regenerating vegetation especially along the river currently is harvested by the community for mulching their banana gardens. This affects the riparian vegetation along the river. In some areas, the community cultivate up to the river bank leaving the river vulnerable to siltation.

Papyrus vegetation cutting for mulching the banana gardens is and thatching houses

Figure 4-52: Harvest of riparian vegetation along River Mishumba by attendant farming communities for purposes of mulching.

4.2.4.6 Overall fauna assessment

A complete assessment of the fauna in the project area was carried out as part of the ESIA and other additional studies. Although some of the species e.g., large mammals have virtually disappeared due to increased conflicts with human activities (e.g., cattle keepers) and related modification of the habitat; the project catchment is relatively rich in fauna biodiversity. However, all the species have been recorded in other parts of the Country and East Africa in general. None of the butterflies, dragonflies, amphibians, reptiles and mammal species recorded in the project area is of ecological concern according to the IUCN 2019 Red list. Ten (10) of the bird species are categorized by IUCN as species of conservation concern. However, most of them were recorded in the catchments outside the irrigation command area. *Only the Grey Crowned Crane showed presence in the irrigation command area and these seem to be regular visitors to the project area.*

There was no significant difference in fauna species richness and abundance between the dry and wet season. More time was required to gather more information for the two seasons. Fauna in Kabuyanda may be providing key ecosystem services in the project area. The ecosystem services may be compromised if the fauna groups are adversely affected by the project. However, as presented in the ESIA report, impact on fauna may be minimal due to the following reasons:

a. There are other streams that join the main Mishumba Stream as it follows downstream. This will reduce the impacts on fauna that may result from reduced water flow downstream;
b. Fauna is highly mobile and some are migratory in nature. They have the capacity to move to other areas once disturbed; and
c. The areas to be affected are those close and along the stream.

Long term research/monitoring is therefore paramount during construction and during project operations.

4.2.4.7 Key Ecosystem Services Provided by The Terrestrial Biodiversity in Mishumba Catchment

According to the National Wildlife Federation (NWF) (2021), an ecosystem service is any beneficial impact that nature provides to human society. The concept shows many benefits that a harmoniously balanced natural world provides to societies and how neglecting the environment has negative consequences for human wellbeing (Jax et al. 2013). A world with strong, healthy ecosystems allows us to have diverse food products, a stronger economy, and make advancements in medicine (NWF, 2021) hence the key reasons why biodiversity conservation is so critical.

According to Millennium Ecosystem Assessment (MA), (2003) and NWF (2021) ecosystem services are of four categories.

a. *Provisioning services*: product or materials that are extracted from nature such as food, water, timber, oil, medicinal plants, plant fibre for clothing
b. *Regulating services:* ecosystem processes that moderate natural systems, including pollination, decomposition, carbon storage and sequestration, climate regulation, surface water purification and flood control. These are benefitting that people obtain from the regulation of ecosystem processes listed herein.
c. *Cultural services*: non-material benefits people obtain from ecosystems like improved mental health, creativity born from nature, recreation, sacred sites and knowledge building
d. *Supporting services:* processes that allow Earth to sustain basic life, and thus all of Earth's biodiversity. These processes include photosynthesis, nutrient cycling, soil formation and the water cycle. Without supporting services, provisioning, regulating, and cultural services would not function (Jax *et al.* 2013).

Terrestrial biodiversity on the other hand refers to animals, plants and micro-organisms that live on land, and also land habitats, such as forests, deserts and wetlands. There are a number of fauna species that were positively identified during the ESIA baseline and subsequent studies of the project area. These harmoniously have been working together to form a balanced / stable natural ecosystem. Evidence shows that increased species richness on average leads to greater functioning of ecosystem (Tilman, 2000; Balvanera *et al*., 2006; Cardinale *et al*., 2006; Ives & Carpenter, 2007).

There are many key ecosystem services provided by terrestrial fauna biodiversity within Mishumba Ecosystem. These services include nutrient cycling, pest regulation, pollination, among others. These services sustain agricultural productivity. Presence of fauna therefore, promotes the healthy functioning of ecosystems.

a) Butterflies

Butterflies help flowers pollinate, eat plenty of weedy plants and provide a food source for other animals. In addition, their presence or absence can tell us a lot about the local environment. An abundance of butterflies is often an indication that an ecosystem is thriving. Adult butterflies and caterpillars are an important source of food for other animals such as bats and birds. Along with nectar, butterflies eat a variety of plants. Some species also provide a natural form of pest control. Butterflies pollinate or carry pollen from plant to plant, helping fruits, vegetables, and flowers to produce new seeds. From the animal point of view, butterflies are near the bottom of the food chain and provide food (especially in their caterpillar stage) for birds, mammals, and other insects.

b) Dragonflies

Dragonflies are important to their environments both as predators (particularly of mosquitos) and as prey to birds and fish. Because these insects require stable oxygen levels and clean water, scientists consider them reliable bioindicators of the health of an ecosystem. Dragonflies do an amazing job of helping humans by controlling populations of pest insects, especially those that bug humans most, such as mosquitoes and biting flies. A single dragonfly has been reported to eat anywhere from 30 to hundreds of mosquitoes per day.

Figure 4-53: Dragonfly (*Julia Skimmer Orthetrum Julia*) preying on a butterfly (*Acraea sp*) (Red arrow pointing at *Acraea sp*)

c) Amphibians

Amphibians play essential roles, both as predators and prey, in their ecosystems. Amphibians contribute to regulating services by reducing mosquito recruitment from ephemeral swamps, potentially controlling other pest species, and indirectly through predation of insect pollinators. Adult amphibians eat pest insects, including those pests that damage crops or spread disease. Amphibians also have important functions in the food webs of both aquatic and terrestrial systems. As tadpoles, they eat algae, helping regulate blooms and reducing the chances of algal contamination. Amphibians provide provisioning services by serving as a food source. Frogs are an important source of food for a variety of animals, including humans, birds, fish, monkeys and snakes. According to the Socio-economic survey conducted in the project area by the study team, 27% of the respondents indicated that they eat a certain type of frog locally known as Enkyeere (Lake Victoria Clawed Frog *Xenopus victorianus*). Lake Victoria Clawed Frog *(Xenopus victorianus)* was among the frogs recorded during the baseline survey for the project. Amphibians can affect ecosystem structure through soil burrowing and aquatic bioturbation and ecosystem functions such as decomposition and nutrient cycling through waste excretion and indirectly through predatory changes in the food web. They also can control primary production in aquatic ecosystems through direct consumption and nutrient cycling.

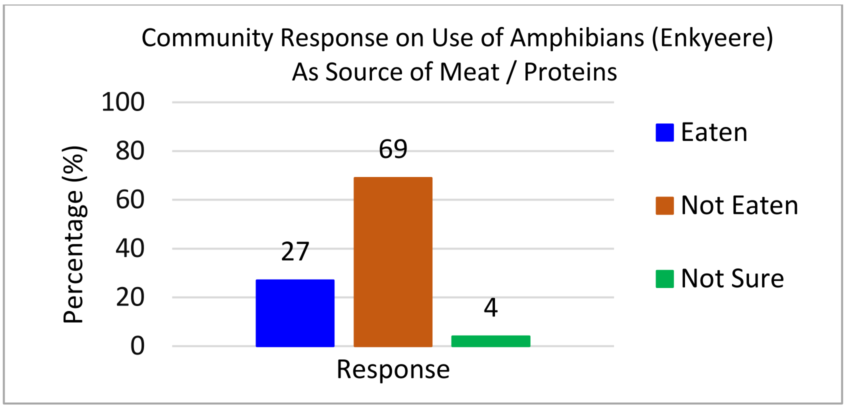


Figure 4-54: Results of the respondents on use of Amphibians as Source of Meat / protein

d) Reptiles

Reptiles also contribute to the four types of ecosystem services: provisioning, regulating, cultural, and supporting. Most available studies report the use of direct services from reptiles. Reptiles are important components of the food webs in most ecosystems. They fill a critical role both as predator and prey species. Reptile species can also have a useful anthropogenic role in ecosystems. In some areas, they help control the numbers of serious agricultural pests by consuming rodent and insect pests.

e) Birds

Birds play a number of roles in ecosystems. They act as pollinators, seed dispersers, predators, scavengers, and ecosystem engineers (Whelan, Wenny, and Marquis 2008). The ecosystem services provided by birds are often indirect and support or enhance other services, and mostly result from foraging. Through foraging, birds act as mobile links that transfer energy both within and among ecosystems, and thus contribute to ecosystem function and resilience (Wenny et al. 2011).

Birds provide pest control regulation ecosystem services through foraging (Michel, Whelan, and Verutes 2020). Birds consuming invertebrates reduce herbivorous insect populations, and plants can respond with increased growth and yields. Thirteen prominent insect feeders were recorded during the studies. These among others include Common Fiscal *Lanius collaris*, Grey-Backed Fiscal *Lanius excubitoroides*, Dusky-Blue Flycatcher *Muscicapa comitata*, Semi-Collared Flycatcher *Ficedula semitorquata*, Barn Swallow *Hirundo rustica*, etc. Removal of birds from the ecosystem would result into insect pest outbreaks.

The predator-prey interactions of raptors hunting rodents can have economic benefits. The eight species of raptors recorded during the studies could be playing a key role in the control of rodent and snake populations in Kabuyanda ecosystem. These include African Hawk-Eagle *Aquila spilogaster*, Long-Crested Eagle *Lophaetus occipitalis*, Crowned Eagle *Stephanoaetus coronatus*, Martial Eagle *Polemaetus bellicosus*, Black Kite Milvus migrans, African Fish Eagle *Haliaeetus vocifer*, African Harrier Hawk *Polyboroides typus* and African Marsh Harrier *Circus ranivorus.* A number of wetland birds e.g., Grey Crowned Crane *Balearica regulorum*, Hadada Ibis *Bostrychia hagedash*, Sacred Ibis *Threskiornis aethiopicus* and Black-Headed Heron *Ardea melanocephala* feed on frogs (amphibians) and by doing so promote nutrient cycling.

Seed dispersal and pollination, are key ecosystem services (regulation services) provided by birds (Michel et al. 2020). Bird species disperse seeds, usually through fruit consumption. Birds disperse the seeds of many woody plant species that have direct value to humans for timber, medicine, food, or other uses. Birds also provide plant pollinating services. Among the species that feed on fruits recorded during the studies include Ross's Turaco *Musophaga rossae* and Eastern Grey Plantain Eater *Crinifer zonurus*. These play a role in seed dispersal. Four species of sunbird were also recorded, including *Cyanomitra alinae* Blue-Headed Sunbird, *Chalcomitra senegalensis* Scarlet-Chested Sunbird, Nectarinia kilimensis Bronze Sunbird and Cinnyris erythrocercus Red-Chested Sunbird. These play an additional key role of provision of pollinating services in addition to other animal species.

Some birds especially vultures, but also raptors, seabirds, gulls, herons, rails, shorebirds, woodpeckers, and passerines are well known for scavenging. By scavenging, carnivorous vertebrates contribute to regulation ecosystem services such as waste removal, disease regulation, and nutrient cycling (Michel et al. 2020). This is a key supporting ecosystem service that birds provide that also results in high volume nutrient cycling. Eight species of raptors (mentioned above) were recorded during the additional studies which species might be playing a big role in scavenging and nutrient cycling.

Birds construct nests that are later used by other species (an ecosystem engineering service). Open-cup and domed nests are often taken over by small mammals, spiders, and bumble bees. Woodpecker cavities are used by birds, mammals, amphibians, and arthropods. Nest burrows created by parrots, owls and kingfishers alter soil properties and affect nutrient cycling. They are also used by other taxa, including birds, snakes, mammals, and amphibians (Wenny et al. 2011).

Birds provide physical products like meat and eggs which are used for food and feathers are used as filling for down duvets, pillows, and coats. Additionally, birds' bodies and feathers are sometimes used for ornamentation (Michel et al. 2020). During socioeconomic survey by the research team, 99% of the respondents indicated that they eat certain bird species. Among the groups of bird species eaten by the community, include Guineafowl and Francolins. During the baseline survey of the project area, no birds of these groups were recorded. However, Biodiversity Inventory survey of Rwoho Central Forest Reserve by the then Forest Department in 1996 (Currently NFA), recorded the occurrence of three species of birds. The birds included *Francolinus sephaena* Crested Francolin, *Francolinus squamatus* Scaly Francolin and *Numida meleagris* Helmeted Guineafowl. Much as these were not recorded during the survey doesn't mean that they do not exist. The fact that they are eaten could mean a lower population, hence it takes time to spot them.

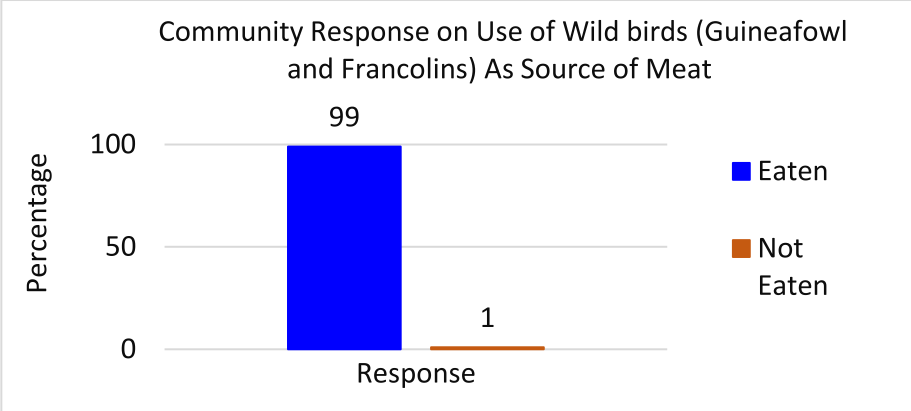


Figure 4-55: Community response on use of wild birds for meat

Birds provide cultural ecosystem services as sources of recreation including birdwatching and hunting, as pets, as well as through inspiring photography, art, and religious customs (Michel et al. 2020). During the socioeconomic survey, it was discovered that certain members of the community have superstitions towards certain bird species. The bird species include *Lophaetus occipitalis* Long-Crested Eagle, *Balearica regulorum* Grey Crowned Crane and *Bostrychia hagedash* Hadada Ibis. Such superstitions mean these birds are not hunted and this promotes their conservation. By promoting their conservation, means the ecosystem service provide by the birds are sustained.

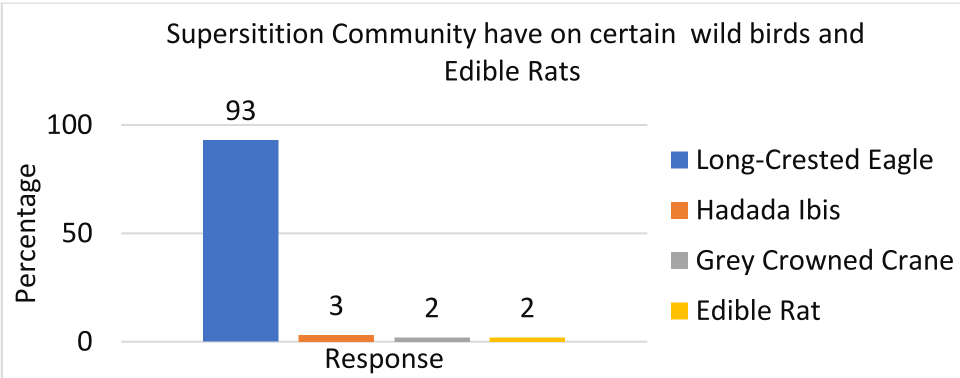


Figure 4-56: Community Superstition on certain wild birds and edible Rat

f) Mammals

Findings of the survey indicate that no big mammals exist in the project area. Only small mammals (five species of rodents and shrews) were recorded. Small rodents can provide biological control through weed seed consumption but may also act as pests, causing crop damage. **Rodents** are important in seed and spore dispersal, pollination, seed predation, energy and nutrient cycling, the modification of plant succession and species composition, and as a food source for many predators. Additionally, some species provide food and fur for human uses.


Pineapple vending – one of the agro-products from the Mishumba catchment

4.3 Social-Economic Environment

4.3.1 Project Location and Beneficiary Areas

The project area covers Mishumba Catchment comprised on Kabuyanda, Kikagate, Ruborogota, Mwiizi, Rukoni East, Nyakitunda sub counties and Kabuyanda Town Council (Refer to Mishumba Catchment map). The beneficiary lower local governments are four (4) namely Kabuyanda Sub-County, Kabuyanda Town Council, Kikagate Sub-County and Ruborogota Sub-County. Within these areas, there are 8 parishes and 162 villages within irrigable area (**Figure** 4-57).

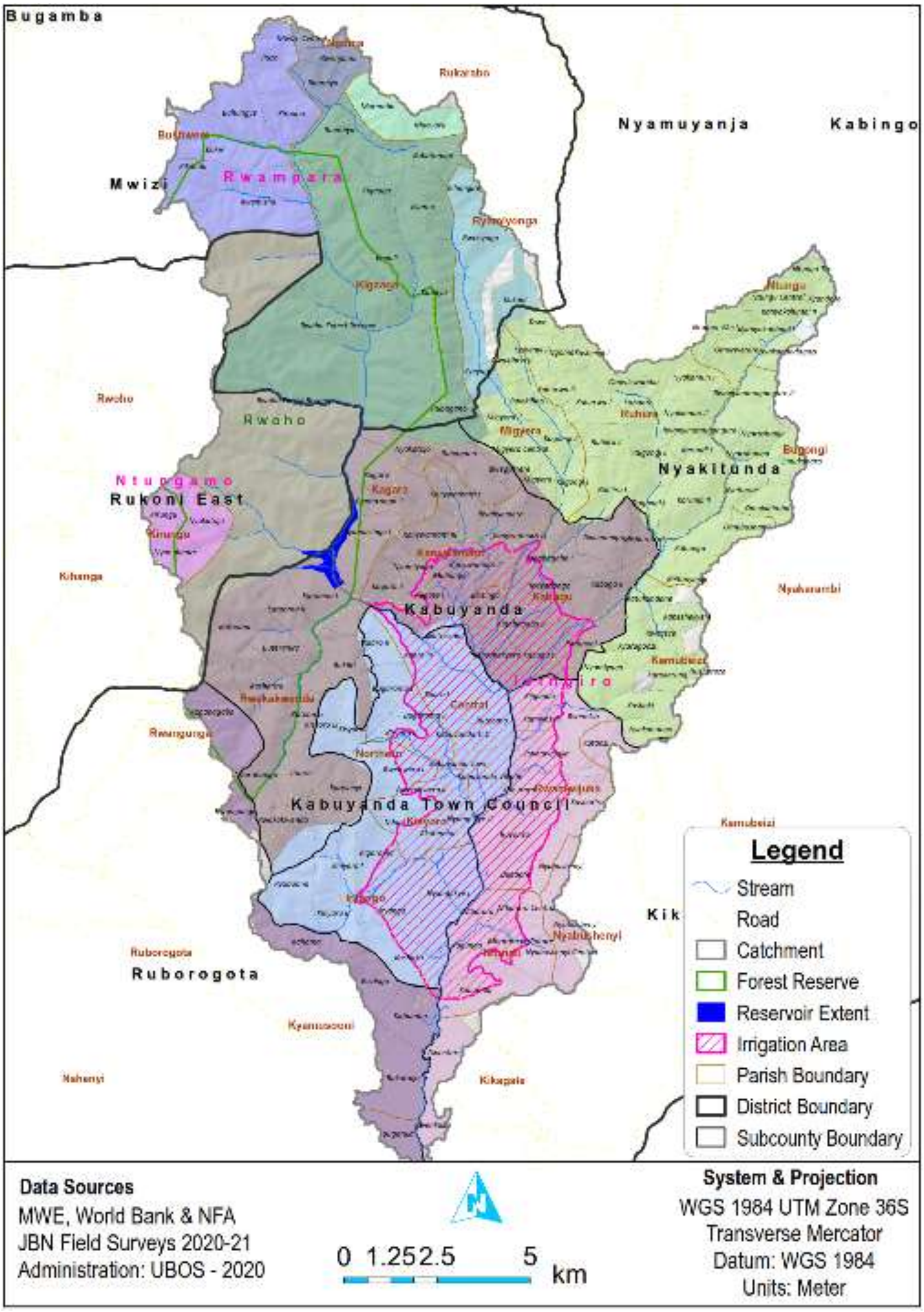


Figure 4-57: Map showing locations of beneficiary areas

4.3.2 Population and Demographic Characteristics

4.3.2.1 Catchment Population

The catchment area has a total population of 138,870 people (66,185 males; 72,685 females) and 20,407 households (refer to Annex 1). Kikagati Sub-County (downstream) has the highest population at 42,999 people (20,264 males; 22,735 females) and 8,766 households. Mwizi subcounty (up-stream) has the second highest population at 28,226 people (13,757 males; 14,469 females) and 1,118 households. Nyakitunda Sub-County has 22,337 people (10,560 males; 11,777 females) and 1,031 households. Kabuyanda Sub-County (dam site area) has 21,193 people (10,036 males; 11,157 females) and 4,297 households. Ruborogota Sub-County has 7,739 people (3,757 males; 3,982 females) and 3,709 households. Kabuyanda TC has 16,376 people (7,811 males; 8,565 females) and 3,567 households. Rukoni East Sub-County has 5,928 people (2,894 males; 3,034 females) and 278 households.

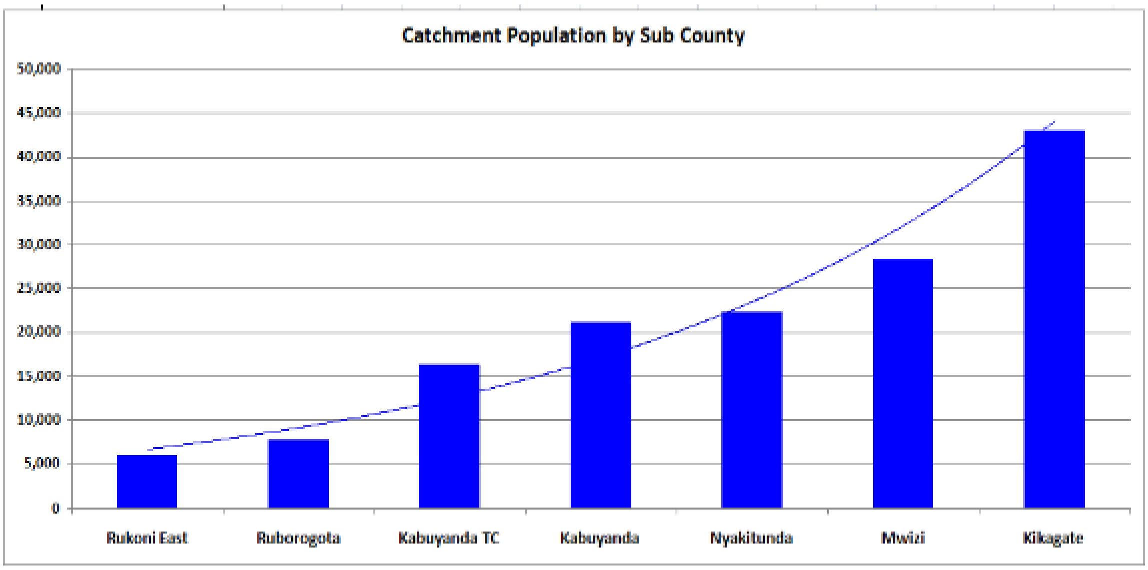


Figure 4-58: Catchment population by Sub-County

4.3.2.2 Population by River Stretch

The upstream area (Mwizi and Nyakitunda) has the highest population at 56,491 people and 2,427 households. The downstream area has the second highest population at 50,738 people and 10,394 households. The Midstream (Kabuyanda SC & Kabuyanda TC) has 37,569 people and 7,864 households.

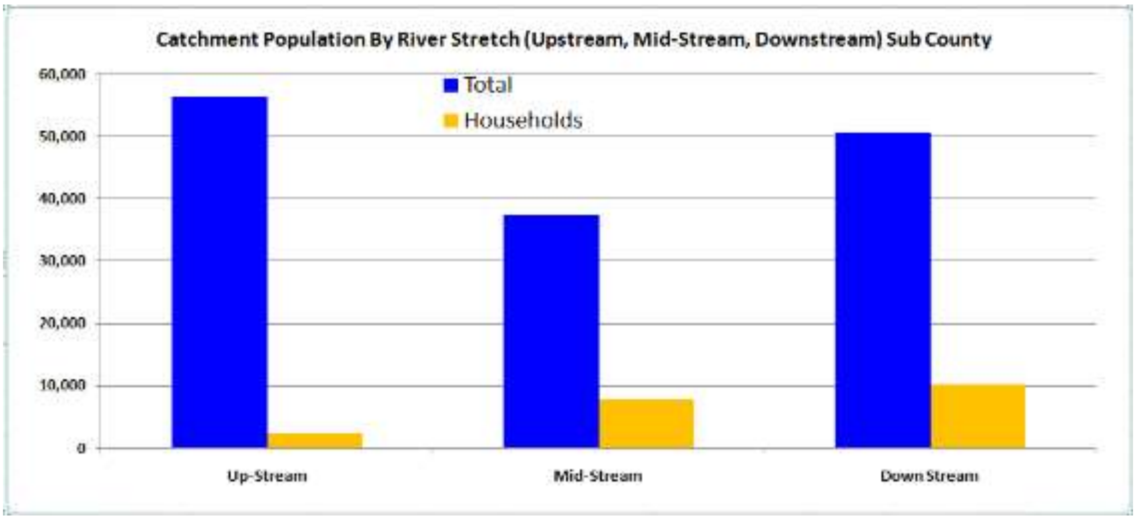


Figure 4-59: Catchment population by river stretch

4.3.2.3 Human settlement patterns

Majorly, people live in dotted, linear and clustered human settlement patterns. In upstream areas (near dam site), linear and dotted settlement is common. In mid-stream, linear settlement along slopes, road and rivers, as well as clustered settlement in trading centers is common.

Figure 4-60: Linear settlement patterns in Kabuyanda trading centre (irrigable area at 36 M 235650, 9895152)

4.3.3 Poverty Trends

Poverty manifests through lack or scarcity of productive resources, consumer goods, food, shelter, health, and clothing and limited access to education services by various households and individuals; income or consumption poverty; human (under)development; social exclusion; ill-being; (lack of) capability and functioning; vulnerability; livelihood un-sustainability; lack of basic needs and relative deprivation. According to recent population census f 2014, Isingiro district was ranked among the thirteen (13) districts with poverty rate above 10%. High levels of poverty are attributed to dominance of subsistence production with limited income-oriented agriculture (NDP III, 202021-2024/25). Over 82.6% (9,603 out of 11,581 households) are dependent on subsistence farming within the irrigable area (UBOS, 2014). The people rely on subsistence farming (crops, animals, agro-pastoralism, artisanal fishing, hunting & gathering) as shown table 6 below. In addition to this, there exist other types of poverty namely a) Water poverty (Eran and Jonathan, 2002) manifesting as inadequate availability, access and utilisation of safe and clean water; b) Child poverty being higher at above 10% (World Bank, 2018); c) urban poverty manifesting in several agglomerations within project areas such as Kabuyanda Town Council, Ruborogota trading centre, among others. The major cause of poverty is lack and/or inadequate income, limited social protection, inability to afford basic needs, limited productivity, and inadequate access to community productive assets and climate hazards such as drought and dry spells. It's anticipated that the irrigation scheme will increase resilience capacity of farming households to produce throughout the year for income and food.

4.3.3.1 Unemployment and Demographic Dividend

Globally, unemployment is a global threat to development standing at 5 percent (ILO, 2019[7]). The unemployed comprise all persons of working age (ILO[8], 2013) categorised as, a) without any work (paid or self); b) currently available for work (paid or self); and c) seeking work. A close look at the labour market situation in Uganda pinpoints unemployment as a major critical issue (DTDA[9], 2019). By the year 2017, the national unemployment rate was 9.4% with the females experiencing higher unemployment rate at 13% than males at 6%. Rural unemployment stands at 6.3% especially among the productive age group of 18 - 65 years (UBOS[10], 2018). Unemployment rate of people aged 15 - 24 years was 15% (13% men and 17% women in same cohort).

The increasing unemployment in the project area is characterised by underemployment, extended labour underutilisation, and total unemployment among others. The youth and other working age groups are worst affected. The major cause of unemployment is mainly lack / limited access and utilisation of productive assets, low savings, illiteracy, limited skills, vulnerability to hazards and shocks such as floods, dry spell, pests and diseases. The unemployment is likely to increase due to rapid population growth. At present, the major coping mechanisms encompass increasing dependence on natural resources especially rivers and forests in terms of artisanal fishing; hunting and gathering; encroachment on river banks in search of 'free' land to cultivate crops among others.

During consultations with LC 1 committees (upstream, mid-stream, down-stream), it was revealed that the level of unemployment was high especially among the youth. However, coping mechanisms tend to diversify among people living near urban and peri-urban settlements. These areas include Kabuyanda Town Council, Rwamijuka - Kifumbira, Ruborogota trading centre. The differing levels of consumption in urban areas influences.

4.3.3.2 Demographic Dividend

The national snapshot on population growth indicates that the median age is 15.9 making Uganda the world's highest fertility rates at 5.91 per woman (2010–2015). Youthfulness means the working-age population grew at a very fast 3.92 percent per annum between years 2011–2017 (World Bank, 2020). This refers to the demographic dividend, defined as the proportion of working

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[7] https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_670542.pdf

[8] *https://www.ilo.org/ilostat-files/Documents/description_UR_EN.pdf*

[9] Report on Uganda Labour Market Profile (2019) by Danish Trade Union Council for International Development Cooperation

[10] *https://www.ubos.org/wp-content/uploads/publications/05_2019STATISTICAL_ABSTRACT_2018.pdf*

age to non-working-age population" (UNFPA[11], 2020). Within this project area of Mishumba catchment, 49% (100,685 out of 205,421) of population are within working age bracket of 14 - 64 years.

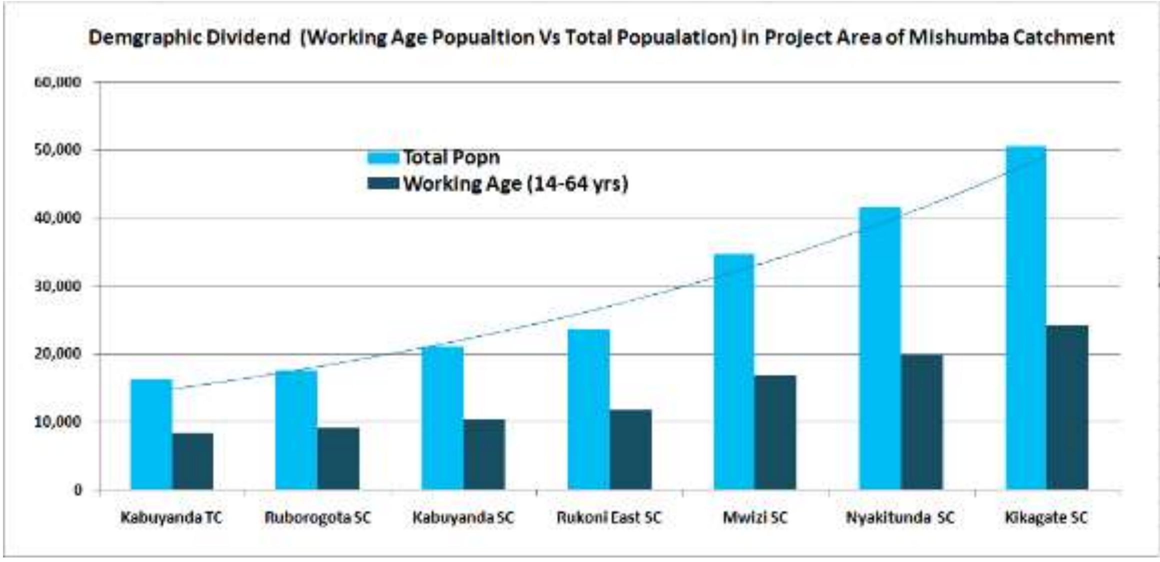

Figure 4-61: Demographic Dividend (Proportion of Working-to-Nonworking populations) in project area of Mishumba Catchment

Implication: The working age group (as able bodied) are the potential users of the ICRP project services. The potential of ICRP towards job creation is significantly high. In order to mitigate possible barriers, the scalability of benefits needs to be considered. One critical aspect is the need for farmer support (new comers like youth and old famers). There is need to reduce the vulnerability to unemployment resulting from inability of youth to access land and other production tools.

4.3.4 Social Services & Infrastructure

4.3.4.1 Roads

The road network within irrigable area stands at 259.84 km. By distribution, Kikagate SC has peak at 83.03 km; 75.99 km in Ruborogota SC; 56.6 km in Kabuyanda SC and 44.82 km in Kabuyanda TC. There are 2 types of roads i.e., feeder and community access roads (**Figure** 4-62). The road conditions are poor, fair and good. Some are motorable especially in the downstream area. In upstream' (above dam area) the roads are of poor conditions and during rainy season they are impassable. The upstream areas (above dam site) are accessed using 2 roads all passing through Kagoto 2 – Kyamazinga 2 (**Figure** 4-64).

[11] https://www.unfpa.org/demographic-dividend

Figure 4-62: Some of the existing feeder and community access roads in the project area

Figure 4-63: A truck stuck in mad due to poor state of roads during the rainy season at E233053, N9899555

Figure 4-64: State of community access and feeder roads in the project area at E232856, N9899713

Figure 4-65: Poor road and river stream used as water sources in the irrigable area at237333, 9895668

4.3.4.2 Education

The education level is categorized as Pre-Primary, Primary Education, Post Primary Education and Training, Business, Technical, Vocational Education and Training (BTVET) Teacher Education and Higher Education.   In terms of education facilities,

Kabuyanda Town Council: There are 6 primary schools. These are Kabuyanda Central P/S, Kaiho P/S, Iryango P/S, Kisyoro P/S, Nyampikye II P/S, Kaaro Karungi P/S (**Figure** 4-67). The total enrollment stands at 2,377 pupils (12 special needs learners); 54 teachers; 20 classrooms and 43 pit latrine stances. The Teacher-Pupil Ratio is 1:44; Classroom - Pupil Ratio is 1: 118; Latrine stance pupil ratio is 1:55.

There are 2 secondary schools namely Kisyoro SS and St Thomas Aqinas. The total enrolment in secondary schools stands at 751. There are 27 teachers; 8 classrooms; 5 permanent latrines. The Teacher pupil ratio is 1:27; Classroom -Pupil ratio is 1:93; Latrine Stance-Pupil ratio is 1:150; Houses-Teacher ratio is 1:27.

Figure 4-66: A secondary school in the irrigable area (mid-stream) at E235058, N9895468

Figure 4-67: Some of the primary schools located in the catchment area (mainly irrigable area)

Kabuyanda Sub-County: There are 7 primary schools. The total enrollment stands at 3,115 pupils (1,715 boys; 1,400 girls). There are 52 teachers; 15 classrooms and 66 pit latrine stances. The

Teacher-Pupil Ratio is 1:44; Textbook-Pupil Ratio is 4:1; Classroom - Pupil Ratio is 1:80; Latrine stance pupil ratio is 1:60. There is one (1) secondary school.

Kikagate SC (Ntundu Parish): There is one (1) primary school located within the irrigable area.

Ruborogota SC (Kyamusooni parish): There is Ibanja primary school, with an enrollment of 241 pupils (2 special needs children). There are 5 teachers and 2 classrooms. There are no teacher houses. There is one secondary school located in Kyamusooni parish.

4.3.4.3 Access to Water

From the dimension of water poverty, there is great community concern about inadequate access to clean and safe water, as well as decent sanitation and hygiene facilities (toilets, hand washing with soap, waste management, among others). Given the increasing rural and urban population (both humans and animals), the demand for water is shooting up. The Deputy CAO of Isingiro DLG stated that *"Water is the biggest challenge that people face especially during drought season".* Majority of households collect water from unprotected water sources such as lake, rivers, streams, ponds, roadside potholes among others (**Figure** 4-69 **- Figure** 4-70). Other sources used include shallow wells, public stand pipes (PSPs), rain water harvesting tanks (**Figure** 4-71), Gravity flow scheme (from Rutemba and Kisyoro), and piped water by NWSC. There is also a newly formed water body at Rugaga in form of a mini lake. It was formed as result of severe flooding of River Mishumba in 2020.

Access to water stands at 69% in Kabuyanda SC and Kabuyanda TC respectively; 56% in Ruborogota SC and 33% in Kikagate SC (MWE/ Water Atlas, 2017). The major sources of water are river streams, shallow wells, protected springs and piped water. The source functionality ranges between 95%-99%. It should be noted that river streams are major source of water for domestic use. The piped water supply covers 73 km (6km in Ruborogota and 67km in Kabuyanda) under the MWE/South Western Umbrella organization.

4.3.4.4 Piped Water & Boreholes

Access to boreholes and piped water sources varies according to parishes. There are 3,003 households accessing piped water (**Figure** 4-68). By distribution, 617 HHs in Kabuyanda SC; 888 HHs in Kabuyanda TC; 662 in Kikagate SC (Ntundu and Rwamwijuka parishes); 834 in Nyakitunda SC (Migyera and Ruhiira parishes); and 2 in Ruborogota SC (Kyamusoni parish). The major piped water systems are gravity flow scheme (GFS) and NWSC.

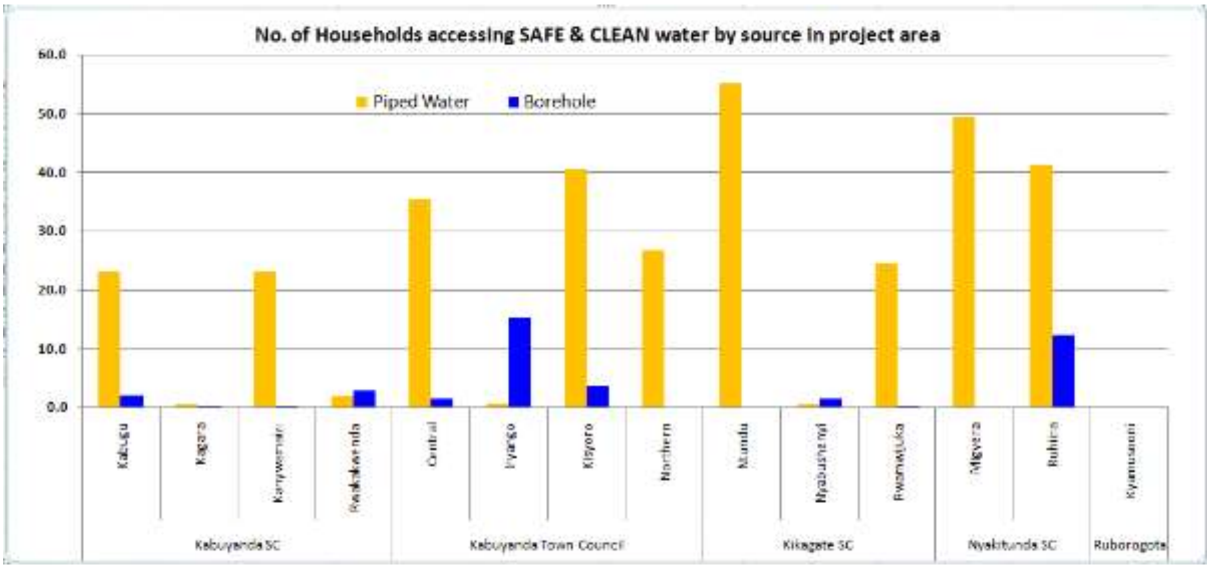

Figure 4-68: Number of households (HHs) accessing piped water & boreholes

Figure 4-69: Children collecting water from the unprotected water source (river) along the road

Figure 4-70: New water body at Rugaga in Ntundu parish (irrigable/downstream area) after the May 2020 flash flood

Figure 4-71: Rain water harvesting tank in Kabuyanda

4.3.4.5 Sanitation & Hygiene

Access to safe and clean water is directly linked to better sanitation and hygiene, which are critical aspects of human health, security, livelihoods, and quality of life. The sanitation and hygiene situation with in irrigable areas varies according to location and parameters of sanitation and hygiene.

Figure 4-72: People and animals struggling for water from unprotected point (river flowing over road)

4.3.4.6 Toilet Coverage

Toilet coverage stands at 2% (279 out of 13,774 HHs) as shown in table in Annex 1 and graph 1 below. By distribution, there are 5.8% (61 out of 4,297 HHs) in Kabuyanda SC; 1.5% (54 out of 3,567 HHs) in Kabuyanda Town Council; 4.3% (120 out of 2,806) in Kikagate Sub-County (Ntundu, Rwamwijuka and Nyabushenyi parishes); 1.3% (24 out of 1,915 HHs) in Nyakitunda Sub-County (Migyera and Ruhiira parish); 1.7% (20 out of 1,189 HHs) in Ruborogota (Kyamusooni parish). The highest number of households with toilets is located in hilly area (upland of irrigable area) in Nyabishenyi parish (70 HHs) and Iryango parish (31 HHs). Within Kabuyanda town Council, a new public toilet has been constructed by MWE/Southern Umbrella.

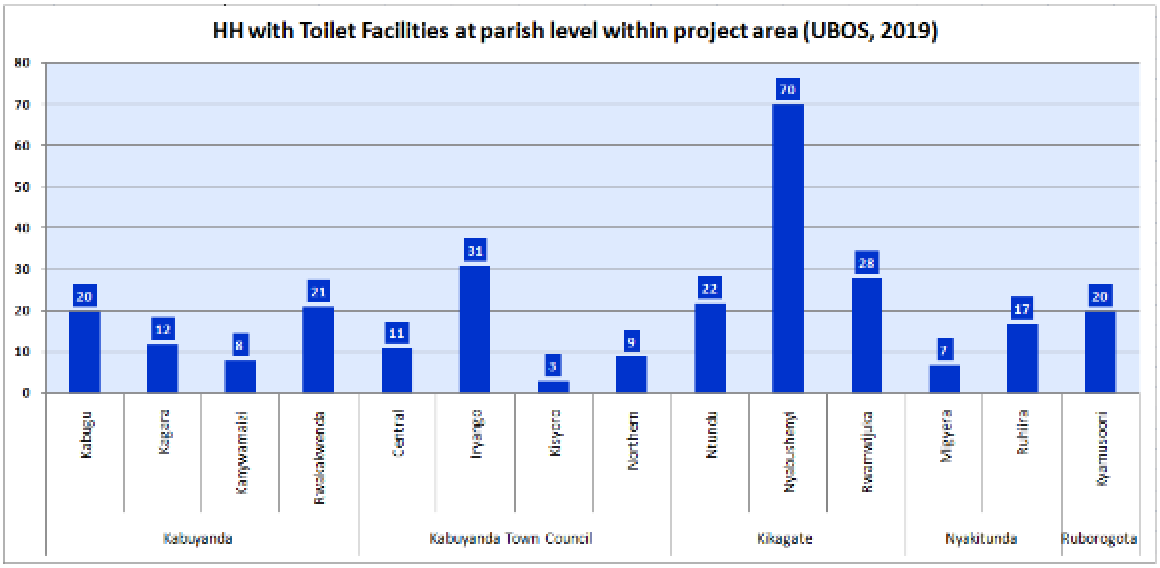

Figure 4-73: Households with toilet facilities at parish level within the project area

4.3.4.7 Solid Waste Management

There is no designated disposal site in Kabuyanda Town Council. The major waste generated is organic waste and average volume of waste collected is 40 tonnes per month.

4.3.4.8 Diseases Incidence and Prevalence (Water related Diseases)

The incidence and prevalence of diseases is increasing. The disease burden is increasing yet it can be preventable through improved water, hygiene and sanitation; vaccination against the child killer diseases, good nutrition and other preventive measures such as use of condoms and insecticide treated nets (ITNs) for malaria (MoH, 2018). The incidences of diseases (new cases) fluctuate due to climate changes (drought and wet seasons). The prevalence (old occurrences) persists because communities have limited access to adequate medical care.

The major water related (Omaswa,2016) diseases and illness are Bilharzia, malaria, diarrhoea, Gastro-Intestinal Disorders, Typhoid, Dysentery, Pneumonia, Cough or Cold, Eye conditions, Skin Diseases, Urinary Tract Infections (UTIs), Meningitis, Sexually Transmitted Diseases STDs/STIs) such as HIV/AIDs. According to 2018 HMIS data for Isingiro, there is rapid increase in incidence of water related diseases especially malaria, diarrhoea, Gastro-Intestinal Disorders, typhoid, Dysentery and Bilharzia. The increase in incidence and prevalence directly constrains household survival. It’s anticipated that the disease incidence (new cases) is likely to increase especially for malaria, HIV/AIDs, etc.

Figure 4-74: Children swimming in the river (midstream) and at high-risk of water related diseases at E236118, N9893136)

4.3.4.9 Access and Utilization of Health Services

Access to health care services refers to the opportunity or ease with which people (users) are able to reach and obtain appropriate services in proportion with their needs. The accessibility of a healthcare service is influenced by factors on an individual, provider and system level (Levesque, *et al*., 2013). People with health problem who visit a health facility for diagnosis and/or treatment are technically referred to as Out Patients relative to the total population of the same geographical area. These visit the Out-Patient Department (OPD) within a health facility, often as new attendance or re-attendance. Within project area, the total number of individuals who accessed health services at nearest Gov't health facility in previous year (2020) was 20,747 (8,294 male; 12,453 female) (**Figure** 4-75). By distribution, Chezho sub catchment had the highest number at 2,079 persons (846 male; 1,233 female). This area is above the dam site and has steep slopes and low lands. The lowest OPD was in Lower Mishumba sub catchment (near Kabuyanda trading centre). The variation is due to influence of urban communities. In Lower Mishumba sub catchment there many health service providers mainly private (drug shops, clinics) whom communities find convenient. In addition, there are Village Health Teams (VHTs) who provide basic services (**Figure** 4-78).

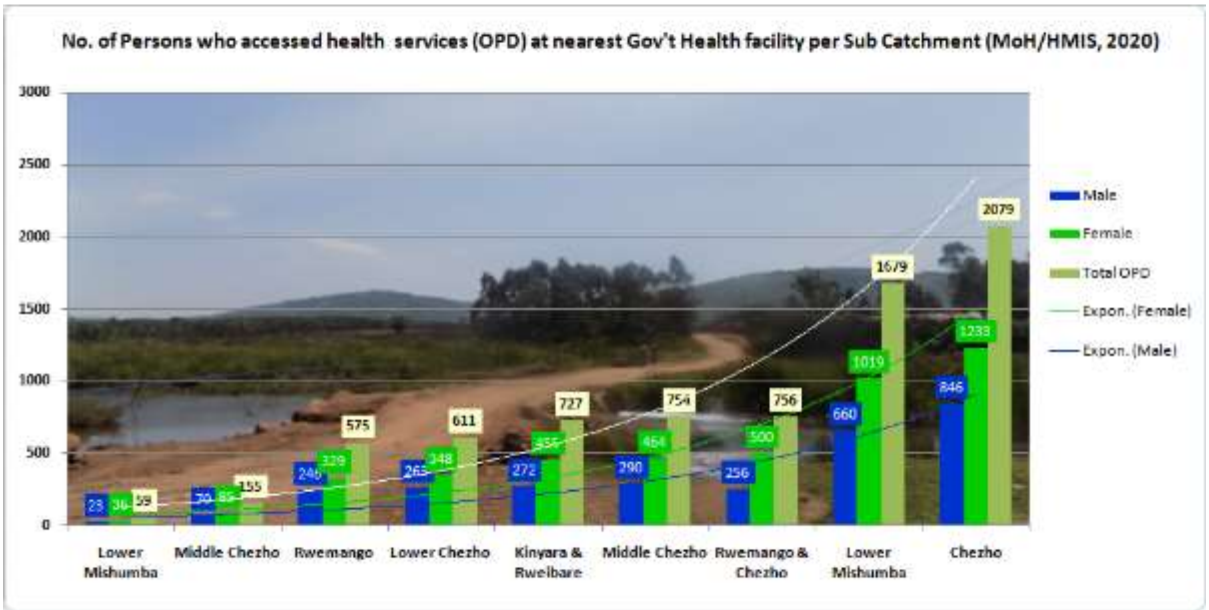

Figure 4-75: Access to health services at nearest Gov't facility per Sub-county

Figure 4-76: Kabuyanda Health Centre IV in Kabuyanda TC (irrigable area E235650, N9895152)

Figure 4-77: Health services offered at Kabuyanda HC IV

Figure 4-78: VHTs serving 2 villages above Dam site (Kyamazinga 1 & 2)

4.3.4.10 HIV/AIDS Situation

4.3.4.10.1 Drivers of Infections

HIV/AIDS is a major factor that affects socio-economic development within the project area. It has been highlighted by different stakeholders during consultations that HIV/AIDS interventions are still inadequate. The major driver of HIV infections is risky sexual behaviours such as having unprotected sexual intercourse, including early sexual debut, multiple sexual relationships, limited and inconsistent condom use. Other drivers of HIV infections include a) rampant transactional, cross-generational and sexual activities; b) poor attitudes such as stigma; c) limited awareness about personal and/or partner HIV status; d) high prevalence of sexually transmitted infections and diseases (STI/Ds); e) low utilization of antenatal care (ANC) and delivery services such as PMTCT; f) low uptake of safe male circumcision (SMC) services; g) sub-optimal scale-up of ART; h) gender inequalities including gender-based violence (GBV) exacerbated by alcohol drinking; i) exposure to risk due to effects of Covid-19 lockdown especially among young girls (adolescents and youth).

4.3.4.10.2 Most At Risk Populations

The Most at Risk Populations (MARPs) include married couples, sex workers, refugees, migrant workers, casual labourers, rural-urban migrants, adolescents, truck drivers, HIV positive persons, youth and children, students, Bar and lodge attendants, farm product traders (transiting outside project area), men and women. The high-risk areas include Kabuyanda Town Council. According to Law Enforcement officer of Kabuyanda Town Council, the number of female sexual workers is estimated to be between 25 – 60 basing n seasonality. The number goes up during festival seasons.

4.3.4.10.3 HIV & STI Prevalence Rate

In terms of HIV prevalence, the South-West region (project area being part of Isingiro district), has the second highest HIV/AIDS rate at 7.9% slightly lower than the highest rate of 8.0% in Central 1 region (UPHIA[12], 2017). The recent Uganda Population-Based HIV Impact Assessment (UPHIA)

[12] Uganda Population-Based HIV Impact Assessment

puts the HIV prevalence high among females at 9.8 (urban) and 6.7 (rural) compared to males at 4.6 (urban) and 4.7 (rural). South-West region also has the second highest viral load suppression (VLS) rate at 68% among 15-64 age group next to North East region at 7.0% (UPHIA, 2017). By age cohort, HIV/AIDs prevalence among 15-64 years age group stands at 6.2 and high among females (7.6) than males (4.7). By comparison, the HIV prevalence in South West is higher than the national rate at 7.5%. At national level, the prevalence of STI (active syphilis) is higher among rural residents at 2.3% compared to 1.6% in urban areas (PHIA, 2017).

Currently, the local government target to reduce HIV incidence. In Kabuyanda Sub-County, the target is to reduce HIV incidence by 40%. During consultations with Kabuyanda HC IV in-Charge, there has been a decline in number of persons undertaking HIV testing. The decline is attributed to the new MoH consolidated guidelines for Prevention and Treatment of HIV in Uganda (MoH, 2016), that emphasises Differentiated Testing, a “Test and Treat approach” for carefully screened eligible persons, unlike the en-masse HIV testing approach that targets everyone in the community.

4.3.5 Livelihoods

4.3.5.1 Farming Activities

The major livelihoods are derived from agriculture (crop and livestock), employing about 88.5 households (16,131 out of 18,231) in Mishumba catchment covering all beneficiary parishes (**Figure** 4-79). The upstream areas have the highest proportion of farming households at 56% (9,055 out of 16,131). Mid-stream has the second highest at 245 (3,780 out of 16,131) and downstream has the lowest at 20% (3,296 out of 16,131) as based on the UBOS/SAP report 2019. The subsistence farming activities are characterized by small land holding, low yields, poor inputs (seeds, planting materials and breeds). There are also fishing activities especially artisanal fishing especially upstream and mid-stream. Commercial aquaculture is downstream. Hunting and gathering is also practiced. Climate change related risks and hazards impend both farming and non-farming activities.

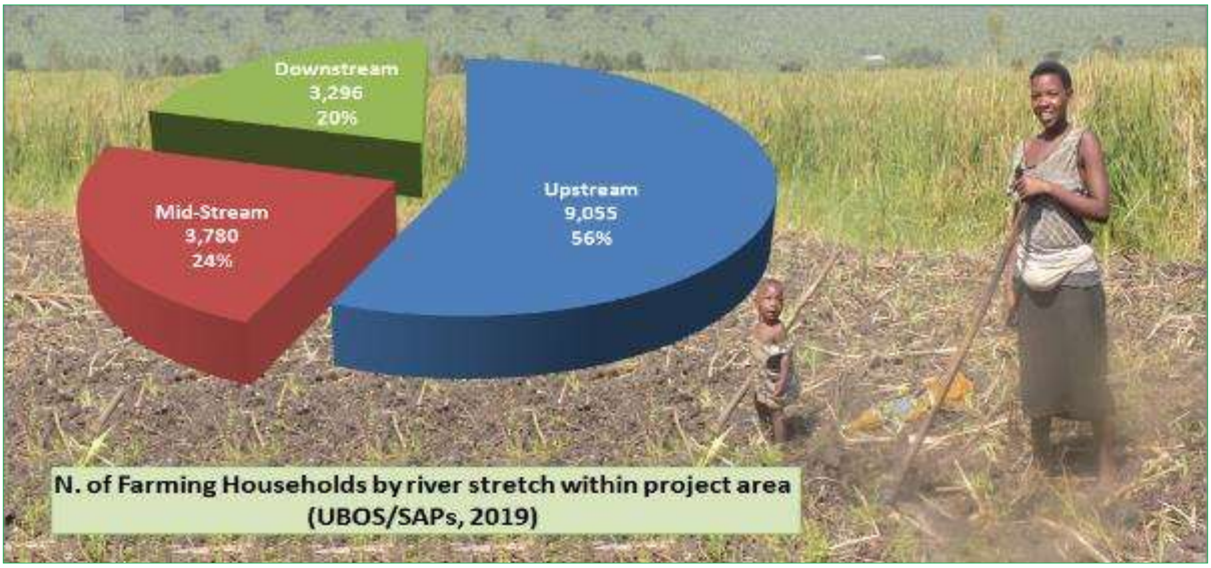

Figure 4-79: Number of farming HHs by river stretch within the project area

Figure 4-80: Fish farming (ponds) in the irrigable area (downstream at E235567, N9890040)

4.3.5.2 Non-Farm Activities

There are also non-farm activities such as commerce especially retail trade in general merchandise, metal fabrication, wood work, vending of food products and operation of small size eating houses and restaurants. Stone quarrying is mainly found in Ndaani Cell in Iryango ward. Brick making is currently undertaken in the low lands of Central and Iryango wards especially along swamps (Mid-stream).

Figure 4-81: Brick making in the lowlands of Central and Iryango wards along swamps (mid-stream)

4.3.5.3 Income security

Majority of households are reported to have substantially low income characterized with rising expenditures on medical costs, food, education and clothing. The main income generating activities include crop and livestock production, casual labour, local brewing, petty trading, brick-laying, remittances by family and friends, boda-boda riding, car washing, dealerships, services, among others.

4.3.5.3.1 Food and nutrition security

Food security at household and community level refers to access to enough food for an active, healthy life of all people at all times (FAO, 2002). A close look at the four (4) pillars of food security indicates that ICRP will play a big role towards Food Availability, Access, Utilization and Stability. The global target (SDG 2) towards Zero Hunger focuses on achieving food security and improved nutrition (SDG Targets 2.2 & 2.1.2) and promoting sustainable agriculture (SDG Target 2.3) through increased investment in rural infrastructure (SD Target 2A) among others (UNDP/SDG Booklet, 2018). In this case ICRP project majorly has potential positive impact towards food security.

4.3.5.3.2 Food Availability & Access

The major foods produced are plantains (all banana varieties), cereals (maize, beans, sorghum, millet, ground-nuts), pulses, vegetables and fruits, root crops, fish, livestock products (milk, meat, eggs). The available food is accessed through own production, purchase and donations. By distribution, the upstream and mid-stream areas have more plantains, fruits and livestock compared to downstream that produce majorly cereals, pulses, vegetables, root crops (cassava, sweet potato, Irish potato) and farmed fish. The women carry heavy burden to ensure food production and availability as well as collecting water and wood fuel for food preparation (which are dominant feminine roles played by women).

Figure 4-82: Maize Garden in the irrigable area (downstream at 36 M 237249, 9894497)

4.3.5.3.3 Food Utilization and Stability

In terms of food intake and diet, the major consumed food items are beans, maize, banana, sorghum and meat. Drinking water is also a major component though majority of households don't use boiled/treated water. It's also used to prepare food and part of sauce. It should be noted that there is low access to safe and clean water sources, majority use river. The water is regarded as salty.

Figure 4-83: Harvested cassava for sale

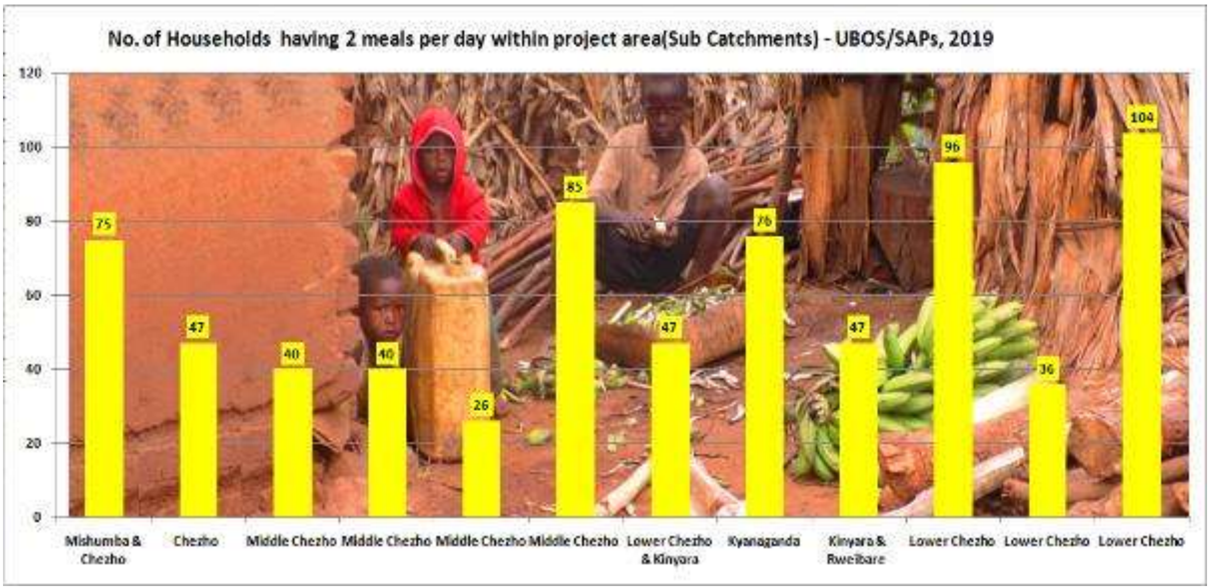

Figure 4-84: Sub-catchment households with 2 meals per day within the project area

4.3.5.4 Nutrition Practices

Nutrition behaviours and practice are mainly determined by cultural and lifestyle preferences. Locally, bananas are major food item on menu. Child malnutrition remains largely a 'hidden problem' with majority reported to be moderately malnourished. There are no records on Severe Acute Malnutrition (SAM) among children. However, the inadequate dietary intake is partly caused by inadequate access to a variety of foods, limited knowledge about good nutrition and micro nutrients.

4.3.6 Domestic Fuel and Energy (Cooking)

The major source of domestic fuel is firewood and charcoal. Charcoal prices range between UGX 20,000-40,000/= per sack. Firewood prices range between UGX 1,000-10,000/=depending on size of bundle. The increased demand for free domestic fuel reduces human pressure on natural resources within sub catchments.

Figure 4-85: Mother & Daughter walking from Dam site to Kyamazinga village after collecting firewood

Figure 4-86: Boy child after collect firewood from near dam site in Kagoto 2 village

Figure 4-87: Boy child after collecting firewood from Rwoho forest

Figure 4-88: Women and children after collecting firewood from upstream (dam area) at 231323, 9900298

4.3.7 Agricultural Production & Productivity

4.3.7.1 Agricultural practices

There are mixed farming practices. Crop production is the dominant agricultural practice in Mishumba catchment. Animal husbandry also takes place and major animals include cattle, goats, poultry. Mono-cropping is majorly used especially for banana and cereals. The method of intercropping in banana gardens is not wide spread. Weeding is majorly done by hand in banana gardens. Agro-forestry especially plantation forest is mainly done upstream in Rwoho Central Forest Reserve (CFR).

Figure 4-89: Mixed farming practices mainly in the midstream and downstream areas of the catchment

There is aquaculture being practiced in downstream areas at E235629, N9889967 which is 1 km to the end of irrigable area in Kabumba cell, Ntundu parish, Kikagate Sub-County, with 6 fish farmers having 22 fish ponds (Figure 4-90). However, it is anticipated that the project will not affect this activity with regard to water availability.

The water diversion from the river into the ponds is not permanent as it done when it is only required during the high flows period and later sealed off. In addition, the diversion is for a short period and volumes are small. Much as the ponds abstract water from the river, the potential residual risks from agro-chemicals on the ponds will be taken care of through:

a. The layout of irrigation fields be designed in a way which minimizes risks of erosion and run-off from the gardens to the river thereby checking any risks of downstream pollution to the river waters;
b. The agro-chemicals to be used by the farmers in the project area are to be those allowed under World Bank OP 4.09, FAO and WHO Guidelines[13] ;
c. Farmers will be trained in integrated pest management (IPM) practices thereby minimizing use of agro-chemicals in pest management.
d. Project financing will not be used for any pesticide products which contain active ingredients that are listed on Annex III of the Rotterdam Convention.

All these measures will check the risks of pollution on the river waters arising from uncontrolled use of agro-chemicals in irrigable area which in a way minimizes potential risks of agro-chemical residual effect in the fish ponds.

[13] FAO 2003 - Safety and Environmental Guidelines
WHO 2010 - International Code of Conduct on the Distribution and use of pesticides

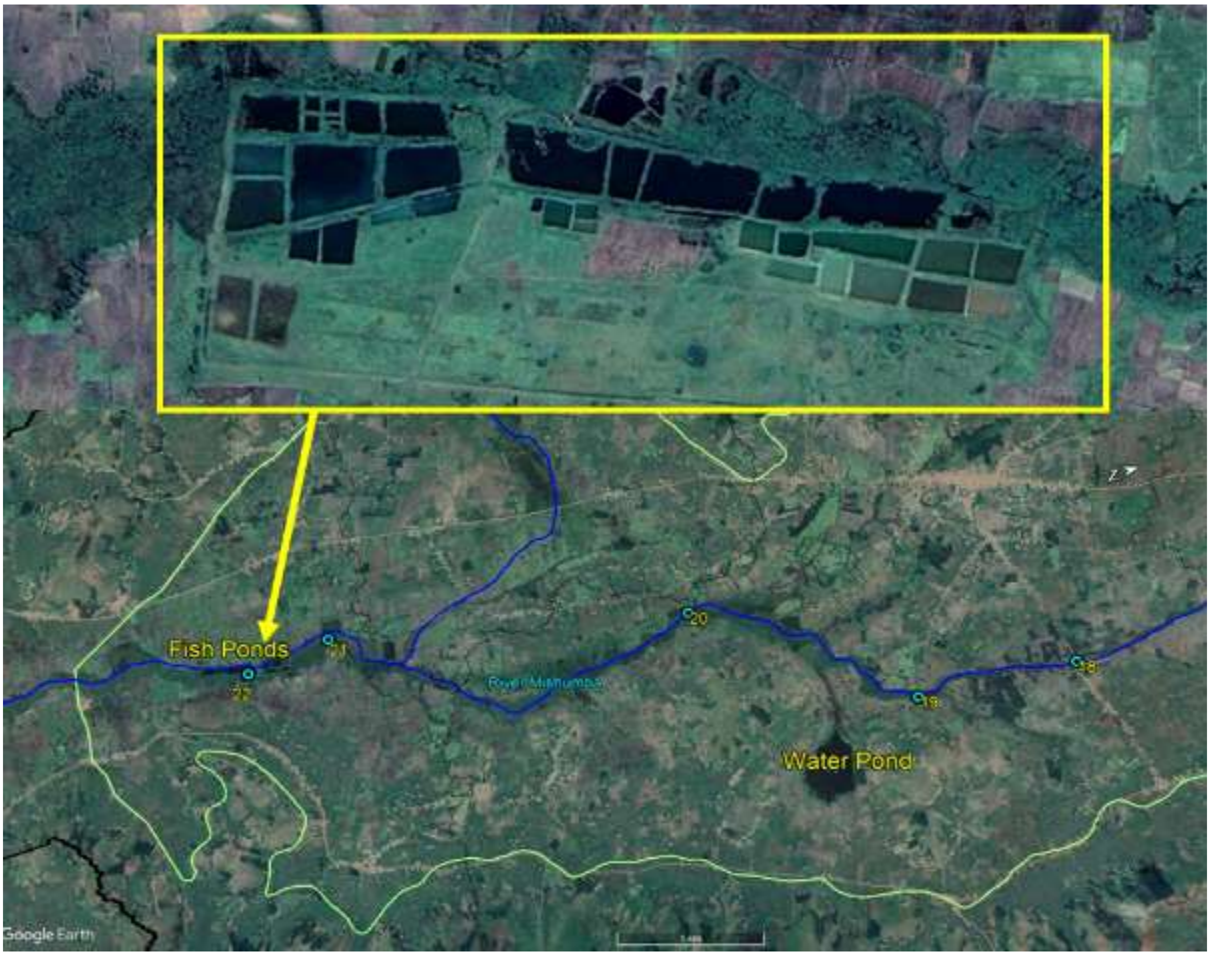

Figure 4-90: Satellite Image (25/03/2021) showing the fish farming activity in the midstream (irrigable area) along Mishumba

4.3.7.2 Access to Agricultural Land

Much of the land is arable but the existence of bare hills with no vegetation cover encourages soil erosion and landslides on the fragile slopes. The topography is mainly a mixture of undulating hills, valleys and fairly flat land. The land tenure is mainly customary, freehold and public ownership. Access land for crop production is not evenly distributed and average land holding for agricultural use is below half acre at household level. Within the irrigable area, communities hire cropping fields from land owners such as the Catholic Church that owns big chunk of low lands in Ntundu parish (downstream). Access to open grazing lands and water is not restricted across the catchment. Over grazing is major challenge. There is also rampant encroachment on river banks, wetland and hills. During community meetings, it was revealed that about 122 households encroached on buffer zones of River Mishumba and River Rweibare. By distribution, the most severally encroached river stretches are Kaaro 3 with about 84 households cultivating within buffer zones; 18 in Kagoto 2, 10 in Kagoto 1 and Katooma 1 respectively.

Figure 4-91: Undulating bare hills prone to soil erosion and landslides in the upstream

Figure 4-92: Undulating bare hills with short vegetation cover prone to soil erosion in the midstream

4.3.7.3 Planting season

The planting season often starts in April and harvesting majorly starts in October. There are two rainy seasons form March-May and October-December, with moderate temperatures. There are two dry seasons from January–March and June- September with high temperatures. Temperature average is 19°C but ranges between 13°C and 26°C. Evaporation averages around 1,350 mm per annum but may be a factor of 3 - 4 times the rainfall amount during the dry season. This reveals a bi-modal season with two peak wet and dry seasons per year.

4.3.7.4 Farm labour

The hand hoe (**Figure** 4-93 & **Figure** 4-94) is still the predominant farm labour tool used for land tillage among poor smallholder and subsistence farmers. The lack of more efficient farm power at the household level has a substantial negative impact on agricultural production and household food security. Many households respond to their shortage of farm power reducing cropped area as they struggle to keep pace with the changing planting seasons. In farming, the productivity is compromised by a lack of physical energy and inappropriate farm labour tools. During a transect walk within irrigable area (downstream), the use of tractors was noticed in areas of Kabumba 2 village (**Figure** 4-95).

Figure 4-93: Some of the crop gardens cultivated by women and children in downstream areas of Ruzinga and Kabumba) between sampling sites 21 and 24

Figure 4-94: Children tilling land midstream (Ruyonza / Rwamwijuka)

Figure 4-95: Tractor opening-up the land (downstream) in Kabumba - Kyamusooni Parish near sampling site 23

4.3.7.5 Water for Production

The major source of water for crop production is rainfall. The river streams are major source of water for livestock. The watering points are along the river streams and swamps. In the downstream areas (Ruborogota Sub-County), there are 10 private valley tanks serving 3 villages. These valley tanks were dug by hand not mechanized equipment. Irrigation is often used for vegetables by Hand & Bucket as well as watering cans. There is no reported case where sprinkler irrigation and/or surface irrigation is practiced. Stakeholder consultations revealed that in upstream areas (outside irrigable area), there are 70 households at Kyamazinga I & II villages are reported to have practiced irrigation by watering can in the last 3 years (2019-2021). In downstream, aquaculture farmers use river streams to farm fish. It should be noted that throughout the Mishumba catchment, the demand for water for production is high during the dry seasons between May-August and January-March. There are prolonged dry periods characterized by climatic aberrations.

Figure 4-96: Hand dug ponds as source of water near sample site 24

Figure 4-97: Valley dam in Kaburara/Rwakijuma that was submerged by floods (May 2020) at E237562, N9893738 near sample site 19 and 20

Figure 4-98: A current satellite aerial image (25th March 2021) showing the submerged valley dam

4.3.7.6 Agro-inputs

The agro-inputs such as seeds and planting materials are mainly indigenous obtained from friends and neighbors. The use of hybrid seeds especially for cereals is continuously growing, and access is hindered by limited income sources and long distance to agro-input dealers. There are few agro-input dealers within catchment area. For instance, there are 3 agro-input dealers within irrigable area located in Kabuyanda Town Council. The major agro-input dealer is Kigarama Farmers' Cooperative Society Limited.

4.3.7.7 Pests and Diseases

From a discussion with small holder farmers at sample point 21 and 22, the rickets are a nuisance to germinating legumes and cereals (Figure 4-99)

Figure 4-99: A ricket which are nuisance to germinating legumes & cereals

4.3.7.8 Agro-chemicals

The common agrochemicals include: a) Cypermethrin used against Aphids; b) Rocket; c) Roundup; d) 24D Amine used as a selective herbicide; e) Others are Extreme; Milralz; Quartz; Ridomil. There is no reported enforcement against counterfeit agrochemicals or restrictions on cross-border trade in agro-chemicals at nearby Uganda-Tanzania and Uganda-Rwanda borders.

4.3.7.9 Agricultural Products

The major products are crops, livestock and aquaculture. The crops are maize, beans, banana, millet, sorghum, coffee. Banana is the dominant crop especially in upper land areas within the catchment. Cereals and fish farming are dominant in low lands especially downstream. There is also increase in vegetables especially cabbage, tomatoes, greens & leafy plants. The major fruits are pine apples (**Figure** 4-100), sugar cane, jack fruit, papaws, mangoes. The major livestock products are live animals, milk, ghee, hides and skins. There is limited primary processing and/or value addition to agricultural products.

Figure 4-100: Children selling pineapples in Akatensani trading centre (midstream) at E236408, N 9897503

4.3.7.10 Post-harvest and Agro-processing Infrastructure

There are poor post-harvest handling practices. The major one is drying on open and dirty/soiled ground especially maize (**Figure** 4-101). There are few farming households with basic post-harvest materials like tarpaulins, hand-maize shellers, food granaries, among others. In terms of agro-processing, there are limited grinding mills and diary product collection centers. In the upstream and mid-stream areas (Kabuyanda SC and Kabuyanda TC), there is only one milk collection center located at Kabuyanda town (**Figure** 4-102). In the downstream area, there is also an un-used bulk store at Kikagati (**Figure** 4-103) constructed by CAIIP programme with funding from African Development bank.

Figure 4-101: Poor methods of drying harvests on a dirty ground

Figure 4-102: Milk collection center in Kabuyanda town council

Figure 4-103: Un-used bulk store (constructed by CAIIP programme with funding AFD) at Kikagati

4.3.7.11 Agricultural Market & Prices

The major crop is banana and it's mainly sold to retail and bulk buyers. The bulk buyers come from as far as Kampala. There are several collections or loading centers for bananas. Cereals are also sold to retail and bulk stores. Rice is majorly sourced from Kagera province in Tanzania. Before Covid-19 lockdown, Rwanda was major destination of food products especially banana and cereals. The farm gate prices are averagely the same throughout Mishumba catchment area.

Agricultural products	Market Prices		
	Farm gate price	Wholesale price	Retail price
Beans	1,500	1,800	2,000
Dry Maize	500	700	2,000 (flour)

Millet	2,000	2,500	3,000
Sorghum	700	1,000	1,500
Banana	4,000 – 5,000	6,000 – 10,000	8,000 – 30,000
Local poultry	10,000 – 20,000	20,000 – 25,000	20,000 – 35,000
Cattle (mature)	800,000 – 1,000,000	1,000,000 – 1,200,000	1,200,000 – 1,800,000

Figure 4-104: A bulk store in Kabuyanda TC

4.3.7.12 Farmer Skills & Knowledge

The farmer skills are mainly indigenous especially the culture of growing banana *(Ebitokye).* The common skills are mulching as form of soil and water conservation. However, the demand for modern farming skills (conventional and organic) is high. During community consultations, it was revealed that communities one-time shunned conventional farming practices that depended on entirely agro-chemicals. They prefer balancing conventional (with minimal use of chemical) and organic methods. However, they lack the skills and knowledge especially of maintaining ecological integrity of the soil, vegetation and landscape (steep slopes).

Figure 4-105: An overview of banana plantations in the irrigable area from Kabuyanda hill

4.3.7.13 Climate Smart Agricultural Practices

In terms of climate smart agriculture practices, majority of farmer households engaged in banana growing practice No-Tillage and mulching using grass and agricultural wastes such as maize stalks. However, there is limited no-tillage for cereals. There is also limited use of contours (**Figure** 4-106), terraces, pasture management, zero grazing, grass restoration, appropriate crop-livestock integration, intercropping. There is bush and grass burning (**Figure** 4-107). There is limited access to climate services especially agro-metrological products e.g., weather and climate forecasts.

Figure 4-106: Cultivating hills without use of contours in Rwoho (upstream) at E231095, N9900676

Figure 4-107: Bush and grass burning practices in the project area

4.3.7.14 Extension Services

There is limited provision of extension services within the irrigable area. The extension officers (crop husbandry) are limited. For instance, there is one extension officer for crop husbandry for both Kabuyanda Sub-County and Kabuyanda Town Council. In terms of animal husbandry, farmers rely on private service providers.

4.3.7.15 Ongoing Agricultural Projects

There are several agricultural promoting projects that include, a) Operation Wealth Creation (OWC); b) Youth Livelihood Fund (YLF); c) Irrigation for Climate Resilience Project (ICRP); d) Development Response to Displacement Impact Project (DRDIP) sub projects on farming especially in areas of Kikagate Sub-County and Kabuyanda Town Council.

4.3.7.16 Challenges in agricultural production

The major barrier to agricultural production include; a) High incidence of climate change variations such as prolonged dry spell, pests and disease, floods amidst limited resilience capacity; b) limited access to cultivable land; c) limited access to climate services; d) poor farming methods; e) limited access to high yielding crop seeds and animal breeds; f) Poor post-harvest handling; g) inadequate access to water for production; h) limited access to extension services; i) fluctuation of market prices, among others.

4.3.8 Gender Dimensions (Women, Children, Disability)

4.3.8.1 Gender Division of Labour

In term of gender division of labour, the labour burden lies on the women and children especially when sowing, weeding. In terms of activity profile, women play more of reproductive and production roles. At farm level, the men mostly participate in opening up land and harvesting. Access to land for crop production is adequately favorable to women, however they have limited control over it regarding ownership and ability to transfer ownership.

4.3.8.2 Gender-based violence (GBV)

The incidence and prevalence of GBV cases is increasing. During village meetings, it was revealed that GBV was related to economic factors. Both women and men experience equal measure of GBV. The most common GBV cases are assault related, especially fighting. It was noted that women beat men, and vice-versa.

4.3.8.3 Child Rights

There is substantial observation of child rights such as right to education, play, guidance, immunization, adequate diet, shelter and medical care. However, child exploitation and child labour at household and community level is evident. Much as children are made to carry out domestic chores, they are exposed to risks such as accidents and injuries. At household level, children provide farm labour, collect water and firewood, and to a large extent regardless of age. The right to play (swimming) in rivers exposes them to skin diseases regardless of sex. Both girls and boys are equally vulnerable.

Figure 4-108: Children fetching water in the project area

4.3.8.4 Cultural heritage

There are no recorded physical cultural resources (PCR) that were identified by communities. More specifically, there are no cultural sites within project area. There are visual arts and handcrafts but on small scale. In terms of intangible culture, communities have beliefs, traditions and values attached to biodiversity especially concerning natural herbs and medicine.

4.3.8.5 Information, Education and Communication

The major information need is about awareness and information dissemination. The common communication channels are word-of-mouth, community events, FM radio and community radios. The major sources of information are friend, neighbors, local leader, religious leaders. The audience characteristics are majorly homogeneous in terms of language, occupation, psycho-social, location, among others.


Community Consultations in Mishumba Catchment (upstream of dam site)

4.4 Ecosystems Services: (Regulating, Provisioning & Cultural goods and services)

An Ecosystems Services Survey (ESS) was conducted during the dry season (March) within the micro catchments of sample sites along river stretches (upstream, mid-steam & downstream). The purpose was to assess the levels of access and utilization of ecosystem services. The purpose was to assess the levels of access and utilization of ecosystem services namely- 1) Regulating (the benefits obtained from an ecosystem's control of natural processes); 2) Provisioning (the goods or products obtained from ecosystems); 3) Cultural – the nonmaterial benefits people obtain from ecosystem services (World Resource Institute, 2008).

4.4.1 Regulating Services

The regulating services were assessed basing on 2 parameters of baseline condition and past trends (monthly / annual). This was done by respective experts that included Biologist/Ecologist, Hydrologist, Vegetation Expert, Zoologist/Fauna Expert, GIS/Mapping Specialist, Environmental Engineer. The findings on the regulating services are presented in a Assessment matrix with a 3-Point Rating Scale i.e., baseline conditions (High, Moderate, Low) and Trends (Increasing, Stable, Declining) as shown in Table 4-22 below.

Table 4-22: Assessment matrix for Regulating Ecosystem Services (Conditions & Trends in past 12 months)

Regulating Ecosystem services	Condition	Trends in Service (past 12 months)	Risk & Opportunities
Water regulation	High	Increasing	Vulnerable to floods due to increasing precipitation due climate variability – especially surface water drainage
Water purification & waste treatment	High	Stable	Increasing, land use change (wetland conversion to agriculture, cultivation on hill slopes, brick making pose a threat. There is high rate of TSS and Turbidity. Water clarity is good as shown in Figure 4-109
Climate regulation	High	Declining	Anthropogenic factors (human induced) are increasing
Soil erosion regulation	Moderate	Declining	Due to heavy rains and inadequate soil conservation practices (Figure 4-110), soil erosion is increasing hence more sediment loads in River Mishumba
Natural Hazard regulation (Floods)	Low	Declining	A severe flood occurred in May 2020 across all river sections (upstream, mid-stream, downstream), affecting human lives and property. There is high risk of reoccurrence.
Natural Hazard Regulation (Fires)	Moderate	Stable	No reported cases of fire outbreak during dry & rainy seasons
Pest regulation	Low	Declining	Climate change is contributing to pest & diseases for crop and livestock
Pollination	High	Stable	

Figure 4-109: State of water clarity at sample point 24 downstream (Nanda village)

Figure 4-110: Tractor clearing wetland vegetation for crop cultivation in downstream between sampling point 20 & 22

4.4.2 Provisioning Ecosystem Services (Access and utilization)

The provisioning and cultural ecosystem services were assessed by focusing on two parameters namely level of access and utlisation, and this was done through use of quantitative ESS survey questionnaire digitalized into KOBO COLLECT FORMS and data captured using mobile devices. By coverage, the ESS sampled 389 respondents (211 males; 178 females). It covered 17 villages surrounding 14 selected sampling sites. By distribution, 53.2% of respondents were located in the irrigable area (mid-stream and downstream) namely 46 in Middle Chezho Sub-catchment, 69 in Kyabaganda & Middle Chezho Sub-catchments and 92 in Lower Chezho Sub-catchment. In Lower Mishumba Sub-catchment (downstream of dam site), 12% (45) respondents were sampled. In total, the ESS covered the following villages - Kagoto 1, Kagoto 2, Kaaro 3, Kaaro 2, Kabumba, Kaburara, Kagunga, Kamwosya, Katoma 1, Kyamazinga 1, Kyamazinga 2, Mbarara 1, Mbarara 3, Nyamiyaga, Nyampikye 2, Ruyonza and Kigando. The findings were used to inform assessment of aquatic ecosystems, habitats, species, and socio-ecological functions and uses, as well as likely impacts by the proposed project.

Locally, the level of access and utilization of ecosystem services (as benefits of nature) creates a major link between nature and local development. These services (e.g., food, fiber and fuel) are key assets of capital and labor. The level of access and utilization varies from one sub catchment to the other. The sampled sub catchments in Figure 4-57 included; 1) Lower Mishumba & Chezho; 2) Lower Mishumba; 3) Lower Chezho; 4) Middle Chezho; 5) Kyabaganda & Middle Chezho; 6) Mishumba & Rweibare; 7) Mishumba; 8) Mishumba & Chezho; 9) Kinyara.

4.4.2.1 Freshwater

Findings show that all respondents (100%) acknowledged that they frequently use river stream to bath and wash clothes. More still, 97% frequently collect drinking water from rivers/streams. By distribution, in Lower Chezho sub catchment the number of persons who frequently collect drinking water was slightly lower at 88%. Lower Chezho sub catchment has relatively high connectivity to piped water in areas of Kabuyanda Town Council, Ntundu, Rwamwijuka and Kyamusooni parishes.

Watering animals: In terms of livestock, 94% frequently use river streams for watering cattle, goats and sheep; while 80% frequently irrigate crops using simple methods such as watering can, buckets. The area that reported frequent use of river streams for watering animals have large population of livestock. These sub catchments are Mishumba, Middle Chezho, Kyabaganda & Middle Chezho and Kinyara. Watering animals is slightly lower in Mishumba & Rweibare sub catchment at 74% of persons who reported frequent use of river streams Figure 4-111 to Figure 4-113**.**

Figure 4-111: Animal (goats) watering in the upstream (dam area) at E232503, N9900414

Figure 4-112: Animal (cows) watering in the midstream (irrigable area) at E237342, N9895670

Figure 4-113: Animal (cows) watering in the downstream (after irrigable area along Kabuyanda – Ruborogota road) at E234934, N9886429

4.4.2.2 Capture Fisheries

Fish for domestic use: The number of persons who frequently capture fish for domestic consumption is 52%; while 29% are not frequently doing it. Majority of the persons (87%) reported to capture fish for domestic use in Lower Mishumba sub catchment covering upstream areas of Kabuyanda. Most of the fishing activities happen in Lower Mishumba sub catchment (87%), Lower Mishumba & Chezho sub catchment (62%); Mishumba & Chezho (57%), Mishumba and Rweibare (52%), Lower Chezho (48%); Kyabaganda & Middle Chezho (45%); Middle Chezho (39%); Kinyara (35%) and Mishumba (35%) (**Figure** 4-114**).** However, there is another newly formed water body used for local fishing at place called Rugaga in Middle Chezho sub catchment (**Figure** 4-115).

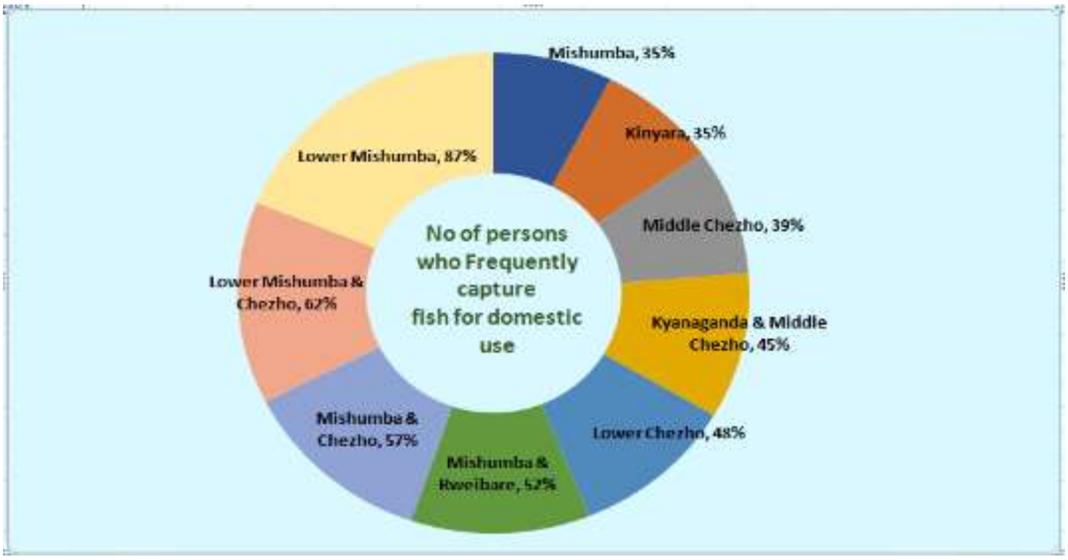

Figure 4-114: Fishing activities as per sub-catchment

Fishing for Income: The proportion of persons who capture fisheries for sale (income) was lowest at 21%; 23% do it but not frequently while majority at 56% said they are not sure if capture fisheries are sold by local people. There are few individuals who carry out aquaculture in Lower Chezho sub catchment (Ntundu and Kyamusooni parishes).

Figure 4-115: A water pond formed as a result of flash flood (May 2020) used for fishing by local people

4.4.2.3 Food Crops

In terms of food, 93% of respondents said they frequently cultivate near the floodplain in order to grow food as shown in **Figure** 4-116 below (Lower Chezho Sub-catchment).

Figure 4-116: Gardens of food crops in the Irrigable areas

4.4.2.4 Wild Fruits

14% (54) households frequently collect wild fruits e.g., berries; 79% (306) not frequently due to scarcity and 7% (29) not sure if other people collect wild fruits.

4.4.2.5 Hunting - Uses of mammals (eaten or not eaten)

The local communities reported to either have eaten or not eaten some of the following biodiversity namely rats (rodents), wild birds, snakes, reptiles (lizards), wild animals, monkeys as shown in **Table** 4-23 and **Figure** 4-117 below.

Table 4-23: Use of mammals (eaten or not eaten) by local communities

Biodiversity	Lower Mishumba &	Lower Mishumba	Lower Chezho	Middle Chezho	Kyabaganda & Middle Chezho	Mishumba & Rweibare	Mishumba	Mishumba & Chezho	Kinyara
Insects e.g., ants wasps	100%	100 %	100%	100 %	100%	100 %	100 %	100 %	100 %
Frogs Ekyeere with short front legs	44%	56%	4%	0%	25%	30%	62%	81%	0%
Antelope	100%	98%	95%	100 %	100%	100 %	100 %	100 %	100 %
Monkeys (Enkyede)	7%	5%	2%	0%	0%	0%	0%	0%	0%
Rats (rodents) (Enkyeli)	0%	2%	0%	9%	6%	0%	14%	5%	0%
Wild birds (Endahi, Enkware Enkofu, etc.)	100%	96%	97%	100 %	100%	100 %	100 %	100 %	100 %
Snakes (Enjoki)	0%	5%	0%	0%	0%	0%	0%	0%	0%
Reptiles (lizards, monitor lizard, esswasa etc.)	0%	4%	3%	0%	0%	0%	0%	0%	0%

Other Wild animals (baboons, fox leopard etc.)	0%	0%	0%	0%	0%	0%	0%	0%	0%

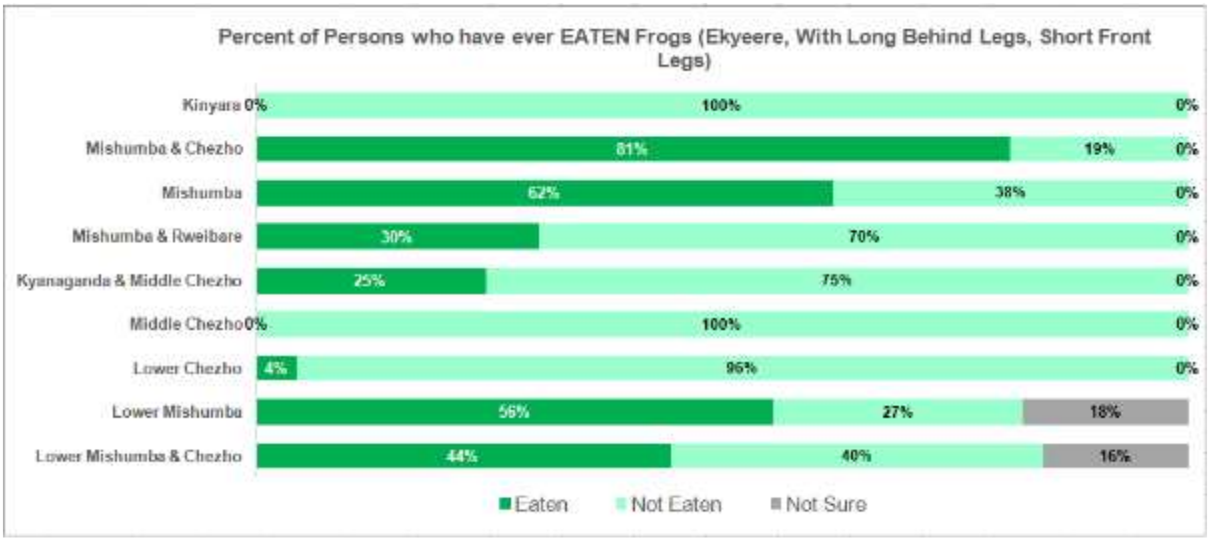

Figure 4-117: Percentage of persons who have eaten or eat particular species of frogs for food

4.4.2.6 Hunting - Use of birds

Averagely, 84% of persons reported to have eaten 1 bird (excluding the domestic avifauna like chicken) per meal; 15% have ever eaten 2 birds per meal; 1% more than 1 bird. The number of persons who have ever eaten 1 bird per meal is higher in Mishumba and Lower Mishumba & Chezho sub catchment at 100%. In Mishumba & Chezho, it stands at 90%; 88% in Kyabaganda & Middle Chezho; 86% in Lower Mishumba; 85% in Middle Chezho.

In terms of weight, 70% of persons reported that average weight of bird ever eaten was 1kg; 10% said weight was 2kg; and 20% stated it was ½ kg (half kilo).

4.4.2.6.1 Major ways of hunting / capturing

The major form of hunting is by use of traps which are used frequently as shown in table below.

Table 4-24: Ranking of major ways of hunting (traps) used as per sub-catchment

Use of traps	Frequently	Not Sure	Not Frequently
Lower Mishumba & Chezho	53%	24%	22%
Lower Mishumba	77%	19%	5%
Lower Chezho	73%	14%	13%
Middle Chezho	93%	7%	0%
Kyabaganda & Middle Chezho	88%	6%	6%
Mishumba & Rweibare	61%	30%	9%
Mishumba	90%	0%	10%
Mishumba & Chezho	71%	29%	0%
Kinyara	100%	0%	0%

4.4.2.7 Wood Fuel

99% frequently collect firewood for domestic use while 85% frequently collect firewood for sale.

4.4.2.8 Timber and Wood Fibre

97% collect building materials (e.g., grass, poles) but not frequently, while only 3% frequently collect raw materials (e.g., papyrus, rattan)

Figure 4-118: Building material (Papyrus) collected from the midstream (irrigable area)

Figure 4-119: Children collecting timber from Rwoho CFR

Figure 4-120: Timber and firewood collection from Rwoho CFR

Figure 4-121: Timber lumbering activity in Rwoho CFR near the dam site

Figure 4-122: Timber lumbering activity in Rwoho CFR in the middle of the reservoir area

4.4.2.9 Natural Medicines

12% frequently collect herbs and medicinal products; 82% not frequently

4.4.2.10 Brick making

4% frequently make bricks from clay; 95% not frequently; 1% not sure

4.4.2.11 Sand Mining

21% mine sand for sale frequently; 50% not frequently; 29% not sure

4.4.3 Cultural Services (Non-material benefits)

4.4.3.1 Recreation or Leisure

6% frequently use for recreation and leisure e.g., swimming, while 2% not frequently; 92% not sure.

4.4.3.2 Spiritual and Religious Values

0.2% frequently use for cultural rituals (e.g., worship spaces); 1.3% not frequently; 98% not sure.

4.4.3.3 Summary

Table 4-25: Summary of Ecosystem Services Survey (ESS) findings

Ecosystem services	Percentage & Frequency		
	Frequently	Not frequent	Not sure
Fresh Water			
Bathing in river stream	100% (386)	0	0
Washing clothes in river stream	100% (386)	0	0
Collecting drinking water	97% (376)	1% (5)	2% (6)
Use river water for crop irrigation	80% (312)	19% (74)	1% (3)
Watering livestock esp. cattle	94% (361)	2% (9)	4% (15)
Foods			
Cultivate near or within wetland (crop land)	93% (357)	7% (25)	1% (2)
Capture fisheries			
Fishing for domestic consumption (food at home)	52% (201)	29% (114)	1% (2)
Fishing for Sale (income)	21% (80)	23% (88)	56% (218)
Wild foods			
Collect wild fruits (e.g., berries)	14% (54)	79% (302)	8% (29)
Wood fuel			
Collect firewood for domestic use	99% (386)	1% (2)	0%
Collect firewood for sale (income)	85% (324)	13% (49)	3% (13)
Fiber (Timber and wood fibers)			
Collect building materials (e.g., grass, poles)	2% (8)	97% (372)	1% (4)
Collect raw materials (e.g., papyrus, rattan)	3% (11)	32% (124)	65% (249)
Biochemicals, natural medicines, and pharmaceuticals			
Collect herbs and medicinal products	12% (47)	82% (313)	6% (24)
Recreation and ecotourism			
Recreation / Leisure (e.g., swimming)	6% (23)	2% (9)	92% (351)
Spiritual and religious values / Ethical values			
Cultural rituals (e.g., worship spaces)	0.2% (3)	1.3% (5)	98% (374)
Other uses			
Mining (sand, stones)	4% (15)	95% (364)	1% (3)
Brick making / pottery	21% (80)	50% (190)	29% (112)

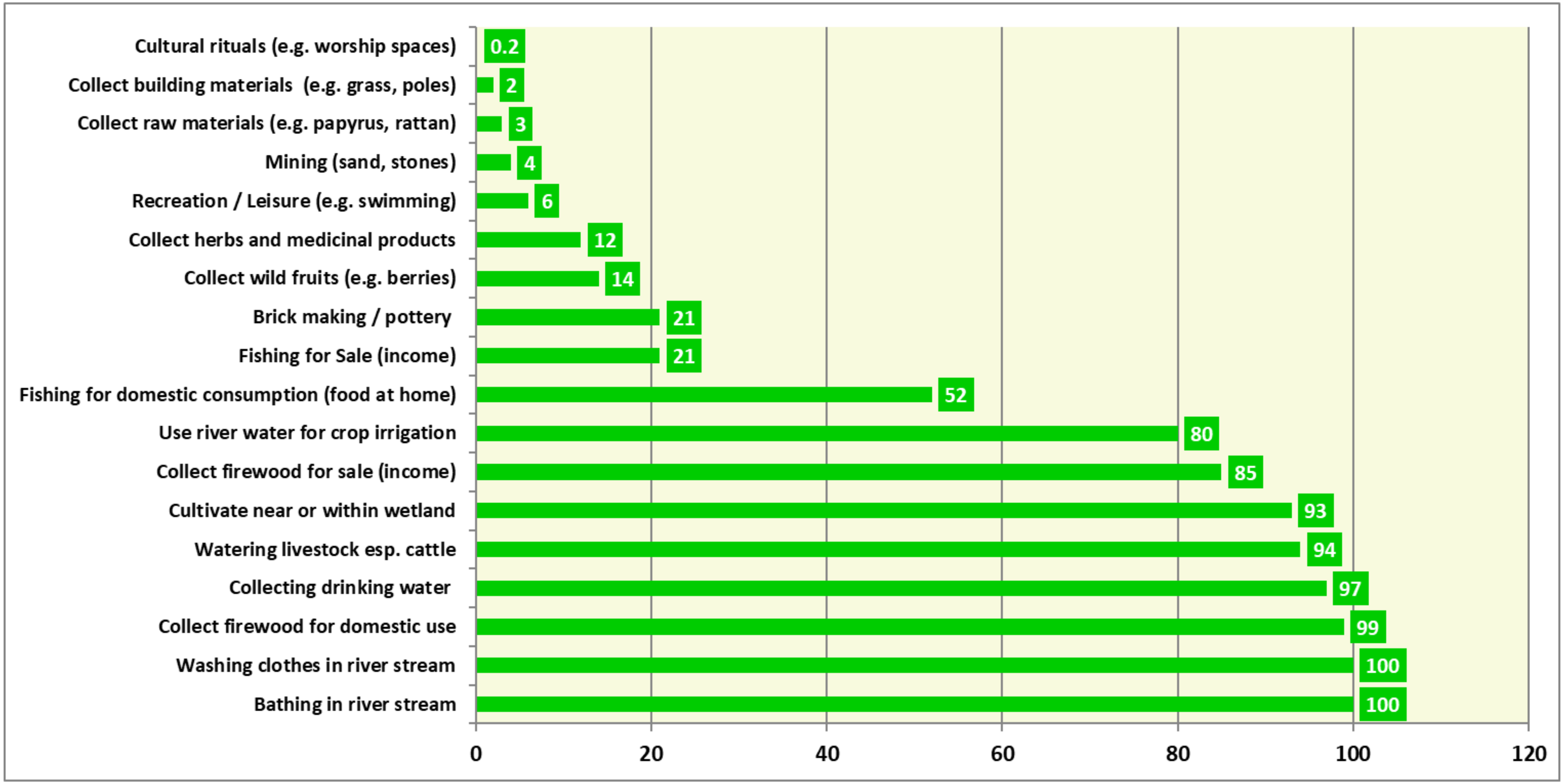

Figure 4-123: Percentage of persons who fluently access and utilise ecosystem services within micro-catchments of selected sample sites

Table 4-26: Number of persons who frequently access or utilize provisioning and cultural ecosystem services

Provisioning & Cultural Ecosystem Services	Lower Mishumba & Chezho	Lower Mishumba	Lower Chezho	Middle Chezho	Kyabaganda & Middle Chezho	Mishumba & Rweibare	Mishumba	Mishumba & Chezho	Kinyara
Use river Water for irrigation crops	93%	100%	75%	72%	94%	83%	57%	30%	83%
Fishing for domestic use (food at home)	62%	87%	48%	39%	45%	52%	35%	57%	35%
Fish for Sale income	47%	20%	28%	0%	9%	22%	17%	22%	17%
Leisure recreation	22%	13%	37%	67%	30%	43%	20%	13%	35%
Collect drinking water	100%	100%	88%	100%	100%	100%	0%	0%	0%
Bathing	100%	100%	100%	100%	100%	100%	100%	100%	100%
Washing clothes	100%	100%	100%	100%	100%	100%	100%	100%	100%
Watering livestock e g cattle	93%	77%	96%	100%	100%	74%	100%	96%	100%
Cultural rituals-worship spaces, sacred sites)	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sand stone mining	2%	0%	0%	0%	0%	0%	0%	11%	0%
Brick making pottery	16%	0%	27%	65%	23%	9%	0%	0%	0%
Collect building mat ls e g grass poles	0%	0%	4%	0%	0%	9%	10%	0%	0%
Collect raw material papyrus rattan etc.	0%	9%	3%	0%	3%	0%	0%	10%	0%
Grow crops near or within wetland	93%	100%	100%	100%	100%	100%	38%	48%	100%
Collect wild fruits e g berries	49%	18%	9%	0%	13%	17%	10%	5%	0%
Collect firewood	100%	100%	100%	100%	100%	100%	100%	100%	100%
Collect herbs and medicine	31%	18%	18%	0%	3%	22%	0%	5%	0%
Collect fuel wood for home use	100%	100%	98%	100%	100%	100%	100%	100%	100%
Collect fuel wood for sale income	84%	95%	66%	93%	81%	91%	91%	91%	100%
Collect Herbs and medicines	11%	0%	3%	0%	6%	9%	22%	22%	0%
Recreation leisure	20%	14%	3%	0%	0%	13%	10%	0%	0%
Cultural rituals sacred sites worship	0%	0%	0%	0%	0%	0%	0%	0%	0%

4.4.4 Major concerns

Table 4-27: Major concerns of local people captured during consultations and the survey

Major Concerns	Lower Mishumba & Chezho	Lower Mishumba	Lower Chezho	Middle Chezho	Kyabaganda & Middle Chezho	Mishumba & Rweibare	Mishumba	Mishumba & Chezho	Kinyara
Need for Compensation of land	91%	86%	17%	9%	35%	100%	52%	81%	0%
Disruption of water sources	100%	100%	100%	100%	96%	100%	100%	100 %	100%
Floods due to dam overflow bursting	100%	100%	58%	100%	100%	100%	14%	5%	100%
People esp. Children drowning in dam	100%	100%	2%	0%	46%	100%	24%	62%	0%
Disruption of Fishing activities	100%	100%	100%	100%	100%	100%	100%	100 %	100%
Disruption of firewood sources	100%	100%	100%	100%	100%	100%	100%	100 %	100%
Disruption of grazing land for animals	100%	100%	88%	91%	90%	100%	100%	100 %	100%
Destruction of crops	100%	100%	25%	23%	36%	100%	62%	100 %	17%
Destruction of property	78%	91%	3%	0%	29%	96%	0%	5%	0%
Disruption of road user's blockage	100%	100%	90%	93%	100%	100%	100%	100 %	83%

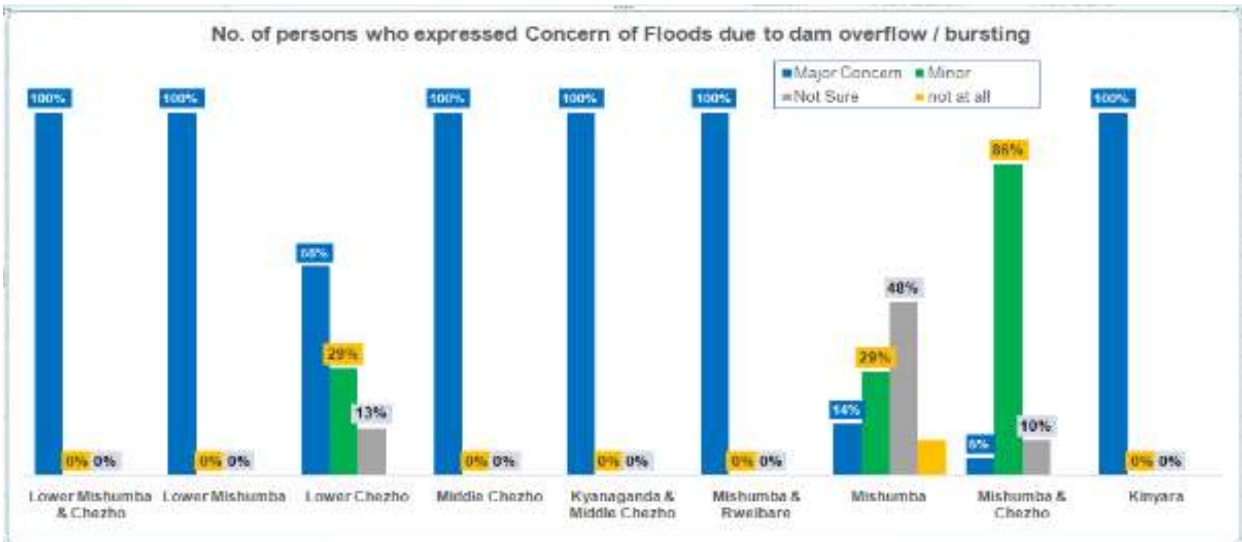

Figure 4-124: Ranking of floods due to dam overflow/break as a major concern by upstream, midstream and downstream communities

River Mishumba gauging station downstream of the proposed dam site and before the Mishumba – Rweibare confluence

5 ENVIRONMENTAL FLOW ASSESSMENT METHODOLOGY

5.1 Environmental Flows (e-flows)

Environmental flows (e-flows) describe the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being" as guided by (The Brisbane Declaration 2007). The declaration, among others concluded that e-flow management provides the water flows needed to sustain freshwater and estuarine ecosystems in coexistence with agriculture, industry, and cities. The declaration also put forward global agenda commitments key among which is to integrate e-flow management into every aspect of land and water management.

It is recognized that the health and sustainability of river ecosystems depends on multiple factors, including flow regime, river hydraulics (e.g., geometry of channel and riparian zone), level of exploitation, presence of physical barriers to connectivity, among others. Thus, it involves a number of biological, geomorphological, physical, and chemical processes in a river that forms and maintains aquatic ecosystems. In addition, it involves stakeholders and experts from multiple disciplines to account for socioeconomic issues (between river flows and livelihoods). Ecosystems include river fauna and flora, floodplains and wetlands watered by floods, groundwater-dependent ecosystems replenished through river seepage, and estuaries (Davis and Hirji 2003).

5.2 Methods of Environmental Flow Assessment (EFA)

According to Brown & King (2003), specifying and understanding the e-flows of a river ecosystem, minimizes or mitigates the impacts of new water resource developments, rehabilitates systems impacted by past developments and allows calculation of the costs of compensating people for such impacts. In order to assess and quantify the e-flows, both prescriptive and interactive approaches can be applied. These include categories of methods like (1) hydrological, (2) hydraulic rating, (3) habitat simulation and (4) holistic methods.

a) **Hydrological Index methods**: these primarily use hydrological data (historical monthly or daily flow records) for making e-flow recommendations for maintaining river health at a designated level. These include the *Modified Tennant (Tessmann), Flow Duration Curve (FDC) analysis* (Q_{90}) and *Range of Variability Approach (RVA),* among others.

b) **Hydraulic rating methods**: use changes in simple hydraulic variables (e.g., *wetted perimeter*) across single river cross-section as surrogate for habitat factors limiting to target biota. A number of measurements are taken during field visits depending on the level of confidence required for the study.

c) **Habitat simulation methods**: Assess e-flows on basis of modeling of quantity and suitability of physical habitat available to target species under different flow regimes (integrated hydrological, hydraulic and biological response data). The adopted models were the *IFIM (Instream Flow Incremental Methodology)* and *PHABSIM (Physical Habitat Simulation)*.

d) **Holistic methods:** consider the whole riverine ecosystem and this holistic idea was raised with the Brisbane declaration in 2007. These methods need experts in different fields. It includes identifying important flow events for all major components of the river, model relationships between flow and ecological, geomorphological and social responses, and use in interdisciplinary team approach to establish recommended e-flow regime/implications of flow scenarios (bottom-up or top-down). These methods include DRIFT, BBM, EPAM, SPAM, FMP, FLOWRESM, among others. In addition, they also consider the river morphological processes, as well as integration of environmental flow assessment with sediment management and dynamics. Due to their depth of evaluation, data collection and extent of expert consultations, application of these holistic methodologies can be time consuming (at least one year).

The assessment of the Environmental Flow Requirement (EFR) was based on the Building Block Methodology (BBM). *The BBM is a methodology – a body of methods that together produces an output greater and more all-encompassing than the methods could produce individually. The BBM tool organises, uses a holistic, structured way and a disparate array of knowledge and data. Each specialist chooses the methods most appropriate for his/her discipline, to produce data in the required form and nature for use in the BBM. The BBM process is used both to guide on this required form, and to organise the incoming data and knowledge to provide the required output. The output, or product, of applying the BBM is a modified flow regime, quantified in space and time. This is specific for the river, and for the desired future condition for that river (King et al., 2008)."*

5.3 Selection of Models

In undertaking this study, basis and key guidance was the Brisbane Declaration as to the need for setting and managing e-flows for the Kabuyanda Irrigation scheme. Given the hydrological and hydraulic status of River Mishumba as described in the introduction section, and requirement for high quality data (hydrological and hydraulics), methodology such as the DRIFT, as stated in the ToR failed to generate any significant meaningful results when applied. Background description and case for the choice of methods used, and the basis for deviation from the methods mentioned in the ToR is provided. To this effect, two (2) feasible models were employed for this assignment including:

a. the Modified Base Flow Index with Threshold (MBFIT) and
b. the HEC RAS model.

5.3.1 The Integrated e-flow analysis Approach

The Integrated e-flow analysis Approach put forward by the WMO (2019) is an interactive approach, ideal for applying holistic models for EFA. The approach is based on disciplines such as hydrology, fluvial geomorphology and ecology. The procedure for the definition of e-flows comprises four main parts: (a) morphological characterization of the river system, (b) hydrological and sediment regime analysis, (c) ecological response to altered flow regime and selection of target communities, and (d) comparison and selection of possible flow release scenarios **(Figure** 5-1**)**. The following sections describe each methodological step.

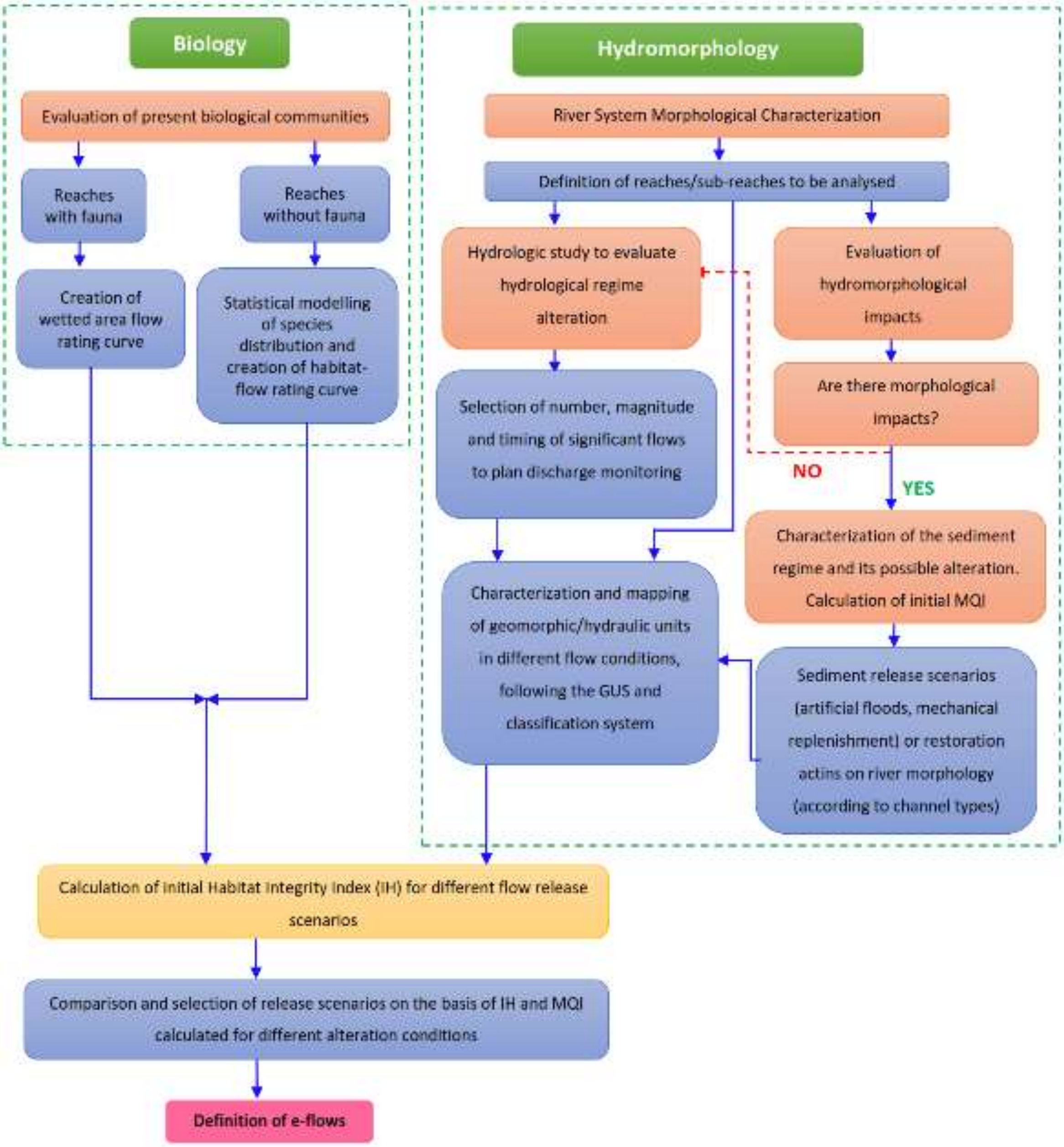

Figure 5-1: Flow chart of the main procedural steps for e-flow assessment integrated with tools developed from the hydrology, fluvial geomorphology and biology

5.3.1.1 Morphological characterization of the river system

Stream morphological characterization was used to: (a) identify the homogeneous hydromorphological reaches (and the related geomorphic units) that are the survey features for successive evaluations, (b) evaluate the status of alteration of the river reach and (c) define the strategies for releasing e-flows. Homogeneous hydromorphological reaches (same channel morphology and hydrological characteristics) have a homogeneous response in terms of hydromorphological processes. Therefore, e-flows were defined considering this reach spatial scale.

A morphology is defined according to a hierarchical segmentation procedure that considers, for each spatial unit, the variation of some characteristic variables, which are significant for project area's spatial scale. Channels were classified based on: (a) channel pattern and confinement conditions, (b) significant discontinuities of control variables (discharges or slope) and (c) sediment type in the channel.

The definition of channel morphology utilised information from satellite imagery and field visits to infer a general characterization of geomorphic units occurring in the reach (presence/absence of units characterizing a certain morphology). In process, each channel typology exhibits a certain typical spectrum of geomorphic units, whose assemblage is the result of processes that determined the local morphology, according to the guiding variables and the boundary conditions that act at the upper spatial scales.

5.3.1.2 Ecological response to altered flow regime and selection of target communities

The fish, flora and fauna communities were proposed as an e-flow indicators and considered as a main target community for the definition of e-flows. Owing to its ecological response, the composition and status of the fish, flora and fauna communities can be used to evaluate and ecologically validate specific e-flow releases. A methodology to define e-flows, based on the status of local fish, can therefore be an efficient tool to determine the impact of hydromorphological alterations (future or present) and to inform stakeholders on the alteration of the environmental status of water bodies.

To determine the composition of the target fish community, it was necessary to list the available species based on the official and historical data available from the public administration or local environmental agencies (fish maps, environmental monitoring among others) and on the life cycle and migration trajectories of involved populations. These lists were subsequently validated through direct fish sampling in the reaches where derivations were planned.

5.3.2 Definition of hydrological environmental flow regime (HEFR)

The HEFR methodology provides a meaningful statistical depiction of the occurrence of instream flows and, when integrated with appropriate biology, water quality, geomorphology, and riparian vegetation overlays, provides a foundation for environmental flow regime recommendations. The first major decision in application of the HEFR methodology is the selection of an appropriate method for hydrographic separation. Methods considered and used in the study included Modified Base Flow Index with Threshold (MBFIT). A key step in HEFR is the separation of hydrologic data into components lumped into five groups: (1) magnitude of monthly flow conditions; (2) magnitude and duration of extreme flow events (e.g., high and low flows); (3) the timing of extreme flow events; (4) frequency and duration of high low flow pulses; and (5) the rate and frequency of changes in flows.

A low flow pils is number of times that the daily time-step hydrograph pulses are below the low-flow threshold for each calendar year; threshold set at 50% of the mean flow rate.

The method is based on simple summary statistics of individual flow regime components. Generally, either the EFC algorithm (in the IHA software) or the Modified Base Flow Index with Threshold (MBFIT) method is used as a convenient tool to parse a hydrograph into individual flow regime components. This is because (1)) it is computationally efficient, allowing for repeated tests and exploratory analyses, (2) there is significant flexibility in setting parameters to parse the hydrograph as well as summary statistics of the flow regime components, (3) the results have the same format as expected results from the TIFP studies, and (4) it provides an initial set of recommendations that reflect key aspects of the natural flow regime including multiple flow components and hydrologic conditions.

Therefore, a hydrographic separation algorithm was used to parse the daily hydrograph into the four flow regime components, based on user-specified parameters. The daily flows were then distilled and hydrographic separation results were output into a suite of summary statistics that form the basis for an environmental flow recommendation.

5.3.2.1 The Modified Base Flow Index Method with Threshold (MBFIT) Algorithm

The Base Flow Index Method was used to separate hydrographs into base flow and runoff components, where every day is assigned some amount of base flow and some days additionally have runoff flow. The method is based upon dividing the daily time series of flows into N-day windows and tracking the time series of minima in each window. The window length N is at the disposal of the user and is considered a measure of the time for a storm hydrograph to substantially recede. The basic functioning of the algorithm is as follows: if the daily flow in excess of the associated minimum is less than the associated minimum of times the parameter RF (Runoff Fraction, RF<1), that day is initially classified as a base flow, unless the flow exceeds the upper threshold. This calculation approach typically has a large emphasis on rate of change and a lesser emphasis on flow magnitude when making distinctions between base flows and high flow pulses.

Using the MBFIT method, subsistence flows and overbank events were coded in similarly to the IHA EFC algorithm. Following the default HEFR parameter set, subsistence flows were identified as the lowest 10% of the initially-classified base flows. Similarly, initially-classified high flow pulse events that exceed the 1.5-year return flow was then classified as overbank flow events.

5.3.2.2 Selection of Flow regimes

The information derived from the HEFR was used to develop the following 4 flow regimes. The selection of four regimes was based on the fact that the flow in the river of interest was very low. These groups were then used to define flow regimes as follows in the **Table** 5-1 below.

Table 5-1: The Flow Regimes Developed for EFA

Environmental Flow	Importance to ecosystem

Component (EFC)	
Low flows	These are the daily flows that occur outside of high-flow peaks. They define the basic hydrological nature of the river: its dry and wet season, and degree of pereniality. The different magnitudes of low-flow in the dry and wet seasons create more or less wetted habitat and different hydraulic and water quality conditions, which directly influence the balance of species anytime of the year.
Small floods	Small floods are ecologically important in the dry season. They stimulate spawning in fish, flush out poor-quality water, mobilize and sort gravels and corbels thereby enhancing physical heterogeneity of the riverbed, and contribute to flow variability. They reset a wide spectrum of conditions in the river, triggering and synchronizing activities as varies as upstream migrations of fish and germination of riparian seedlings.
Large floods	Large floods trigger many of the same responses as do the small ones, but additionally provide for scouring flows that influence the form of the channel. They mobilize coarse sediments, and deposit silt, nutrients, eggs and seeds on flood plains. They inundate backwaters and secondary channels, and trigger bursts of growth in many species. They re-charge soil moisture levels in the banks, inundate flood plains, among others.
Flow variability	Fluctuating discharges constantly change conditions through each day and season, creating mosaics of areas inundated and exposed for different lengths of time. The resulting physical heterogeneity determines the local distribution of species: higher physical diversity enhances biodiversity.

The low flows: the daily flows between high-flow peaks are divided into data sets for different seasons:

- wet-season low flows; and
- dry-season low flows.

The high flows: the peak events of higher flow are allocated to one of the following:

- four size classes of intra-annual floods; and
- floods with a return period of up to 2, 5, 10 and 20 years.

Low flows are distinguished from high flows using one of two criteria: the rate of change of the slope of the daily hydrograph, or the discharge at which selected features of the channel become inundated. The four classes of intra-annual floods are delineated by simple halving of magnitudes from the 1: 2-year flood, as halving the magnitude of an event results, in general terms, in a significant change in the sediment-moving power of the flood. However, due to the small magnitudes of flow in the rivers, intra-annual floods were not divided.

5.3.2.3 Derivation of Hydraulic characteristics of flow regimes at sampling points

The modeling of the hydraulic characteristics of the sampling point for each flow regime was done using the HEC-RAS model. HEC-RAS uses a number of input parameters for hydraulic analysis of the stream channel geometry and water flow. These parameters are used to establish a series of cross-sections along the stream. In each cross-section, the locations of the stream banks are identified and used to divide into segments of left floodway, main channel, and right floodway.

At each cross-section, HEC-RAS uses several input parameters to describe shape, elevation, and relative location along the stream such as:

- River station (cross-section) number.
- Lateral and elevation coordinates for each (dry, unflooded) terrain point.
- Left and right bank station locations.
- Reach lengths between the left floodway, stream centerline, and right floodway of adjacent cross-sections.
- Manning's roughness coefficients.
- Channel contraction and expansion

The outputs of the model include the top width, velocities, wetted perimeter, hydraulic depth, flows for different parts of the stream at the sampling point, Froude numbers, among other parameters for each of the flow regime identified. This information was then overlaid with the sampling outputs from the ecological surveys to describe the different ecological conditions and requirements at each Sampling site.

5.3.3 Environmental Flows Assessment for key fish species as representatives of key biomes in the catchment

The fishes and other living aquatic organisms in rivers are usually adapted to the particular patterns of flow found there, and as such it is expected that the planned changes in flow in River Mishumba will disrupt the adaptations of the living organisms therein, in a manner different from the regular natural receding and flooding of the catchment with alternating dry and wet seasons. In River Mishumba, it was established that they are generally two categories of fishes, the limnophilic ones which include tilapias and haplochromine species, and those that are rheophilic represented by African catfish and Victoria carp. The rheophilic were found mainly occupying runs and ripples in the main channel of the river, while the limnophilic occupied exclusively pool waters and closer to the adjoining vegetation and or swamps. Changes in flow will, therefore, tend to favour one or other of these communities, increasing flows leading to a larger presence of rheophilic species, decreasing flows encouraging colonization by limnophilic species. Adequate flows are also essential for the breeding and migration of these fishes especially in wet season as physiologically fish respond to flood conditions by becoming sexually ripe and by migrating to breeding grounds. In case of Victoria carp and African catfish that is upstream, while for tilapias and haplochromines that is in the flooded sandy and vegetated plains. In both forms, most especially the limnophilic species, certain critical levels of flow are needed to maintain certain types of breeding substrate in a suitable condition for spawning. In this study, the holistic method was used following basic steps:

a. acquisition of the flow-related information on respective fish species in River Mishumba, including an estimate of fish species composition, abundance and habitat use in relation to flow conditions;
b. linking the respective fish species to key aspects of the flow regime using a conceptual model;
c. identifying and aligning the e-flow demands for the biodiversity with the environmental flow objectives; and
d. Using the hydraulic and hydrologic data and models generated under hydrological modelling to determine the magnitude, duration, frequency and timing of flows required to meet these

objectives; and the particulars on the flow-related ecological requirements of each fish species and developmental stage known or expected to occur in the different reaches of River Mishumba as per occurrence of different fish species.

Given the paucity of long term or time series data, the ephemeral nature of River Mishumba, and limited knowledge of how the contained fisheries biodiversity actually responds to the natural changes in flow in River Mishumba, the method used here for EFA was informed by the Building Block Methodology as developed in South Africa for such circumstances (King, 2008). This was based on updating of knowledge of species occurrence and distributions following set longitudinal zonation (reaches) of the river along with hydrology and socioeconomic data generated during the surveys. In adopting the BBM methodology the study also took in consideration the following assumptions as given by the developers of the methodology:

a. The biota associated with a river can cope with those low flow conditions that naturally occur in it often, and may be reliant on higher flow conditions that naturally occur in it at certain times. This assumption reflects the thinking that the flows that are a normal characteristic of a specific river, no matter how extreme, variable or unpredictable they may be, are ones to which the riverine species characteristic of that river are adapted and on which they may be reliant. On the other hand, flows that are not characteristic of that river will constitute an atypical disturbance to the riverine ecosystem and could fundamentally change its character.
b. Identification of what are felt to be the most important components of the natural flow regime and their incorporation as part of the modified flow regime will facilitate maintenance of the natural biota and natural functioning of the river.
c. Certain kinds of flow influence channel geomorphology more than others do. Identification of such flows and their incorporation into the modified flow regime will aid maintenance of the natural channel structure and diversity of physical biotopes.

Additionally, the study considered literature and assessed the physical and chemical tolerance ranges, specific flow-related requirements, and vulnerable lifecycle stages, of key species to the extent possible within the study time. The study sought and established existence of sites, species or communities of special importance in Mishumba Catchment that were likely to be affected by development of the irrigation scheme including identifying ecologically the key species in the system and their essential flow-related requirements. Here the study considered aquatic wildlife (fish species) and riparian vegetation communities owing to the limited secondary data and lack of time to gather data for other ecological components. Inputs on aquatic mammals, reptiles and amphibians, water birds and macrophytes were also included but largely as to their occurrence. Thus, the methodology incorporated and used relevant secondary and primary data on information on the river. The following ecological aspects were selected following Kleynhans (1999) model, as the basis for the assessment

a. For both instream and riparian components of the river: the overall species diversity, and the presence of rare and endangered species, unique species (i.e., endemic or isolated populations) and communities, and species intolerant of change.
b. Reaches with a high diversity of habitat types such as pools, riffles, runs, rapids, waterfalls and riparian forests.

c. Biodiversity in its general form (i.e., sensu Noss 1990), as far as available information allows inclusion of this aspect.
d. Importance of the river or stretch of river in providing connectivity between different parts of the system, that is, whether it provides an important migration route or corridor for species' movements.
e. The presence of conservation or other relatively natural areas along the river section. The sensitivity (or fragility) and resilience of the system.
f. Biotic and abiotic components of the river should be considered.

The assigning of importance and value for the key species and ecological components was guided by the description in **Table** 5-2**.**

Table 5-2: Framework for assigning of ecological importance in setting of e-flows to different species and species groups in Mishumba catchment

Rare and endangered biota	Biota can be rare or endangered on a local, Provincial or National scale. Useful sources for this information include the South African Red Data Books that are suitable for assessment on a National scale.	• Very High (Rated 4). One or more species/taxa rare or endangered on a national scale. • High (3). One or more species/taxa rare or endangered on a Provincial/regional scale. • Moderate (2). More than one species/taxon rare or endangered on a local scale. • Marginal (1). One species/taxon rare or endangered at a local scale. • None (0). No rare or endangered species/taxon at any scale.
Unique biota	Include endemic or uniquely isolated species populations (or taxa, i.e., in the case of invertebrates) that are not rare or endangered. Do not include rare and endangered species assessed in the previous category. The assessment should be based on professional knowledge. The Fynbos Biome in the Western Cape is a hotspot of biodiversity with many endemic species. This region is thus assessed separately.	• Very High (4). One or more populations (or taxa) unique on a National scale. For the Western Cape, rate at the Biome scale. • High (3). One or more populations (or taxa) unique on a Provincial/regional scale. For the Western Cape, rate at a sub-regional scale (i.e., northern, western, southern and karroid). • Moderate (2). More than one population (or taxon) unique on a local scale. • Marginal (1). One population (or taxon) unique at a local scale. • None (0). No population (or taxon) unique at any scale.
Intolerant biota	Intolerant taxa include those that are known (or suspected) of being intolerant to decreased or increased flow conditions, as well as to flow related changes in physical habitat and water quality. As little	• Very High (4). A very high proportion of the biota dependent on permanently flowing water during all phases of life cycles. • High (3). A high proportion of the biota dependent on permanently flowing water during all phases of life cycles.

	experimental information is available on the intolerance of indigenous biota, assessment should be based on professional judgement. Where all rivers are perennial (and would thus score highly), use fish only. š	• Moderate (2). A small proportion of the biota dependent on permanently flowing water during some phases of life cycles. • Marginal (1). A very low proportion of the biota temporarily dependent on flowing water for the completion of life cycles. Sporadic and seasonal flow events expected to meet needs. • None (0). Few if any biota with any dependence on flowing water.
Species/taxon richness.	This kind of assessment should be based on the grouping of ecologically similar rivers. However, such a system is still under development, and so at present should be based on professional judgement.	• Very High (4). Rated on a National scale, except for the Western Cape where it is rated on a Biome scale. • High (3). Rated on a Provincial or regional scale, except for the Western Cape where it is rated on a sub-regional scale (i.e., northern, western, southern and karroid). • Moderate (2). Rated on a local scale. Marginal/low (1). Not significant at any scale. • A rating of none is not appropriate in this context.

Table 5-3: Framework for assigning ecological importance and sensitivity

Ecological Importance and Sensitivity	Class Range of Median
Very high: Rivers that are unique on a national or even international level based on biodiversity aspects.	> 3 and 4
High: Rivers that are unique on a national scale based on biodiversity aspects.	> 2 and 3
Moderate: Rivers that are unique on a provincial or local scale based on biodiversity aspects.	> 1 and 2
Low/marginal: Rivers that are not unique at any scale.	> 0 and 1

5.3.4 Consideration of the e-flow requirements of other biodiversity

The fish was used as a key indicator organism for impact in unnatural flow changes to the other biodiversity. These included the vegetation and flora, fauna, invertebrates and the socio-economic indicators. However, in assessing the impacts and devising management measures to mitigate the impact, each species needs and requirements was be taken into account and these were stated in the biodiversity and e-flow management plan.

A flood along River Mishumba that destroyed a community access during the wet season (November 2020)

6 ENVIRONMENTAL FLOW ASSESSMENT (EFA)

6.1 Derivation of the Environmental flows (e-flows) Requirement

The process of establishing the environmental flow requirement involved undertaking a hydrologic analysis to establish the different flow regimes and floods of various return periods. A hydraulic analysis was then undertaken to enable the conversion of biotic requirements into flow values. Flow requirements at the sampling points were then established and used to infer the necessary releases at the dam.

6.1.1 Modified Base Flow Index (MBFI) with Threshold approach

The Hydrologic analyses established the initial building blocks for the study as follows :the low flows, maintenance flows, small floods, fresh nets and large floods. These five (5) flows components provide a heuristic framework for describing the ways in which an organism experiences river flow variability i.e., the hydrologic changes that are directly related to the quality of ecosystems. For instance, low flows determine the amount and characteristics (e.g., temperature, flow velocity, connectivity, etc.) of aquatic habitat that is available for most of the year.

Table 6-1 shows the rates of different flow regimes developed using MBFIT method over the 12 months with thresholds for change in rates (Table 6-2) including percentiles and recurrence intervals against their magnitude in Table 6-3.

Table 6-1: MBFIT analysis of flow rates of River Mishumba flows for 12 months

	0.25	0.5	0.75
Month	**← MBFIT → 25th**	**← MBFIT → 50th**	**← MBFIT → 75th**
Jan	0	0	0
Feb	0.10	0.10	0.20
Mar	0.20	0.20	0.40
Apr	0.40	0.60	0.60
May	0.20	0.40	0.60
Jun	0.10	0.10	0.10
Jul	0.10	0.10	0.10
Aug	0.10	0.10	0.10
Sep	0.10	0.10	0.30
Oct	0.20	0.40	0.60
Nov	0.40	0.60	0.70
Dec	0.20	0.30	0.60

Table 6-2: Rates of change in flows over the 12 months under the HEFR approach

	Rate of Change
% Increase on rise	0.25
% Decrease on fall	0.05

Table 6-3: Thresholds in form of percentiles, recurrence intervals against the magnitude for River Mishumba

	Thresholds	
	Percentile	Magnitude
high flow upper	0.75	0.8
high flow lower	0.25	0.2
	Recurrence interval	Magnitude
extreme low flow	0.1	-
small flood	2	1.8
large flood	5	2.4

Table 6-4: Summary of current flow regime using different methodologies

Quartile	**MBFIT**		
	25th	**50th**	**75th**
	m^3/s	**m^3/s**	**m^3/s**
Jan	0	0	0
Feb	0.1	0.1	0.2
Mar	0.2	0.2	0.4
Apr	0.4	0.6	0.6
May	0.2	0.4	0.6
Jun	0.1	0.1	0.1
Jul	0.1	0.1	0.1
Aug	0.1	0.1	0.1
Sep	0.1	0.1	0.3
Oct	0.2	0.4	0.6
Nov	0.4	0.6	0.7
Dec	0.2	0.3	0.6

The long-term timeseries (**Table** 4-2) of flows were analyzed to characterize flows, in terms of the parts of the flow regime recognized for each sampling point.

Flow	**Importance to ecosystem**
Low flows	These are the daily flows that occur outside of high-flow peaks. They define the basic hydrological nature of the river: its dry and wet season, and degree of pereniality. The different magnitudes of low-flow in the dry and wet seasons create more or less wetted habitat and different hydraulic and water quality conditions, which directly influence the balance of species anytime of the year.
Small floods	Small floods are ecologically important in the dry season. They stimulate spawning in fish, flush out poor-quality water, mobilize and sort gravels and cobles thereby enhancing physical heterogeneity of the riverbed, and contribute to flow variability. They reset a wide spectrum of conditions in the river, triggering and

	synchronizing activities as varies as upstream migrations of fish and germination of riparian seedlings.
Large floods	Large floods trigger many of the same responses as do the small ones, but additionally provide for scouring flows that influence the form of the channel. They mobilize coarse sediments, and deposit silt, nutrients, eggs and seeds on flood plains. They inundate backwaters and secondary channels, and triggers bursts of growth in many species. They re-charge soil moisture levels in the banks, inundate flood plains, among others.
Flow variability	Fluctuating discharges constantly change conditions through each day and season, creating mosaics of areas inundated and exposed for different lengths of time. The resulting physical heterogeneity determines the local distribution of species: higher physical diversity enhances biodiversity.

The naturalized flow regimes at the dam site, their extent and hydraulic/hydrologic characteristics are presented in **Table** 6-5**.** These characteristics act as the basis for the description of the existence or non-existence of relevant ecological situations.

Table 6-5: Flow regimes and their extent and hydraulic/hydrologic characteristics

Flow regime	Flow limits in m^3/s
Dry season flows, Dry Years	0.05
Wet season flows, Dry Years	0.11
Dry season flows, Wet Years	0.1
Wet season flows, Wet Years	0.3
High flows lower	0.2
High flows upper	0.8
Small floods	1.8
Large floods	2.4

Conversion of the summary hydrological statistics to information on local hydraulic conditions is the vital link that allows river scientists to understand why river features and species occur where they do.

6.2 Results of the hydraulic analysis at the sampling points affected by the dam

A quantitative understanding of a river's flow regime, its physical structure, and its depth/velocity regime, derived jointly and severally from hydrological and hydraulic analyses, is a prerequisite for deriving quantitative information about its ecological functioning.

The various biotic components are mainly represented in terms of parameters such as water depth, flow velocity, wetted perimeter and water surface width. Time is added as a parameter, by referring to the frequency of occurrence of a particular discharge, or the duration of inundation resulting from a particular flooding event. Duration, depth and lateral extent of inundation are especially relevant when considering the water requirements of riparian biotas. The results of hydraulic analysis and modelling therefore form the essential link between the flow of water in the river in cubic meters and the way in which river scientists express the water requirements for the river system itself. The product of the hydraulic analyses comprises a series of relationships between discharge and, among other parameters, water depth, flow velocity, wetted perimeter and water surface width. This information was used to quantify flow requirements for the river reaches from other parameters as presented in the figures below.

6.2.1 Sampling Point 3

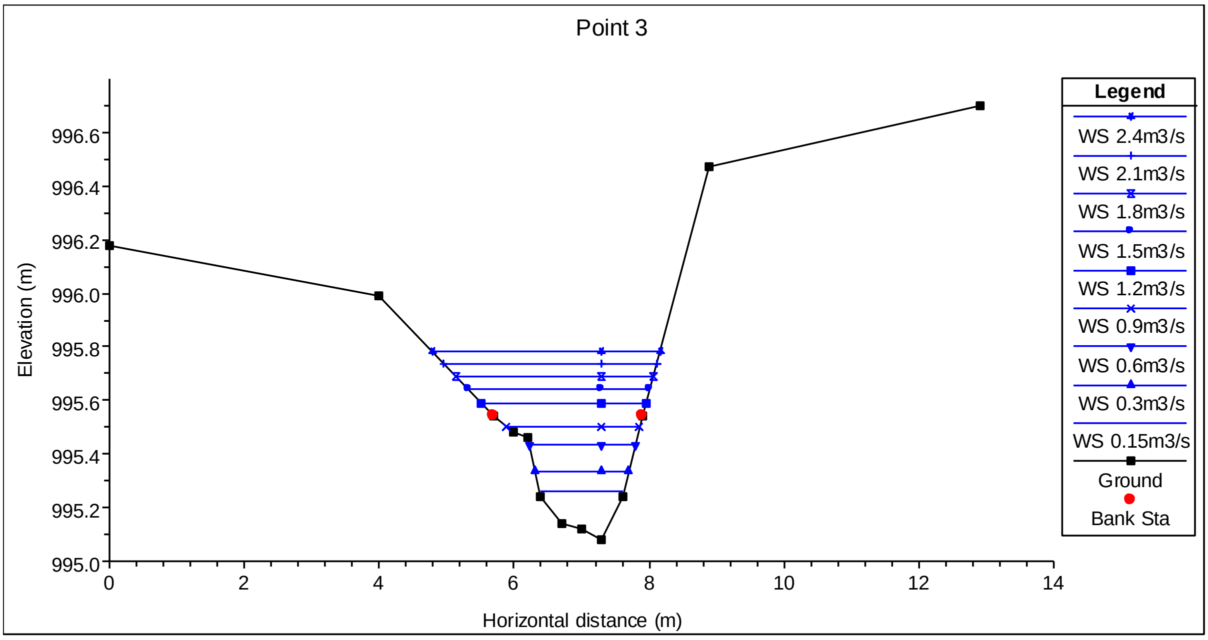

Figure 6-1. Water surface levels at various discharges at sampling point 3

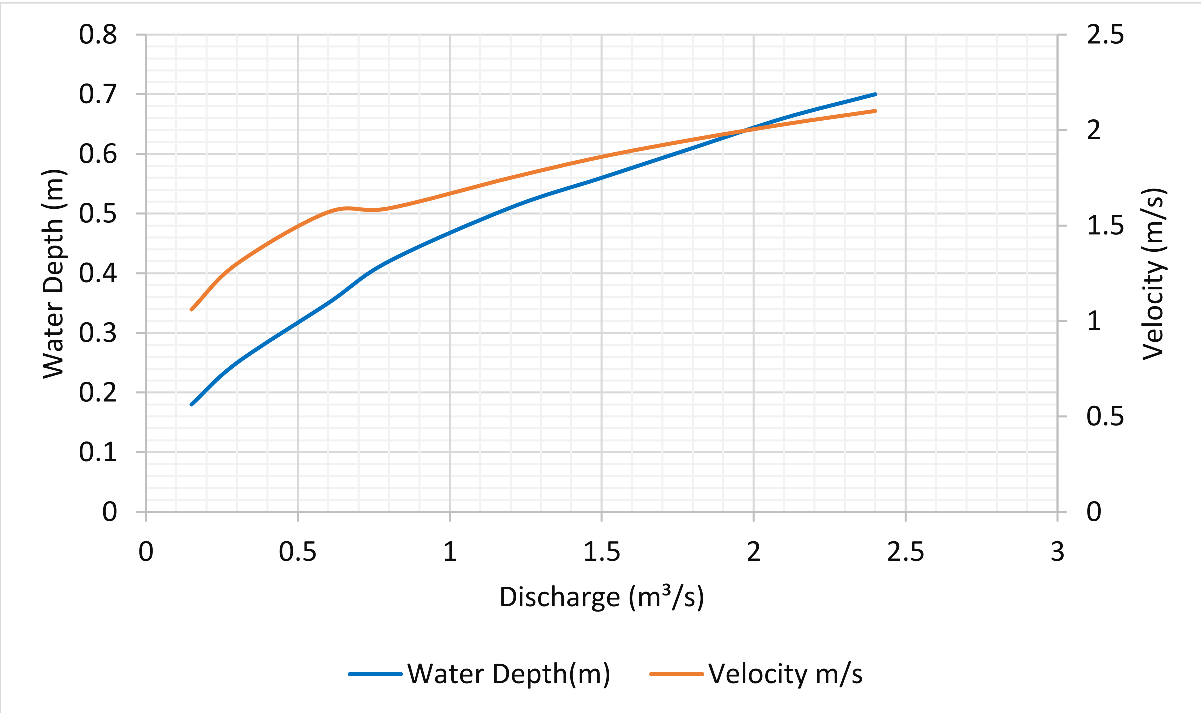

Figure 6-2: Discharge against water depth and velocity at sampling point 3

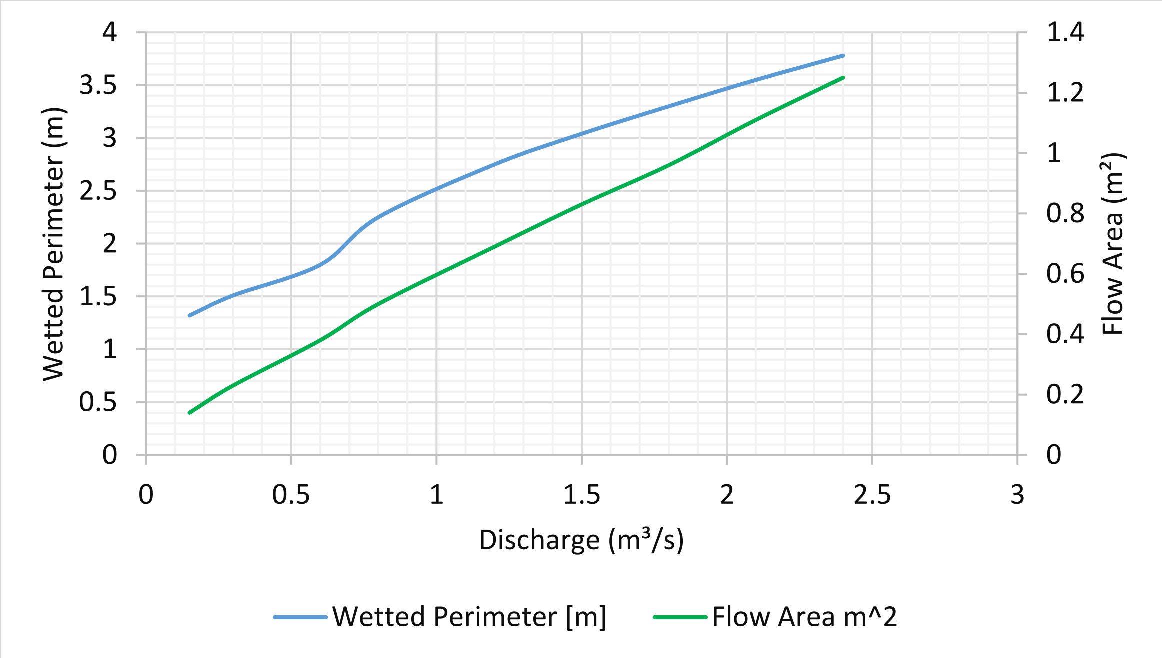

Figure 6-3: Discharge against wetted perimeter and flow area at sampling point 3

6.2.2 Sampling Point 6

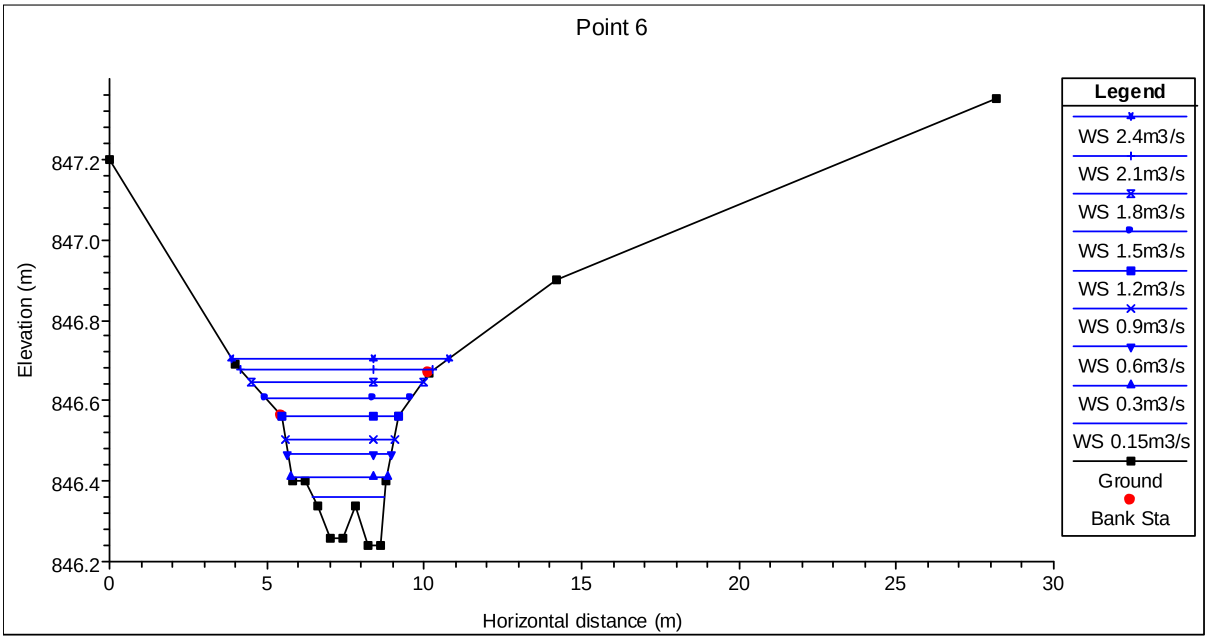

Figure 6-4: Water surface elevation for various discharges at sampling point 6

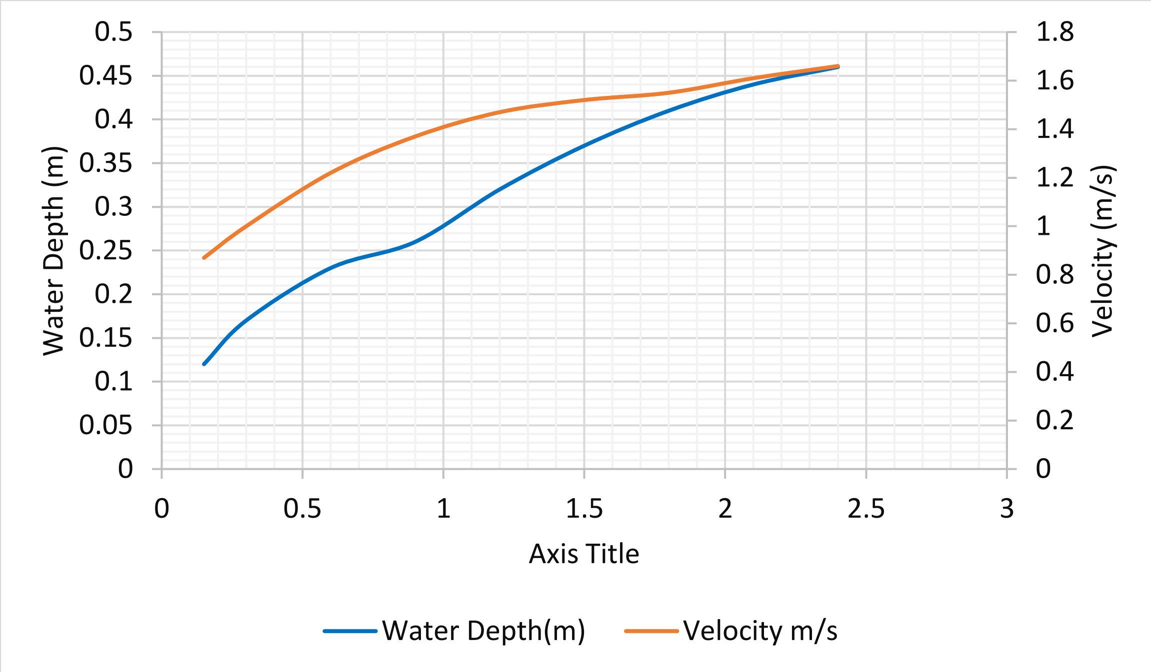

Figure 6-5: Discharge against water depth and velocity at sampling point 6

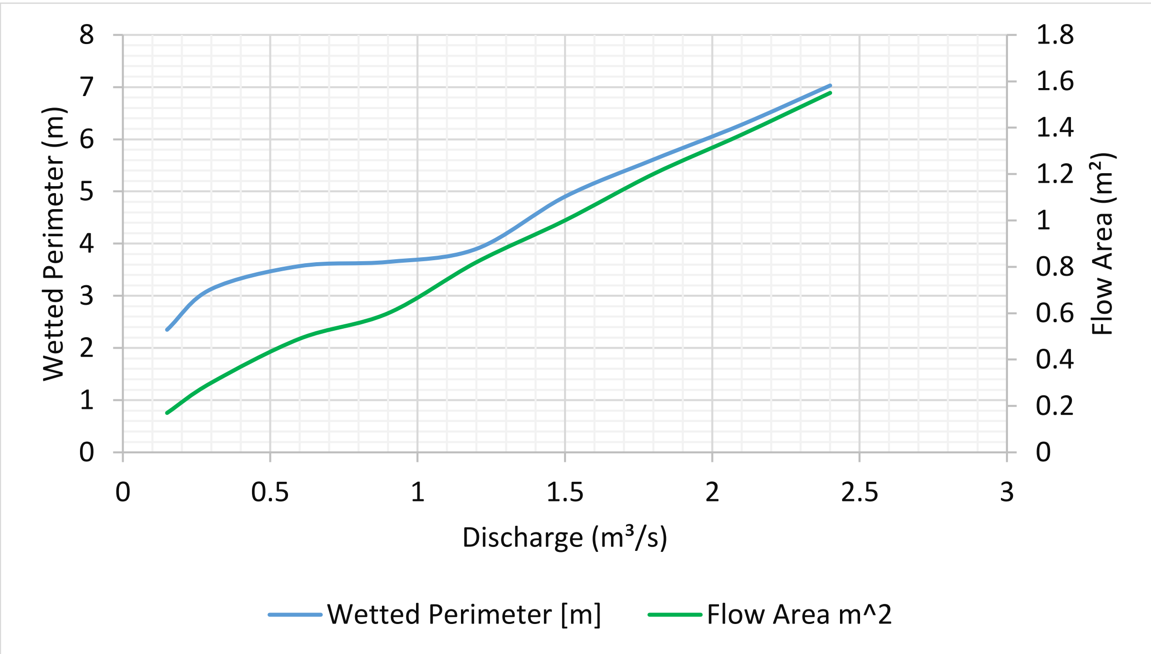

Figure 6-6: Discharge against wetted perimeter and flow area at sampling point 6

6.2.3 Sampling Point 8

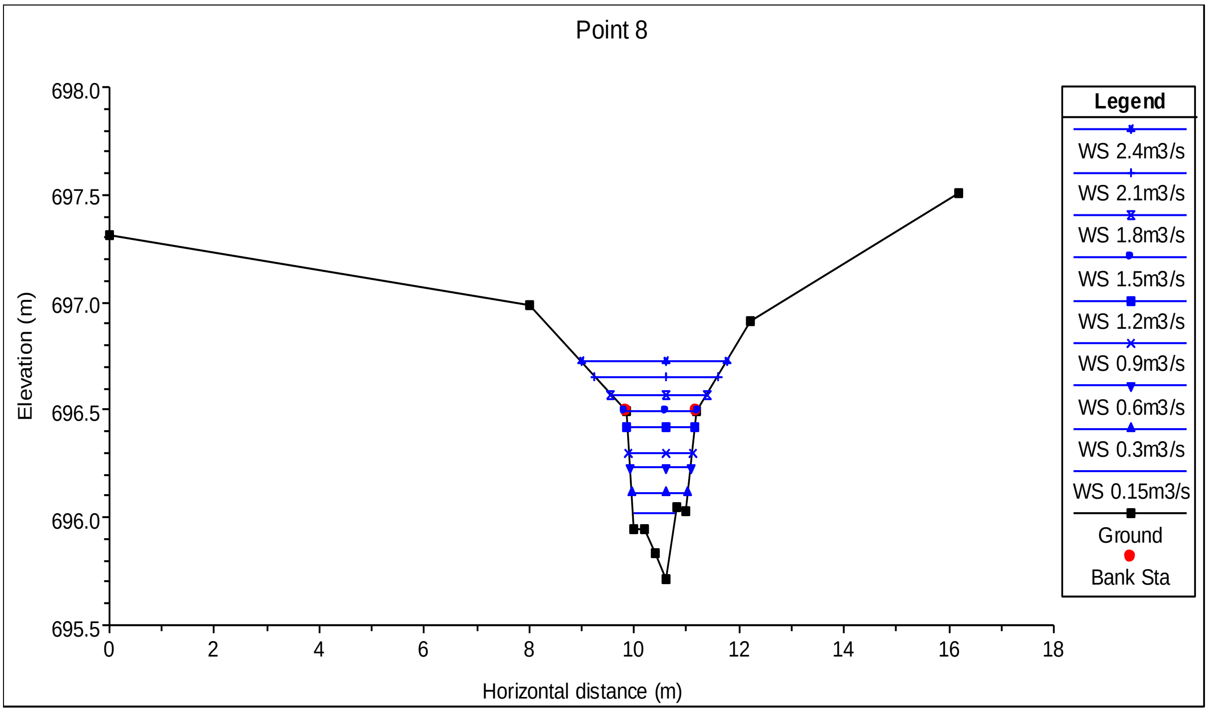

Figure 6-7: Profile showing water surface levels for various discharges at sampling point 8

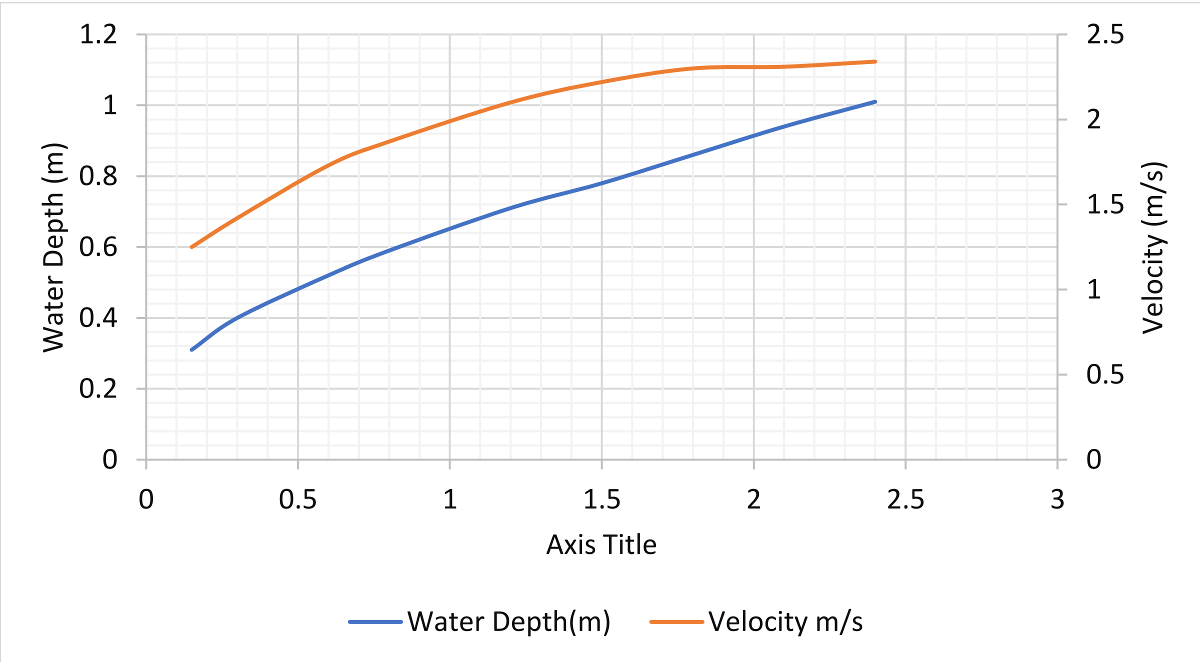

Figure 6-8: Discharge against water depth and velocity at sampling point 8

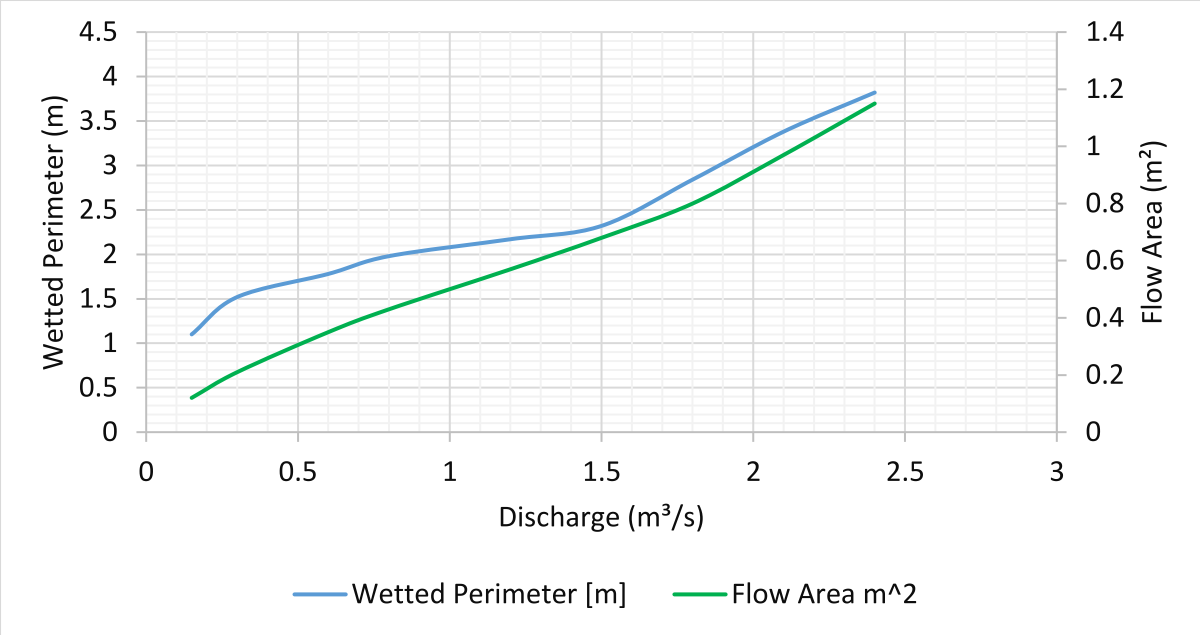

Figure 6-9: Discharge against wetted perimeter and flow area at sampling point 8

6.2.4 Sampling Point 14

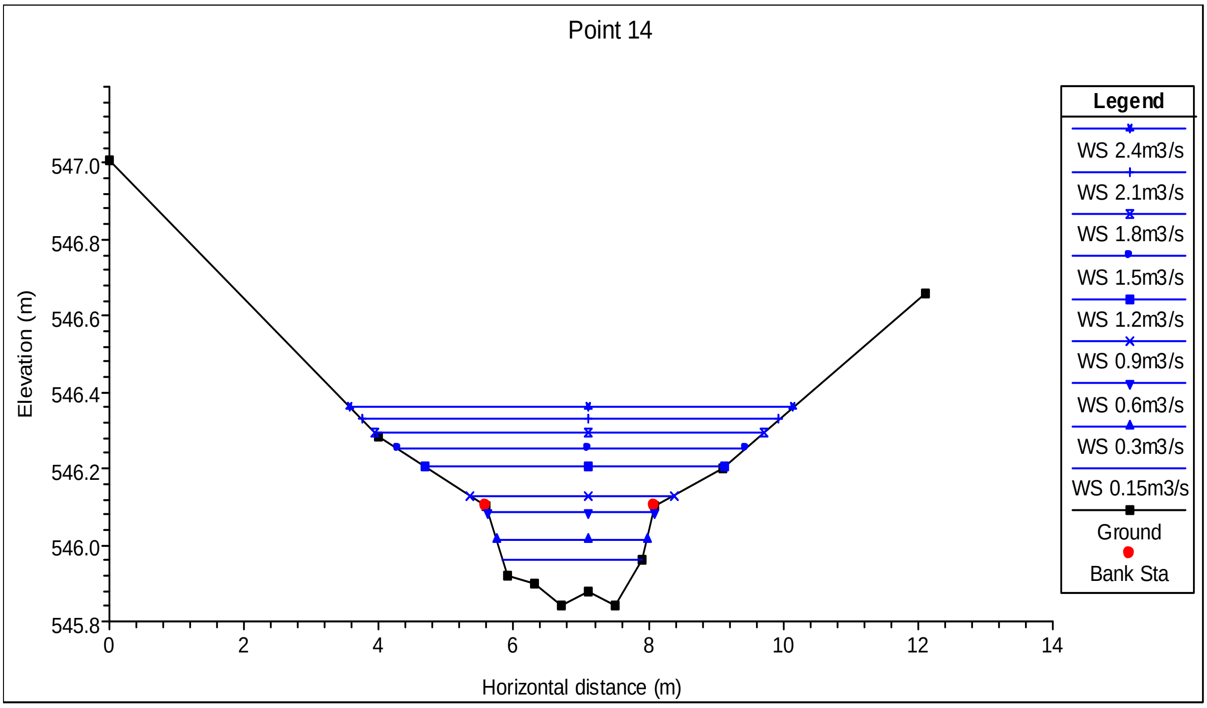

Figure 6-10: Profile showing the water surface levels for various water discharges at sampling point 14

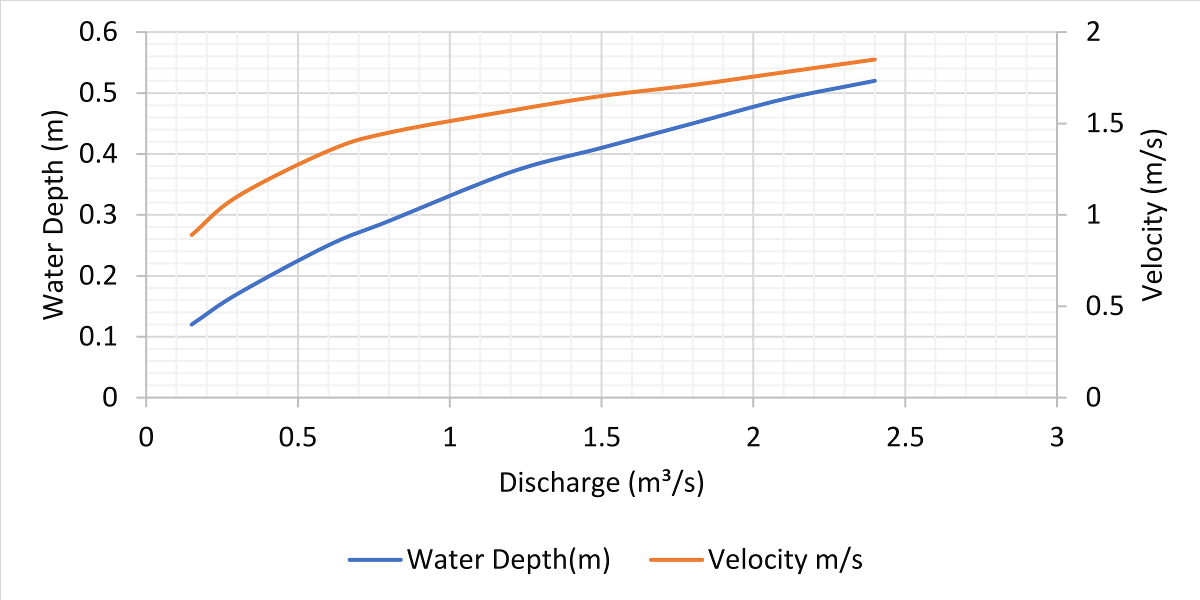

Figure 6-11: Discharge against water depth and velocity at sampling point 14

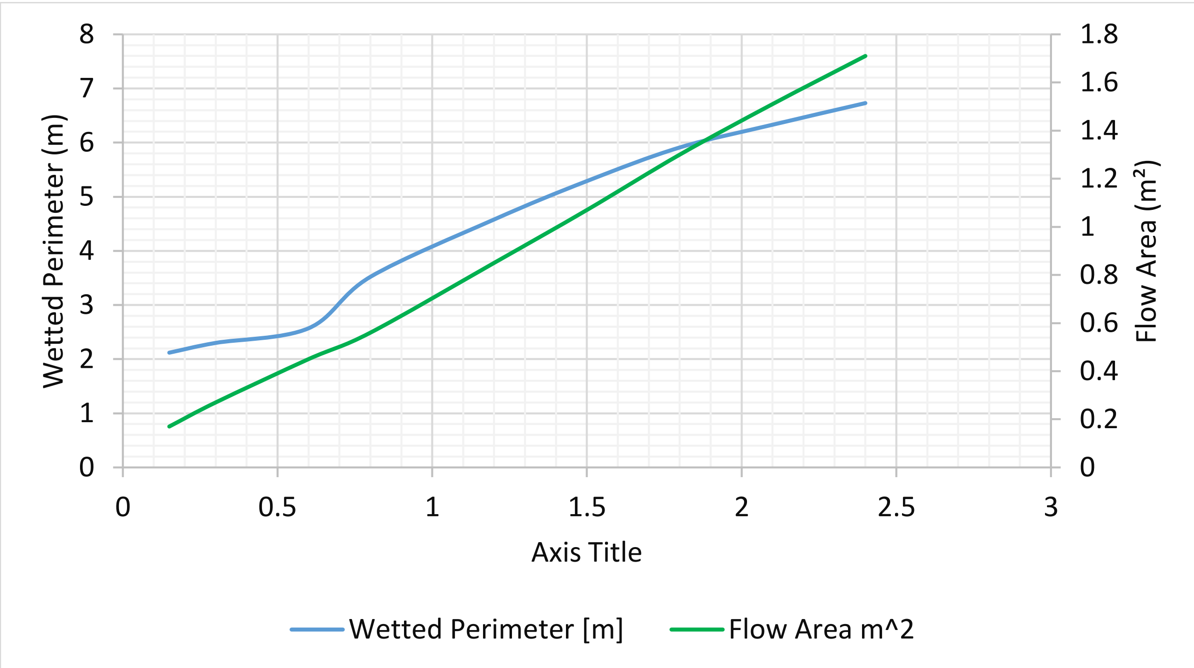

Figure 6-12: Discharge against wetted perimeter and flow area at sampling point 14

6.2.5 Sampling Point 15

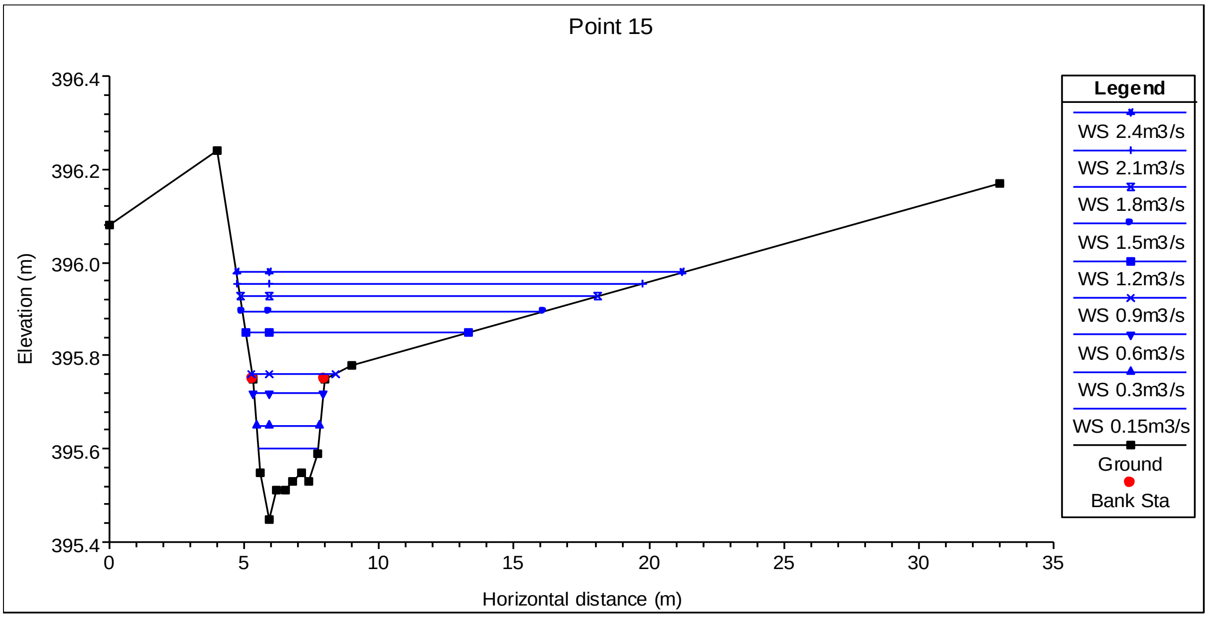

Figure 6-13: Profile showing water surface levels for various discharges at sampling point 15

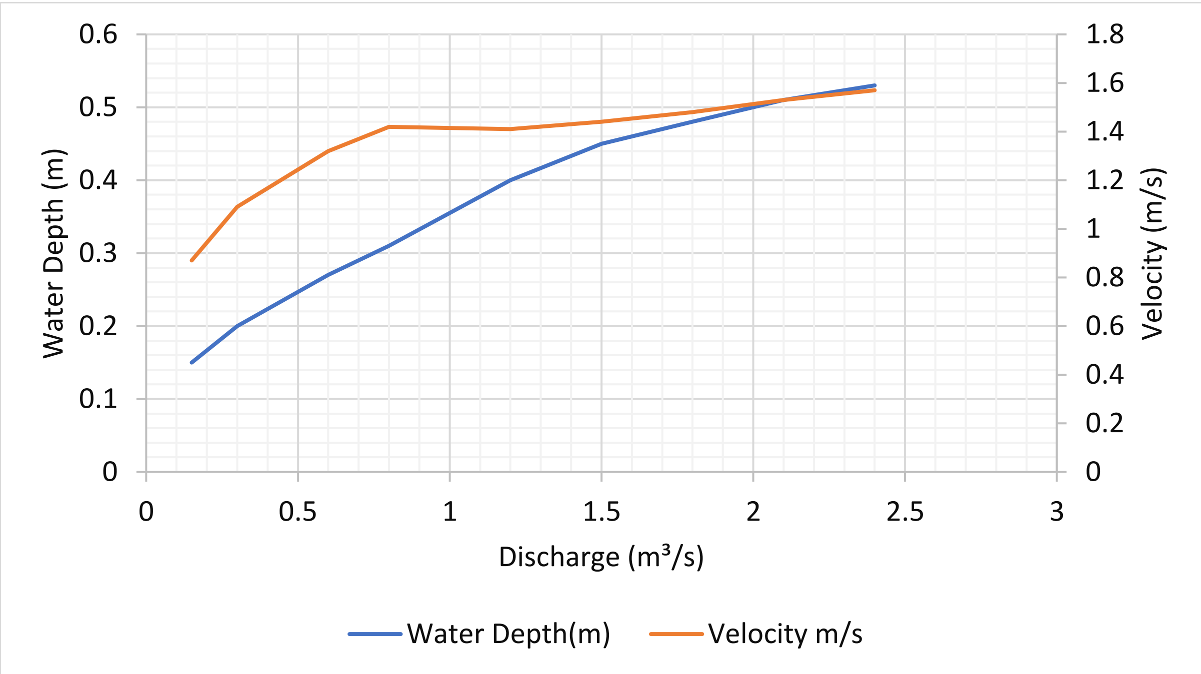

Figure 6-14: Discharge against water depth and velocity at sampling point 15

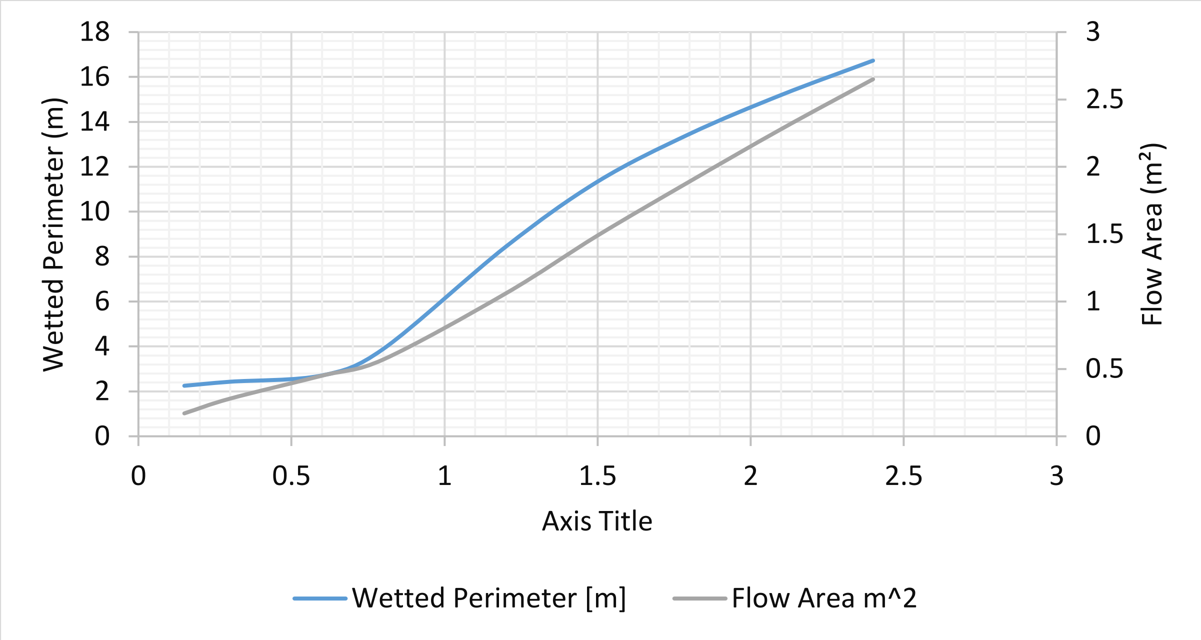

Figure 6-15: Discharge against wetted perimeter and flow area at sampling point 15

In situ **water quality measurements along River Mishumba in the dam area**

6.3 Establishment of the Environmental flow Requirement (EFR)

The goal of the assessments was to establish the effects of the e-flows on ecosystems and biodiversity by establishing the connection between hydrological and ecological processes, and modelling the effects of losing a natural or a well-balanced flow regime. This can be variation structure of the river, changes in size and extension of associated floodplains and wetlands, changes in available (quantitative and qualitative) aquatic and riparian habitats, extent of modification of the structure and composition of vegetation stands, impact on vital cycles of a wide range of aquatic organisms (benthic micro-organisms, phytoplankton, zooplankton, fishes, and others). Others include the change in the diversity and abundance of migrating species, colonization of habitats by alien species, change in ecological function of the river system as a corridor and ecosystems connector, loss of cultural and recreational values, determination of economic changes with changes in river flow and structure, and change in role of the river as a basic resources supplier and source of livelihoods in attendant rural communities.

The following section develops the e-flow requirements for various species. The development of e-flow requirements for various species was based on species whose water requirements are dominated by others and would not require further analysis. This is based on the understanding that by satisfying the requirements of those that require more water, their requirements will automatically be met. Therefore, flow requirements concentrated on the requirement for fish, in the papyrus for flora and fauna. It should be understood that these flows were superimposed with the flow required for flushing or maintenance of the river reaches. It has already been indicated that the floods for the return period of 2 years and 5 years will be maintained for this purpose.

6.3.1 Water flow dependence of observed aquatic species

Flow regimes are separated into low flows, flow pulse, high flows and the flood period, where in case of Uganda and other tropical areas are largely determined by whether it is rainy or dry season. Low flows are basically associated with reduced rainfall, while flow pulses are generally attributed to sudden flow increases generated by intense rain activity usually between March and June but could occur even up to October. High flow is in main channel flood, which includes intra-annual floods of about four (4) times a year.. The flow components are broadly associated with particular times of the year. Description of different flow components is shown in **Table** 6-6**.**

Table 6-6: Description of flow components for River Mishumba

Flow component	Hydrological description	Relevant season for River Mishumba
Low flow	Continuous flow through the channel during the lowflow season, keeping shallow in-stream habitats wetand deep pools.	Nov. to Mar.
Low flow	Continuous flow through the channel during the lowflow season, keeping in-stream habitats wet and fishpassage possible	Dec. to Feb.
Flow pulse	Increases in flow that exceed the low flows as a result of occasional out of season rains	Feb. to Nov.

Flow pulse	Increases in flow that exceed the low flows as a result of heavy rainfall events	Apr. to Jun.
High flow	In-channel flood, some localized inundation, but no general spill onto the floodplain	Jul. to Nov.
Flood	Overbank flood. Higher and less frequent than bank full flows, and spill out of the channel onto thefloodplain.	Aug. to Nov.

6.3.1.1 Conceptual models of flow components and fish species requirements

Flow-related requirements of key fish species were determined from the literature and general knowledge of the ecology of Lake Victoria Region *(Greenwood 1966, Welcomme 1967; Kaufman, 1992; Balirwa 1992; Mwanja 2000)*. The foundation for formation of flow-ecology mode of tropical systems as generally described by *Sharma & Dutta (2020)* was used to inform the development of associations between fish and the major components of the flow regime of River Mishumba in terms of magnitude, frequency, duration, timing, rate of change and variability of the flow of the river. These associations are broadly represented as a conceptual model of flow-fish relationships Figure 6-16 and Figure 6-17 respectively, show the links between individual flow components and flow requirements for rheophilic (Victoria carp and African catfish) and limnophilic (Singida tilapia, Albert tilapia, and Zilli's tilapia) fishes. Note that, whilst conceptual frameworks are generalized for all the fishes in respective two groups, the assessment of the e-flow here was based on Victoria carp for the rheophilic group, and on Singida tilapia for limnophilic group.

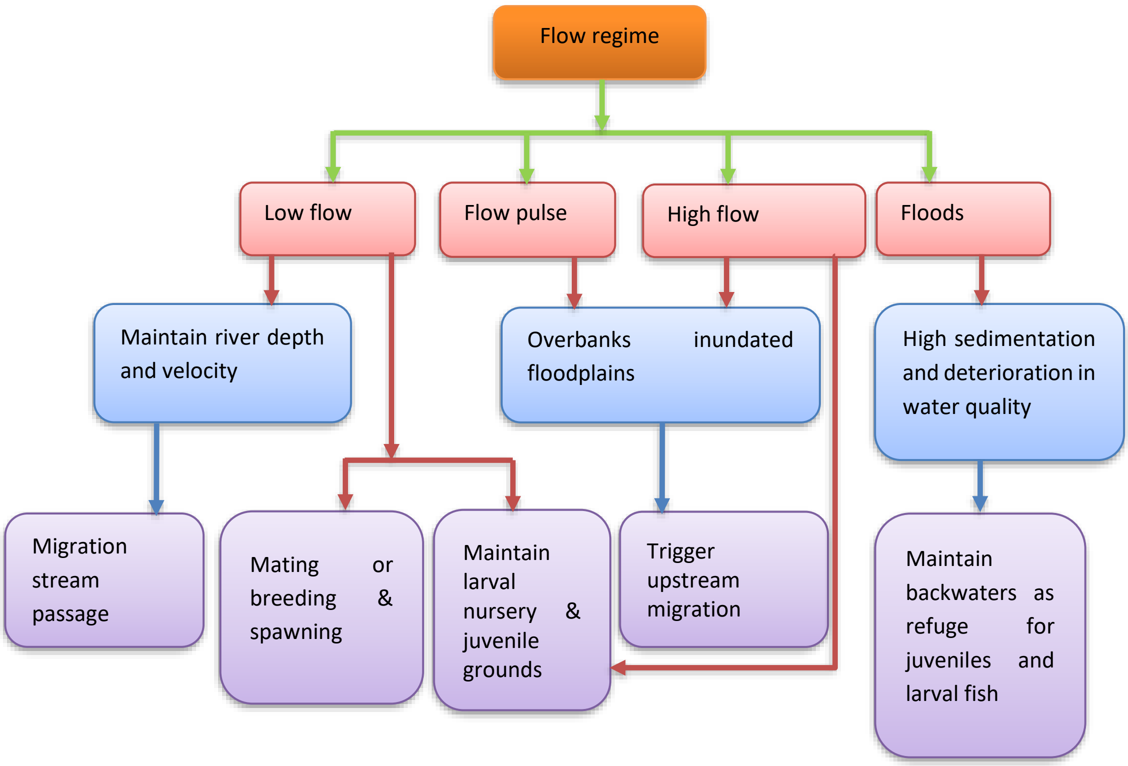

Figure 6-16: Conceptual diagram showing the links between individual flow components and flow requirements for rheophilic fishes of River Mishumba

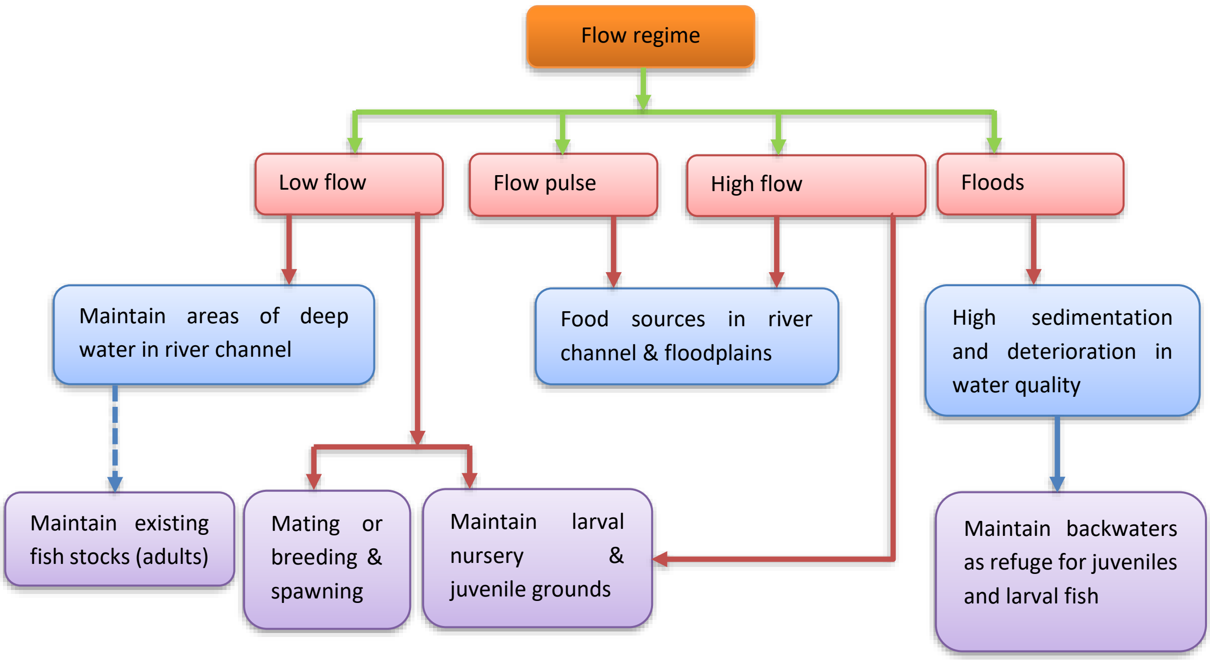

Figure 6-17: Conceptual diagram showing the links between individual flow components and flow requirements for limnophilic fishes of River Mishumba

Ecological feeding and associated requirements for key ecological biodiversity at the different sample points where fish were found during both the dry and wet seasons are described in the Table 6-7, Table 6-11 and Table 6-12 below:

Table 6-7: Ecological characteristics and requirements for different stages of key fish species caught in River Mishumba

Sampling Point	Characterisation of site	Fish species captured at site	Stage and Number of fish captured	Description of habitats or point of capture (water flow, wetted area and depth)	Season of capture	Flow requirements for captured species – Optimal conditions including duration and season	Flow requirements for captured fish species – medium conditions (maintenance) including duration and season	Flow requirements for captured species for sub-optimal (threshold or survival conditions) including duration and season
3	Upstream of Mishumba River	Victoria carp	06 fingerlings	Deep and fast waters through forest with ferns in littoral waters	Wet	Fast waters – can be shallow or deep (>**30 cm**) for upstream migration for breeding and spawning • In the months of **March** and **August**. • **12 days** of each month Flowing water (shallow) to allow for downstream migration for spent breeders and young to River Kagera • In the months of **May** and **Nov** • **4 days** of each period	Fast flowing waters within channel at depth of 15 to 30 cm for breeding and spawning. • In the months of **March** and **August**. • **4 days** of each month Flowing water (shallow) to allow for downstream migration for spent breeders and young to River Kagera • In the months of **May** and **Nov** **4 days** of each period	Fast flowing waters within channel at depth of 15 cm for breeding and spawning. • In the months of August. • **4 days** of each month Flowing water (shallow) to allow for downstream migration for spent breeders and young to River Kagera • In the months of **Nov** **4 days** of each period
6	Confluence of Kisyabagari, Rugonjo and Mishumba	African catfish	1, fingerling, 3 sub-adults	Deep and fast, with mud and silt substrate with boulders	Wet	Fast flowing water for trigger breeding and spawning	Fast flowing water for trigger breeding and spawning	Fast flowing water for trigger breeding and spawning

Sampling Point	Characterisation of site	Fish species captured at site	Stage and Number of fish captured	Description of habitats or point of capture (water flow, wetted area and depth)	Season of capture	Flow requirements for captured species – Optimal conditions including duration and season	Flow requirements for captured fish species – medium conditions (maintenance) including duration and season	Flow requirements for captured species for sub-optimal (threshold or survival conditions) including duration and season
	Confluence of Rugonjo and Mishumba	African catfish	04 sub-adults	Deep and fast waters with mud and silt substrate.	Wet	• 30 cm to 60cm • April and October • 12 days of each season	• 30 cm • April and October • 4 days in each season	• • October • 4 days in each season
8	Mishumba River	Victoria carp	03, adults	Fast flow portions of the river	Dry	Flowing water (shallow) to allow for downstream migration for spent breeders and young to River Kagera • 30 to 60 cm depth • In the months of January to February. • **6 days** of each of the two months.	Flowing water (shallow) to allow for downstream migration for spent breeders and young to River Kagera • At least 30 cm depth • In the months of Jan to Feb. • **6 days** of each two months	Flowing water (shallow) to allow for downstream migration for spent breeders and young to River Kagera • 15 cm depth • In the months of Jan to Feb. **4 days** of each the two months
	Confluence of Rweibare and Mishumba	Zilli's tilapia	3, adults	Vegetated slow flowing waters	Dry	Deep slow flowing waters to allow for lateral migration for breeding, spawning and feeding. • > 30 cm depth • The month of Dec. • **6 days** of each of the two months.	Deep slow flowing waters to allow for lateral migration for breeding, spawning and feeding. • > 15 cm depth • The month of Dec. • **6 days** of each of the two months.	Deep slow flowing waters to allow for lateral migration for breeding, spawning and feeding. • > 15 cm depth • The month of Dec. • **4 days** of each of the two months.

Sampling Point	Characterisation of site	Fish species captured at site	Stage and Number of fish captured	Description of habitats or point of capture (water flow, wetted area and depth)	Season of capture	Flow requirements for captured species – Optimal conditions including duration and season	Flow requirements for captured fish species – medium conditions (maintenance) including duration and season	Flow requirements for captured species for sub-optimal (threshold or survival conditions) including duration and season
		Albert tilapia	1, adult	Swampy banks	Wet	Deep slow flowing waters to allow for lateral migration for breeding, spawning, brooding, nursing and feeding. April to June and August to November • > 50 cm depth • The months of April and October. **4 days** of each of the two months.	Deep slow flowing waters to allow for lateral migration for breeding, spawning, brooding, nursing and feeding. April to June and August to November • > 30 cm depth • The months of April and October. **4 days** of each of the two months.	Deep slow flowing waters to allow for lateral migration for breeding, spawning, brooding, nursing and feeding. April to June and August to November • > 15 cm depth • The month of April. **4 days** of the two months.
11	Mid-stream of Chezho River	African catfish	4 adults	Fairly vegetated stream	Wet	Flooded banks to allow for lateral migration for feeding purposes • > 30 cm depth • The months of April and October. • **12 days** of each of the two months.	Flooded banks to allow for lateral migration for feeding purposes • > 30 cm depth • The months of April and October. **4 days** of each of the two months.	Flooded banks to allow for lateral migration for feeding purposes. • 15 cm depth • The months of October. **4 days** of each of the month.
14	Lower reaches of Mishumba River before Point 15 and the confluence with River Chezho	No fish caught	N/A	Fast but fairly vegetated channel habitat.	Wet	N/A	N/A	N/A

Sampling Point	**Characterisation of site**	**Fish species captured at site**	**Stage and Number of fish captured**	**Description of habitats or point of capture (water flow, wetted area and depth)**	**Season of capture**	**Flow requirements for captured species – Optimal conditions including duration and season**	**Flow requirements for captured fish species – medium conditions (maintenance) including duration and season**	**Flow requirements for captured species for sub-optimal (threshold or survival conditions) including duration and season**
15	Before the confluence of Mishumba and Chezho (after the Kabuyanda – Nyakitunda murram road)	African catfish	3 sub-adults	Deep, fast with silt and pebbles substrate	Wet	Deep fast flowing waters for downstream and lateral migration of juvenile catfish fish. • >50 cm depth • The months of April and October. • **12 days** of each of the two months.	Deep fast flowing waters for downstream and lateral migration of juvenile catfish fish. • >30 cm depth • The months of April and October. • **4 days** of each of the two months.	Deep fast flowing waters for downstream and lateral migration of juvenile catfish fish. • >15 cm depth • The months of April and October. • **4 days** of each of the two months.
24	Downstream of Confluence of Chezho and Mishumba	Zilli's tilapia	1, adult	Deep and slow, and highly vegetated.	Dry	Deep pools of water connected to the adjoining swamps for feeding, breeding, spawning, brooding and nursing of young ones. • >30 cm water depth • Months of Dec and Jul. • **4 days** of each of the two months.	Pools of water connected to the adjoining swamps for feeding, breeding, spawning, brooding and nursing of young ones. • 15 to 30 cm water depth • Months of Dec and Jul. **4 days** of each of the two months.	Deep pools of water connected to the adjoining swamps for feeding, breeding, spawning, brooding and nursing of young ones. • 15 cm water depth • Months of Dec. **4 days** of each of the two months.
		Singida tilapia	4, subadults		Wet	Deep pools of water connected to the adjoining swamps for feeding,	Deep pools of water connected to the adjoining swamps for feeding, breeding,	Deep pools of water connected to the adjoining swamps for feeding,

Sampling Point	Characterisation of site	Fish species captured at site	Stage and Number of fish captured	Description of habitats or point of capture (water flow, wetted area and depth)	Season of capture	Flow requirements for captured species – Optimal conditions including duration and season	Flow requirements for captured fish species – medium conditions (maintenance) including duration and season	Flow requirements for captured species for sub-optimal (threshold or survival conditions) including duration and season
						breeding, spawning, brooding and nursing of young ones. • >50 cm water depth • Months of April and October. • **12 days** of each of the two months.	spawning, brooding and nursing of young ones. • 30 to 50 cm water depth • Months of April and October. • **4 days** of each of the two months.	breeding, spawning, brooding and nursing of young ones. • 15 cm water depth • Months of Oct. • **4 days** of the month.

Table 6-8: Summary of Environmental Flow Requirement for fish

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sampling Point 3												
Optimal Depth (cm)	-	-	30	-	30	-	-	30	-	-	30	-
Minimum Depth	-	-	15	-	15	-	-	15	-	-	15	-
Duration, days	-	-	12, 4	-	4	-	-	12,4	-	-	4	-
Optimal Flow	-	-	0.45	-	0.45	-	-	0.45	-	-	0.45	-
Minimum flows	-	-	0.05	-	0.05	-	-	0.05	-	-	0.05	-
Sampling Point 6												
Optimal Depth (cm)	-	-	-	30	-	-	-	-	-	30	-	-
Minimum Depth	-	-	-	15	-	-	-	-	-	15	-	-
Duration, days	-	-	-	12, 4	-	-	-	-	-	12, 4	-	-
Optimal Flow m3/s	-	-	-	1.1	-	-	-	-	-	1.1	-	-
Minimum flow m3/s	-	-	-	0.22	-	-	-	-	-	0.22	-	-
Sampling Point 8												
Optimal Depth (cm)	30	30	-	50	-	-	-	-	-	50	-	30
Minimum Depth	15	15	-	15	-	-	-	-	-	15	-	15
Duration, days	6, 4	6, 4	-	6,4	-	-	-	-	-	6,4	-	6,4
Optimal Flow m3/s	0.15	0.15	-	0.5	-	-	-	-	-	0.5	-	0.15
Minimum Flow m3/s	0.05	0.05	-	0.05	-	-	-	-	-	0.05	-	0.05
Sampling Point 14												
Optimal Depth (cm)	-	-	-	-	-	-	-	-	-	-	-	-
Minimum Depth	-	-	-	-	-	-	-	-	--	-	-	-
Duration, days	--	-	-	-	-	-	-	-	-	-	-	-
Optimal Flow m3/s	-	-	-	-	-	-	-	-	-	-	-	-
Sampling Point 15												
Optimal Depth (cm)	-	-	-	50	-	-	-	-	-	50	-	-
Minimum depth	-	-	-	15	-	-	-	-	-	15	-	-
Duration, days	-	-	-	12, 4	-	-	-	-	-	12, 4	-	-
Optimal Flow m3/s	-	-	-	2.0	-	-	-	-	-	2.0	-	-

Minimum flows m3/s	-	-	-	0.15	-	-	-	-	-	0.15	-	-

The optimal EFR derived from the various environmental flow requirements cannot be possibly achieved from the naturally varying flows from the river sections that have been referenced for all sampling points. The minimum flows were converted into the following discharges for each sampling point as shown in the Table 6-9:

Table 6-9: Minimum flows converted into discharges at each sampling point

Sampling point	Point 3	Point 6	Point 8	Point 14	Point 15
Minimum implicated flow m^3/s	0.05	0.22	0.05	-	0.15
Percentage time flow exists (%)	90%	75%	90%		72%
Timing	Mar, may, Aug, Nov	Apr, Oct	Jan, Feb, Apr, Oct, Dec	-	Apr, Oct

Table 6-10: Resultant environmental flow time-series for the fish requirements

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow m^3/s	0.05	0.05	0.05	0.22	0.05	0.05	0.05	0.05	0.05	0.22	0.05	0.05

Table 6-11: Environmental flow requirements for key vegetation and flora for their sustenance

Sampling Point	Vegetation	Species	Optimal period required for water presence	Recommended duration for maintenance	Minimum possible period	Optimal Water depth required	Maintenance Water Depth	Minimum Water Depth
3	Cyperus riverine vegetation and bushed fallow in valley with Eucalyptus sp and Pinus sp in Rwoho CFR on hill slopes	*Cyperus papyrus*	Dec-Sept (10 months)	Dec-July (8 months)	Dec-July (8 months)	100 cm	30 cm	20 cm
		Cyperus denudatus	Dec-Aug (9 months)	Dec-July (8 months)	Dec-July (8 months)	10 cm	5 cm	3 cm
		Hydrocotyle ranunculoides						
		Ludwigia abyssinica						
		Leersia hexandra						
		Persicaria madagascariensis						
		Persicaria setosula						
		Cyclosorus interraptus						
		Typha capensis						
6	Cyperus riverine vegetation with patches of bare ground and short bushes	*Cyperus papyrus*	Dec-Sept (10 months)	Dec-Aug (9 months)	Dec-July (8 months)	100 cm	30 cm	20 cm
		Cyperus denudatus	Dec-Aug (9 months)	Dec-July (8 months)	Dec-July (8 months)	10 cm	5 cm	3 cm
		Melanthera scandens						

		Ludwigia abyssinica						
		Leersia hexandra						
		Persicaria setosula						
		Typha capensis						
8	Cyperus-Typha-Persicaria riverine marsh with patches of planted Eucalyptus sp and maize	*Nymphaea nouchali*	(Jan-Dec) 12 months	Dec-Sept (10 months)	Dec-July (8 months)	60 cm	40 cm	30 cm
		Cyperus papyrus	Dec-Aug (9 months)	Dec-July (8 months)	Dec-July (8 months)	100 cm	30 cm	20 cm
		Cyperus denudatus	Dec-Nov (9 months)	Dec-July (8 months)	Dec-July (8 months)	10 cm	5 cm	3 cm
		Cyperus exaltatus						
		Melanthera scandens						
		Ludwigia abyssinica						
		Ludwigia octovalvis						
		Echinochloa pyramidalis						
		Leersia hexandra						
		Persicaria senegalensis						
		Persicaria setosula						

		Cyclosorus interraptus						
		Typha capensis						
14	Typha marsh; Fish ponds surrounded by *Cynodon dactylon*	*Nymphaea nouchali*	(Jan-Dec) 12 months	Dec-Sept (10 months)	Dec-July (8 months)	40 cm	30 cm	20 cm
		Hygrophila auriculata	Dec-Nov (9 months)	Dec-July (8 months)	Dec-July (8 months)	10 cm	5 cm	3 cm
		Cyperus articulatus						
		Cyperus denudatus						
		Melanthera scandens						
		Ludwigia abyssinica						
		Leersia hexandra						
		Paspalum scrobiculatum						
		Persicaria madagascariensis						
		Cyclosorus interraptus						
		Typha capensis						
15	Typha-Cyclosorus-	*Nymphaea nouchali*	(Jan-Dec) 12 months	Dec-Sept (10 months)	Dec-July (8 months)	40 cm	30 cm	20 cm

	Leersia riverine vegetation	*Melanthera scandens*	Dec-Nov (9 months)	Dec-July (8 months)	Dec-July (8 months)	10 cm	5 cm	3 cm
		Ludwigia abyssinica						
		Leersia hexandra						
		Persicaria madagascariensis						
		Persicaria setosula						
		Cyclosorus interraptus						
		Typha capensis						

Table 6-12: Fauna Species that may be affected by the environmental flow

Sampling Point	Species	Optimal water depth required	Maintenance Water Depth	Minimum water depth	Optimal period required for water presence	Recommended duration for maintenance	Minimum possible period
Sampling Point No. 3	Dragonflies						
	Brachythemis leucosticta Southern Banded Groundling	60cm	shallow	Shallow	Jan-Dec Throughout the year	Six months of rainy season March to May and Sept to Nov	Six months of rainy season March to May and Sept to Nov
	Amphibians						
	Phrynobatrachus mabebiensis Dwarf Puddle Frog	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*

	Natal Puddle Frog *Phrynobatrachus natalensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Mascarene Rocket Frog *Ptychadena mascareniensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Birds						
	Motacilla aguimp African Pied Wagtail - w	Shallow Walks on land feeding along water edges	Shallow	Shallow	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*
Sampling Point No.6	Dragonflies						
	Nesciothemis cf farinosa Eastern Blacktail	60cm	*shallow*	*Shallow*	*Jan-Dec Throughout the year*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Palpopleura portia Portia Widow	60cm	*shallow*	*Shallow*	*Jan-Dec Throughout the year*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Amphibians						
	Natal Puddle Frog *Phrynobatrachus natalensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Mascarene Rocket Frog *Ptychadena mascareniensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Birds						

	Motacilla aguimp African Pied Wagtail - w	Shallow Walks on land feeding along water edges	Shallow	Shallow	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*
Sampling Point No.8	Dragonflies						
	Brachythemis leucosticta Southern Banded Groundling	60cm	*shallow*	*Shallow*	*Jan-Dec Throughout the year*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Orthetrum Julia Julia Skimmer	60cm	*shallow*	*Shallow*	*Jan-Dec Throughout the year*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Palpopleura portia Portia Widow	60cm	*shallow*	*Shallow*	*Jan-Dec Throughout the year*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Amphibians						
	Hyperolius kivuensis Kivu Reed Frog	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Phrynobatrachus mabebiensis Dwarf Puddle Frog	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Natal Puddle Frog *Phrynobatrachus natalensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Mascarene Rocket Frog	Shallow	Shallow	shallow	*Six months of rainy season*	*Six months of rainy season*	*Six months of rainy season*

	Ptychadena mascareniensis				*March to May and Sept to Nov*	*March to May and Sept to Nov*	*March to May and Sept to Nov*
	Angola River Frog *Amietia angolensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Birds						
	Black-Headed Heron *Ardea melanocephala* - w	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Hadada Ibis *Bostrychia hagedash* - w	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Motacilla capensis Cape Wagtail - W	Shallow Walks on land feeding along water edges	Shallow	Shallow	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*
Sampling Point No.14	Dragonflies						
	Brachythemis leucosticta Southern Banded Groundling	60cm	*shallow*	*Shallow*	*Jan-Dec Throughout the year*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Amphibians						
	Phrynobatrachus mabebiensis Dwarf Puddle Frog	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*

	Natal Puddle Frog *Phrynobatrachus natalensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Mascarene Rocket Frog *Ptychadena mascareniensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Birds						
	Black-Headed Heron *Ardea melanocephala* - w	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	African Crake *Crex egregia* - AwG	Shallow waters	Shallow waters	Shallow waters	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Hadada Ibis *Bostrychia hagedash* - w	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Motacilla capensis Cape Wagtail - W	Shallow Walks on land feeding along water edges	Shallow	Shallow	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*
Sampling Point No.15	Dragonflies						
	Orthetrum Julia Julia Skimmer	60cm	*shallow*	*Shallow*	*Jan-Dec Throughout the year*	*Six months of rainy season*	*Six months of rainy season*

						March to May and Sept to Nov	*March to May and Sept to Nov*
	Palpopleura portia Portia Widow	60cm	*shallow*	*Shallow*	*Jan-Dec Throughout the year*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Amphibians						
	Hyperolius kivuensis Kivu Reed Frog	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Phrynobatrachus mabebiensis Dwarf Puddle Frog	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Natal Puddle Frog *Phrynobatrachus natalensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Mascarene Rocket Frog *Ptychadena mascareniensis*	Shallow	Shallow	shallow	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Birds						
	Woodland Kingfisher Halcyon senegalensis - A	Shallow waters	Shallow waters	Shallow waters	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Black-Headed Heron *Ardea melanocephala* - w	Shallow waters through which they can wade without getting	Shallow waters through which they can wade without	Shallow waters through which they can wade without	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*

		their bodies wet	getting their bodies wet	getting their bodies wet			
	Hadada Ibis *Bostrychia hagedash* - w	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	Shallow waters through which they can wade without getting their bodies wet	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*	*Six months of rainy season March to May and Sept to Nov*
	Motacilla aguimp African Pied Wagtail - w	Shallow Walks on land feeding along water edges	Shallow	Shallow	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*	*Jan-Dec Throughout the year*

Table 6-13: Summary of Environmental Flow Requirement for flora

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sampling Point 3												
Optimal Depth (cm)	100	100	100	100	100	100	100					100
Minimum Depth	20	20	20	20	20	20	20					20
Duration, days	30	30	30	30	30	30	30					30
Sampling Point 6												
Optimal Depth (cm)	100	100	100	100	100	100	100			60		
Minimum Depth	20	20	20	20	20	20	20			30		
Duration, days	30	30	30	30	30	30	30			12		
Sampling Point 8												
Optimal Depth (cm)	100	100	100	100	100	100	100	50	50	50	50	30
Minimum Depth	20	20	20	20	20	20	20	15	15	15	15	15
Duration, days	30	30	30	30	30	30	30	4	4	4	4	4
Sampling Point 14												
Optimal Depth (cm)	100	100	100	100	100	100	100	50				100
Minimum Depth	20	20	20	20	20	20	20					20
Duration, days	30	30	30	30	30	30	30	4				30
Sampling Point 15												
Optimal Depth (cm)	100	100	100	100	100	100	100			50		100
Minimum depth	20	20	20	20	20	20	20			15		20
Duration, days	30	30	30	30	30	30	30			12,4		30

Table 6-14: Minimum flows converted into discharges at each sampling point

Sampling point	Point 3	Point 6	Point 8	Point 14	Point 15
Minimum implicated flow m^3/s	0.2	0.4	0.1	0.4	0.3
Percentage time flow exists (%)	72%	53%	82%	53%	62%

The flow that can be realized in 8 months out of the 12 months, the flow exceed 60% of the time. This provides an estimated flow of about 0.35 m^3/s. By excluding the flow from the tributary joining the river just downstream of the reservoir, it implies that the reservoir release of about 0.24m^3/s is expected for the 8 months from December to July. With a decision to maintain the papyrus at sampling point 8, the environmental flow time series in the river are as in Table 6-15

Table 6-15: Resultant environmental flow time-series for the papyrus requirements

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Flow m^3/s	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.22	0.05	0.1

The suggested e-flows above also provide for critical low-flow events, allowing for colonization of newly exposed areas/habitat as the river changes its form and flow, such as emergent sandbars, which could provide important in-stream habitat when water levels rise. The periodic freshens and floods will also provide for sustenance of water quality, regular “ecological” cleansing or refreshing of the river system, and creation of conditions which are needed to sustain the sensitive macroinvertebrates. The release of high flows and floods during the rainy seasons is expected to provide the required cues for spawning in all the seven fish species encountered, and will allow for sustenance of these species including the critically endangered ones especially for the flow-sensitive rheophilic species. In short, the suggested e-flows will provide for sustaining and maintaining of the variability in River Mishumba's hydrology, which will ensure that the different components of the river’s hydrograph continue to play their respective roles in maintaining the ecological health of the system.

The e-flows have been designed to imitate the natural flows and the ecological requirements of the two groups of fish, those that prefer sedentary and slow-flowing waters and those that prefer fast flowing waters. Maintaining the hydrological and hydraulic variability of the Mishumba River has been the key guide in the e-flow assessments, and in the developed biodiversity and e-flow management plan for Mishumba River basin in lieu of the development of Kabuyanda Irrigation Scheme. The e-flow assessment explicitly calls for allocating sufficient flows - with a reserve flow - in part to "protect aquatic ecosystems" and enable ecologically sustainable water resources development.

The suggestion is that reserve flow will capture designed environmental flow components, including mean monthly baseflows should mimic the seasonal variation according to the natural flow regime with some select high flows and floods. Environmental flows have been prescribed for the basin in consideration of the ecological requirements for the key species encountered in Mishumba River; and these have also considered the expected effects of the dam on different reaches of the river and catchment of Mishumba, with the emphasis on and expectations of due diligence in the implementation of the set e-flows by Kabuyanda Irrigation Scheme Management as part of a long-term and adaptive management strategy with a goal of sustaining and maintain the contained biodiversity.

6.3.2 Proposed flow regime from the ESIA

The flows proposed under the ESIA from the perspective of the sampling points include the release from the reservoir and inflows from the Rweibare tributary. It should be noted that Rweibare is a tributary just downstream of the proposed reservoir site. The Table 6-16 below shows the total flows and contribution from the reservoir and Rweibare tributary.

Table 6-16: Contribution of Rweibare tributary, release from the reservoir and total flows

Month	Rweibare contribution (m^3/s)	Releases from Reservoir (m^3/s)	Total flow downstream of Reservoir and tributary (m^3/s)
Jan	-	0.05	0.05
Feb	0.07	0.05	0.12
Mar	0.09	0.05	0.14
Apr	0.13	0.11	0.24
May	0.11	0.11	0.22
Jun	0.04	0.11	0.15
Jul	0.04	0.05	0.09
Aug	0.04	0.05	0.09
Sep	0.09	0.11	0.20
Oct	0.11	0.11	0.22
Nov	0.13	0.11	0.24
Dec	0.11	0.05	0.16

6.4 Comparison of scenarios and final recommended EFR

6.4.1 Structuring and Presentations of Scenarios

Three (3) main requirements for scenarios are the ability to: (i) provide a range of options of what the future could be like, using scenarios of potential river changes and social impacts; (ii) provide simple summaries of each scenario of river change in a context that the decision makers can relate to; and (iii) express the financial implications of each scenario in terms of both impacts and costs for compensation or mitigation purposes and benefits, e.g., increased crop production.

The nature of scenarios is influenced by the decision-makers' needs. A wide range of ecological, social and economic components may be involved, or just a simple statement of required flows during some critical period, and each case should be treated on merit. Scenarios for a river that is not seen as particularly "important", and where there is no potential conflict over water, may be less detailed than for more or high-profile rivers. The scenario development in this study aimed at the following three items:

a) To meet a specific yield. The requirement to abstract a specific volume of water. The least-damaging way of doing this could be advised, together with the predicted ecological (and social and economic) consequences.

b) To meet a specific condition. That is to maintain a certain river condition and ecosystem feature. The amount of water that could be abstracted whilst meeting this objective could be advised.

The first step in the development of scenarios involved the analysis of flow time-series data to develop:

(i) Flow duration curves (FDCs) to examine the percentage of time that a flow of a given size is exceeded;
(ii) Time-series graphs to examine the sequence of flow events, particularly during very dry or very wet conditions;
(iii) Baseflow separation to highlight the potential for significant groundwater-surface water interactions;
(iv) Spells analysis to describe flow spells (flow events above or below a defined threshold, such as freshes; and
(v) Flood frequency analyses to examine the frequency and magnitude of larger floods. Different components of the flow regime that were thought to play a role in the maintenance of river ecosystems were identified. The time series data were then allocated to the flow categories, with each day's data accounted for in on of them. The summary data from these flow categories then provided a perspective on the river for the ecological understanding of the river reaches. This summary data was then used to compare the past and potential future flow regimes.

Flow duration curves were used in combination with hydraulic models to provide insights on river ecosystems such as the time that any one vegetation zone on a river is inundated. A first estimate of the inundation-exposure regime that a zone experienced were calculated and then a judicious use of the FDC for different time periods would indicate when the exposure and inundation periods were. Understanding this correlation, and thus the inundation conditions, the zone was exposed to and therefore the possible needs allowed a prediction of whether a change in the flow regime would cause the zone to shrink, expand, adjust to a higher or lower place on the bank, or completely disappear. For quantitative predictions, five (5) severity levels of change were used to rate the scenarios including;

- 0 = None – No impact resulting from the change in the streamflow
- 1 = Negligible – Hardly noticeable impact resulting from change in the streamflow
- 2 = Low - Descernable but with limited effect resulting from change in the streamflow
- 3 = Moderate – Incident to minor effect resulting from change in the streamflow
- 4 = High – Intense effect of the damage resulting from change in the streamflow
- 5 = Very high – Critical level of damage resulting from change in the streamflow

Table 6-17: Development of different flow regimes under the current situation.

Flow regime	**Present situation m^3/s**
Dry season low flows, Dry Years	0 - 0.14
Wet season low flows, Dry Years	0 - 0.22
Dry season low flows, Wet Years	0 - 0.19
Wet season low flows, Wet Years	0 - 0.41

High flows lower	0.2
High flows upper	0.8
Small floods	1.8
Large floods	2.4

At sampling point 3, the stream experiences low flow with an average velocity of about 1.3 m/s and channel depths of 0.25m in the dry season. The velocities of average of flows are about 1.16m/s at depths of 0.21m in the dry seasons and 1.59m/s at depths of 0.42m in the wet season.

At sampling point 6, the stream experiences low flow with an average velocity of about 0.78 m/s and channel depths of 0.1m in the dry season. While in the wet season the river experiences low flows with velocity of about 1.0m/s and depths of 0.17m. The velocities of average flows are about 0.94m/s at depths of 0.14m in the dry seasons and 1.33m/s at depths of 0.26m in the wet season.

At sampling point 8, the stream experiences low flow with an average velocity of about 1.11 m/s and channel depths of 0.27m in the dry season. While in the wet season the river experiences flow of velocity of about 1.42m/s and depths of 0.4m. The velocities of average flows are about 1.2m/s at depths of 0.36m in the dry seasons and 1.87m/s at depths of 0.59m in the wet season.

At sampling point 14, the stream experiences flow with an average velocity of about 0.79 m/s and channel depths of 0.1m in the dry season. While in the wet season the river experiences flow of velocity of about 1.1m/s and depths of 0.17m. The velocities of average flows are about 0.98m/s at depths of 0.14m in the dry seasons and 1.43m/s at depths of 0.29m in the wet season.

6.4.2 Description of scenarios

The overall discharge in the river reaches under consideration are quite small, therefore, there is very limited room for manipulation of flows to provide meaningful variations. From this perspective and that the only investment using significant water in the catchment is the proposed irrigation scheme, only three (3) scenarios were studied.

Scenario one (1) represents the water required for the e-flows as deduced from the analysis of flows from sampling points 3, 6, 8, 14 and 15 including the maintenance of the high and low floods.

Scenario two (2) comprises the proposed releases by the ESIA study report but with an addition of releasing low and high floods as in the previous scenario.

Scenario three (3) is when the releases are increased in by twenty percent (20%) and forty percent (40%) of the Mean Annual Flow (MAF) during the dry and wet season respectively. It also includes the maintenance of the high and low floods. The Table 6-18 below gives the summary of the flows within each scenario.

Table 6-18: Summary of flow regimes under different scenarios

Flow regime	Present situation m^3/s	Scenario 1 (EFR) m^3/s	Scenario 2 (Project) m^3/s	Scenario 3 (Increased Release) m^3/s

Dry season low flows, Dry Years	0.14	0.1	0.05-0.12	0.21
Wet season low flows, Dry Years	0.22	0.22	0.12-0.24	0.33
Dry season low flows, Wet Years	0.19	0.1	0.05-0.12	0.21
Wet season low flows, Wet Years	0.41	0.05-0.22	0.12-0.24	0.33
High flows lower	0.2	0	0	0
High flows upper	0.8	0	0	0
Small floods	1.8	1.8	1.8	1.8
Large floods	2.4	2.4	2.4	2.4

6.4.3 Flow-ecosystem relationships

According to flow - ecology relationships for different biodiversity forms in Mishumba catchment including floral and terrestrial fauna and identified fish species within the River Mishumba, the hydraulics, frequency and duration of water flow required to sustain them were derived based on the natural frequency and duration for the dry and wet seasons based on field assessments. The modelling of the environmental flow requirements for respective biodiversity established that the requirements are differ for different periods, and as such it will be necessary to revalue the environmental flow requirement of key biodiversity forms from time to time in accordance to the change of river channel form. In addition, there are a number of non-flows related issues which impact the different forms of the biodiversity, such as natural sedimentation, excessive vegetation clearance, water pollution, dams and levee construction, use of destructive production or farming gears and inputs.

6.4.3.1 Ecological importance and sensitivity rating of River Mishumba

The river was rated used using 0 to 4 scale to determine its importance and sensitivity. This helped to categorize Mishumba in the range of low/marginal, moderate, high and very high. Table 6-19: Framework for assigning ecological importance and sensitivity for River Mishumba according to BBM Methodology

Table 6-20: Ecological importance and sensitivity rating for River Mishumba according to BBM Methodology

Rate	Ecological Importance and Sensitivity	Class Range of Median
Very high	Rivers that are unique on a national or even international level based on biodiversity aspects.	> 3 and +4

High	Rivers that are unique on a national scale based on biodiversity aspects.	> 2 and 3
Moderate	Rivers that are unique on a provincial or local scale based on biodiversity aspects.	> 1 and 2
Low/marginal	Rivers that are not unique at any scale.	> 0 and 1

The flow-ecosystem relationships were then developed by comparing the existing flows in the river reaches and the ecological requirements of fish species encountered in the wider basin under study. **Table** 6-21 shows the assigned ecological importance of Mishumba catchment following the BBM framework in terms of biodiversity. The catchment has a low rating despite having critically endangered species because these species occur elsewhere in the wider Kagera Basin and other waters in Lake Victoria Region such as Kooki lakes complex, Nabugabo lakes complex and Kyoga lakes complex (Mwanja, 2000). There are also known unique frlora and terrestrial or aquatic mammals and other animals in this catchment. The framework also shows that there are only few fauna species that are intolerant to flow changes because most of them especially adults and sub-adults (juveniles) have the ability to migrate downstream and laterally. But this presupposes those conditions to migrate are presented in the channel or through regular overbank flows even in the dry season to allow connection between the Mishumba channel and destinations of the migrating fish (R. Kagera) for the rheophilic species, and adjoining swamps for limnophilic species.

Table 6-21: Framework for assigning of ecological importance in setting of e-flows to different species and species groups in Mishumba catchment

Rare and endangered biota	Singida tilapia is Critically Endangered Victoria carp is Critically Endangered (*Source: IUCN Red List*)	• None (0). No rare or endangered species/taxon at any scale. The few existing species are restricted to deeper waters at the estuary of Mishumba to R. Kagera which is far outside of the project areas.
Unique biota	No unique or endemic biodiversity found in River Mishumba. *(Source: field survey and expert knowledge)*	• None (0). No population (or taxon) unique at any scale.
Intolerant biota	A number of taxa are intolerant to reduced flow while others are intolerant to fast waters. But this is an ephemeral river with organisms able to migrate both downstream to River Kagera, or lateral to swampy areas where they take refugee	• Marginal (1). A very low proportion of the biota temporarily dependent on flowing water for the completion of life cycles. Sporadic and seasonal flow events expected to meet needs.

	from both low water or high flow pulses. *(Source: field survey and expert knowledge)*	
Species/taxon richness.	This kind of assessment should be based on the grouping of ecologically similar rivers. However, such a system is still under development, and so at present should be based on professional judgement.	Moderate (2). Rated on a local scale. Marginal/low (1). Not significant at any scale.

River Mishumba was rated moderate since it contains relatively moderate biodiversity at local level. All the other species are found elsewhere in other more ecologically significant ecosystems than the project area

A description of the recommended flow regimes is given in Table 6-22 below in terms of magnitude, frequency, duration, timing and rates of change. Based on the hydrological assessment and modelling above, expert's consideration and discussions, the recommended flows have been determined by studying the outputs of the different approaches and professional judgement. Therefore, flows in Table 6-22 presents the pristine environment required for the fish species. This makeup the recommended flow regime to satisfy the e-flows to be released at the dam during operation phase. A relationship between these pristine conditions and the existing river conditions was studied and also summarized in Table 6-23 below. Further description of the application of the regime is provided in the sections that follow.

Table 6-22: Summary of the biology and flow-related ecological requirements of five fish species in River Mishumba

Fish species	**Singida tilapia**	**Albert tilapia**	**Zilli's tilapia**	**Victoria carp (Ningu)**	**African catfish**
Fish length (cm)	3.5 to 5.0	4.0 to 18.0	6.8 to 12.0	3.0 to 4.5	8.0 to 18.0
Microhabitat	Adult				
Depth (m)	0.58	0.58	>1	>0.15	0.78
Velocity (m/s)	0.399	0.399	0.23	0.2	0.75
Substrate	Mud with silt	Mud with silt	Mud	Multiple	Mud, pebbles, slit
Cover	Emergent Vegetation	Emergent Vegetation	Thick Vegetation	Multiple	Boulders and debris
Feature	Low current pools	Low current pools	Open and slow waters	Open water	
Microhabitat	Juvenile				
Depth (m)	0.30	0.50	>1	0.15	0.50 to 2
Velocity m/s)	0.15	0.63	0.23	0.83	0.83
Substrate	Mud	Mud with silt	Mud	Pebbles & slit	Pebbles & slit
Cover	Plant debris at bottom	Grasses and	Thick vegetation	Grasses	Grasses, rocks
Feature	Shallow and slow	Confluence, runs & ripples	Vegetated shores slow waters	Runs & ripples	Runs & ripples
Microhabitat	Migratory passage requirements				
Min. depth (m)	N/A	0.30	N/A	0.20	0.30
Max. vel. (m/s)		0.30		0.22	0.63
Migratory time		Mar to Oct		Apr to Oct	April to Oct

Microhabitat	Reproductive requirements				
Spawning season	Mar to Oct	Mar to Oct	N/A	Apr to Oct	Jul to Dec
Spawning migration	N/A	Lateral to flooded areas		Upstream during rains	Against water flow – upstream
Spawning cues	Seasonal rains Floods	Seasonal floods	Seasonal rains, vegetation	High rains, increased water levels	High rains, Increased water levels, fast flowing waters
Micro-habitat	**Incubation habitat requirements**				
Depth (m)	>0.30 to 1	>0.30 to 1	>0.30 to 1	>0.15 to > 1	>0.30
Velocity (m/s)	<0.20	<0.20	<0.20	>0.15	>0.60
Substrate	Mud and sand	Mud and sand	Emergent plants	Vegetated rocks/pebbles	Mud
Cover	Vegetated shores	Vegetated shores	Vegetated shores	Vegetated shores	Emergent plants
Temp (°C)	24 to 30	24 to 30	24 to 30	24 to 30	24 to 35
Incubation duration	3 to 4 days and 6 to 9 for brooding fry	3 to 4 days and 6 to 9 of brooding fry	3 to 4 days	2 to 6 days	Does not incubate eggs.
Diet	Minimal to feeding	Minimal to feeding	Minimal to feeding	Rotifers	Fish fry, insects

Table 6-23: Comparison of observed fish species requirements with the existing instream flow conditions

Objective	**Relevant species**	**Flow component**	**Hydraulic criteria**	**Timing**	**Conclusions from Current habitat Conditions downstream of the proposed damsite**
Maintain sufficient water depth in pools for large-bodied fish	Singida tilapia, Albert tilapia, Zilli's tilapia, & adult African catfish	Low flow	• Max D > 1.5 m • Velocity: 0.1–0.4 m/s	November to March,	Under normal flows, river experiences flow depths of about 0.3m which is comparatively to shallow for this species. Velocities range from 1m/s to about 1.4m/s in the river reaches and are way much higher than the recommended flows.
Stimulate spawning	Victoria carp and Africa catfish	Flow pulse	• D: 0.5–1.5 m at peak of flow pulse. • Inundated adjoining land area and increased back water • Velocity <0.3 m/s	April to July	Under normal flows, river experiences flow depths of about 0.3m which is comparatively to shallow for this species. Velocities range from 1m/s to about 1.4m/s in the river reaches and are way much higher than the recommended flows.
Provide new habitat and feeding opportunities for fish	Adult and juveniles of Singida tilapia, Albert tilapia, Zilli's tilapia, and African catfish	High flow	• Average D > 0.3 m; • Velocity: 0.3 m/s to 1.2 m/s	April to Jul	Under normal flows, river experiences flow depths of about 0.3m which is within the mentioned limits for this species. Velocities range from 1m/s to about 1.4m/s in the river reaches. These flows are within the flows experienced in the river during the

					mentioned period. However, the fish species except for the Africa catfish, were not registered at the sampling points under consideration though they were found elsewhere in the basin.
Provide new habitat and feeding opportunities for fish, while putting place measures to mitigate the increased sedimentation load and low DO that is likely to cause mortality	Albert tilapia, Zilli's tilapia, African catfish and haplochromine fishes	Flood Average	• D > 0.8 m; • Velocity: 0.2 m/s –1.2 m/s	March to June and July to October	Under normal flows, river experiences flow depths of about 0.3m which is comparatively to shallow to the minimum required for this species. Velocities range from 1m/s to about 1.4m/s in the river reaches and are higher than the recommended flows too.

6.4.4 Analysis of scenarios and sedimentation regime

The impact of changes in the sediment regime was analyzed using the *Hjulström-Sundborg diagram* presented in the Figure 6-18 below. According to Final Design Report (MoWE 2019), sediments of 241.7 Ton/km²/year from Mishumba catchment area (90km²) will be trapped by the dam after construction. This is equivalent to 30.68% of the 21,750 tons/year (total sediment) from the entire catchment area (293.31 km²) to be realised at the main outlet. The different flows were analyzed to investigate the possible changes in the deposition and settlement potential of various sediment particles noting their existence as settled materials /substrate or in suspension based on the expected velocities under the different flow regimes in each scenario. The Hjulström-Sundborg diagram shows the relationships between particle size and the tendency to be eroded, transported, or deposited at different current velocities

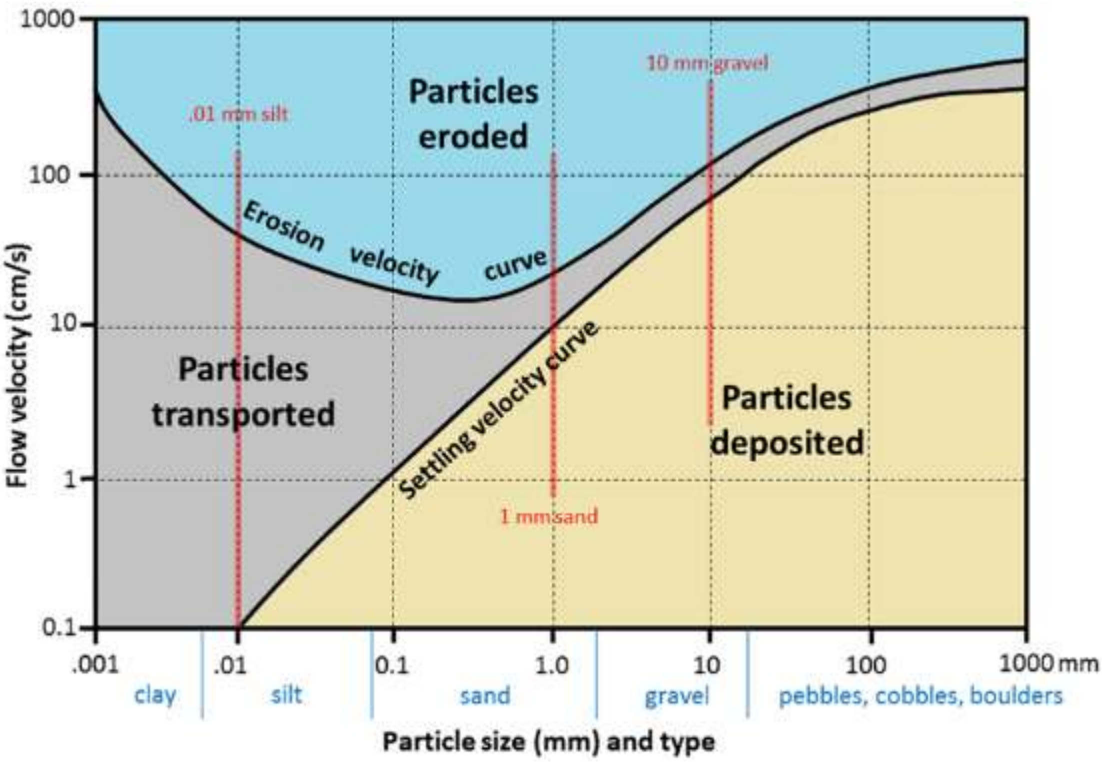

Figure 6-18: Relationships between particle size and the tendency to be eroded, transported, or deposited at different current velocities

Table 6-24: Bed sediment description at selected sampling points

Sampling Point	Bed Sediment description
3	Silt and mud
6	Silt, with pebbles of 4-20 mm
8	Silt, mud with material
14	Swamp/ farm
15	Silt and gravel of 2-64 mm

The Table 6-25 below presents the impact of the flow scenarios on different particle sizes in the river reaches .

Table 6-25: Impact of the scenarios on the sediment regime

Scenarios	Clay	Silt	Sand	gravel	Pebbles, cobbles & boulders
Present	Erosion /Transported	Eroded	Eroded	Eroded	Deposited
Scenario 1	Erosion /Transported	Eroded	Eroded	Eroded	Deposited
Scenario 2	Erosion /Transported	Eroded	Eroded	Eroded	Deposited
Scenario 3	Erosion /Transported	Eroded	Eroded	Eroded	Deposited

For all the three scenarios, the flow velocities will vary between 100 cm/s and 140 cm/s and the curve flatten as discharge increases. From the *Hjulström-Sundborg* diagram above, clay particles will remain suspended and silt, sand and gravel will be eroded. The stream bed sediments are comprised of silt to gravel materials. For all scenarios including the present situation, there is no deposition expected to take place due to medium or low flows. Pebbles, cobbles and boulders will be potentially deposited in all scenarios at these flow ranges. Consequently, there is no significant change expected in the sediment transport mechanisms under low flow to high flows downstream of the dam. In all scenarios, the high floods are to be maintained and therefore their sedimentation characteristics will not be affected downstream of the dam, therefore sediment balance for pebbles, cobbles and boulders is not envisaged to change. To enable ease of flushing sediments out of the reservoir, the environmental flow release structures within the dam should be placed as low as possible to allow as much sediment as possible to pass through the reservoir.

6.4.5 Impact of scenarios on irrigation potential

The present situation implies that no water is taken out of the river and therefore the irrigation scheme does not take place. Scenarios 1 and 2 do not reduce on the amount of water required for irrigation and therefore it can be concluded that their impact on the proposed irrigation scheme is negligible. Scenario 3 allows a release that will reduce the amount of water required for irrigation by approximately 30% implying a possible reduction in the irrigated area in the same range.

6.4.6 Analysis of scenarios against indicator list

Discipline	Indicator	Scenario 1	Scenario 2	Scenario 3
Irrigation	Irrigated Area	Negligible	Negligible	Significant
Sedimentology	Deposition/erosion characteristics	Negligible	Negligible	Negligible
Water quality	Nitrates	Negligible	Negligible	Negligible
Vegetation	Papyrus areas	Negligible	Negligible	Negligible

Fish	Spawning Areas	Negligible	Negligible	Negligible
Invertebrates	Skates and beetles	Negligible	Negligible	Negligible
Socio-economic	Fishing	Negligible	Negligible	Negligible
Overall		**Negligible**	**Negligible**	**Significant**

Scenario 3 has a significant impact on the proposed irrigation scheme. Scenario 1 and scenario 2 do not have significant impacts on the scheme, however, scenario 2 corresponds to the proposed irrigation area and allows for more releases downstream. Therefore, the recommended release schedule from the reservoir is as in Table 6-26. Scenario 2 provides more water to the environment in comparison to scenario one. And this excess water is not needed in the irrigation scheme.

The three (3) scenarios have been designed to ensure minimum impact on the key indicator species (biodiversty) with negligible disruption on the social economic activities currently in the catchment. Therefore, all the 3 scenarios envisage minimum and negligible impact on the biodiversity and social economic activities with the e-flows for all the scenarios set to meet the requirements of all indicators.

Scenario 2 provides more water to the environment in comparison to scenario 1 and this excess water is not needed in the irrigation scheme. Scenario 1 is based on the minimum e-flows following field-based asssessments whereas scenario 2 considers the minimun requirements based on the field data and sets standard minimum requirement for the indicators. Therefore, scenario 2 is considered more appropriate than scenario 1.

6.4.7 Conclusion on e-flow

Table 6-26 gives the recommended release for the e-flows from the reservoir and the overall recommended downstream flow which includes the contribution from the immediate downstream tributary. The proposed release schedule is the same as the one proposed by the ESIA studies. There is no need for any adjustments required in the dam design and operations for this purpose since there is variation in volume and e-flow. However, a flow of 1.8m^3/s will be released once in every two (2) years in the month of April for 12 hours and a flow of 2.4m^3/s will be released once in every five years in the month of April for 12 hours. These flows will be required to maintain the channel morphology downstream the reservoir. For the impacts of flow changes on the sediment regime and channel morphology, it is concluded that the recommended change in flows will not affect the deposition and erosion patterns within the river.

Table 6-26: Recommended water release schedule from the reservoir

Month	Baseflow	Releases from Reservoir (m^3/s)	Total flow downstream of Reservoir and tributary (m^3/s)	Pulses	Small Floods	High floods
Jan	0	0.05	0.1	0		

Feb	0	0.05	0.12	0		
Mar	0	0.05	0.14	0		
Apr	0	0.11	0.24	0	1.8 m^3/s every after 2 yrs for 12 hrs.	2.4m^3/s every after 5 yrs for 12 hrs.
May	0	0.11	0.22	0		
Jun	0	0.11	0.15	0		
Jul	0	0.05	0.10	0		
Aug	0	0.05	0.10	0		
Sept	0	0.11	0.20	0		
Oct	0	0.11	0.22	0		
Nov	0	0.11	0.24	0		
Dec	0	0.05	0.16	0		

Some of the groups of people who live in the midstream (irrigable area)

7 STAKEHOLDER CONSULTATIONS AND CONCERNS

Under regulation (16) of the Environmental and Social Assessment regulations for Uganda (2020) and best international practice, the project developer is required to undertake public consultation during the ESIA process. Therefore, the intended project must be publicly disclosed to stakeholders (at all levels throughout project cycle) that are likely to be affected. The public disclosure also demonstrates the anticipated effects and benefits in a language understood by those communities. The World Bank's Operational Policy 4.01 likewise emphasizes consultation and public disclosure of the project. During this additional study, stakeholder engagements were conducted through consultation as per the requirements of the Environmental and Social Assessment regulations, 2020. It involves stakeholder identification, mapping and consultations.

The stakeholders targeted were those entities (individuals, farmer households, institutions, enterprises, state & non-state actors) who are affected and / or affect the ICRP biodiversity and ecological flow management. All stakeholder consultations ensured freedom of expression of opinions and concerns and well as providing participants with the information they needed to be involved in a meaningful way, and it communicates to participants how their input affects the decision. At start, stakeholders were identified and mapped then consultative meetings were organised. The stakeholders mapped included the following: National Stakeholders (ministries, departments & agencies, MDAs), Upper and lower local governments (Technical Staff e.g. SAS, Parish Chiefs, Extension Officers), Village leaders (LC I Chairpersons), CSOs, Community groups (farmers, forest user groups, youth groups, fishermen, hunters, brick makers, sand miners, water user committees, etc.), in the project area (e.g. forest user groups) and other key stakeholders e.g. NGOs/CBOs, Cooperative Societies, small and large scale farmers among others.

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7.1 Objectives of Stakeholder Consultations

The objectives of stakeholder consultations were as follows:

a. To identify and assess issues and concerns issues related to the project scope, relevance, influence to the stakeholders, administrative aspects, traditional setting of the project and reinforce aspects identified in the ESIA Report (2019).
b. To identify and assess priorities, interests, level of influence, modifications, enhancement and mitigation measures in relation to project impacts on biodiversity and ecological flow management plan of ICRP.
c. To determine the need and key elements of the stakeholder engagement plan (SEP) to be used during the project implementation

7.2 Categories of Stakeholders

The consulted stakeholders included the following:

N°.	Category of Stakeholders	Name/Title of Stakeholder	Consultative methods used

1	Ministries, Departments & Agencies	• Ministry of Water and Environment (MoWE) • Directorate of Fisheries Resources - Ministry of Agriculture Animal Industry and Fisheries (MAAIF) • National Fisheries Resources Research Institute (NAFIRRI)	Consultative meetings Phone interviews
2	Higher local Governments	• Isingiro District Fisheries Office	Consultative meetings Phone interviews
3	Lower local Government (Technical Staff)	• Kabuyanda Sub County Local Gov't • Kabuyanda Town Council • Kikagate Sub County Local Gov't • Ruborogota Sub County Local Gov't	Consultative meetings Community meetings
4	Civil Society Organisations (CSOs)	• Environmental Alert • WCS • Nature Uganda	Phone interviews
5	Academia	• Mbarara University of Science & technology (MUST) • Makerere University	Phone interviews
6	Community (Project Affected / beneficiaries)	• Forest user groups at Kagoto 2 village (dam site area) • Village LC 1 Committee of Kagoto 2 village (dam site area) • downstream farmer communities (Nombe village) • upstream of dam site communities (Kyamazinga 1 & Kyamazinga 2 villages) • irrigable area communities - farmer communities in downstream and mid-stream in Ntundu parish – Kikagate Sub County)	Community meetings Ecosystems Service Survey Questionnaire FGDs KIIs

7.3 Results of Stakeholder Consultations (Issues & Concerns)

7.3.1 Local Governments (Kabuyanda SC, Kabuyanda TC, Kikagati SC and Ruborogota SC)

a) Consultation meeting with Technical Staff of Kabuyanda Sub- County (SAS, Parish Chiefs, Extension Officers)

Category of stakeholders	Key issues and concerns raised by Technical Staff of Kabuyanda Sub County (SAS, Parish Chiefs, Extension Officers)
Kikagati Sub County Technical Staff	• The technical staff welcomes the project in the area. Though it's covering only one parish in Kikagate Sub County (Ntundu parish)

Senior Assistant Secretary (SAS) – Twinomugisha Samuel0783683372 Parish Chief – Alije Amos 0787690649 CDO / Extension Officer – Abigaba Irene	• The major crops grown in areas that are covered by irrigation scheme are maize, sorghum, Irish potatoes, and sweet potatoes though on small scale due to limited land. • Banana is a traditional crop for cash and food. It fetches more money, with 3 harvest per month • The biggest plantation yields 100-150 batches of banana per season / month. The lowest has 1 batch of banana • The major banana varieties are locally known as BWAZILUME, NSHEYI, LWAMIGOGO, KIBUZI • The poor rely on banana, because they offer casual labour in banana gardens. The youth and women get short term jobs. • There is increasing degradation of swamps in almost all villages within the irrigable areas in Ntundu parish in villages of Kigando, Kamwosya, Rwakijuma, Kaburara, Ruyonza, Bubare. There is distilling of local brew (waragi) • Our major worry is dam busting hence causing a disaster. The busting may be due to shoddy work, and disregard of indigenous knowledge. • In April and May water levels increase, but floods don't happen always. • There are hazards due to climate change such as floods that have destroyed roads and bridges in Kamwosya. The Rwabishari bridge is not crossable. • The trends of past hazards are easily remembered by locals. • In 1982, floods destroyed property and animals in Ruhanda / Katoma river sections • In 2017, floods destroyed Nombe bridge (downstream), it swept away graves and burial sites; death of livestock. The most affected areas were Kigando, Rutoma, Nyakitunda, Bugongi, Kyefurwe, Kifulwe, Kabuyanda, Kaburara. The disaster was so strong and was all over the national news. • The irrigable area is in flood plain. • The area with high agricultural potential is Ruyonza. • In downstream areas, many people don't own land but they hire small plot of land at UGX 500,000/= for quarter acre per season per year. • When the irrigation starts, the farmers should be supported with irrigation pumps. • The extension staff have not seen the design of the irrigation system and dam; they request for an explanation so that they understand how best the project will work. • The farmers should be supported because the cost of additional irrigation equipment is expensive. • There is need to plant trees and establishment of nursery beds • The use of rattan and papyrus is reducing because people have bought iron sheets

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- There is leisure beach in Rwamishari along River Kamwosya in Nyampikye village. People go there to swim in the afternoon


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b) Consultation meeting with Technical Staff of Kabuyanda Sub County (SAS, Parish Chiefs, Extension Officers; GISO)

Category of stakeholders	Key issues and concerns raised by Technical Staff of Kabuyanda Sub County (SAS, Parish Chiefs, Extension Officers; GISO)
KABUYANDA SUB-COUNTY Technical Staff Senior Assistant Secretary (SAS)- Parish Chiefs Agricultural Extension Officer GISO	• We welcome the dam and irrigation scheme. However, in order for people to participate fully let the project meet the urgent need for domestic water supply. • The major concern is demand for domestic water. This should be addressed before the irrigation scheme • The land is getting scarce for farmers to grow on large scale. • We have not yet engaged with planners of the irrigation scheme. You (JBN Consults & planners) are among the first people to come here and have a discussion about the project. • Kabuyanda Sub County has little local revenue sources • Climate change especially drought severally affects our farmers. • Fishing is common in our area. We propose that the dam should be restocked with fish and fishing activity should be regulated as it is done in Bwizibwera / Rwanyamahembe Sub County in Mbarara district. • Locals can be trained in modern fishing skills • There should not be a contracted fish farmer to take care of the dam. Everyone should have equal benefits. • There is need for swamp demarcation with pillars. The sub county has no money • There is need for environmental training of locals and technical staff. • We have one agricultural extension officer shared among Kabuyanda Sub County and Kabuyanda Town Council.

	• We propose that the project can recruit Environmental Assistants (EA) and be based at Sub County. • There is need to have Kabuyanda Sub County Dam Task Force to manage conflict and oversight. • There is need for a police post near the dam site. • There is likelihood of conflicts over land, restriction on resource use especially in case people are stopped from dam area, and demarcations of river buffer zones. • An alternative footpath across the dam site area should be established, because if construction starts almost all villages on northern side will have no access to sources of firewood. This will be dangerous. • There is need to construct bridges using appropriate materials. • The wildlife-human conflicts are negligible. • There is need to increase the environment budget at sub county from UGX 200,000/= per year. • We need Kabuyanda Sub County Environment and Climate Change Strategy • The locals should be given jobs with first priority to people who live near the dam • The government should offer additional farmer support. The farmers may not have money to buy additional irrigation equipment e.g., sprinklers. • There is no known case of irrigation in banana plantation that has ever happened in our sub county. can sprinklers irrigate a banana plantation? The government should help us and train the banana farmers. 

c) Consultation meeting with Technical Staff of Kabuyanda Town Council (Town Clerk, Mayor, Town Agents, Enforcement Officers, Community Development Officers, Health Inspector)

Category of Stakeholders	Key issues and concerns raised by Technical Staff of Kabuyanda Town Council (Town Clerk, Mayor, Town Agents, Enforcement Officers, Community Development Officers, Health Inspector)

KABUYANDA TOWN COUNCIL Technical Staff (SAS, Parish Chiefs, Extension Officer, Health Inspector);	• Are the beneficiaries aware about the project? The leaders have been participating in the meetings, but are the locals fully aware? How will the project raise awareness about the project? • During the NESAP (design), few people could come to the meetings. There was no public disclosure. • The theory of the project is good, but the practical part of it is disturbing. People need to know how the irrigation system will work. • Is this the first irrigation scheme in Isingiro district? • There is no physical plan for Kabuyanda Town Council. How will the irrigation scheme affect the town? • The physical plan costs UGX 700million to develop. The project should help us on that. • We have a plan of expanding the town to municipality status in future. • In order to manage the irrigation scheme, there is need for an umbrella unit managed by respective lower local governments (Kabuyanda TC, Kabuyanda SC, Kikagate SC & Ruborogota SC) • We have a problem of poor waste management, with illegal dumping in irrigable area especially swamps. There is no gazetted disposal site. Will the project support town council in establishing a landfill, or compost site? The compost could be good for farmers. • The major crops are banana, beans, maize. • There are charcoal burners and sellers, with limited access to renewable energies such as briquettes. The demand for firewood will increase and yet we rely on forests and woodlots. • There is low coverage of energy saving stoves. • Town council needs to plan for climatic hazards such as floods. • We are concerned about any future occurrence of floods. Last time it happened It destroyed property such as roads, bridges, houses and human death (4 people killed). • Floods destroyed 7 bridges. These include: Byaruhaga-Akarere bridge; Mapengo-Akatesani bridge; Nshakirahe-Akatesani-Kyapa bridge; Mbarara-Ruti-Kabuynda bridge; Bigwera bridge; Rwabisheni-Kabumba bridge; Kamyoshya-Rwamijuka bridge; Nombe bridge. • The dry spell and drought affect communities as well. Between 2007-2008, the drought was so intense that even the price of cattle went down to UGX 20,000-30,000/= per cattle. • The rivers dried. These included R. Kalwenyi; R. Kizanyibaleba; R. Tebongire. only River Mishumba was flowing but water levels were low. • There is need for a disaster management plan • The swamp demarcation may be problematic. There is need for sensitization. • There is bylaw on environment but it's not yet approved.

	• The farmers will need more support in terms of inputs. • We have two farmer societies namely Kigarama Farmers Cooperative Society with 176 members and Kabuyanda Dairy Farmers Cooperative Society • There are 6 millers, 2 coffee processors, • Vegetable growing will increase due to irrigation. 

d) Consultation meeting with Ruborogota Sub County Technical Staff (SAS, Parish Chiefs, CDO)

Category of stakeholders	Key issues and concerns raised by Technical Staff of Kabuyanda Sub County (SAS, Parish Chiefs, Extension Officers; GISO)
Ruborogota Sub County Technical Staff (SAS, Parish Chiefs, CDO);	• We are not fully aware about the irrigation scheme • How many villages will it benefit in Ruborogota Sub County? • The farmers need to be supported. • We need to first look at the detailed design of the irrigation scheme • We propose that the Ministry and DLG organizes a stakeholder meetings / consultation to hear concerns about design. • The demand for irrigation goes beyond the proposed beneficiaries.  

e) Consultations with Parish Chiefs (Dam Site) – Kanywamizi and Kagara parishes

Category of stakeholders	**Key issues and concerns raised by Parish Chiefs (Dam Site) – Kanywamizi & Kagara parishes**
Parish chiefs of Kanywamizi and Kagara parishes (dam site) – Kabuyanda Sub County Francis - Kanywamizi parish Abaine Asaph – Kagara parish chief (+256 782962197 / +256757655593)	Issues and concerns of Parish chiefs of Kanywamizi and Kagara parishes (dam site) – Kabuyanda Sub County • There was a big flood in April-May 2020 that destroyed property, livestock and human death. 5 people died in Kabulala and Ruyonza villages in Kikagate Sub County (downstream). • Access to basic health services is still a challenge. There need to be a health facility nearby. • We have been told that irrigation scheme will be downstream not in our areas of Kagara and Kanywamizi parishes/ • There are no farmer extension officers. • The communities are continuing to encroach on the swamp due to scarcity of land and poor farming methods. • The enforcement of environment laws e.g., swamp protection is weak. We the parish Chiefs do the enforcement but there is no funding at Kabuyanda Sub County. • People plant banana along river buffer zones because they are not marked. The degradation is mainly in 6 villages namely Katooma 1, Katooma 2, Kagoto 1, Kagoto 2, Akatesanyi (central ward) and Rwakwakeda. • At LC 1 villages, the secretaries for environment are nominated but are not inducted and they don't know what to do. • There is no sub catchment management plan for River Mishumba. • There are no environmental guidelines to parish Chief to refer to. We are also ignorant of many environmental protection issues. We need to be trained. 

7.3.2 Village Communities within target areas (Dam Site, Irrigable Areas and Non-beneficiary areas outside target area)

a) Consultations with Forest user groups at Kagoto 2 village (dam site area)

Category of Stakeholders	**Key issues and concerns raised by forest user groups at Kagoto 2 village (dam site area)**
Forest Users at Kagoto 2 village (dam site area) on 4th March 2021	Issues and concerns of Forest user groups at Kagoto 2 village (dam site area) • The river is the major source of water. We totally rely on the river because all the boreholes are not functional. They are located at Kagoto 1 and Nyamiyanga villages. • We rely on Rwoho Central Forest Reserve (CFR) to get firewood especially dry eucalyptus and pine (dead wood and cut-offs) • We fear police and national Forest Authority (NFA) because they arrest us for harvesting / collecting firewood from the forest reserve, yet we have nowhere to get it from • Yes, it's true sometimes we cut trees without permission. However, our children often collect residues / cut offs from those timber / lumbering sites within the forest • There are many camps of licensed men who cut trees, so we talk to them and they give us cut-offs, then we give them food especially bananas. For each 2 batches of banana a, they give us poles of pine trees. We use the wood for domestic and commercial uses especially brewing local brew (waragi). Others resell the firewood to make profit because the demand is high. One bicycle full of firewood is sold at UGX 15,000/=; 1 piece of wood is at UGX 500-700/= • There were many wild fruits before they planted pine and eucalyptus trees in Rwoho CFR. The most common wild fruits are locally known as AMAYILUNGI, ENTUTU, AAYONZA and AMATEJEJERE. But now they are scarce. • We fear that when construction starts, our road will be blocked and it will be hard to access the forest, as well as moving to next village of Kyamazinga. This is the shortest distance from Kabuyanda-Kagoto 2-Kyamazinga (7km). the alternative route is Kabuyanda-Kanywamizi-Kyamazinga (10-15km) • When the road is closed, the transport costs will increase. Currently, a commuter motorcycle (boda-boda) charges UGX 4,000/= from Kagoto to Kyamazinga. A truck taking building materials charges UGX 100,000/= from Kisoryo 2 to Kyamazinga. The cost will double if the road is blocked. • The youth need jobs because unemployment is high. In Kagoto 2 village, there are about 70 youth without jobs out of total population of 350 people. • The unemployed youth resort to artisanal fishing in the river streams. However, the severe flooding that happened in 2020, washed away the fish downstream together with the swamps where fish used to breed. The most common type of fish was ENSOZI. We sell it at UGX 2,000/= per batch (11 fish x 1 batch). The common fishing method is use of basins and net • The community suffers from water related diseases such as malaria, diarrhea, bilharzia, typhoid.

	• We need to know about the detailed plan of the dam construction. Let the government bring engineers and they show us and we also ask the questions. • When construction starts, will the youth get jobs? • The construction will attract sex workers from Kabuyanda town, and they offer cheap sex at UGX 1,000 per encounter. Its better the workers rely on the sex workers but not our children and wives. 

b) Consultations with LC 1 Committee of Kagoto 2 village (dam site area)

Category of stakeholders	Key issues and concerns raised by Technical Staff of Kabuyanda Sub County (SAS, Parish Chiefs, Extension Officers; GISO)
Kagoto 2 LC 1 Village Committee (Headed by Chairperson, (Mr. Aggrey Lukabaza - 0784561152 / 0759368393)	• There are 6 neighboring villages surrounding the dam site area. These are Kagoto 2, Katooma 1, Katooma 2, Kyamazinga 1, Kyamazinga 2 and Kagara. • In my village (Kagoto 2), there are 401 people living in 335 households with about 60% children; 120 youth and 70 female headed households (widows) • The major problem we face is lack of clean water sources. There are no boreholes, shallow wells. Piped water stops at Kabuyanda Town council which is 6km away. • We rely on river Mishumba and its streams. There are 5 water points along those rivers locally known as AMAZIBA. All villages use those points. Even livestock use the same water points (AMAZIBA) • Community collects herbs and medicinal plants from the forest reserves and swamps along the rivers. The herbs and medicinal plants are mainly used to treat diseases and illnesses such as diarrhea, gastronomic ulcers, syphilis, worms, allergy, nose bleed, malaria, EKIBAARE, EKIGARAGA, EFFUMBI, ESWUMBWE. • The common herbs and medicinal plants are OMULULUZA, EMILAVUMBA, AKABIDIRIZI, OMUFULULA, OMWIHURA, OMWETAGO, OMWESAMULO, OMUSHINYA, OMWAMIRA, EMBOGA / ESWIGA

	• There is artisanal fishing going on along the river streams. The head of local fishermen is called NDYABAYIKA. • There are over 170 herbalists (70 in Kagoto 1 and 100 in Kagoto 2 villages) • There are 6 Traditional Birth Attendants (TBAs) but they work silently because they were banned by government. However, people still rely on them because the nearest health facility (Kanywamizi HC III) is located about 6km away. • There are also Village health teams (VHTs). We have no drug shop on the village. • We were told that the villages near dam site will not benefit from irrigation, is it true? • We don't have any farmer group. We have no extension officer. Our saving and cooperative society (SACCO) called KABUYANDA AGRICULTURAL SACCO collapsed. The only major project that used to support us called MILLENIUM VILLAGE PROJECT also closed. There is a new programme called DRDIP but it's not yet here in our village. • We need treated piped water • Is it possible to have a look at the design of the dam? • Our other concerns are about safety of the children. There should be measures to ensure children and even adults don't drown in the dam. • we are concerned about resettlement actions. Will the payments be made by 1st march 2021? Every day they promise us yet people want to do other things. Other people have resumed constructing their houses because they have over waited. 

c) Consultations with downstream farmer communities (Nombe village)

Category of stakeholders	Key issues and concerns raised by farmers in downstream areas (Nombe village)

Farmers in downstream areas (Nombe village)	• we heard about the dam that will be constructed in Kabuyanda. How will it look like? • Will the water be affected? • The river is our major source of water for domestic use and livestock • The fishing in river is common. We get food • There are also insects • The antelopes are very few. • There are birds such as ENTUHE (Crested Crane), ENYAWAWA, ENYANJI, EBIKONA, EKANGA, ENDAHI (commonly eaten). • There are also birds treated with superstition such as KAMUSHUSHUGU, EKIHUNYIRA / EKIHIHIZI • Fish farming is happening but done especially by one man called MILISERA at Kabumba village (upstream) 

d) Consultations with 2 village communities upstream of dam site (Kyamazinga 1 & Kyamazinga 2 villages)

Category of stakeholders	**Key issues and concerns raised by 2 village communities upstream of dam site (Kyamazinga 1 & Kyamazinga 2 villages)**
2 village communities upstream of dam site (Kyamazinga 1 & Kyamazinga 2 villages)	• We use the river to irrigate some crops down in the valley especially vegetables • There are 70 households that use river to irrigate. These rivers are locally known as River Rwabashura and River Owogwabashura. • We also use the river water for domestic use. We have no other water source apart from the river. There are 26 water vendors who sell a jerrycans at UGX 1,000 • We use the river for fish. There are 40 people who do fishing using nets and locally made baskets

	• Our biggest fears are about our children drowning in the dam when its full of water, because it hard to stop children from collecting firewood and fish. • The other fear is blocking the road to Kagoto village and to forest to collect firewood. If they construct dam, will they create an access route to the forest? If they don't, then we shall have to suffer with firewood. • Our livestock graze in the valley where the dam will be constructed. Is there an alternative grazing land? • We gather fruits and wild food in the forest. We pass through the valley. Some people also go there to hunt, though the animals are now rare. • We have limited access to health services. We rely on VHTs who also don't have enough drugs and appropriate requirements for treating patients. • Will design of the dam be shown to us and we give our opinion? 

e) Consultations with 6 village communities near the dam site (Katooma 1, Katooma 2, Kagoto 1, Kagoto 2, Karo 3, Nyamiyanga)

Category of stakeholders	**Key issues and concerns raised by 5 village communities near the dam site (Katooma 1, Katooma 2, Kagoto 1, Kagoto 2, Karo 3, Nyamiyanga)**
5 village communities near the dam site (Katooma 1, Katooma 2, Kagoto 1, Kagoto 2, Kagara)	• There are many people and households near the dam site. • We were told that the dam will be multi-purpose. That it will help in irrigation, electricity, fish farming, livestock farming, piped water. • We promised compensation for loss of our land but it has delayed. • We are concerned about accidents. They told us that the dam will be zoned into two i.e., red zone and blue zone. • We graze our livestock in the dam area. Will they compensate us for the grazing land? • The major challenge in our villages is lack of access to safe and clean water. We rely on rivers. • Dry spell and drought affect us especially in May and August.

	• The construction will block roads to school. How will our children cross the valley / river to go to school? • Though we want development (ETUGUKA), is greatly concerned about floods. Last time they came without warning. • Will the dam have an alarming system in case of floods due to raising water levels? • We have small land holdings of not more than 2 acres. People grow near the river and swamp. They have encroached on the river and it will be very hard to stop them. • There are about 122 households growing crops in swamp and river basins (10 in Kagoto 1; 18 in Kagoto 2; 84 in Kaaro 3; 10 in Katooma 1). They grow food crops such as yams, banana beans, maize, sorghum. • What fertilizers will the project give us? • We were told that some villages will not benefit from irrigation?  

	

f) Consultations with farmer communities in downstream and mid-stream in Ntundu parish – Kikagati Sub County)

Category of stakeholders	**Key issues and concerns raised by farmer communities in downstream and mid-stream in Ntundu parish–Kikagate Sub-County (Kabumba, Kagunga, Rutare, Bikurungu, Kinjubuka, Mbarara 3, Nyihita)**
	• There are 8 villages within the irrigable area in Ntundu parish. These area Kabumba, Kagunga, Rutare, Bikurungu, Mbarara 2, Kinjubuka, Mbarara 3, Nyihita • Kabumba is the most populated village with 355 households. The lowest population is in Bikurugu village with 50 households. • The biggest problem is lack of access to safe and clean water. We rely on river streams and a new water body formed after floods in Ruyonza. • There are about 20-40 fish ponds but owned by a few individuals • People go hunting but there few wild animals • There is a tin mine downstream? Will it affect the flow of the rivers? • There is a lot of soil erosion especially at Nyampikye • There is increasing disease incidence and prevalence • HIV/AIDs prevalence is high in Kagunga and Kabumba villages • The major diets are bean, cassava, banana, maize flour, vegetables • Most people hire land from Catholic Church • The demand for irrigation to grow vegetables is higher than the need to irrigate banana gardens. • Unemployment is high


VHT

People and animals surviving on River Mishumba in the midstream (irrigable area)

8 IMPACT ASSESSMENT, ENHANCEMENT & MITIGATION MEASURES

8.1 Positive Impacts and Enhancement Measures

The positive impacts have been respectively classified as direct, indirect, short, medium, long-term, highly significant, moderate, no significant, temporary, permanent and continuous. Please refer to Impact Matrix at end of this section for details.

8.1.1 Pre-Construction Phase

a) **Favorable Social acceptability, community involvement and support for ICRP:** The prevailing conditions of social acceptability are a positive impact in that it has created an enabling environment for project success. During stakeholder consultations, it was observed that expectations are inclined on improving livelihoods and local development. The Kabuyanda Sub County Local government officials clearly stated that the ICRP will greatly succeed because it's being supported by all stakeholders (potential beneficiaries, local government and local leaders). The favorable social acceptability has enabled successful completion of preliminary surveys e.g., ESIA, RAP. It's anticipated that other additional pre-construction activities will be completed successful. These include: land acquisition, acquisition of construction equipment and materials, site clearance, construction of access roads, improvement of existing roads, construction of management's camp, workers' camp and offices and transportation of construction material and equipment to the project sites. This positive impact is classified as direct, short, medium, long- term, highly significant, permanent and continuous.

Enhancement measures: There is need to conduct additional stakeholder consultations and information disclosure focusing on a) new proposed management plans; b) BEMP; c) Project or programme performance reports including the status on implementation. This will be in line with MoWE/ESS Policy Framework and OP 4.01.

8.1.2 Construction Phase

a) **Short term employment opportunities for local communities:** The ICRP will create direct and indirect employment to local people for a period of 2 years. The possible direct jobs include community workers (casual labour) and semi-skilled (masons, plumbers, painters, drivers, community educators). These will be involved in construction works for the dam, spillway, intake and bottom outlet, irrigation networks, drainage networks and other structures, site clearance, excavation, blasting and surfacing of cleared areas. There will be additional indirect employment opportunities such as supplier workers, petty business (e.g., restaurants, drinking points, etc.). This positive impact is classified as direct, short, highly significant, permanent and temporary. The wages earned will enhance access to basic needs among the local communities. In order to maximize the above positive social impact, it will be necessary to consider the following enhancement measures.

Enhancement measures

- Involve LC 1 village leaders in identifying casual and semi-skilled workers (Offer Identification / registration forms).

- The contractor will be encouraged to prioritize employing the locals for jobs that they qualify for or can do (casual), in order to reduce impact of labour influx to the host community by external workers.
- ICRP should integrate social protection mechanisms such as offering casual jobs to vulnerable and marginalised people using group model (labour intensive public works). NB. Benchmark with NUSAF 3 program funded by World Bank that uses a labour-intensive public works model. The vulnerable and marginalised groups include the PAPs e.g., displaced households, women, youth, disabled persons, lactating mothers, widows, older persons and child headed households.

8.1.3 Dam filling Phase

In this report the positive environmental effects during the dam filling phase have been captured and most suitable enhancement measures identified.

a) **Creation of new or expanded habitats for aquatic wildlife, and attraction of terrestrial life forms.** The filling of the reservoir will lead to expanded living spaces and enable processes of biological colonization, creating new habitats for different aquatic life forms while also leading to emergence of new terrestrial water dependent life forms.

Enhancement measures

- Monitor the colonization and changes in assemblage of aquatic and terrestrial life forms as the dam fills so as to possibly weed out an unwanted invasive life forms such as water hyacinth.
- Facilitate movement and colonization of the filling reservoir with naturally suitable life forms, such as sedentary deep water loving forms.

b) **Changes in hydraulics and hydrological parameters** of the river allowing for increased clarity of water and primary productivity to support new life forms in the reservoir.

Enhancement measures

- Implement a monitoring plan to study the changes in hydraulic and hydrological parameters of the stream, and how the changes are impacting on productivity of the waters.

c) **Shift of fish communities from lotic to lentic components.** It is expected that during the filling, the abundance percentage of lentic fish will increase with creation of more sedentary or less flowing and deep water habitats. As such, after the filling, lentic or limnophilic fishes are expected to increased significantly in abundance – and will result in a typical lacustrine fishery, but will also offer transitional and riverine zones for corresponding lotic fish assemblages. On monitoring after filling and stabilization of the reservoir, Singida tilapia, a critically endangered fish species can be moved from the lower reaches to a new and more appropriate habitat setting, in the formed water reservoir but with careful ecological modelling studies for conservation purposes.

Enhancement measures

- It is suggested that long term monitoring should be conducted right from the filling stage to established and stablised stage of the reservoir, with regular evaluation of the changing ecological effects, and different strategies implemented in these three zones for conservation purposes.

- Monitor and translocate lotic (rheophilic fishes) to transitional and riverine zones, or completely outside the reservoir to adjoining streams (tributaries) south of the dam.

8.1.4 Operation & Maintenance Phase

The ESIA provided most of the positive impacts in each of the phases of ICRP implementation. Under this report, only a few additional positive impacts were identified to avoid repetition and duplication of effort.

a) **Reduction and/or taming of predators of aquatic organisms through clearance of vegetation and physical structures:** there will be a reduction in and or taming of predators of aquatic organisms, especially those for fishes therefore, it anticipated that disturbed fauna will migrate to nearby habitats. The impact will be indirect, medium & long term, positive for aquatic organisms and likely to occur with a moderate magnitude.

Enhancement measures

- Monitor the presence and abundance of natural predators of aquatic organisms.
- Where possible facilitate natural movement of fauna to nearby habitats.

b) **Enhanced aquatic habitat through creation and maintenance of new water reservoir with deep settled waters:** Inundation and occupying of more grounds will allow aquatic wildlife colonization and establishment. This will establish biodiversity communities typical of expanded water pools and associated backwaters and creation of new fisheries. The dam will create a water reservoir which will possibly enhance the aquatic habitats. This will offer the opportunity for pisciculture and aquaculture and favourable habitats for water fowl, both permanent and migrating. This will harness the opportunities to initiate aquaculture at the reservoir. This will be a direct and positive impact, very likely to occur with a large magnitude.

Enhancement measures

- Put in place a reservoir management plan.
- Bird sanctuary can be created around reservoir
- Allow for “facilitated” natural migration and colonization by all fishes in the catchment.

- Establish a formal community-based fishing regulatory framework against excessive and bad fishing practices.

c) **Regulated flow of water especially during the dry periods of the year:** This will allow for management and addressing of natural periods of reduced flow or drying out providing the affected aquatic wildlife or terrestrial organisms that depend on the continued River Mishumba flow to survive with the managed continued flow. This will be a direct and positive impact, very likely to occur with a large magnitude.

Enhancement measures

- Adherence to and regular updating of e-flow management plan

d) **Regulated human settlement and socio-economic activities in irrigation command area:** The project will offer enhanced capacity to regulate and tame human driven change in the catchment with opportunities to eliminate or curb the destructive socio-economic and settlement activities in the catchment. This will be a direct and positive impact, very likely to occur with a large magnitude.

Enhancement measures

- Sensitization of beneficiary communities and farmer organization and training on managed and planned agriculture production.
- Scale-up environmental education and protection actions at all lower local governments e.g., strengthen role of LC 1 Environmental Secretary in monitoring and reporting

e) **New breeding grounds due to creation of backwaters with blockage of channels:** During the operation phase, it will be impossible to avoid leakage of the irrigation system. Leakages are will likely create artificial ponds (stagnant water), swamps or artificial aquatic habitats of value for flora and fauna. New habitats of certain species of fauna will be emerge within the irrigation command area. Therefore, the Irrigation command area will become breeding ground for most amphibians with increased juvenile recruitment rate. Such a situation may also become good foraging habitats for birds such as ducks, egrets, ibises and herons, and reptiles such as *Forest Cobra* and *Nile Monitor* since they partially feed on amphibians hence harnessing the gains in biodiversity. This impact will be direct and positive, very likely to happen with major significance.

Enhancement measures

- Protection of created habitats
- Sensitization of attendant communities on the need for protection and conservation of biodiversity.
- Regular survey and monitoring of created habitats.

f) **New Dam and associated irrigation infrastructure:** There will be an enhanced production and productivity in an equitable and gender responsive, climate smart and market oriented agricultural practice. This will be a direct and positive impact, very likely to occur with a large magnitude.

Enhancement measures

- Adhering to Biodiversity and E-flow Management Plan
- Implementation of catchment management plans and measures in close collaboration with the host communities.

Figure 8-1: Modified riverine along the proposed reservoir area (bare land) without any aquatic habitats

8.1.5 Level of Intensity of Positive Impacts

The intensity of positive impacts has been rated per sections of river stretch (Upstream, Midstream & Downstream) as shown in **Table** 8-1.

Table 8-1: Level of Intensity of Positive Impact per river section

Positive Impacts by Level of Intensity (*High = 1; Medium= 2; Low =3)*	**Stretch / Section of River**			
	Up-stream	**Mid-Stream**	**Down stream**	**Entire Project Area**
PRE-CONSTRUCTION PHASE				
Favourable Social acceptability, community involvement and support for ICRP	High	Medium	Medium	High
Increased visibility and stakeholder support due to pre-construction engagement such as Field Visits, Design Presentation at DLGs & Ground Breaking ceremonies.	High	High	High	High
CONSTRUCTION PHASE				
Short term direct & indirect employment opportunities for local communities (casual & semi-skilled jobs; local businesses e.g., restaurants, suppliers.	High	Medium	Medium	High
Potential appreciation of value for property such as land, houses for rent that are near the water facilities	High	Medium	Medium	High

Positive Impacts by Level of Intensity (*High = 1; Medium= 2; Low =3*)	**Stretch / Section of River**			
	Up-stream	**Mid-Stream**	**Down stream**	**Entire Project Area**
(reservoirs, boosters, transmission lines, distribution tanks).				
Rehabilitation of roads and bridges (feeder and community access roads) in dam site area and irrigable area	High	High	High	High
Increase in positive sexual behaviours due to adherence to social safeguards (e.g., workplace HIV/AIDs policy) for workers at construction sites	Medium	Medium	Medium	Medium
Increase in petty trade opportunities – new kiosks will be opened up to serve influx of workers in short run at water works sites.	High	Medium	Medium	High
Reduced gender disparities in terms of women and youth accessing short and direct employment at construction sites	High	Medium	Medium	High
Skills transfer / on-Job Training of local workforce in relevant skills e.g., plumbing, painting, etc. the skills transfer will benefit locals.	High	Medium	Medium	High
OPERATION PHASE				
Reduction and/or taming of predators of aquatic organisms through clearance of vegetation and physical structures	High	High	Medium	High
Enhanced aquatic habitat through creation and maintenance of new water reservoir with deep settled waters	High	Medium	Low	High
Regulated flow of water especially during the dry periods of the year	Medium	High	High	High
Regulated human settlement and socio-economic activities in irrigation command area	High	High	High	High
New breeding grounds due to creation of backwaters with blockage of channels	High	Medium	medium	High
New Dam and associated irrigation infrastructure for better agricultural production and productivity	Medium	High	High	High
Transformation of agriculture practice from subsistence to commercial agriculture	Medium	High	High	High
Sustainable and optimal use of irrigation water resources	Medium	High	High	High
Improved food security due to increased crop & livestock production	Medium	High	High	High
Increase in employment in agricultural value chain (direct & indirect)	Medium	High	High	High
Increased crop acreage & yields	Medium	High	High	High
Improved social infrastructure (irrigation schemes, domestic water supply, roads, etc)	High	High	High	High
Gender empowerment and reduced gender disparities	High	High	High	High
Increased Crop diversification and intensification	Medium	High	High	High
Improved tourism (agro and eco-tourism)	High	High	High	High
Increased local trade and value chain development	High	High	High	High

Positive Impacts by Level of Intensity **(***High = 1; Medium= 2; Low =3)*	**Stretch / Section of River**			
	Up-stream	**Mid-Stream**	**Down stream**	**Entire Project Area**
Increased rural transformation & urbanization	High	High	High	High
DECOMMISSIONING PHASE				
Creation of short-term employment (Casual jobs) involved in dismantling the work sites / camps.	High	High	High	High

8.2 Negative Impacts and Mitigation Measures

8.2.1 Pre-Construction Phase (Risks)

a) **High incidence of grievances arising due to delayed and faulted compensation, demarcation of buffer zones and restrictions over resource use:** There is growing concern about delayed compensation and valuation methods used. This is evident in the dam site area and conveyance/distribution networks. There are possible conflicts arising from demarcation of buffer zones of rivers and restrictions on use of natural resource. This is short term and direct impact but not continuous. The receptor *Sensitivity* is assessed to be *medium. it will not delay / hinder construction to take place, but will instigate social distress to a minimal level.* This is a *Temporary* and *reversible* Impact. The impact *Intensity* is *medium* because it affects livelihoods directly. This will give rise to *moderate* impact significance.

Impact Significance		**Sensitivity of Receptor**			
		1 Very Low	2 Low	**3** **Medium**	4 High
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium **3**	3 Minor	6 Moderate	**9** **Moderate**	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures:

- Ensure compliance to recommendations of the RAP report
- Conduct adequate information disclosure about RAP process and benefits of relocations certain points especially near dam site and buffer zones of rivers.
- Implement livelihood restoration actions as proposed in RAP report
- Meaningfully consult and involve host communities during development and implementation of catchment management plans.

b) **Mismanagement of compensation packages at household level**: There is likelihood of mismanaging compensation packages at household levels arising from inadequate skills and knowledge in financial planning and management, gender-based violence and family conflicts.

The mismanagement of compensation is likely to affect children and women because they have limited property ownership rights over land, houses, crop-gardens among others. Given the patriarchal nature of the family relations, the men will dominate the decisions on how to allocate compensation packages especially funds. This is short, medium and direct impact but not continuous. The receptor Sensitivity is assessed to be medium because it directly creates deprivation and gender-based vulnerability at household and community levels in terms of GBV, social exclusion, child rights violation among others. This is impact is permanent and irreversible. The impact Intensity is high and its significance is major.

<table>
<tr><th colspan="2" rowspan="2">Impact Significance</th><th colspan="4">Sensitivity of Receptor</th></tr>
<tr><th>Very Low
1</th><th>Low
2</th><th>Medium
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<tr><td rowspan="4">Intensity of Impact</td><td>Very Low
1</td><td>1
Negligible</td><td>2
Minor</td><td>3
Minor</td><td>4
Minor</td></tr>
<tr><td>Low
2</td><td>2
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Moderate</td></tr>
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Medium</td><td>3
Minor</td><td>6
Moderate</td><td>9
Moderate</td><td>12
Major</td></tr>
<tr><td>High
4</td><td>4
Minor</td><td>8
Moderate</td><td>12
Major</td><td>16
Major</td></tr>
</table>

Mitigation measures:

- Ensure compliance to recommendations of the RAP report in terms of financial literacy and family finance management and planning
- Engage local leaders in sensitizing PAPs
- Implement livelihood restoration actions as proposed in RAP report

c) **Degradation of existing stocks with abandonment of fishing control and regulations with anticipated takeover and development of Mishumba catchment for irrigation.** Due to the limited operation budgets and lack of empowerment of fishing communities, there is a chance that DLG and Lower Local Governments may halt the activities for control and regulation of fishing activities in the Mishumba catchment with the knowledge that the catchment is in the process of being taken up for development of irrigation, and control of fishing activities as such is no longer tenable and important. This is likely to lead to increase in indiscriminate fishing seriously damaging the existing stocks in the catchment. This is **a long term** and **direct impact**. The receptor ***sensitivity*** is assessed to be ***low.*** This is ***temporary*** and can be ***reversible*** impact. The impact ***intensity*** is ***medium*** and a ***moderate*** impact significance in periods of intense project activity.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	**Medium 3**	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	3 Medium	3 Minor	6 Moderate	**9 Moderate**	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures:

- DLGs and LLGs should be compelled and facilitated by MWE and MAAIF to continue with control and regulation of fishing activities as provided for in existing regulatory framework.
- MAAIF should put in place management measure to ban artisanal trap fishing and or closed fishing season using existing Fish (closed) Rules, 2008, for closed season fishing, to prevent the harvest of Ningu during their peak **spawning** periods (rainy season).
- To protect and ensure continued use of the identified breeding and spawning areas in Mishuma River tributaries within the Mishumba Catchment by NIngu, the project should facilitate MAAIF and concerned DLGs and LLGs to establish a community **Conservation Educational Managed** area covering key spawning and nursing habitats for **Ningu** to improve the sustainability of the fishery – using the Fish (Lacustrine Protected Area) Rules, 2007. This should include training, exposure and provision of skills for alternative livelihoods for the fishermen.
- MAAIF and MWE should sensitize the fishing community members throughout the preparation phase on the requirement for them to adhere to established rules and regulations for fishing, and to desist from using destructive gears.
- The project should provide local leaders and known fishing community leaders with information generated in the additional surveys on the importance of the catchment in terms of fisheries especially as a home to key ciritically endangered fish species.
- LLGs fisheries managers should be facilitated to continue monitoring and capturing the required information on fishing activities.

8.2.2 Construction Phase

The Kabuyanda Irrigation Scheme project has negative impacts, during the planning, construction and operational phases. However, the identified impacts shall be mitigated according to the mitigation hierarchy. These have been placed according to the phases of the project as follows:

a) **Loss of habitat due to clearance of vegetation and physical features from construction sites:** During the construction phase, there will be habitat disturbance, fragmentation and eventual loss. It is expected that in order to ease access to the dam facility, access roads will be constructed, or the existing ones will be improved. If this option is upheld, there will be some disturbance of both the physical and biotic components of the environment in the project area. Some of the species of plants are habitat-specific, e.g., *Cyperus* papyrus and other *Cyperaceae*. These only grow in swamps and loss of their suitable habitat will reduce inhabitable space and hence their abundance. However, the impact of upgrading the existing roads on the vegetation will instead be minor. The major areas to be affected are dam site area. Loss of foraging, basking, roosting, patching, reproduction and hiding habitats for fauna will also occur. Butterflies will lose habitats as they virtually occur in all habitats ranging from pristine to disturbed and are mobile, and derive most of their nutritional requirements and some non-nutritional resources from plants. There will be loss of habitats due to alteration of water quality from siltation, opening up the channel to erosion, and eutrophication, will affect many species, especially fish, amphibians, aquatic reptiles and insects. Birds will be affected directly by loss of habitats and home range quality. This is **short term** and **direct impact**. The receptor ***sensitivity*** is assessed to be ***MEDIUM;*** it will disrupt both physical and biotic components. This is ***temporary*** and can be ***reversible*** impact. The impact ***intensity*** is ***medium*** and a ***moderate*** impact significance in periods of intense project activity.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	**Medium** 3	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium **3**	3 Minor	6 Moderate	**9** **Moderate**	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures:

- Machine operators should be sensitized to carry out vegetation clearance in sections and limit vegetation clearance to portions of the land to be affected.
- Relocate animals that cannot flee on their own and this should be done by qualified / trained person (engage Uganda Wildlife Authority and/or Uganda Wildlife Education Center (UWEC Zoo).
- During vegetation clearance, spare mature indigenous trees whenever possible.
- Restore the environment around the site of activity.
- Restriction of the activities only to the areas that must be disturbed to avoid unnecessary habitat loss or alteration.
- Closely monitor and supervise the operations to ensure compliance. This role should begin with the project staff but will also require regular checking by the relevant officers responsible for compliance of development projects to the approval terms and conditions.
- In order to minimize impact on the habitat, all the project workers, including those in supervisory positions to the ground men, should be sensitized to increase their awareness

about the need to minimize environmental damage. This will have to be done before the operations begin in earnest.

b) **Loss or injury of fauna:** The clearance of construction site may lead to unintentional loss of fauna life or injury while some may be buried unknowingly. This may especially be so for reptiles, amphibians and small mammals which hide in crevices, holes and under leaf / vegetation litter. Road kills may also become common due to increased motorized traffic in the project area. In addition, diversion of water will lead to mortality of aquatic wildlife. This will be a direct and negative impact of low magnitude but likely to happen with a moderate impact in periods of intense project activity. This is **short term** and **direct impact** but not continuous. The receptor ***Sensitivity*** is assessed to be ***medium;*** it will lead to injuries or loss of fauna / biotic components. This is ***temporary*** and can be ***reversible*** Impact. The impact ***intensity*** is ***medium*** (dam area) with a ***moderate*** impact significance.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	**Medium 3**	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	**6 Moderate**	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures

- Set and observe speed limits in the project area
- Areas identified for clearance should be searched for fauna and if found, the fauna should be translocated to safety.
- Plans to scare way fauna from construction sites should be made before undertaking vegetation clearance should be undertaken
- Only qualified personnel should handle wildlife or fauna in case translocation is necessary.
- Diversion of river and stream channels for construction should be made after careful survey of the sites.

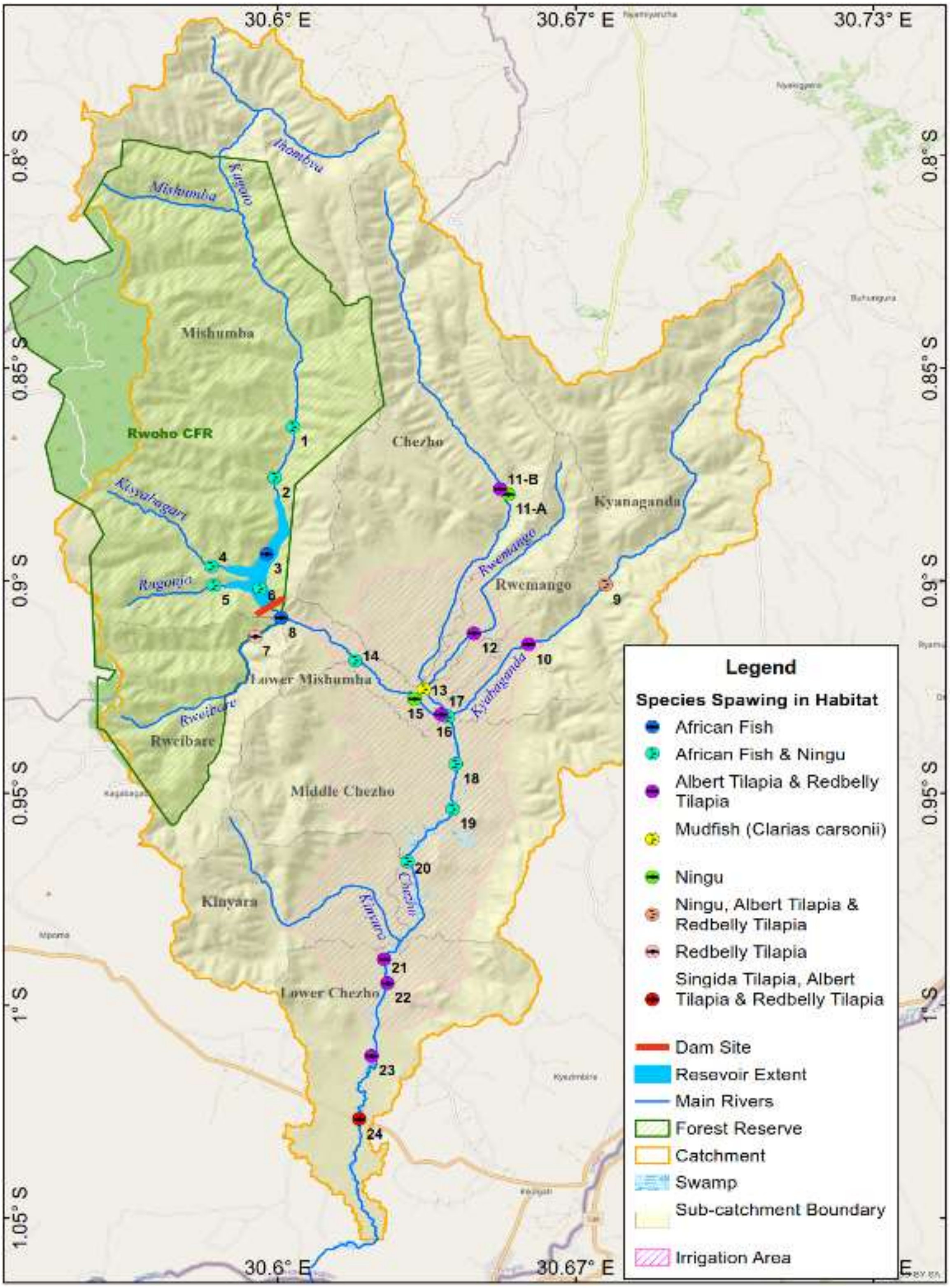
c) **Interference with fish reproductive ecology and loss of breeding, spawning and nursing grounds with reduced, altered and or diverted flow during construction of the dam.** The construction of Mishumba Dam for Kabuyanda Irrigiation scheme poses generally an impact on fish communities and populations as migrations and ecological movements of fish will be interrupted, delayed or even stopped. The dam and irrigation scheme also poses a risk of reducing quality, quantity and accessibility to habitats by fishes, which can in turn have negative impact on the population of the fish. Fish can also be detrimentally affected during their transit when flowing over spillways. Changes in discharge regime or water quality can also have indirect effects upon fish species due to loss of feeding and reproduction cues; while upstream and downstream predation for migratory fish may be delayed and concentrated due to the presence of the dam and the habitat becoming more favourable to certain predatory species. There is also a chance of decline in populations of the migratory fish species due to interference with migration for feeding and breeding purposes. This effect can lead to the extinction of species, where no spawning grounds are present in the river or its tributary downstream of the dam. Fortunately, for Mishumba catchment there are number of tributaries and Kagera River itself with even more suitable feeding, breeding and nursing sites than Mishumba River, which if protected will certainly increase the chances of the fish species multiplying in number. This is **long term** and **direct impact** but with very clear and appropriate alternative spawning sites within the catchment as indicated in the map below. The receptor ***Sensitivity*** is assessed to be ***low*** as a result of multiple alternatives**;** the construction of the dam will lead to diversion and altered water flow in the main channel but will most likely not affect the key tributaries such as Chezo River with alternative breeding and spawning sites. This is impact is therefore ***manageable***. The impact ***intensity*** is ***medium*** (for the dam area) but very low for the tributaries with a ***moderate*** impact significance.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	**Low 2**	Medium 3	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	**6 Moderate**	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures

- The map below shows the spawning and breeding habitats while table gives the key characteristics of the ***spawning*** areas/habitats of these species and suggested measures for protection of these ***spawning*** sites. It is evident that whereas there are some ***spawning*** areas lie above the proposed dam site on Mishumba RIver, there a number of alternative ***spawning*** areas just below the dam and in other tributaries (Chezho River, Rwemango River and Kyabaganda River) in the catchment including for Ningu as already existing spawning sites for key fish species. This means the damming will not stop the breeding activities in the catchment for this critically endangered species, and neither will it completely prevent upstream migration in the catchment for purposes of breeding. However as a mitigation, MAAIF using the Fish (Lacustrine Protected Area) Rules, 2007, should gazzatte the identified spawning sites as part of a community protected area against active and destructive fishing, including training, exposure and provision of skills for alternative livelihoods for the fishermen.
- Establish local educational conservation areas for critically endangered species, Ningu and Singida tilapia, covering the key identified spawning areas as indicated in the table below.

- Develop Mishumba catchment-wide species survival plans for Singida tilapia and the Ningu.
- Monitor, capture and translocate live individuals of the Ningu above the dam point to River Rweibare, River Kyabaganda and River Rwemango.



Map showing the spawning and breeding habitats

Protection plan of the identified spawning sites of key indicator fish species encountered in the Mishumba Catchment with suggested protection measures

Sampling point	Vegetation	Depth and Flow Rate	Sediment	Species Spawning in Habitat	Suggested method for protection for breeding and spawin grounds
1	Highly vegetive this is the gauging point for water levels.	deep and fast	Mud and gravel from construction	African catfish and Ningu	Capture & translocation of surviving Ningu to midstream or Rweibare, Chezho and Kyabaganda
2	Little with cactus, but has forest with ferns	Deep and fast	Has rocks from	African catfish and Ningu	Capture & translocation of surviving Ningu to midstream or Rweibare, Chezho and Kyabaganda
3	Highly vegetated	Deep and fast	Boulders with silt and plant debris	African catfish	Capture & translocation of surviving Ningu to midstream or Rweibare, Chezho and Kyabaganda
4	Highly vegetated	Shallow and slow	Mud	African catfish and Ningu	Capture & translocation of surviving Ningu to midstream or Rweibare, Chezho and Kyabaganda
5	Highly vegetated	Shallow and first	Mud	African catfish and Ningu	Capture & translocation of surviving Ningu to midstream or Rweibare, Chezho and Kyabaganda
6	Lititle vegetation with cactus, has ferns and papyrus brought by flood.	fast and deep	Mud and silt from marram rocks.	African catfish and Ningu	Capture & translocation of surviving Ningu to midstream or Rweibare, Chezho and Kyabaganda
7	Highly vegetated	Shallow& slow	Mud	Redbelly tilapia	Maintenance of aquatic vegetation and periodically monitor the species occurrence.
8	Vegetated with a confluence	deep and fast	mud with silt	Ningu	Maintenance of vegetation at site, with fast moving waters.

9	Highly vegetated	deep and slow	clay and gavel	Albert tilapia & Redbelly tilapia	Create a Community facilitated Ningu Educational Conservation Site and ban fishing during rainy seasons.
10	highly vegetated	deep and slow	silt, mud and pebbles	Albert tilapia & Redbelly tilapia	Create a Community facilitated Ningu Educational Conservation Site and ban fishing during rainy seasons.
11-A	Highly vegetated	shallow and fast	silt and pebbles	Ningu	Create a Community facilitated Ningu Educational Conservation Site and ban fishing during rainy seasons.
11-B	Highly vegetated	deep and slow	Mud	Albert tilapia & Redbelly tilapia	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
12	Moderately vegetative with cultivated land	Shallow & slow	Mud with pebbles	Albert tilapia & Redbelly tilapia	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
13	Modedrately vegetative with cultivated land.	Shollow & slow	Mud with pebbles.	Mudfish (Clarias carsonii)	Create a Community facilitated Ningu Educational Conservation Site and ban fishing during rainy seasons.
14	Moderately vegetative	Shallow and fast	silt wth mad	African catfish and Ningu	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
15	highly vegetative	Deep and fast	silt with pebbles	Ningu	Create a Community facilitated Ningu Educational Conservation Site and ban fishing during rainy seasons.
16	highly vegetative this forms aback pool of water	deep and fast	mud with a lot of plant debris at bottom	African catfish and Ningu	Create a Community facilitated Ningu Educational Conservation Site and ban fishing during rainy seasons.
17	highly vegetative this forms aback pool of water	deep and slow	mud with silt	Albert tilapia & Redbelly tilapia	Create a Community facilitated Ningu Educational Conservation Site and ban fishing during rainy seasons.

18	Highly vegetative	Deep and fast	gravel and silt	African catfish and Ningu	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
19	Highly vegetative	Deep and fast	mud, plant debris and marram pebbles	African catfish and Ningu	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
20	Highly vegetative	deep and fast	clay, plant debris and pebbles from the marram road	African catfish and Ningu	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
21	highly vegetative surrounded by gardens and within flood plain	shallow and slow	mud and plant debris	Singida tilapia, Albert tilapia and Redbelly tilapia	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
22	highly vegetative	deep and slow	Mud	Singida tilapia, Albert tilapia and Redbelly tilapia	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
23	highly vegetative	deep and slow	Mud	Singida tilapia, Albert tilapia and Redbelly tilapia	Continous monitoring, and regulation and control of fishing activity during peak of breeding.
24	highly vegetive	deep and slow	mud	Singida tilapia, Albert tilapia and Redbelly tilapia	Create a Community facilitated Singida tilapia Educational Conservation Site and ban fishing during rainy seasons.

d) **Reduction of woody vegetation during site clearance:** Some trees, shrubs and herbaceous plants will be cut down during site clearance. The herbaceous vegetation regenerates faster than the woody plants, but the slow-growing woody species take longer to regenerate, hence reduction in woody vegetation. There will be loss a certain of trees yet they are key to the natural regeneration processes of the vegetation communities. They act as source of seed for re-colonization and hence important for recruitment and succession. Their removal will reduce the regeneration potential of the affected species. This impact is direct and long-term basis (immediately, during and construction) since it will be restricted to the project area. The receptor sensitivity is assessed to be medium because impact is likely to be continuous during operation phase. This is temporary and can be reversible impact. The impact Intensity is low affecting about 1 km² of dam area with a moderate impact significance.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	**Medium 3**	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	**6 Moderate**	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation proposals:

- Sensitize workers about the need to conserve biodiversity and role of trees and other plants in the environment i.e., before operations.
- Replant low-stature trees indigenous to the area along the affected areas but outside the right of way beneath the transmission lines, after construction.
- During operations, spare the large trees by circumventing the routing of the transmission line and/or access roads, as much as possible.
- Support monitoring of performance of the planted trees i.e., after planting (operation phase).
- Support community-led nursery establishment, tree planting and agro-forestry (fruit trees)

e) **Pollution due to oil spills and leakages, as well as agro-chemicals and pesticides:** During construction activities oil spills from dispensing fuel during maintenance of vehicles and equipment could result in contamination of water sources or soil sediments. This may be so especially if old equipment's are used in the construction. Excessive use of agro-chemicals and pesticides during the operational phase may also cause pollution of the water sources especially downstream. Oil spills and excess agro-chemicals are a major irritant that will contaminate food sources, displace species to different areas where conditions are habitable. Spills of petroleum products into water have also been shown to inhibit tadpole growth and prevent metamorphosis in amphibian breeding. The will an indirect and negative temporarily lasting impact during the construction work activities. It will possibly occur with moderate magnitude. This impact is direct. It's on short-, medium- and long-term basis (immediately and during construction). The receptor Sensitivity is assessed to be high because impact is likely to be continuous during operation phase in irrigable area. This is temporary and can be reversible impact. The impact Intensity is low but to some extent it directly affects human health and its associated medical costs. It has a moderate impact significance.

<table>
<tr><th colspan="2" rowspan="2">Impact Significance</th><th colspan="4">Sensitivity of Receptor</th></tr>
<tr><th>Very Low
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Moderate</td><td>12
Major</td></tr>
<tr><td>High
4</td><td>4
Minor</td><td>8
Moderate</td><td>12
Major</td><td>16
Major</td></tr>
</table>

Mitigations and enhancements

- Impact cannot be avoided and requires effective risk management
- Avoid intentional spilling of petroleum products.
- Implementation of the water act and wetlands policy, specifically articles that prohibits pollution and dumping of waste.
- Machinery should be well serviced and should be in good working condition. Servicing of equipment's should be done at camps far off the project area.
- Farmers be advised to purchase MAAIF and UNBS approved agrochemicals from licensed agrochemical shops. They should also use the chemicals in recommended application rates.
- Train famers on purchase of right agrochemicals, their safe transportation, storage, safe application, and proper disposal of used and contaminated containers.
- Support local farmer cooperative to supply agro-chemicals and seeds
- Promote ecologically friendly agricultural farming (organic and climate smart agriculture, Community Supported Agriculture (CSA)
- For fuel dispensers at camps, workshops and equipment areas, the fuel tanks shall be kept in bunded walls to contain any spills and dispensing areas paved with drainage fitted with oil interceptors. Oil spill kits shall be kept at active construction sites, workshops to handle and accidental spills.

f) Vibration from machinery and Noise nuisance: It is envisaged that the likely sources of noise will be from the movement and operation of machines, trucks and equipment. The operation of heavy construction equipment may also result in minor vibrations at the immediate project site under construction. Noise may be a major irritant, in some cases interrupting communication and eventually social organization of amphibians, birds and mammal communities. This impact is negative and direct but of short-term basis (immediately and during construction). The receptor sensitivity is assessed to be low. This is temporary and reversible impact. The impact intensity is low because it will be experienced during the active hours of the construction activities. It has minor impact significance.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	**Low** **2**	Medium 3	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low **2**	2 Minor	**4** **Minor**	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigations and enhancements

- Where applicable, equipment should be fitted with silencers to reduce noise.
- Machinery should be well serviced and in good working condition in order to limit noise production by machines.
- Adhere to Occupation and Health Safety requirements
- Noisy activities and use of heavy vibration equipment shall be restricted to day time.

f) **Impairment of regulating ecosystem services due to habitat alteration**: The regulating services of ecosystems i.e., the benefits obtained from an ecosystem's control of natural processes will be altered. Any activity that affects the structure, diversity or composition of a habitat naturally affects its ability to provide ecological services. These regulating services that will be altered include the habitat's ability to cycle nutrients, reduced ability for water cycling, reduced regulation of carbon levels in the atmosphere, changes in suitable habitats to biodiversity, reduced ability to control soil erosion and flooding and hence affecting the watersheds. This is short, medium term (2-years), direct and indirect impact but not continuous. The receptor sensitivity is assessed to be high; it will disrupt regulating ecosystems services which in term will impact on the provisioning services (esp. fish, water) as well. This is temporary and can be reversible impact. The impact intensity is low and a moderate impact significance.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	Medium 3	**High** **4**
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 **Minor**	4 Minor
	Low **2**	2 Minor	4 Minor	6 Moderate	**8** **Moderate**
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures

- Efforts should be made to circumvent the most sensitive natural vegetation areas such as gallery forest and localized groundwater swamp starting at point 16 (S0.932036°, E30.638183°) going downstream.
- Efforts should be made to protect water catchment areas upstream Efforts should be made to protect water catchment areas upstream by restoring degraded wetlands and riverbanks, through community collaborative groups.
- Provide extension services to the host communities to diversify their agricultural activities and thence income, in order to reduce encroachment on wetlands and riverbanks.
- Undertake compliance assistance and sensitization of communities on benefits of sustainably utilizing and managing natural resources (wetlands, riverbanks, forests, etc).

g) **Interference and reduced water flow in the river:** Reduced water flows during construction works and the reduced quality of return flows is likely to impact on downstream ecosystems i.e., between the dam site and the confluence with Rweibara. The needs of water biodiversity downstream will be compromised since a diversion channel large enough to convey water will be created. This will allow the river to continue flowing through the natural course hence the downstream aquatic biota may not be affected by changes to the hydrology or morphology of a river system. The impact will be direct and negative to occur with a small magnitude. It will be very low during wet seasons and low in dry season. This impact is negative and direct. It's on short and medium-term basis (immediately and during construction). The receptor sensitivity is assessed to be low because it will not affect ecosystems. This is temporary and reversible Impact. The impact intensity is low because it will have to happen during construction phase of 2 years. It has minor impact significance.

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Moderate</td><td>12
Major</td></tr>
<tr><td>High
4</td><td>4
Minor</td><td>8
Moderate</td><td>12
Major</td><td>16
Major</td></tr>
</table>

Mitigation measure

- Create a diversion channel (a coffer dam/dyke so that the river-flows through) around the construction site to allow for continued flow downstream during construction and filling of the reservoir.
- Maintain the recommended e-flows in the river proposed under Chapter 6, section 6.4. filling of the reservoir

h) Conflict over Leadership & Management roles

There are possible conflicts of leadership and management roles among community stakeholder such as project committees, grievance redress committees and village councils. The drivers for the conflict would be due to sharing rewards and opportunities from the ICRP. This is short, medium term and direct impact but not temporary. The receptor sensitivity is assessed to be low; it will to some extent disrupt some project activities. This is impact is reversible. The impact intensity is low and its significance is minor impact.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	**Low** **2**	Medium 3	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low **2**	2 Minor	**4** **Minor**	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures:

- Ensure stakeholder involvement and participation in all project stages.
- Ensure transparency in electing community committees e.g., project management committees through open nomination and/or voting mechanisms.
- Provide regular extension services such as training the various community and farmer groups on basic management approaches and resolution of conflicts/ differences.

i) Destruction of cultural heritage and archaeological sites: The construction works will destroy some identified archaeological sites such as Early Stone Age (ESA) lithics (Acheulian) and Middle-Late Stone Age lithics (MSA-LSA, Sangoan and Lupemban). The sites are the type locality for the Nsongezi Series (ICRP-ESIA Report, 2019). However, the sites are of low and limited significance to the community in terms of past and present traditional, spiritual and sacrificial importance. This impact is long term, direct and permanent. The receptor Sensitivity is assessed to be very low because communities have limited relationship with the sites. This is temporary and can be Irreversible Impact. The impact Intensity is very low and impact significance is negligible.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	Medium 3	High 4
Intensity of Impact	**Very Low** **1**	1 **Negligible**	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures

- Sensitize local community about archaeological findings before site clearance to the community and its leaders
- Report any unforeseen discovery of cultural significance during construction works to the Department of Museums and Monuments.

j) **Risks of increased Incidence& Prevalence of HIV/AIDS and STDs:** Like any other project with mass recruitment, influx of immigrant labour is bound to occur. Most often these workers will not come with their families and some may be single. This will encourage the formation of new social networks with the resident community; increase in sex workers (prostitution) and the spread of HIV/AIDS and STDs. Additionally, sex workers may camp in the project area to engage in prostitution with construction workers. It should be noted that HIV prevalence rate in Isingiro district is at 6% slightly higher than the 5.9% National prevalence rate. With an influx of workers for a period of 2 years, the risk of increased incidence and prevalence of HIV is may be moderate. HIV/AIDs negatively affect life and productivity at individual, household and community levels. This impact is short, medium and long term. It has direct, continuous and permanent dimensions. The receptor sensitivity is assessed to be low since HIV/AIDS already exists and there are health facilities in the project area but the intensity impact may be high due to its related disasters. This is a permanent, continuous and irreversible impact hence a moderate impact significance.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	**Low 2**	Medium 3	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	**8 Moderate**	12 Major	16 Major

Mitigation measures

- Contractors should implement HIV/AIDs workplace policy
- Sensitize workers and community on HIV/AIDs prevention, HIV Testing, counseling and condom distribution be encouraged for both workers, sex workers and local community. The pathways for transmission of HIV/AIDS and STIs are well known, foreseeable and can be mitigated.
- Prioritize recruitment of local people for casual jobs in order to minimize labour influx.
- Institute a code of conduct for workers to regulate their social behaviour among the community.

- Accommodate most of the migrant workers in camps to minimize interaction with the host communities.

8.2.3 Dam filling Phase

The Risks expected during the dam filling were assessed and analysed as detailed below:

a) **During dam filling there will be alterations in physical chemical conditions of the river** both within the reservoir and downstream of the dam that may have serious negative effects on the aquatic systems such as effects from the alteration of the natural temperature, sedimentation and flow regime resulting in increased vulnerability of the downstream area. There is expected to be alterations in physical chemical conditions will the filling of water reservoir including electrical conductivity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Nitrates, Phosphate levels, attributed to accumulated organic matter with sudden and intense changes in the key attributes of aquatic habitats, followed by predominantly heterotrophic processes, with possible thermal stratification and anoxic conditions. With changes in species dominance leading to displacement and or loss of some species.

Mitigation measures

- The changes in physical chemical conditions of the reservoir and downstream of the dam site will have to be monitored and water flow adjusted according to EFR to reduce or eliminate any serious negative effects of the dam filling on the physical and biological aquatic systems.
- There shall be continuous survey and assessment of the water reservoir and downstream conditions and communities while filling of water reservoir so as to allow for exit route (migration) of displaced species further downstream or facilitated movement of such forms to more appropriate habitats within the catchment.

b) **There is expected to alterations and changing levels in Total Suspend Solids (TSS) and water turbidity, accompanied by increased retention of large particles and continued flow of the smaller and more fine particles.** This change in water clarity and reduced flow of sediments will impact both the biological colonization in the reservoir and existing life forms downstream of the dam leading to ecological imbalances and likely migration or loss of other forms.

Mitigation measures

- The monitoring plan should be implemented to regularly assess changes in physical parameters including TSS and turbidity, with necessary adjustments in water flow and adjustments in sediment flow at the spillway so as to allow heterogenous particle flow downstream.

c) **Eutrophication and floating aquatic vegetation.** Eutrophication is expected to occur in the reservoir due to the sendentary waters waters, nutrient loading from flooding of nearby grounds, causing increased algal production and increased emergence of aquatic vegetation including floating weeds, which results in temporary loss/destruction of fishery habitats; loss of feeding and breeding cues for aquatic organisms including fishes; emergence of nuisance species and disease vectors such as mosiquitos; and rapidly diminishing water flow currents that may lead to disorientation of fishes and other aquatic organisms. Owing to the limited fish stocks, primary nature of river upstream of the dam, and limited vegetation upstream, the filling of the dam will medium intensity of impact. Also given that upstream had relatively minor aquatic biodiversity, both in number and species richness, the sensitivity of the receptor will be medium. It is also expected that the fish and other aquatic biodiversity will have moved downstream with perturbances felt during the dam construction through the diversion channels set up to facilitate dam construction. This therefore makes the impact moderate and reversible.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	**Low 2**	Medium 3	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	**4 Minor**	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation

- Removal of debris and minimizing of cutting of vegetation prior to filling of the reservoir to avoid extensive rotting and enrichment of the waters.
- The refilling plan should include occasional drawdown of reservoir water levels so as to get rid of the aquatic weeds.

8.2.4 Operation and Maintenance phases

a) Habitat loss: During the implementation phase, there will be further vegetation clearance in the downstream as cultivation intensifies. The availability of water will encourage farming on large scale hence increased hectarage of most farmers. This will farmers to clear the remaining riverine vegetation hence reducing the habitat. Furthermore, for easy access most of the established facilities, access roads will be constructed, or the existing ones will be improved. If this option is upheld, there will be some disturbance of both the physical and biotic components of the environment in the project area. Habitat disturbance, fragmentation and eventual loss, due to vegetation clearance and excavations can impact fauna groups. The destruction will lead to loss of foraging, basking, roosting, patching, reproduction and hiding habitats for fauna. Modification of the natural landscape through deforestation, urbanisation and agricultural encroachment, and the subsequent alteration of water bodies by erosion, eutrophication and siltation, is impacting on the ecological status of Odonata in Africa (Dijkstra *et al.,* 2011). Birds also occur across a broad geographical range and in a large number of habitat types; and some species specialize within narrow habitat bands which renders them sensitive to habitat change (Davenport, T. and Howard, P. 1996). The habitat/vegetation loss will slightly affect the home range quality of the fauna species but restricted to the project activity sites not the whole catchment. This is likely to be of low magnitude with significant impact in periods of intense project activity. Also, the impact of upgrading the existing roads on the vegetation will instead be less. This is long term, direct and continuous. The receptor sensitivity is assessed to be low because it's anthropogenic in nature. This is permanent and can be reversible Impact. The impact Intensity is low with minor impact significance.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	**Low 2**	Medium 3	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	**4 Minor**	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation and enhancement measures

- All farmers should be sensitized to increase their awareness about the need to minimize environmental damage while carry out vegetation clearance during cultivation in the irrigable area and limit vegetation clearance to portions of the land to be affected. This is to allow fauna to migrate to adjoining bushes during the operations.
- Relocate animals that cannot flee on their own and this should be done by qualified/trained person.
- During vegetation clearance, spare mature indigenous trees whenever possible.
- Restriction of the activities only to the areas that must be disturbed to avoid unnecessary habitat loss or alteration.
- Closely monitor and supervise the irrigation operations to ensure compliance with the EFR and BEMP. This role should begin with the project staff but will also require regular checking by the relevant officers responsible for compliance of development projects to the approval terms and conditions.

b) Proliferation of invasive species of plant: Invasive plants have a large potential to suppress the native flora and change the structure and composition of the vegetation as they spread to spread prolifically. Already, at least two species occur within the project area, i.e., *Lantana camara* and *Mimosa pigra*. This impact is negative, direct and indirect. It's on medium- and long-term basis. The receptor sensitivity is assessed to be medium because it affects structure of vegetation with more disturbance compared to humans and livestock. This is continuous, permanent and reversible impact. The impact intensity is medium. It has moderate impact significance.

Impact Significance	**Sensitivity of Receptor**			
	Very Low 1	Low 2	**Medium 3**	High 4

Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium **3**	3 Minor	6 Moderate	**9** **Moderate**	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation proposals:

- Sensitize workers and communities about the dangers and threats the invasive species pose to ecosystem stability so they minimize moving them into or out of the project area.
- Restore disturbed areas immediately after operations to allow natural regeneration take place to close up the disturbed areas with natural vegetation.
- Monitor growth of invasive species of plants.
- Mechanically remove them before flowering/fruiting stage.

  The importation of good soil from other places for restoration should be avoided as this is likely to introduce invasive species of plants.

c) **Reduced Water Flow in the river:** Impounding water for irrigation may impact on downstream ecosystems in the irrigable area. The needs of water fowl and downstream aquatic biota may be affected by changes in the hydrology or morphology of a river system. This indirectly impact on breeding in bird species richness and population abundance since it may decrease as a result of reduced water flow. Water birds that use the project area for feeding purpose may go elsewhere in search for food in wetter areas. Reduced water flow will have an impact on vegetation which also form nest-building materials for birds, which material is concentrated in riparian areas. Amphibians are the land animals that retained some aquatic adaptations, and thus require water for many important parts of their life cycle and way of life. Amphibians need water for reproduction, respiration, feeding, etc. Reduced water flow affects the hatching of insects or availability of insects on which amphibians, reptiles and birds depend. Reduced water flow can affect dragonfly larval stages by altering stream environmental conditions, and adults by loss of perches, shade and hunting habitat.

   As noted earlier, the alterations in water flow and damming of River Mishumba will also impact the distribution and occurrence of key fish species, and the damming initially will change the migratory patterns of the fish species from upstream of River Mishumba to use of fast flow sections in midstream and other adjoining channels such as Chezho River for breeding purposes.

   However, in case the recommended EFR plan is followed, the impact this impact operation phase will be of insignificant magnitude in both dry and wet seasons. This impact is negative and direct. It’s on low - and long-term basis. The receptor sensitivity is assessed to be medium because it affects ecosystems. This is permanent and reversible impact. The impact intensity is low because e-flows to be released have been estimated and recommended. It has moderate impact significance.

Impact Significance		Sensitivity of Receptor			
		Very Low 1	Low 2	**Medium 3**	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	**6 Moderate**	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigations and enhancements

- Periodic release of water or recharging of the rivers in in line with set flows (Table 6-27) be done to keep the processes and survival of biota in the downstream areas.
- Key or major breeding areas will be mapped and considered as "ecological significant areas" and where appropriate provide with special protection measures to allow continued breeding of the target species. The special protection measures will include water flow adjustments, use of bypasses in case of increased flow, or provision of high flows to maintain fast currents for those species that prefer fast flowing water during the breeding season (refer to the map showing spawining areas above).
- Maintenance and protection of swamps to allow for continued ecological services including feeding, breeding and nursing of both aquatic and terrestrial wild life. The wetlands will be protected against reclamation and or being overflooded.
- Creation of habitats within Mishumba channel and or within adjoining streams as alternatives to those that may have been submerged or dried out, or in response to displacement of species that are need of breeding areas. This will include use of akadijas, water channeling, water flow adjustments, among others.

d) **Water abstraction and farming close to river channels in the irrigable area**. Review of the set EFR and consideration that livestock is predominantly downstream of Mishumba catchment, the development of the irrigation scheme will have none to negligible impact on live stock . The impact magnitude will be small since e-flows requirements took into consideration the social economic needs. Additionally, the presence of more adjoining streams of Rweibare, Chezho, Rwemango and Kyabaganda with adequate flows will maintain the water availability downstream of the dam. This impact is negative and direct. It's on medium- and long-term basis. The receptor sensitivity is assessed to be medium because it affects ecosystems. This is likely to be permanent and reversible impact. The impact intensity is very low since the affected stretch will only be between the dam site and the Chezho confluence. It has minor impact significance.

Impact Significance		Sensitivity of Receptor			
		Very Low 1	Low 2	**Medium 3**	High 4
Intensity	**Very Low 1**	1 Negligible	2 Minor	3 Minor	4 Minor

	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigations and enhancements

- Water abstraction and release should strictly follow the set e-flow requirements in Chapter 6 – Section 6.4. It should be noted that the fish ponds will not be affected because they only divert water during rainy season and have been catered for in the e-flow requirements.
- Establish and maintain a buffer zone along the river banks as provided in law. The buffer zone is 30 meters away from the highest water point as per the National Environment, Wetlands, River Banks and Lake Shores Management Regulations, No. 3/2000.

e) **Loss of early March - April flow pulse:** Loss of opportunity for strong spawning cues in some years, potentially reduces spawning and recruitment over sequences of years. Therefore, this potentially inhibits downstream migration for Victoria carp and African catfish. It also increases the exposure probability of breeding individuals to be trapped and caught by fishers. In addition, there is a likelihood of capturing destructing juveniles migrating back to the open waters for feeding.

Mitigation Measures

Use of set e-flows to create high pulse flows for at 4 days so as to provide the breeding and spawning cue for the target upstream migratory species at the beginning of the rain season (March, sometimes April), and at the end of the rain season (June or July) to allow for downstream migration of the spent females and hatchlings.

f) **Reduced high flow (bank full flood) April - May and July – October**: This leads to loss of substantial food resources and habitat in shallow flooded areas for the *Singida tilapia, Albert tilapia, Zilli's tilapia, African catfish, Victoria carp* and *haplochromines*. This also inhibits downstream migration of *Victoria carp* and *African catfish*.

Mitigation Measures

use of set e-flows to allow for high flows for at least 4 days to allow for continued flooding of the plains, and their use for lateral migration for purposes of feeding and breeding especially of the sedentary water loving forms

g) **Likely loss of fish habitats for feeding, breeding, spawning and nursing, and curtailing downstream or upstream, and lateral migration of fishes**

Mitigations

- stablishment of a special fish propagation and release station
- declare a general fishing ban in the upper to allow the remaining individuals to recruit
- Put in place rigorous fishing reporting and monitoring program with community sensitization and participation
- Regulate and control the extraction of natural resources, especially plants, gravel and stone excluding from gazzetted breeding areas to avoid alterations to the hydro-geomorphological characteristics that migratory species seek for their reproduction.
- Conduct periodic studies (yearly for the first 3 years of operation, and then biennial) to determine the impact of irrigation, agro-industrial waste and changed resources extraction patterns on the fish species in Mishumba River
- Initiate a system for monitoring the density of larvae and their identification using NGS metabarcoding,
- Establish information campaigns with participation and involvement of the attendant fishing communities so to raise awareness of the importance of the target spawning area for local fisheries
- Strengthen management and use of irrigable area to eliminate or reduce foreseen impacts on fish and aquatic biodiversity and inculcate the value of biodiversity protection, highlighting the importance of rivers and their connectivity for conservation.

h) **Regulation will reduce low flows from December to March during the dry period, and after regulation:** there will be a reduction in depth of refuge pools in the river and possibilities of desiccation. This may expose fish to predators due to capture and with time this may result into possibilities of desiccation and reduction in feeding grounds. This will be an indirect and low negative impact, with high chances to occur. The impact magnitude will be moderate.

i) **Loss of overbank flood July – October:** This leads to reduction of food resources and habitat on floodplains. A reduction of sediment concentration results in Dissolved Oxygen (DO) increases and fish mortality decrease. These further changes competition and predation and loss of opportunity for creating new competitive advantages for some species e.g., the *Singida tilapia, Albert tilapia, Zilli's tilapia, African catfish.*

j) **Increased inter-annual flow variability of high flows and overbank floods July – October:** There may be increased variability of recruitment over sequences of years which increase variability of downstream migration over sequences of years for *Singida tilapia, Albert tilapia, Zilli's tilapia, African catfish.*

k) **Altered duration of high flows and overbank floods July – October:** A decreased duration of availability of food resources and habitat in backwaters and floodplains, lowers growth rates and lower body size, higher mortality from competition whereas an increased duration of availability of food resources and habitat in backwaters and floodplains, triggers higher growth rates and increased body size, higher mortality from predation of *Singida tilapia, Albert tilapia, Zilli's tilapia, African catfish.*

l) **Reduction in flow and discharge in April – June** due to impoundment and or abstraction for agricultural production may result in reduced recruitment due to mortality of fry and juveniles. There is easy capture of spent females and males returning from breeding and nursing ground that leads to failure to mate and spawn due to lack of passage Larval and juvenile habitat decrease as well as loss of fish passage.

m) **Regulated flow regimes, and increase in unnatural sedimentation, and pollution**: this **e**xposes the fish to predators and excessive capture due to capture. It affects the survival of fish, interfere with feeding, respiratory, and reproductive activities of fish and other aquatic organisms and directly impact on the health of the aquatic organisms.

These will be indirect and lowly negative impacts, with high chances to occur and large impact magnitude. This impact is negative and direct. It's on medium- and long-term basis. The receptor sensitivity is assessed to be medium because reduced river flow affects humans and biodiversity. This is permanent and reversible impact. The impact intensity is low since it only partially affects the area between the dam site and the Chezho confluence beyond which, there is enough water based on the contribution of independent streams i.e., Mishumba (43%) whereas Chezho and Kyabaganda contribute about 57%. In addition, the contribution of Rweibare stream just downstream of the damsite, will not render the river dry as it contributes about 18% of the flows in this section and e-flow requirements have been set and recommended. It has moderate impact significance.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	**Medium** **3**	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low **2**	2 Minor	4 Minor	**6** **Moderate**	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigations and enhancement for (g) to (l)

- Water flow rates regulation and release must comply with set e-flow management plan.
- Periodic recharging of the rivers in dry periods with irrigation water should be done.
- The environmental flow requirements (EFR) in section in should be implemented and followed.

n) **Impairment of ecosystem service provision due to habitat alteration:** The provision of ecosystem services is one of the areas that are bound to be affected by the proposed activities. Any activity that affects the structure, diversity or composition of a habitat naturally affects its ability to provide ecological services. These services may include the habitat's ability to cycle nutrients, contribute to water cycling, regulate the carbon level in the atmosphere, provide suitable habitat to biodiversity, control soil erosion and flooding and acting as watersheds. This impact is direct, medium and long term. It's continuous and the receptor sensitivity is assessed to be low; it will disrupt all ecosystems services. The impact intensity is low. It has a moderate impact significance.

Impact Significance	**Sensitivity of Receptor**			
	Very Low	**Low**	Medium	High

		1	**2**	3	4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	**6 Moderate**	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation proposals

- Efforts should be made to circumvent the sensitive natural vegetation areas such as gallery forest and localized groundwater and floodplains particularly at S0 52.685 E30 35.923 (site 2) in Rwoho CFR.
- Efforts should be made to protect water catchment areas upstream.

o) Gender based constraints and vulnerability: There are possible gender constraints and vulnerabilities affecting poor women, youth, children headed households, older persons and disabled persons. These include: a) v*ulnerability to market forces* resulting from new competition; price fluctuations of agricultural produce especially vegetables; b) climate change related vulnerability to hazards such as floods in downstream areas resulting from overflow of rivers in Nyakitunda sub county (outside dam site), as well as reduced adaptive capacity among the poor households. This impact is medium and long term. it has indirect, continuous and permanent dimensions. The receptor sensitivity is assessed to be medium because it scales up vulnerability among the poor of the poorest. This impact is permanent, continuous and reversible. The impact Intensity is medium and impact significance is moderate.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	**Medium 3**	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	**9 Moderate**	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures

- Support community groups (women, youth, disabled persons, older persons) with production inputs as a measure of production safety nets.
- Support livelihood restoration activities

p) Increased use of agro-chemicals: The operation of ICRP will scale-up use of agricultural chemicals for growing vegetables mainly. There are also risks of exposure to fake agricultural chemicals. These agricultural chemicals have diverse negative effects on environment and human health. This impact is medium and long term. It has direct, continuous and permanent dimensions. The receptor *Sensitivity* is assessed to be medium because agricultural chemicals have diverse negative effects on environment and human health. This impact is permanent, continuous and reversible. The intensity is medium and impact significance is moderate.

<table>
<tr><th colspan="2">Impact Significance</th><th colspan="4">Sensitivity of Receptor</th></tr>
<tr><th colspan="2"></th><th>Very Low
1</th><th>Low
2</th><th>Medium
3</th><th>High
4</th></tr>
<tr><td rowspan="4">Intensity of Impact</td><td>Very Low
1</td><td>1
Negligible</td><td>2
Minor</td><td>3
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Minor</td></tr>
<tr><td>Low
2</td><td>2
Minor</td><td>4
Minor</td><td>6
Moderate</td><td>8
Moderate</td></tr>
<tr><td>Medium
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Minor</td><td>6
Moderate</td><td>9
Moderate</td><td>12
Major</td></tr>
<tr><td>High
4</td><td>4
Minor</td><td>8
Moderate</td><td>12
Major</td><td>16
Major</td></tr>
</table>

Mitigation measures:

- Conduct farmer training and sensitisation on proper use of agricultural chemicals.
- Support farmer groups in accessing quality agricultural chemicals and safety equipment.
- Restriction on types and quality of agro-chemicals used
- The developed pest management plan should be adopted

  Directorate of Water Resources to undertake periodic (fortnightly) monitoring of water quality in order to detect and timely avert any pollution from agrochemicals.

q) Land conflicts and evictions

The ICRP will increase the demand for cultivable land and settlements. Within the irrigable area, there is likelihood of land conflicts resulting from eviction and/or restriction on cultivators within swamps and privately owned lands. It should be noted that landlords hire out land to cultivators especially in downstream areas of Ntundu. This impact is short and medium-term. It has direct, continuous and permanent dimensions. The receptor sensitivity is assessed to be high because the poor households depend on land, including women who often do not have land ownership rights. This is a permanent, continuous and irreversible impact. The impact intensity is low since the land tenure system can be controlled and impact significance is moderate.

<table>
<tr><th colspan="2">Impact Significance</th><th colspan="4">Sensitivity of Receptor</th></tr>
<tr><th colspan="2"></th><th>Very Low
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<tr><td rowspan="4">Intensity of Impact</td><td>Very Low
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Major</td></tr>
<tr><td>High
4</td><td>4
Minor</td><td>8
Moderate</td><td>12
Major</td><td>16
Major</td></tr>
</table>

Mitigation measures:

- Sensitize communities about environmental laws for wetlands/swamps, land rights, etc.
- Establish and maintain a buffer zone along the river banks as provided in law. The buffer zone is 30 meters away from the highest water point as per the National Environment, Wetlands, River Banks and Lake Shores Management Regulations, No. 3/2000.

r) Encroachment on floodplains in the irrigable area in search of cultivatable land

There will be increased encroachment on floodplain in search of cultivable land for crops. This impact is short, medium and long term. It has direct, continuous and permanent dimensions. The receptor sensitivity is assessed to be medium because encroachment affects natural resources. This is a permanent, continuous and reversible impact. The impact Intensity is low since it can be easily controlled legally and impact significance is moderate.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	Low 2	**Medium 3**	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	**6 Moderate**	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures:

- Sensitize communities about environmental laws wetland, forest, land rights, etc.
- Demarcate buffer zones for swamps and rivers
- Regulate / provide appropriate resource user rights
- District Environment Officer and NEMA to enforce the National Environment (wetlands, Riverbanks, and Lakeshores) Management Regulations.

s) Use of irrigation water for domestic use (drinking, cooking, bathing, washing)

The irrigation networks are more likely to be used as domestic water sources, to collect water for drinking, bathing, washing and other domestic shores. This is because at present access to safe and clean water (piped water, boreholes) is limited. The piped water system only covers Kabuyanda Town Council. Communities rely on river streams which are located in valleys. The irrigation distribution networks will act as alternative sources, yet they have untreated water. The continuous use of unsafe water is likely to affect human health by increasing human health risks such as incidence of water related diseases. Even when people are given new safe water sources, it will not generally stop the use of irrigation networks for domestic purposes. This impact is short, medium and long-term. It has direct, continuous and permanent dimensions. The receptor sensitivity is assessed to be low because the demand for water for domestic use will not vary much. This is a permanent, continuous and reversible impact. The impact intensity is low and impact significance is minor.

Impact Significance		**Sensitivity of Receptor**			
		Very Low 1	**Low 2**	Medium 3	High 4
Intensity of Impact	Very Low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	**4 Minor**	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation measures:

- Provide alternative safe water sources especially piped water supply.
- Sensitize about prevention of water related diseases
- Establish conditions for eligibility for ICRP that encompass household to have basic household sanitary facilities such as pit latrines, energy saving stove, clean drinking water containers.

t) **Sedimentation:** The expected sediments from project catchment area (90km²) to be trapped by the dam will be 241.7 Ton/km²/year. This is equivalent to 30.68% of the 21,750 tons/year (total sediment) from the entire catchment area (293.31 km²) to be realised at the main outlet (Final Design Report, MoWE 2019). According to Section 6.4 above, the fast flows (velocities) and slope don not allow deposition of sediments between sampling point 3 and 15. This is true for both the current situation and all the three (3) scenarios that deposition will not take place in this river section. The downstream swamp of Mishumba provides several ecosystem services including sediment trapping, flood attenuation, streamflow regulation, water quality enhancement benefits, carbon storage, biodiversity maintenance among others. However, sediment accumulation in a swamp/wetland impact species richness by smothering plants. This implies the impact of 30.68% sediment starvation in Mishumba catchment will lessen on its impacts on the downstream areas and this will be realised in the areas after sampling point 16 where sedimentation takes place in the swamp. In addition, the retention of nutrients upstream (damming of Mishumba), reduction of fertility of swamps, or affecting their carrying capacity will be of negligible limitations on biological productivity like fisheries in areas downstream since the general reduction in sediment is small. Therefore, the impact is likely to happen and will be long-term. It will be indirect and negative small with having a low magnitude and moderate significance.

Impact Significance		Likelihood of Occurrence				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation and enhancements

- Implement targeted sediment management. The Design Report (MWE, 2019) recommended sediment flushing as the mosty viable option for sediment management among the following; sediment bypass and sediment augmentation downstream of reservoir.
- Conduct e-flow and implement the recommended e-flow requirements (Section 6.4).
- For ease of flushing sediments out of the reservoir, the e-flow release structures within the dam should be placed as low as possible to allow as much sediment as possible to pass through the reservoir.

8.2.5 Level of Intensity of Negative Impacts

The intensity of positive impacts has been rated per sections of river stretch (Upstream, Midstream & Downstream) as shown in table below.

Negative Impacts by Level of Intensity (*High = 1; Medium= 2; Low =3)*	**River stretch / section**			**Entire Project Area**
	Up-stream	**Mid-Stream**	**Down stream**	
PRE-CONSTRUCTION PHASE				
High incidence of grievances arising due to delayed and faulted compensation, demarcation of buffer zones and restrictions over resource use	High	Medium	Low	High
Mismanagement of compensation packages at household level	High	Medium	Low	High
CONSTRUCTION PHASE				
Loss of habitat due to clearance of vegetation and physical features from construction sites	High	High	High	High
Loss or injury of fauna				
Reduction of woody vegetation during site clearance	High	High	High	High
Pollution due to oil spills and leakages, as well as agro-chemicals and pesticides	Medium	Medium	Medium	Medium
Vibration from machinery and Noise nuisance	High	Medium	Medium	High

Negative Impacts by Level of Intensity (*High = 1; Medium= 2; Low =3)*	**River stretch / section**			**Entire Project Area**
	Up-stream	**Mid-Stream**	**Down stream**	
Impairment of regulating ecosystem services due to habitat alteration	High	High	High	High
Interference and reduced water flow in the river	High	High	High	High
Conflict over Leadership & Management roles	High	High	High	High
Loss of habitat	High	Medium	Medium	High
Impairment of regulating ecosystem services due to habitat alteration	High	Medium	Medium	High
Destruction of cultural heritage and archaeological sites	Medium	Medium	Medium	Medium
Risks of increased Incidence& Prevalence of HIV/AIDS and STDs	High	High	High	High
OPERATION PHASE				
Habitat loss	High	High	High	High
Proliferation of invasive species of plant	High	High	High	High
Reduced Water Flow in the river	High	High	High	High
Water abstraction and farming close to river channels in the irrigable area	Medium	High	High	High
Regulation will reduce low flows from December to March during the dry period, and after regulation	High	High	High	High
Loss of early March - April flow pulse	High	High	High	High
Reduced high flow (bank full flood) April - May and July – October	High	High	High	High
Loss of overbank flood July – October	High	Medium	Medium	High
Increased inter-annual flow variability of high flows and overbank floods July – October	High	High	High	High
Altered duration of high flows and overbank floods July – October	High	High	High	High
Reduction in flow and discharge in April – June due to impoundment and or abstraction for agricultural production	High	High	High	High
Regulated flow regimes, and increase in unnatural sedimentation, and pollution	High	High	High	High
Ecological imbalances	High	High	High	High
Gender based constraints and vulnerability	High	High	High	High
Increased use of agricultural chemicals	Low	High	High	High
Land conflicts and evictions	High	High	High	High
Encroachment on swamps in search of cultivatable land	High	High	High	High
Use of irrigation water for domestic use (drinking, cooking, bathing, washing)	High	High	High	High

8.2.6 Environment and Social Impact Identification Matrix

The impact matrix below indicates the significance of positive and negative social impacts as well as enhancement and mitigation measures.

Table 8-2: Social Impact Identification matrix for ICRP Kabuyanda (Dam construction & Operations of Irrigation System)

No	POSITIVE Social Impacts	Social	Environmental	Positive	Negative	Direct	Indirect	Short	Medium	Long- term	Significant	Moderate	Not significant	Temporary	Permanent	Continuous	ENHANCEMENT & MITIGATION MEASURES
	PRE-CONSTRUCTION PHASE																
1	Favourable Social acceptability, community involvement and support for ICRP	√		√		√		√	√	√	√				√	√	Make additional stakeholder consultations and information disclosure especially on proposed management plans and BEMP (as per MWE/ESS Policy Framework and OP 4.01)
2	Increased visibility and stakeholder support due to pre-construction engagement such as Field Visits, Design Presentation at DLGs & Ground Breaking ceremonies.	√		√		√			√		√				√	√	Ensure effective and timely information disclosure
3	High incidence of grievances arising due to delayed and faulted compensation, demarcation of buffer zones and restrictions over resource use	√			√	√		√			√			√			
4	Mismanagement of compensation packages at household level	√			√	√		√	√		√				√		
	CONSTRUCTION PHASE																
	Short term direct & indirect employment opportunities for local communities (casual & semi-skilled jobs; local businesses e.g., restaurants, suppliers.	√		√		√	√	√			√			√			• Involve LC 1 village leaders in identifying casual and semi-skilled workers (Offer Identification / registration forms) • Integrate social protection mechanisms such as offering casual jobs to vulnerable and marginalised people using group model (labour intensive public works). NB. Benchmark with NUSAF 3 program funded by World Bank that uses a labour-intensive public works model.
	Potential appreciation of value for property such as land, houses for rent that are near the water facilities (reservoirs, boosters, transmission lines, distribution tanks).	√		√		√	√	√	√	√		√			√	√	Engage local governments to ensure they don't over tax agricultural related value chains
5	Rehabilitation of roads and bridges (feeder and community access roads) in dam site area and irrigable area	√		√		√			√			√		√			Engage with communities and LGs to ensure sustainable road maintenance
6	Increase in positive sexual behaviours due to adherence to social safeguards (e.g., workplace HIV/AIDs policy) for workers at construction sites	√		√		√	√		√		√			√			The contractors should work closely with are health service providers e.g., HIV testing and outreaches
7	Increase in petty trade opportunities – new kiosks will be opened up to serve influx of workers in short run at water works sites.	√		√		√		√	√	√	√				√	√	Ensure effective sensitisation and awareness building
8	Reduced gender disparities in terms of women and youth accessing short and direct employment at construction sites	√		√													As above

No	POSITIVE Social Impacts	Social	Environmental	Positive	Negative	Direct	Indirect	Short	Medium	Long- term	Significant	Moderate	Not significant	Temporary	Permanent	Continuous	ENHANCEMENT & MITIGATION MEASURES
9	Skills transfer / on-Job Training of local workforce in relevant skills e.g., plumbing, painting, etc. the skills transfer will benefit locals.	√		√		√		√	√	√	√				√	√	Offer opportunities for skills transfer by contractors
	Conflict over leadership roles, reporting and motivation packages for project committees	√			√												
	Destruction of cultural heritage and archaeological sites	√			√	√				√			√		√		
	Loss of habitat		√		√	√		√				√		√			
	Impairment of regulating ecosystem services due to habitat alteration		√		√	√	√	√	√			√		√			
	OPERATION PHASE																
10	Transformation of agriculture practice from subsistence to commercial agriculture	√		√					√	√	√				√	√	Integrate with other development programmes in area e.g., OWC, NAADs, etc
11	Sustainable and optimal use of irrigation water resources	√		√				√	√	√	√				√	√	Provide support mini-micro irrigation to vulnerable-poor households
12	Improved food security due to increased crop & livestock production	√		√		√	√	√	√	√	√	√			√	√	
13	Increase in employment in agricultural value chain (direct & indirect)	√		√		√	√	√	√	√	√	√		√	√	√	
14	Increased crop acreage & yields	√		√		√		√	√	√	√	√		√	√	√	
15	Improved social infrastructure (irrigation schemes, domestic water supply, roads, etc)	√		√		√	√	√	√	√	√	√		√	√	√	
16	Gender empowerment and reduced gender disparities	√		√		√	√	√	√	√	√	√		√	√	√	
17	Increased Crop diversification and intensification	√		√		√		√	√	√	√	√		√	√	√	
18	Improved tourism (agro and eco-tourism)	√		√		√		√	√	√	√	√		√	√	√	
19	Increased local trade and value chain development	√		√		√		√	√	√	√	√		√	√	√	
20	Increased rural transformation & urbanization	√		√		√		√	√	√	√	√		√	√	√	
21	Gender based constraints and vulnerability	√			√		√		√	√	√	√			√	√	
22	Increased use of agricultural chemicals	√	√		√	√	√	√	√	√	√	√			√	√	
23	Land conflicts and evictions	√	√		√	√	√	√	√	√	√	√		√	√	√	
24	Encroachment on swamps in search of cultivatable land		√		√	√	√	√	√	√	√	√		√	√	√	
25	Use of irrigation water for domestic use (drinking, cooking, bathing, washing)	√			√	√	√	√	√	√	√	√			√	√	
	DECOMMISSIONING PHASE																
26	Creation of SHORT-TERM employment (Casual jobs) involved in dismantling the work sites / camps.	√		√		√	√	√				√	√	√			

8.3 Cumulative Impacts & Mitigation Measures

This section takes into consideration the definition of cumulative impacts as defined in the earlier ESIA report 2019. The ESIA report states that ***"The U.S. Council on Environmental Quality (1997) defines cumulative impacts as the impact on the environment which results from the incremental impact of the action when added to their past, present and reasonably foreseeable future actions regardless of who undertakes such an action. These impacts can be individually limited but cumulatively considerable, or for which the incremental effects of individual projects are considerable. In practice, assessment of cumulative impacts requires consideration of other assessment concepts, which are different from the conventional approaches used in a normal ESIA"***. This BEMP report complements the ESIA findings.

Under this section, the cumulative impact assessment is based on IFC Good Practice Handbook on Cumulative Impact Assessment and Management (IFC, 2019). The concern for assessment of cumulative impacts is driven by the need to understand the conditions of Valued Environmental and Social Components (VECs) that are expected to result from the combination of development impacts and natural forces. Chapter 4 above presents the baseline conditions that have been benchmarked to come up with Thresholds (limits of acceptable change). According to IFC, if such thresholds are not established, the significance of cumulative impacts cannot be determined.

The cumulative impact assessment of environment and social parameters cover the project area and its influence zone (Mishumba catchment, Sub Counties and districts). It focused assessing impacts in relation to the following aspects;

a) Beneficiaries and the project owners' activities and facilities that are a component of the project;

b) Potential impacts from unplanned, but predictable developments caused by the project that may occur later or at a different location;

c) Indirect project impacts on biodiversity or on ecosystem services upon which Affected Communities' livelihoods are dependent;

d) Associated facilities which are not part of the project but without which the project may not be viable; and

e) Incremental impacts, on areas or resources used or directly impacted by the project, from other existing, planned, or reasonably defined developments at the time the risks and impacts identification process is conducted.

8.3.1 Valued Environmental and Social Components (VECs), Future Conditions & Thresholds

The selection of VECs was done and was based on their viability or sustainability to remain diverse and productive over time despite the irrigation scheme. There is need to ensure sustainable use of resource by both developers and communities. Generally, during VEC selection several factors were taken into account namely; a) Abundance at sample sites; b) Ecological importance; c) Human health; d) Socioeconomic importance; e) Cultural heritage; f) Data Availability. The selected VECs are based on social safeguard perspective and the impacts on VECs presented are successive, incremental, and/or combined, induced.

Table 8-3: Some of the planned and on-going projects within Isingiro (Kabuyanda)

Project	Proximity to or location within the Kabuyanda ICRP	Potential Impact
Existing Projects		
Kikagati Hydropower Project I	The water diversion point ($210m^3/s$, gross head of 8.5m, 11.5m high weir, and 3 turbines) will be located on R. Kagera about 10km downstream of the irrigable area. R. Mishumba (along which the dam will be constructed) is a tributary to R. Kagera	Kikagati HPP I is a 16MW run-of-river (RoR) hydro-electric project located along the Kagera River in West Uganda on the Tanzania-Uganda border. The project is ground-breaking co-operation between the Tanzanian and Ugandan government with power being provided to both countries constructed by Berkeley Energy since 2014. The project's intake, powerhouse, fish ladder and camp site are in Uganda while the animal passage is in Tanzania. The project will have a positive impact to Uganda at large by providing access to power and increased revenue The impoundment or dam catchment of 90 km^2 is about 30% of the total R. Mishumba catchment (294 km^2) and is only 0.15% of the entire R. Kagera basin (58108 km^2) Therefore, the reduction in flows of R. Mishumba will not affect the planned project.
New Water supply system for Kabuyanda Town Council	The water abstraction site is downstream of the dam area, within the irrigation command area and will be a groundwater source (borehole).	It has a positive impact by providing clean and safe water to residents of Kabuyanda Town Council. There is no key interaction between this project and R. Mishumba ecosystem though there is geographical overlap, hence, no negative impact. However, there is likely contamination of groundwater quality in case of excess or uncontrolled use of pesticides under the Kabuyanda irrigation project.

		Therefore, monitoring of groundwater quality within Kabuyanda should be done during operation and maintenance phase.
Planned or Foreseen Projects		
Kikagati HPP II (Nshongenzi)	The water diversion point will be located on R. Kagera about 12 km and 22 km downstream of HPP I and irrigable area respectively. R. Mishumba (along which the dam will be constructed) is a tributary to R. Kagera	The HHP II will involve construction of a weir will be built near the proposed intake (Nsongezi). According to the Feasibility Study prepared by Fichtner in September 2012. The project will have a positive impact to Uganda at large by providing access to power and increased revenue The impoundment or dam catchment of 90 km² is about 30% of the total R. Mishumba catchment (294 km²) and is only 0.15% of the entire R. Kagera basin (58108 km²) Therefore, the reduction in flows of R. Mishumba will not affect the planned project.
South Western Cluster - Development of Water and Sanitation Infrastructure for the Mbarara-Masaka Areas (Kagera Water Works) – Funded by AFD	The water abstraction point (intake of 8 m^3/s) will be located on R. Kagera about 20km downstream of the irrigable area. R. Mishumba (along which the dam will be constructed) is a tributary to R. Kagera	The project will have a positive impact to residents of Kabuyanda and Isingiro District at large by providing clean and safe water hence improved sanitation. The impoundment or dam catchment of 90 km² is about 30% of the total R. Mishumba catchment (294 km²) and is only 0.15% of the entire R. Kagera basin (58108 km²) Therefore, the reduction in flows of R. Mishumba will not affect the planned project.
Rehabilitation of existing boreholes	Birere, Nyamuyanja, Masha, Kabingo, Nyakitunda, Kikagate, Kabuyanda, Ruborogota, Ngarama, Kashumba, Mbaare, Endiinzi, Rushasha, Rugaaga, Kabuyanda town council, Kaberebere town council, Isingiro town council	There is also a positive impact by providing clean and safe water to the communities. These being existing underground water sources, there will be no interaction between these projects and River Mishumba ecosystem. However, there is likely contamination of groundwater quality in case of excess or uncontrolled use of pesticides under the Kabuyanda irrigation project.

		Therefore, monitoring of groundwater quality within Kabuyanda should be done during operation and maintenance phase.

The projects in Table 8-3 (Isingiro DLG plan (2015/16 – 2019/20)) are expected to have major cumulative impacts when intermingling with the Kabuyanda irrigation scheme. The projects with the highest likelihood of cumulative impacts are the New Water supply system for Kabuyanda Town Council under MWE and South Western Cluster - Development of Water and Sanitation Infrastructure for the Mbarara-Masaka Areas (Kagera Water Works) specifically the Isingiro Component under MWE/NWSC, due to the size of the projects and the geographical overlapping within the command area. However, the Mishumba catchment only covers 0.15% of the entire R. Kagera basin and New Water supply system for Kabuyanda will utilise only groundwater and as such, will not impact directly on the proposed projects. This is because there is no exiting interaction between this project and River Mishumba ecosystem. However, there is likely minimal impact on groundwater quality in case of heavy use of pesticides. Pesticides use is expected to be minimal since Ministry of Agriculture is promoting more the application of integrated pest management. Therefore, monitoring of groundwater quality within Kabuyanda should be done during operation and maintenance phase.

8.3.2 Cumulative Impacts and Mitigation Measures

The possible collective effects of Kabuyanda irrigation project and of other external stressors (developments) on the VECs were considered. Explicitly, considering the effects of extra interactions with other projects on an appropriate scale, considering past, present and future impacts on the same VEC. Therefore, it involves the assessment of the contribution of the Kabuyanda Irrigation Scheme to the predicted cumulative impacts. These impacts include;

8.3.2.1 Impact on Hydrology and Hydraulics

The implementation of Kabuyanda Irrigation project (specifically dam construction) will provide water for irrigation. However, this is likely to cause changes in the local hydrological regime within the river ecosystem. Therefore, it is crucial to diagnose the interrelationship between river flows and the water table which may be changed. This is because the ecological uses of River Mishumba are in a stable state with the existing regime which may not be the case due to changes by the project. These changes will happen both upstream and downstream of the dam area along the river system. The anticipated cumulative impacts are also attributed to the use of the water, especially irrigation of large areas that are currently under subsistence agriculture. The cumulative factors include the following;

- **i)** In the long-term, one of the anticipated challenges to the scheme is the rise in the local water-table (waterlogging) that can be caused by low irrigation efficiency. Poor water distribution systems, poor main system management and poor in-field irrigation practices also contribute to the problem. This can be easily mitigated by increasing field application efficiency to meaningfully lessen the rise in the groundwater.
- **ii)** Effects of the dam, reservoir storage and associated water abstraction to the increasing demand for social needs and the ecological requirements, hence potential long-term

reduction to available flows. The project will result in storage or diversion of 70-80% of the mean river flow resulting in modification of the hydrology of the system.

- **iii)** Downstream of the dam, the river flow dynamics may suffer modifications including others flood regimes, moderated but lower levels and runoff distribution, decrease in downriver sediment transport, decrease of downriver flux of nutrients as well as disruption of flora and fauna along the river length;
- **iv)** Changes due to construction of the dam may result in changes to the biodiversity. There is potential attraction of new animal species into the dam reservoir including, snakes and certain fish species and lesser aquatic fauna. Emergence of new wildlife species in the greater area may have notable conflicts with people's safety;
- **v)** Reduction of stream flow in the downstream of the dam also affects the capacity of the handling the pollutants discharging from agricultural, settlements and urban areas including agro-chemicals, organic matter and urban pollutants through dilution,
- **vi)** The hydrological connection between rivers and groundwater in the areas around them, i.e. the reservoir impoundment, limitation of river flow, as well as the induced farming irrigation activities and these groundwater-based water projects will have cumulative impacts on groundwater. The impoundment of reservoir may alter the groundwater level in the near vicinity of the reservoir. The impact of diversion of river flow to irrigation on groundwater table will depend on the soil permeability as well as the agricultural practices and climate. Other ongoing groundwater abstraction projects will have a direct impact on the water table.

8.3.2.2 Impact on Mishumba River Ecology and Biology

The implementation of Kabuyanda Irrigation scheme will automatically have consequences of the change of land use/cover and water use in the project area, cumulative effects on the land around the project and on aquatic ecosystems that share the catchment.

a) Effect of the reservoir on hydrology and hydraulics of the catchment

The establishment of the reservoir was assessed to be of added value in management of floods and prolonged droughts in Mishumba Catchment. In times of occasional heavy rains, the effects of uncontrolled flooding in Mishumba River can cause serious and severe damage to crops and production infrastructure. The reservoir will therefore provides means for holding the excessive water, and will allow for controlled release of such water with appropriately controlled flooding where required. Similarly, the reservoir is envisaged to be in addressing the effects of prolonged droughts or dry seasons through controlled release of water from the reservoir. The challenge is however is the anticipated increase in flooding downstream, and its associated effects including submerging of the terrestrial vegetation and other terrestrial biodiversity.

Radically altered flood regimes following the establishment and controlled release of water from the reservoir may also have negative impacts. This will require follow up during the operational phase of the project as many socioeconomic activities including farming, wetland fishing and others are known to rely on natural flooding regimes. Floods also are critical in maintaining biodiversity as they trigger spawning and migration and are responsible for recharging of nutrients and food materials for the aquatic biodiversity. Controlled floods may also result in a reduction of groundwater recharge via flood plains and a loss of seasonal or permanent wetlands.

Finally, changes to the river morphology may result because of changes to the sediment carrying capacity of the flood waters. This may be either a positive or negative impact.

The likelihood of this impact occurring was assessed as **CERTAIN** since it is a direct result of the key activity of the Kabuyanda ICRP, the establishment of the dam for creation of reservoir to supply water for irrigation. The impact magnitude is **MEDIUM** as it has been appropriately technically designed to address some of envisaged impacts but will also affect all aspects of the proposed project including both agricultural production and biodiversity and ecological flow management. Therefore the significance of this impact is major.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation

- Technically planning and engineering to provide for establishment and control of the operation and maintenance of the reservoir as well as regulation of the flow of the water from the reservoir.
- As with low flows, the operation of dams offers excellent opportunities to mitigate the potential negative impacts of changes to flood flows.
- The designation of flood plains may also be a useful measure that allows groundwater recharge and reduces peak discharges downstream. This is one of the positive functions of many areas of wetland.
- It is important that new irrigation infrastructure does not adversely effect the natural drainage pattern, thus causing localized flooding.

b) Land and water interactions in Mishumba Catchment

Mishumba Catchment is greatly modified ecosystem and as such the land and water use in the basin is largely driven by socioeconomic activities within the basin. The geophysical processes, such as water quantity and quality as well as erosion, are largely determined by extent of the socioeconomic activities (NECOC 2017). The consequences have been reduced afforestation, increased erosion, reduction in wetland cover and expansion of unplanned agricultural production activities. The Kabuyanda ICRP project is expected to lead to organized production activities and better management of Valuable Ecosystem Components albeit with noticeable impact in the basin. The ICRP development is within an area in which the existing socioeconomic activities have led to significant reduction in vegetation cover and severely impacted on aquatic resources such as fish. The impounding of water with construction of the dam will lead to creation of a reservoir, which will result in water overland further reducing the vegetation cover and displacing animals.

The daming will also lead to change in stream flow or hydrological regime affecting the flow variability and the magnitude and frequency of floods. Furthermore, the daming will limit the natural sedimentation process and control the recharging and nutrient loading of stream waters affecting the current production activities. The damming will also greatly disturb the stream channel, stream hydraulics, water quality, the riverine habitat, and the aquatic and riparian ecosystems. The ecological integrity and complexity of flowing water systems depend on their natural dynamic character. Deviations from the natural flow regime can therefore impair water quality, ecosystem functions, and characteristics of aquatic and riparian environments (Poff *et al.* 1997).

The cumulative impacts here have been assessed to result from primary and secondary impacts. The primary impacts envisaged here include water pollution, flow regime change, loss of land with reservoir creation, and change in land use. The secondary impacts identified include change in water quality; loss of connectivity of different habitats; change in soil ecology, change in limnology of the river and reservoir water, increased erosion and sedimention; change in sedimention flow; and change of landscape and aesthetic value at dam site.

Upstream erosion may result in the delivery of fertile sediments to downstream of the catchment. However, this gain is a measure of the loss of fertility of upstream eroded lands. A major negative impact of erosion and the associated transport of soil particles is the sedimentation of reservoirs and abstraction points downstream, such as irrigation intakes and pumping stations. Desilting intakes and irrigation canals is often the major annual maintenance cost on irrigation schemes. The increased sediment load is likely to change the river morphology which, together with the increased turbidity, will effect the downstream ecology.

The likelihood of this impact occurring is assessed as highly likely since it is a direct result of the key activity of the Kabuyanda ICRP. The damming is required to ensure that there is enough water to meet the irrigation needs. The impact magnitude is **MODERATE** because although the likelihood of the impact is **CERTAIN**, the whole dam design, operation and maintenance plan of the dam and reservoir; and design, location and operation and maintenance of associated water supply and irrigation infrastructure, have been planned so as to mitigate the identified impacts. Therefore the significance of this impact is **moderate**.

<table>
<tr><th colspan="2" rowspan="2">Impact Significance</th><th colspan="5">Likelihood of Occurrence</th></tr>
<tr><th>Certain
5</th><th>Likely
4</th><th>Possible
3</th><th>Unlikely
2</th><th>Rare
1</th></tr>
<tr><th rowspan="4">Impact Magnitude</th><th>High
4</th><td>Major 20</td><td>Major 16</td><td>Moderate
12</td><td>Moderate 8</td><td>Minor 4</td></tr>
<tr><th>Medium
3</th><td>Major 15</td><td>Moderate
12</td><td>Moderate
9</td><td>Minor
6</td><td>Minor
3</td></tr>
<tr><th>Low
2</th><td>Moderate
10</td><td>Moderate
8</td><td>Minor
6</td><td>Minor
4</td><td>Insignificant
2</td></tr>
<tr><th>Negligible
1</th><td>Minor
5</td><td>Minor
4</td><td>Minor
3</td><td>Insignificant
2</td><td>Insignificant
1</td></tr>
</table>

Mitigation Measures:

- Conduct In-depth engineering survey and assessment of the site for the planned infrastructure (dam, irrigation networks and other auxiliary structures) within the core project zone. This is so as to put in place the required safeguards to prevent, reduce or mitigate the identified impacts. This should be followed by adoption and integrating of preventive operational maintenance within the overall dam management, operation and maintenance programme.
- Measurement and monitoring the effects of erosion and sedimentation at different points of the irrigation system with regular treatments and addressing of such effects such as sediment release and improving water flow network through channeling or cannel development.
- Proper land planning and management for both the infrastructure development and irrigable area coupled with controlled water releases that mimic the natural water flow and responds to not only the agricultural production needs but also the biodiversity and landscape needs of the catchment.

c) Disruption of the river and natural sedmination flow by the damming of River Mishumba

Cumulative impacts of the damming of the Mishumba River will disrupt the river flow, create back flow and reservoir. The dam itself will act as a barrier to the natural flow of the sediments while the resevior will exacerbate the soil erosion as a result of the interference with the sediment balance of the river caused by dam construction and reservoir operation. The dam facilities and secondary effects may also led to a cumulative impact on flow regulation of the watershed and soil protection with seasonal discharges changing significantly, especially in dry season as irrigation scheme mitigates the reduced water table through peaking operations – pulses, overbank flooding and surface water supply for irrigating of the crops.

The dam and associated irrigation facilities and secondary effects may also have a cumulative effect by enhancing habitat fragmentation and loss of connectivity between the terrestrial and aquatic environment. For the terrestrial environment this is related to land conversion while for the aquatic environment this is related to flow regulation, channel diversion as well as the irrigable area and production activities targeted.

The likelihood of this impact occurring is ranked as **CERTAIN** due to damming of the Mishumba River, an integral or central component of the planned development, Kabuyanda ICRP. The Impact Magnitude is assessed as **MEDIUM** because the dam has been designed to ensure and maintain chanel flow with set e-flows. The significance of this impact is therefore **major**.

<table>
<tr><th colspan="2" rowspan="2">Impact Significance</th><th colspan="5">Likelihood of Occurrence</th></tr>
<tr><th>Certain
5</th><th>Likely
4</th><th>Possible
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<tr><td rowspan="3">Impact Magnitude</td><td>High
4</td><td>Major 20</td><td>Major 16</td><td>Moderate
12</td><td>Moderate 8</td><td>Minor 4</td></tr>
<tr><td>Medium
3</td><td>Major 15</td><td>Moderate
12</td><td>Moderate
9</td><td>Minor
6</td><td>Minor
3</td></tr>
<tr><td>Low</td><td>Moderate</td><td>Moderate</td><td>Minor</td><td>Minor</td><td>Insignificant</td></tr>
</table>

	2	10	8	6	4	2
	Negligible **1**	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation

- Ensure the designs of the dam and associated infrastructure are based on in-depth site studies and latest technology that incorporates safeguards against identified hazards.
- Set appropriate e-flows and regular releases of the sediments to compensate for the envisaged changes in flow and to sustain the channel flow and the associated ecological services and biodiversity.

d) Effect on the Underground water reserves and recharge system

The dam and reservoir operation will have inadvertent effects on the groundwater levels. Excessive draw down of water in the reservoir will adversely affect the underground water reserves and the existing users of groundwater whether it is required for drinking water for humans and animals or to sustain plant life (particularly wetlands), especially at dry times of the year. Over time the well springs may dry up if this practice is done repeatedly, and may also affect the channel flow especially during low flows in the dry seasons. This may have enormous repurcussions on both natural and human environment and especially adversely effect marginal and wetland biodiversity as well as the poor people. The poor may resort to use of alternative sources of water that carry health risks, particularly water sources infested with worms and schistosomiasis. Also severe and continued reduction in the water table level (groundwater mining) with drawdown of the reservior, may also lead to significant land subsidence with consequent damage to structures and difficulties in operating hydraulic structures for flood defence, drainage and irrigation. According to the nature of the soils, especially for organic soils like the case of Mishumba catchment, the change in soil structure may be irreversible.

On the otherhand the low efficacy of the irrigation structures, in the long-term, may lead to unusal rise in the local water-table (waterlogging). The poor water reticulation and distribution systems, coupled with poor main system management and inefficient in-field irrigation practices will certainly lead to water logging. Fortunately for Mishumba Catchment, there is a reasonable hydraulic gradient to allow for movement of water downstream. The challenge however is that the key is characterized by hot weather, and the high water table may lead to rising groundwater through capillary action which will evaporate, leaving salts in the soil. The high water table will also make it difficult to work the soil for agricultural production.

The likelihood of this impact occurring is ranked as **UNLIKELY** due to terrain and landscape of the Mishumba Catchment, and the fact that the design and e-water flow system has been set to avoid and or reduce excessive daw down but also efficiently supply and drain irrigation water. The Impact Magnitude is assessed as **MEDIUM** because of the seasonal variations and occasional prolonged droughts which may lead to excessive draw down, and or high rains which may lead to less demand for water and poor drainage of irrigable area. The significance of this impact is therefore minor.

Impact Significance	**Likelihood of Occurrence**

		Certain **5**	**Likely** **4**	**Possible** **3**	**Unlikely** **2**	**Rare** **1**
Impact Magnitude	**High** **4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium **3**	Major 15	**Moderate** **12**	Moderate 9	Minor 6	Minor 3
	Low **2**	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible **1**	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation

- A possible advantage of reducing the water table level prior to the rainy season is that it may increase the potential for groundwater recharge. Lowering the water table by the provision of drainage to irrigation schemes with high water tables brings benefits to agriculture.
- Any changing availability of groundwater for drinking water supply needs to be assessed in terms of the economics of viable alternatives.
- Set the field application efficiency for irrigation for the different seasons at levels that ensure well balanced levels of the groundwater.

e) Water and air quality

The change in hydrological regime as a result of establishment and operation of Kabuyanda ICRP project and its associated irrigation infrastructure may alter the capacity of the environment to assimilate water soluble pollution. In particular, reductions in low flows may result in increased pollutant concentrations already discharged into the water course either from point sources, such as the cottage mining and agroprcoessing industry, irrigation drains and adjoining settled areas, or from non-point sources, such as application of agrochemicals that leak into groundwater and soil erosion. Reduced flood flows may also remove beneficial flushing, and reservoirs may cause further concentration of pollutants. In case of increase in low flows, the effect on solute dispersion will likely be beneficial, particularly if the solutes are not highly soluble and tend to move with sediments.

Poor or extensive use of pesticides is likely to effect plants, fish and other aquatic biodiversity, birds and mammals including humans. Persistent use of such pesticides is in itself a danger as these pesticides, soluble or not soluble, may bond chemically to soil particles and may be transported by erosion even beyond the Mishumba Catchment. Use of organochlorine insecticides such as DDT, dieldrin and endosulfan, is particularly hazardous to aquatic systems and become rapidly concentrated in the food chain up to the higher tier (human beings). Also non-specific herbicides can rapidly affect the supply of food, and yet the associated risks are likely to increase if a monoculture is practiced, as is typical of many developed irrigation systems that are aimed at increasing overall production. In addition, the use of both natural and chemical fertilizers may result in an excess nutrients as all may not be picked by the crops, which excess nutrients can cause problems in the adjoining wetlands, interconnected rivers, River Mishumba and main Kagera River. Key nutrients of target include the nitrates and phosphate. Whereas nitrates are highly soluble and therefore may quickly reach water bodies, the phosphates tend to be fixed to soil particles and therefore will reach water courses when soil is eroded or during floodings. The excessive nutrients that reach water bodies may result in eutrophication and increased algal blooms, and due to death and rotting of algal matter and resulting in depletion of oxygen in water bodies. In the reservoir, the depletion of oxygen may occur due to the excessive organic material that is submerged during the filling process resulting in bed decays and waters with progressively less oxygen. Other possible causes of depletion of oxygen will be suffocation of terrestrial animals that can move with the filling of the reservoir and or the mortality of aquatic ones due to change in water quality. The depletion of oxygen may end up causing anaerobic decomposition that will result in production of gases such as hydrogen sulphide, methane and ammonia all of which are poisonous and some of which contribute to the greenhouse effect. The production of greenhouse gases may also be produced by irrigated crop field and this may need to be investigated and mitigations put in place. The other cumulative impact is that change in water quality as aresult of the Kabuyanda ICRP will lead to disruption of natural food chains and webs, and the loss of agricultural production.

The likelihood of this impact occurring is ranked as **POSSIBLY** with the creation of a reservoir which will hold and increase the resident time for water that will allow settling of solutes and salts in the irrigation water and sediments. It is also possible in that farmers are mostly likely to use chemicals in form of fertilizers and pesticides. The Impact Magnitude is assessed as **HIGH** because of the interference in the natural movement of chemicals and the change in hydrological regimes in the Catchment. The significance of this impact is therefore **moderate**.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation

- Reservoir area should be cleared of organic matter and animals facilitated to move prior to impoundment to limit anaerobic decomposition once the dam is filled.
- The Kabuyanda ICRP should adopt integrated pest management including considering of use of low use of chemical methods and or use of natural herbicides.
- Limit use of non-specific and non-target use of agrochemicals
- Adopt a rigorous water quality monitoring system from filling to the operation phase.

f) Soil salinity

The key reasons for increase in soil salinity on an irrigation scheme are:

• Salts carried in the irrigation water are liable to build up in the soil profile, as water is removed by plants and the atmosphere at a much faster rate than salts. The salt concentration of incoming flows may increase in time with development activities upstream and if rising demand leads to drain water reuse;
• Solutes applied to the soil in the form of artificial and natural fertilizers as well as some pesticides will not all be utilized by the crops;

• Salts which occur naturally in soil may move into solution or may already be in solution in the form of saline groundwater. This problem is often severe in deserts or arid areas where natural flushing of salts (leaching) does not occur. Incase of high level of groundwater the rise of such that water through capillary action and evaporation of such water will leave salts on the surface and in the upper layers of the soil; and,
• The transfer from rainfed to irrigation of a single crop, or the transfer from single to double irrigation may create a "humidity/salinity bridge" in the soil, between a deep saline groundwater and the (so far) salt-free surface layers of the soil.

The likelihood of this impact occurring is ranked as **LIKELY** as salts and solutes will be concentrated by the standing water in the reservoir, and that farmers are surely going to apply agrochemicals together with the effluents from cottage industries. The Impact Magnitude is assessed as **MEDIUM** as use of chemicals will be moderated and guided by experts. The significance of this impact is therefore **moderate.**

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation

- There is need for careful soil monitoring before and during the operational phase of Kabuyanda ICRP with regular soil sampling and testing.
- Use of fertilizers and chemicals should be appropriately guided based on the nutrient assessment and kind of crops targeted.
- The irrigation water supply and flooding should allow for flushing of the soils and irrigation facilities.

g) Effect on natural and human environment with establishment and Operation of Kabuyanda dam and reservior

The operation of the Mishumba River dam and reservoir may have significant impact on the river ecology downstream. The drastic change in the hydrological regime will have cumulative impacts on natural and human environment, channel morphology, and water (surface and underground) recharge and flow systems. The operation of Mishumba River dam may also lead to a number of disease hazards associated with dams some of which can be minimized, others eliminated by careful operation. The identified diseases and parasites include malaria, schistosomiasis, river blindness, flukes and worms. The establishment and operation of the dam may also lead to establishing of aquatic weeds and invasive floral and fauna species within and around the reservoir and other irrigation infrastructure over time.

The likelihood of this impact occurring is ranked as **POSSIBLY** as surveys showed that the area although highly disturbed or lacked prisitine natural ecosystems, did not have invasive species and did not have typical known terrestrial and or aquatic weeds. The Impact Magnitude is assessed as **LOW** because of the location of the dam in upstream of the catchment, and area naturally of limited established natural vegetation. The significance of this impact is therefore minor.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigations

- Put in place technically and engineering-wise feasible measures to ensure efficacy of the dam in terms of its main functions, namely irrigation, flood protection and biodiversity sustenance.
- Conduct assessment and analysis of downstream demands so as to determine and set the minimum compensatory flows for the different seasons, both for the natural and human environment. This should be done at the design stage and regularly updated during operation of the dam and reservior.
- The design should as much as possible mimic natural flooding regimes in planning and setting the dam offtake facilities. In particular, passing flood flows early in the season to enable timely recession agriculture may have the added advantage of passing flows carrying high sediment loads.
- Rooted aquatic weeds and invasive species along the shore (or in shallow reservoirs) can be partially controlled by alternate desiccation and drowning. The local communities, especially user communities can also put in place measures to de-weed the reservoir and associated irrigation infrastructure, and alternative use the weeds as animal fodder and building materials.

a) Ecological imbalances

Irrigation activities may alter the water table and general hydrological regime of the ecosystems. An imbalance in the general ecology of the landscape may be brought about by many potential impacts some of which may be of relatively minor significance in their own right but they often interact to produce a cumulative effect over a prolonged period of time. This can result in very significant long-term changes to the local ecology. Consequences might include effects on the microclimate and exposure of the soil to erosion. Changes in microclimate may result in a wide variety of potential impacts. The impacts may range from reduction in diversity and abundance of the local flora and fauna, thereby decimating biodiversity; decline in critical socio-economic services such as in pollinators and predators of vector. Irrigated agriculture often provides improved conditions for crop diseases to develop, particularly fungal and bacterial foliage diseases. Diseases and weeds can also spread quickly. Any change to a more uniform environment on the project lands is likely to favour vigorous species adapted to a wide variety of conditions. Species, such as insects and rodents, are often regarded as pests. The preferred habitats of natural predators, such as snakes and birds, may be reduced by land use changes and by the increased use of pesticides. Increased application of agro-chemicals poses a threat of pollution both on-site and off-site, with not only environmental but also health effects on humans, other organisms and ecosystems. The impact is **likely** to happen and will be long-term. It will be indirect and negative with having a **medium** magnitude and **moderate** significance.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation Measures

- Implement the biodiversity and environmental flow management plan
- implement the recommended environmental flow requirements (EFR).
- Closely monitor the hydrological aspects such as water table, flow rates, and also the physical and chemical properties of the water.

b) Proliferation of aquatic invasive species

From the field surveys, two invasive species of plants are already known to occur within the project area. These are *Lantana camara* and *Mimosa pigra*. These occurred at several points and hence have a potential to increase even further within and outside the project footprint. flourish mainly because of disturbances that create unstable environmental conditions in an ecosystem. They tend to be favoured by high dispersive power and high tolerance to unsuitable conditions.

The River Kagera system already has the alien invasive *Eichhornia crassipes* (water hyacinth). Fragments and small clumps of this aquatic alien invasive may be observed floating, being carried by running river water. In instances, the aquatic invasive weed forms fairly large mats sometimes trapped in *Vossia cuspidata* but is mostly being drifted down the river, in small clumps, single plants or its fragments (PROESS Consulting Engineers 2016). Creation of more flooded areas within the Kabuyanda Irrigation area is **unlikely** to lead to invasion of aquatic species such as the Water Hyacinth from the Kagera river system since Kagera is downstream. Other potential alien/invasive species include *Pistia stratiotes* (Nile Cabbage) and *Salvinia molesta* (Kariba Weed). The likelihood of this impact occurring is ranked as **UNLIKELY** and impact magnitude as **MEDIUM.** The significance of this impact is **MINOR**.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	Moderate 12	Moderate 9	**Minor 6**	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation Measures:

- Sensitise all project staff and workers about the dangers of alien/invasive species, measures to prevent their invasion, and their identification for early intervention.
- Prevention of the introduction, release or escape and spread of alien/invasive species, including training and capacity building in their management, when the invaders are still absent
- Institute a Monitoring Plan for alien/invasive species for their prevention, early detection and management in case they invade the project areas.
- Early eradication through implementation of an integrated program when there is still a small and localised population, in case the alien/invasive species invade.
- Long-term management and containment of established invasions including restoration and human adaptation to the ecological, health and/or economic impact when the invasion is widespread and abundant, with the aim of suppressing the invader's population but also protecting resources as control costs increase.

h) Effect on floral biodiversity by Kabuyanda ICRP

Although the additional survey did not find any rare or vulnerable plant species in the catchment, the presence of this floral biodiviersity is critical for the functioning and ecological services of the Mishumba Catchment. The establishment including construction works and setting up of the dam and associated irrigation structure, has the immediate effect of clearance of existing vegetation. This is also the case that in long term the project will result in clearance of land of existing vegetation for production and or submerging what is existing during the flooding and supply of existing water. It is more likely that other species comfortable in the new ecolological setting will emerge. This however may also open room for invasive species whose seed is normally impeded with improved seed for crops brought in from outside the area. The project is likely also to have impact on wetland plant species in the long term through encroachment or regulation of flow of water in such areas. Also the terrestrial plant species may be affected by reservoir flooding, de-watering downstream of dams; construction of transmission lines, access roads or canals or through lowered water tables.

Impact Significance		Likelihood of Occurrence				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation

- Clearance of vegetation and or submerging should be carefully considered to avoid loss of floral biodiversity.
- Ecological water flow regimes should be set taking in consideration the identified floral biodiversity while noting that some plants may be obligate and others may be facultative aquatic plants.

i) Change in faunal composition, abundance and behavior

The cumulative impacts here will be on the wild terrestrial animals and aquatic organisms (especially fish). Most noticeable will be on those of known or potential significant ecological and economic importance such as the fisheries on which the communities rely for fish supply. Also critical in this regard will be the relics of previous highlights of the fishery of Lake Victoria, Singida tilapia and Victoria carp (Mwanja et al. 2012, Rutaisire, 2003) which were confirmed to be extant in Mishumba Catchment with the additional surveys and assessment. The effects or cumulative impacts of the identified impacts will be disruption and loss of breeding and spawning grounds; disruption in upstream migration of rheophilic migratory species including Victoria carp; creation of new habitat for limnophilic species with establishment of a reservoir, displacement of terrestrial animals down stream with the reservoir and clearing of vegetation cover, building and establishment of a new fishery at the reservoir, loss of habitats for birds, reptiles and small mammals identified along the river and associated habtats.

The likelihood of this impact occurring is ranked as **LIKELY** due to damming and disruption of the river flow, clearing and loss of vegetation during construction and filling of the reservoir, loss of land to the reservoir and infrastructure construction, and secondary effects including change in water quality, increased soil erosion, change in water depths and flow rates. The Impact Magnitude is assessed as **LOW** because the basin has other sites in which the species will moved or facilitated to move, the e-flows have been set to facilitate and mitigate changes in biodiversity, special conservation areas and breeding sites have been identified and mapped for protection under the **BEFMP**, and there are plans and processes that have been designed as part of system for Kabuyanda ICRP to limit the effects of the identified impacts. The significance of this impact is therefore **moderate**.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation

- Animals should be allowed or facilitated to move before filling of the reservoir. Where possible the filling should be done in a way that allows the animals to escape.
- Critical or vulnerable species, especially the two fish species – that is Singida tilapia and Victoria carp, should be protected and continuously monitored to ensure continued existence. Where possible special conservation areas should be established to protect the remnant pockets of individuals in the Mishumba catchment.
- The BEFMP should be implemented and the implementation monitored to ensure compliance to and effectiveness of identified practices and measures.

c) Risk of severe floods due to damaged dam and changed landscape

The new constructed dam will pose a risk of flooding due to longevity, and uncertain adherence to repair and maintenance (O&M) plans. Basing on oral history and trend line analysis, there have been two severe floods due to over flooding of River Mishumba and River Kyabaganda (Middle Chezho& Kyabaganda Sub catchments). The river flooding happened April, May and June 2020, affecting approximately 122 households in Lower Mishumba & Middle Chezho Sub-catchments. During community consultation meeting, the cause of flooding in River Mishumba was attributed to climatic hazard of heavy rainfall in upstream area of the dam site. By the time it occurred, there was no rain that had happened within dam site villages. The flooding was unexpectedly spontaneous. Locally, property destroyed included cattle, poultry, houses, distilling site for local potent gin called waragi, trees and human death. Basing on the previous trends, there is likelihood that the same flooding can happen again in future after project completion. In the same way, there is a possibility of dam floor embankment walls to weaken and allow huge volume of water to leak, infiltrate and/or burst. Findings from Ecosystems Service survey indicate that all respondents stated that if similar floods happen again, its impact will be magnified because the floods may cause overflow, and/or destroy (tear open) dam floor embankment walls.

The flooding is anticipated to cause ecological alterations including saturation of soils impairing growth of the non-purely aquatic flora. Such plants are not adapted to severe waterlogging, and may not cope with the saturated conditions. The same impact is anticipated on fauna that is not purely aquatic in different groups of invertebrates and vertebrates. The resultant effect will be submerging and destruction of some species, reduction in abundance of the affected species of flora and fauna, local migration of some fauna, especially small mammals and reptiles.

It should be noted that available reports on hazard risk assessment in Isingiro by National Emergency Coordination and Operations Centre (NECOC) in 2017 categorized the floods as LOW risk. There's need to update the data following severe floods of May 2020. Additionally, there is an anticipated induced risk of floods due to broken high pressurized distribution pipes. This may be attributed to lifespan of pipes, vandalism and gaps in safety management.

The likelihood of this impact occurring is ranked as POSSIBLE due to consequences of current and future climate variability and extreme events especially heavy rains and Impact Magnitude as HIGH because it will be disastrous to communities upstream, mid-stream and downstream. The significance of this impact is moderate.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	**Moderate 12**	Moderate 8	Minor 4
	Medium 3	Major 15	Moderate 12	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation Measures:

- Conduct In-depth Climate Risk Screening and Climate Proofing of the infrastructure (dam, irrigation networks and other auxiliary structures) within the core project zone. This will enable the integration of climate change factors into ICRP as a rural development project in order to enable avoidance, if possible, or reduce future costs related with climate change induced hazards, risks and vulnerabilities. The Climate Proofing Screening tool could be possibly used by the ICRP with help of the Climate Change Department at Ministry of Water & Environment (CCD/MWE). The findings of the climate proofing will inform decision making and investment in long-lasting and environmentally sound, economically viable, and socially acceptable mitigation measures to be implemented throughout the ICRP project cycle (planning, design, construction, operation, and decommissioning).
- Implement and/or strengthen the Kagera Catchment Management Plans (CMP) with emphasis on River Mishumba Sub Catchment in order to control anthropogenic (human) threats and effects of climate variability and extreme events.

a) Changes in patterns of fishing activities

Most of the capture fishing activities are done along rivers in Lower Mishumba sub catchment (87%), Lower Mishumba & Chezho sub catchment (62%); Mishumba & Chezho (57%), Mishumba and Rweibare (52%), Lower Chezho (48%); Kyabaganda & Middle Chezho (45%); Middle Chezho (39%); Kinyara (35%) and Mishumba (35%). The aquaculture being practiced in the downstream (existing fish ponds at Sample site 22 (Lower Chezho Sub-catchment). Overtime, as the dam is constructed and river flow altered, if the recommended amounts of e-flows are not maintained i.e., released in specified periods, the damming may have direct negative impact on fishing activities downstream i.e., reduced fishing which is partially a livelihood source to the downstream communities. In downstream, there is likely increase in aquaculture (fish ponds and crop farming) especially in Ntundu parish in Kikagate SC, Kyamusooni parish in Ruborogota and Kabuyanda Town Council. The likelihood of this impact occurring is ranked as a **LIKELY** and Impact Magnitude is **LOW**. The impact magnitude is **MODERATE**.

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Mitigation Measures:

- Form groups of artisanal fishermen in upstream, midstream and downstream, and engage their representatives during project activities.
- Earmark position of artisanal fishermen group on GRM committees (ensure that they MUST be represented).
- Provide alternative livelihoods to artisanal fishermen that use river sections within dam site and critical dam area. These are headed by local elder called Muzeyi Ndyabayika (C/O Kagoto 2 village chairperson).
- Provide appropriate technology to artisanal fishermen that is not destructive to river resources, as well as disseminating information and knowledge in value addition for existing fisheries.
- Avoid fish farming in dam (no fish stocks and/or cages) to avoid diverse social risks that may arise. Note that even though artisanal fishing takes place, only 35% of households capture fish for home consumption and 17% for sale within Mishumba catchment (dam site), and 20% capture fish for sale in Lower Mishumba (critical dam area). So, stocking fish in the dam, would create a new competitive enterprise with no clear arrangement that would manage it and ensure all people benefit from it equally. In case fish farming

happens, it will also pose a threat to dam safety. The ideal situation would be to leave it as it was before project.

- Create sensitize communities about importance of protecting the river and how to utilise the ecosystem services it offers (with emphasis on avoiding drinking untreated / unboiled water drawn from the river).
- Maintain recommended amounts of e-flows, ensuring water release in specified periods

8.3.2.3 Impact on Socio-economics

a) Vulnerability due to discrepancies in access to irrigation equipment

In order to ensure effective use of irrigation water, there is need for farmer households acquire supplementary irrigation equipment vis-à-vis crop types. Given the fact that ICRP will cater for Irrigation system installations, the beneficiary households will have to meet the cost of acquiring supplementary irrigation equipment to be used in improving the water delivery method to crops especially banana. One possible equipment is the micro sprinklers used in banana plantations but they not available in irrigable area at the moment. There is no agro-input dealer reported to have supplied any. It's likely that the poor farming households will be vulnerable in terms of continuous exposure to drought, food and income insecurity. More so, the poor may be vulnerable to land conflict arising from acquisition of big chucks of land for irrigated farm production by the rich individuals and/or institutions. The likelihood of this impact occurring is ranked as **LIKELY** and Impact Magnitude as **MEDIUM.** The significance of this impact is **MODERATE**.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation Measures:

- Support farmers with supplementary irrigation equipment for banana and coffee. It should be noted that banana plant has higher canopy than the proposed sprinklers proposed in the design report. It's also notable that since banana growing is more profitable than vegetables, it's anticipated that if the banana farmers are to perceive the ICRP as useful then their banana crops should be irrigated effectively.
- Conduct research and innovation to develop and disseminate sprinkler systems that are higher than banana canopy in order to help farmers irrigate banana gardens. The innovations in sprinkler systems could be undertaken by both private sector, academia and/or national agricultural research centers (e.g., NARO/MAAIF).

- Support area-based farmer groups, SACCOs and cooperatives with revolving credit facilities to help them support farmers with additional requirements.

b) Scaling localized Inequality (beneficiaries Vs non-beneficiaries)

The ICRP will contribute localized inequality between the beneficiary and non-beneficiary households within the project area (Mishumba catchment and irrigable areas). The inequality will accrue from barriers in terms of spatial / location, access and utilization capabilities. This will be continuous. At present, the proportion of beneficiary communities within the irrigable area is smaller compared to non-beneficiaries with in the core and influence zones of the ICRP project components (dam and irrigation networks). The benefits to communities within the irrigable area in terms of improved climate resilience to drought by use of irrigation, will indirectly trickle to non-beneficiaries. For instance, over 30 villages located upstream near the dam site are outside the irrigable area, but they will benefit from improved food production in the area. By not directly benefiting from the irrigation facilities, the communities outside irrigable area are more vulnerable to climate variability and extreme events (e.g., drought, dry spell). This will minimize social inclusion hence inequality and grievances. The irrigation scheme will benefit communities within irrigable area compared to a big proportion of communities that are severally affected by drought and dry spells in entire project area. The likelihood of this impact occurring is ranked as **LIKELY** and impact magnitude as **MEDIUM.** The significance of this impact is **MODERATE**.

Impact Significance		**Likelihood of Occurrence**				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	**Moderate 12**	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	Minor 6	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Mitigation Measures:

- Extend the irrigable area to cover communities located upstream near and/or close to dam site. These areas include Kanywamizi parish (Kyamazinga 1, Kyamazinga 2, Kagara, Kanywamizi 3, Nyamiyanga, Kagoto 1, Kagoto 2); Rwakakwenda parish (Kaaro 1, Bugarama 1, Katooma 1, Katooma 2).
- Integrate non-beneficiary communities (near middle stream and downstream areas) into other development projects such as 1) World Bank funded OPM/DRDIP (Development Response to Disaster Impact project) that supports micro irrigation projects within the project area (core zone of Kabuyanda TC, Kabuyanda and Kikagate Sub Counties); 2) Local government investments.

c) Incidence of diseases (water related and NCDs)

There is recorded evidence that the incidence of water related diseases has been increasing over the years due to high population which has limited access to safe and clean water. Piped water supply for domestic use is limited to urban areas of Kabuyanda Town Council and it's accessed through paying fees averagely UGX 100-300/= per jerrycans. Given the domestic water consumption projections, the irrigation piped network will be regarded as a free domestic water source for domestic chores (drinking, cooking, bathing, washing, etc.). Even though MWE under Southern Umbrella and NWSC has extended piped water in mid-stream and downstream area (Kabuyanda, Kikagate and Ruborogota), the connections are few compared to demand. The exposure to untreated water from reservoir in itself poses health risks such as disease. The incidence (new cases) of typhoid, bilharzia and other disease will increase over the years. It should be noted that the piped network for irrigation is more likely not to have same operation and maintenance (O&M) plan like those used by domestic piped water supply systems. Over time, the weakening O&M for irrigation system is likely to give way to more risks. In addition, the increased use of agro-chemicals will scale-up contamination of water and soil, hence risks of communicable and non-communicable diseases (NCDs) and illnesses among humans. The likelihood of this impact occurring is ranked as a CERTAIN and impact magnitude is LOW. The impact magnitude is MODERATE.

<table>
<tr><th colspan="2" rowspan="2">Impact Significance</th><th colspan="5">Likelihood of Occurrence</th></tr>
<tr><th>Certain
5</th><th>Likely
4</th><th>Possible
3</th><th>Unlikely
2</th><th>Rare
1</th></tr>
<tr><th rowspan="4">Impact Magnitude</th><th>High
4</th><td>Major 20</td><td>Major 16</td><td>Moderate
12</td><td>Moderate 8</td><td>Minor 4</td></tr>
<tr><th>Medium
3</th><td>Major 15</td><td>Moderate
12</td><td>Moderate
9</td><td>Minor
6</td><td>Minor
3</td></tr>
<tr><th>Low
2</th><td>Moderate
10</td><td>Moderate
8</td><td>Minor
6</td><td>Minor
4</td><td>Insignificant
2</td></tr>
<tr><th>Negligible
1</th><td>Minor
5</td><td>Minor
4</td><td>Minor
3</td><td>Insignificant
2</td><td>Insignificant
1</td></tr>
</table>

Mitigation Measures:

- Support timely distribution of portable water through collaboration with undergoing piped water supply projects such as 1) Kagera Water Works / Isingiro Distribution Phase 3 implemented by MWE/NWSC; 2) South Western Umbrella / WSDF / MWE; 3) OPM/DRDIP Domestic Water projects e.g., GFS; 3) Millennium Village project e.g., GFS; 4) District Local Government projects e.g., shallow wells, boreholes, etc.
- Support portable water storage technologies for domestic use (not production) at household and community level. These technologies may include construction of rain harvesting water tanks.
- Support communities with water treatment solutions for drinking water e.g., distribution of water guard (e.g., aqua-safe tablets), clay water filters, energy saving stoves for boiling water, access to firewood sources e.g., Rwoho CFR, among others.

d) Conflict over restriction on use of buffer zone resources (land and access route to firewood sources)

At present there is high rate of encroachment and degradation of swamps and river banks. The demand for agriculture land force people to encroach on river banks and swamps. This practice is wide spread. For instance, there are 108 encroachers who cultivate within buffer zone of 100 meters along rivers and swamps in 3 villages of Kagoto 2, Kagoto 1 and Katooma 1. Along these rivers, there are no pillars to demarcate the buffer zone. As a requirement, the ICRP will be required to construct pillars as guided by the laws. Though communities may understand (after consultations), the demand for cultivable land will continue due to population increase. Over a given period, lapses in environmental law enforcement may induce more encroachment.

Conflict over Firewood: Restricted access to firewood collection inside Rwoho CFR using footpath through dam site (reservoir) may cause community conflicts. For instance, all communities in 2 villages of Kyamazinga 1 & 2 all pass through the dam site area to collect firewood in Rwoho CFR. The footpaths are located within the proposed dam site. During construction and operation phase, access routes will be blocked. The alternative routes to Rwoho forest are long distances which women and children who are major firewood collectors may not be able to walk to and fro. These restrictions of access to resources will cause conflict. The likelihood of this impact occurring is ranked as a POSSIBLE and Impact Magnitude is LOW. The impact magnitude is MINOR.

Impact Significance		Likelihood of Occurrence				
		Certain 5	**Likely 4**	**Possible 3**	**Unlikely 2**	**Rare 1**
Impact Magnitude	**High 4**	Major 20	Major 16	Moderate 12	Moderate 8	Minor 4
	Medium 3	Major 15	Moderate 12	Moderate 9	Minor 6	Minor 3
	Low 2	Moderate 10	Moderate 8	**Minor 6**	Minor 4	Insignificant 2
	Negligible 1	Minor 5	Minor 4	Minor 3	Insignificant 2	Insignificant 1

Other Mitigation Measures

- Support the implementation of Catchment Management Plans (CMPs) already in place under the Kagera Catchment Management zone / Victoria WMZ (MWE/ Mbarara Regional Office).
- Collaborate with NFA to ensure community collaborations in accessing fuelwood from Rwoho CFR;
- Construct river bridges across River Mishumba to enable movement to Rwoho CFR. The bridge should allow non-motorized traffic foot, bicycles and motorcycle) and located between dam site and sampling point 8.
- Establish alternative river crossing using wood from Kagara parish to Rwoho CFR especially for communities whose access routes (footpath to Rwoho CFR will be permanently blocked by dam especially Kyamazinga 1, Kyamazinga 2, Kagoto 2 and Kagara).

Cultivation along River Mishumba in the midstream (irrigable area)

9 BIODIVERSITY AND ECOLOGICAL FLOW MANAGEMENT PLAN (BEPM)

9.1 Overview

The Biodiversity and Ecological-Flow Management Plan (BEMP)" is designed for monitoring and mitigating the effects of the planned dam construction on River Mishumba, and the development and operation of Kabuyanda Irrigation Climate Resilience Project (Kabuyanda ICRP). The plan is based on data and information gathered during the ESIA development, and on primary data gathered during the additional surveys and sampling as a way of updating the ESIA information and filling the gaps in that data. The additional surveys and sampling have revealed that Kabuyanda ICRP construction activities have the potential to generate a wide range of environmental impacts on ecologically valuable receptors including designated sites, sensitive habitats and vulnerable, threatened and endangered species. In all, the project when well implemented has a large potential to enhance ecological conservation.

The BEMP seeks to proactively address such impacts and proposes to use an adaptive management approach (plan-do-check-act-re-plan) to reduce their potential severity, based around the use of 'Biodiversity Specialists, Hydrologists and Physical Scientists' to plan and regularly update the management plans, clear the route prior to any activities including removal of any vegetation.

9.1.1 Purpose of this Biodiversity and Ecological-flow Management Plan

Project construction and operation and maintenance activities can create negative outcomes on the ecological environment within Mishumba catchment that is targeted for development and operation of Kabuyanda ICRP, with some of ecological aspects such as existence of vulnerable and endangered species in the catchment being regarded as highly sensitive together with other highly valued ecological components of the biodiversity. This management plan therefore:

- Outlines actions and measures necessary for the effective management of biodiversity in Mishumba catchment;
- Identifies and covers identified impacts upon biodiversity;
- Details specific control measures to be implemented by Kabuyanda ICRP and its contractors (and subcontractors), to achieve this;
- Incorporates the requirements of the ESIA findings, international standards, Uganda legislation, the Bank's requirements and Project-specific construction permits.

By doing this, the Biodiversity and E-flow Management plan defines the actions and measures necessary for the overall management of biodiversity and environmental flows for both the Project beneficiary (Kabuyanda ICRP attendant communities) and contractors in line with the applicable law and other obligations.

9.1.2 Scope of the Biodiversity and Environment flow Management Plan

This plan covers all construction and operation and maintenance activities of Kabuyanda ICRP, and is applicable to all persons involved with the project, Contractors and Subcontractors. Whilst this plan will act as a 'framework' to determine what the different actors including contractors will be expected to produce, the contractors are required to ensure that all the requirements are adopted within their own management plans. Further information on Roles and Responsibilities is provided in sections within this plan.

9.1.3 Document Management

Documents will be managed and controlled by the Project Contract Manager within Ministry of Water and Environment (MWE). The methods for document management and improvement during the construction phase will be described in the Document Guide to be developed by MWE Project Management Unit (PMU).

9.2 Project Approach to Biodiversity and Ecological Flow Management

Project construction and operational activities have the potential to generate a wide range of environmental impacts on ecologically valuable receptors including sensitive habitats. The plan seeks to proactively address such impacts and proposes to use an adaptive management approach (plan-do-check-act-re-plan) to reduce their potential severity, based around the use of experts' advice on clearing the route prior to implementation of planned activities in terms of reducing the impact of those activities on biodiversity.

9.2.1 Supervision of Biodiversity and Ecological Flow Management Plan

It is important to translate mitigation requirements written in the ESIA and the BEFMP as well as Contractors Environment and Social Management Plan (CESMP) or any other plans into practical measures on the ground. It is also important to ensure that all persons involved in the construction and supervision of the project activities are fully aware of the requirements as outlined in the BEMPs. This can be conducted via project launch trainings and practical toolbox talks ahead of the construction phase with specific focus on e-flow requirements to sustain patches of wetland vegetation (including effective control of works near water) and effective avoidance and minimization of impacts during the construction phase of the project.

To coordinate responses to environmental concerns during construction and ensuring that the e-flow requirements are met, a number of technical reporting mechanisms will be set up to allow for issues to be raised and resolved in an efficient manner. These will be integrated with the project's Environmental Social Safeguards Supervision. They should form pre-enabling surveys ahead of the construction works including mapping of the sensitive areas. These should be used by the Supervising Engineer and the contractor to update the contractor's Environment and Social Management Plan (CESMP) including timing of works, and amendments to construction method statement as may be required. The reporting on progress of construction works should involve compliance to e-flow requirements in the monthly construction review meetings.

9.2.2 Key responsibilities of the Safeguards Supervising Consultant and the Resident Engineer

a) Ensuring that the pre-works data collection surveys are completed sufficiently to ensure:
   - Biodiversity in the Mishumba catchment is mapped and areas to be impacted are quantified;
   - Environmental flow requirements are determined for different reaches and respective biodiversity contained therein.
   - Locations of sensitive habitats and occurrence and distribution of value ecosystem components mapped. These habitats might include:
     - ✓ Forests
     - ✓ Riparian areas;
     - ✓ Pools and backwaters (and areas holding water ephemerally);

- ✓ Adjoining swamps in Mishumba catchment;
- ✓ Tributaries of River Mishumba with the project area;
- ✓ Notable vegetated areas e.g., grasslands and areas of scrub;
- ✓ Invasive plant species.

- Key locations for valuable, notable and vulnerable (threatened and endangered) species identified and their protection measures outlined and operationalized.

b) Action plans for biodiversity conservation activities and e-flow management emanating from all Kabuyanda ICRP planned activities around sensitive sites/habitats, (including sensitive riparian areas) are drawn and published;

c) Walkthrough (rapid assessment) surveys immediately prior to works commencing in an area are conducted. The purpose of such surveys will be to identify features such as:

- Animal breeding and nursing grounds;
- Evidence of breeding activities;
- Species to receive specific restoration etc.

d) Tool box talks to contractors to ensure compliance are provided.

e) The works and moving of any species discovered away from the work sites is technically supervised;

f) The day-to-day checks such as checking trenches for fauna and ensuring the other components of the CESMP are followed and appropriately monitored;

g) The findings from the field for reporting back to relevant stakeholders at regular intervals (at every month) are mapped and reported;

h) Species data in the field to ensure that the receptors selected for Biodiversity Action and e-flow Management Plan (BAP) monitoring are appropriate and updated; and,

i) Adequate data is captured to inform the monitoring within the BAP.

9.2.3 Protection of Designated Sites

During the additional surveys, a list of the identified biodiversity at designated sites should be protected. This includes the baseline data in **Chapter 4** that covers the Fisheries biodiversity **in Section 4.2.2.3 (Table** 4-12**)**, Vegetation and Flora diversity **in Section 4.2.3.1 (Table** 4-13**)** and Fauna biodiversity in **Section 4.2.4.2** i.e., Butterflies **(Table** 4-15**),** Dragonflies **(Table** 4-16**)**, Amphibians **(Table** 4-17**)**, Reptiles **(Table** 4-18**)** and Birds **(Table** 4-19**)**.

9.2.4 Site / habitat specific method statements

Sensitive habitats along River Mishumba (**Table** 9-1) identified in line with the ESIA and during the additional surveys in the catchment may require specific method statements to limit impacts. The method statements to be drawn up for works within areas of concentrated biodiversity or areas with vulnerable species and sensitive habitats should contain the following information as a minimum:

- Location of the designated site/sensitive habitat and the reaches within which the prescriptions of the method statement should be applied;

- Specific habitats within the area, their locations and any specific floral or faunal associations;
- Any details obtained in the pre-works services;
- Any special input required from the Hydrologist and Biodiversity Specialist;
- Explicit details of the proposed mitigations which should be applied in the area;
- Details of any specific construction practices which should be applied in the area;
- Details of any timing restrictions which apply to works in the area; and
- Restoration details for the habitats within the area where the method statement applies.

Table 9-1: Description of key habitats of focus in Biodiversity and E-flow Management Plan

Habitats	Section of catchment	Distance from dam (km)	Description of site
Swamps	Downstream	2	Swamps adjoining streams and river.
River banks	Dam extent, midstream and downstream	1 to 7	Areas especially where overbank flows take place
Forest reserves	Midstream and Downstream	2 to 7	Replanted forests with little or no natural vegetation
Dam site (extent)	Dam extents	within 2	This includes the reservoir, the dam and immediately after the dam
River Mishumba	Dam extents, midstream and downstream	within 7	This includes the main channel of R. Mishumba
Small streams	Midstream and downstream	2 to 7	Adjoining streams in the irrigable area contributing to water flow in R. Mishumba

9.2.5 Working in Habitat Areas

Key habitats are sites where biodiversity was found in the additional surveys including those harbouring vulnerable species. The CESMP and Operational ESMPs will have specific action plans for the sites (Annex 7 and Annex 9:) to match the conservation status and biodiversity richness of these sensitive sites.

9.2.6 Conservation of Notable Species

Table 9-2 below outlines a subset of the notable species that are likely to be encountered in the catchment and will require specific mitigation and a rough identification of where they are expected to be found. This will be further detailed following the detailed mapping to be produced by the biodiversity experts before work commences (Annex 7 and Annex 9). These species have been selected to drive appropriate mitigation and restoration.

Table 9-2: Notable and protected species that may be encountered in the project areas

Plants	• None of concern
Amphibians	• None of the species found is of conservation concern.

Avi fauna	• Crowned Eagle, Stephanoaetus coronatus, regionally vulnerable. • Martial Eagle, Polemaetus bellicosus, near-threatened (Uganda) & it is regionally (Africa) vulnerable • Blue-Headed Sunbird Cyanomitra alinae, Red-Chested Sunbird Cinnyris erythrocercus and Cardinal Quelea cardinalis is African region responsibility • Semi-Collared Flycatcher, Ficedula semitorquata, near-threatened. • African Crake, Crex egregia, near-threatened at the African region and National Red list for Uganda • African Marsh Harrier Circus ranivorus, near-threatened in Africa region. • African Darter, Anhinga rufa, vulnerable in Africa and also in Uganda • Grey Crowned Crane, Balearica regulorum, vulnerable globally, near-threatened in Africa, and endangered in Uganda
Fish, bivalves and crustaceans	• Singida tilapia (Oreochromis esculentus) locally known as Ngege, least concern • Victoria carp (Labeo victorianus) locally known as Ningu, least concern
Invertebrates	• None of conservation concern
Mammals	• None of conservation concern
Reptiles	• None of conservation concern

9.3 Roles and Responsibilities

9.3.1 Overview

An integrated approach to biodiversity management involves a range of stakeholders, including the Project Management Unit (Ministry of Water and Environment, Ministry of Agriculture Animal Industry and Fisheries), the Contractors (and subcontractors), local authorities, regulatory agencies and the general public. Such a system therefore requires robust processes regarding information dissemination, training, designation of responsibility, management actions, monitoring, control, and corrective actions. Generic roles and responsibilities for the Company and Contractors are detailed below. An initial RACI matrix (defining who is Responsible, Accountable, Consulted and Informed) and split of activities between key stakeholders is shown in **Table** 9-3 below with further information on specific responsibilities for CESMP actions outlined in Annex 7 to this CESMP. A detailed RACI matrix should be developed by the EPC contractor prior to work on site commencing.

Table 9-3: Initial split of activities

Activities	Beneficiary PMU	Beneficiary's Biodiversity Specialist	Contractors (constructor)	Contractor Biodiversity Specialist
Initial Ecological Surveys	***R***	***A***	***I***	***I***

ESIA Clearance	***R***	***A***	***I***	***I***
Pre-Construction and Pre-Operational Surveys	***R***	***A***	***I***	***I***
Development of construction biodiversity e-flow management plan	***I***	***M***	***R***	***A***
Development of operational biodiversity and e-flow management plan	***I***	***M***	***R***	***A***
Dissemination of information and training to workforce	***I***	***M***	***R***	***A***
Management and monitoring of day to day ecological impacts	***I***	***M***	***R***	***A***
Ecological mitigation Implementation	***I***	***M***	***R***	***A***
Audit of contractor performance	***A***	***R***	***C***	***C***
Corrective actions	***I***	***M***	***R***	***A***
Management of cooperation	***A***	***I***	***A***	***I***

(R=responsible, A= accountable, I= Informed, C= Consulted M= monitoring role)

The operational cooperation procedures will be set in the statement of works that will be the responsibility of the contracted firm or organization for the construction and also for the operation with approval of the statements by MWE (Beneficiary PMU) and the Contractor.

9.3.2 Beneficiary PMU's Roles and Responsibilities

The PMU's management roles and responsibilities during project construction and project operation are summerised here below:

The project will be implemented through existing Government structures, relying mainly on Government staff. Individual consultants – where necessary - will be recruited where the Ministry has inadequate capacity. The PMU will comprise Government staff and individual consultants recruited for the purpose of ensuring efficient project implementation. The PMU is headed by the Project Coordinator in MWE who will be assisted by the Co-Coordinator in MAAIF. The PMU will work closely with all project staff and relevant stakeholders, and among others perform the following roles:

- take overall lead in coordinating project implementation and supervision activities.
- coordinate and manage preparation of required project studies (TORs, ESIA & RAP) and Engineering Designs, including incorporation of the various ESMP and BEMP requirements in the Bidding Documents and Contracts.
- secure the required statutory approvals at various levels of project implementation.
- undertake procurement of Supervision Consultants and Contractors.
- Prepare and submit periodic reports to PS-MWE, MAAIF, Finance, and World Bank.
- ensure smooth coordination with other Central Government Agencies such as National Forestry Authority, NEMA, and the District Authorities, including site visits and supervision.

At local level, staff will be designated from the relevant implementing departments, chaired by the Chief Administrative Officer, to provide technical oversight on implementation at LG level. The District staff will consist of the District Production Coordinator, District Engineer, District Community Development Officer, District Natural Resources Officer, District Agricultural Officer, District Water Officer, Senior Agricultural Engineer and District Commercial Officer. The District and Sub county Officials will take lead in engagements with the Communities and Local Authorities. They will lead in mobilization of communities to take part of project implementation activities including implementation of catchment management activities, sensitization and information dissemination, formation of Grievance Redress Committees and ensure satisfactory resolution of grievances received during project implementation.

9.3.3 Contractor Roles and Responsibilities

Overarching Contractor HSSE requirements are defined in the relevant articles of their contracts and associated mandatory annexes - Work of statement document. Each contractor must also implement all relevant requirements of the CESMPs, including this Biodiversity CESMP. Contactors are also responsible for ensuring that any subcontracted work also meets these requirements. Contractors will therefore be required to present to the Beneficiary, represented in the project by MWE Contract Manager in accordance with the requirements, their proposed approaches to:

- Prevention and management of ecological impacts on site
- Any other conditions outlined in this CESMP and Operations ESMPs or its appendices.
- In addition, Contractors will present the Beneficiary (MWE) with details of: their proposed team responsible for implementing requirements management and monitoring for biodiversity protection and environmental flows.
- Contracts / agreements' pre staff team responsible for implementing requirements management and monitoring for the protection of biodiversity and their CVs,
- Records any ecological impacts.

Further specific responsibilities of both Supervising Consultants and the contractors/sub-contractors are outlined in the annexes to this plan.

Table 9-4: Contractor Roles and Responsibilities

Roles	Responsibilities
Works Contractor	• Develop their own plans for Biodiversity Management in accordance with the requirements of this Plan and in accordance with criteria established by The Contracting Parties of Biodiversity and Environmental flow Management Services. • Compliance with the legislation and the management procedures for the biodiversity. • Application of the biodiversity protection management techniques within the works as required by The Contracting Parties of Biodiversity and E-flow Services.

	• Providing information / training of all personnel engaged in the project with particular focus on works in sensitive areas. • Designates by decision the person / persons responsible for implementing the requirements of this Plan (contractor). • Any biodiversity impact will be reported directly to MWE Contract Manager and to the Biodiversity and E-flow Management team. • Assures the necessary resources and the means to implement the biodiversity protection measures. • Within the Project, the responsibility for managing the biodiversity aspects lies with the contractor in line with the "polluter pays" principle.
The Supervising Engineer and Safeguards Supervising Consultant	• Ensure that all activities are carried out in accordance with the requirements of this Plan • Oversee development of the Biodiversity Management Plan in compliance with the requirements of this Management Plan and with the Environmental Agreement. • Ensure that construction activities and activities are conducted in accordance with the requirements of this Biodiversity Management Plan. • Ensures compliance with all environmental requirements required by the agreement, opinions / views issued by the custodians / administrators of protected areas to project. • Provides notification and consultation to custodians / administrators of protected natural areas for the conduct of work within the protected natural areas. • Ensure compliance with the measures proposed in the report on the ESIA study made for the project including implementation of biodiversity protection and e-flow management requirements as detailed in this report. • Coordinate and supervises all activities related to the implementation of this plan. • Establish actions and apply all necessary measures to protect biodiversity, according to the law. • Carry out the monitoring of biodiversity and meeting of the e-flow requirements. • Provide communication with contractors' decision makers in applying the requirements of the Plan. • Prepare and submits to the environmental authority and MWE an annual report that will include the results of biodiversity and e-flow monitoring and actions / measures taken to protect biodiversity and ensure set e-flow requirements are met. • Reports on all hazards, incidents and non-conformities. • Perform routine inspection on work sites to ensure that all activities are carried out in accordance with this Plan.

	• Monitoring the works and moving any species discovered away from the works in line with requirements of this plan. • Undertaking day-to-day checks such as checking for fauna and ensuring the other components of the ESMPs are followed in line with requirements of MWE Biodiversity Specialist.

9.4 Management, Mitigation, Monitoring and Verification

9.4.1 Management Actions

A range of management actions (and other mitigation measures) are required to be implemented in respect of biodiversity and e-flow management. The specific management actions and measures required of MWE as contract manager and its contractors are described in the ESMP.

9.4.2 General Monitoring Activities

Monitoring provisions for this Biodiversity and E-flow Management Plan have been developed through the following process:

Table 9-5: Monitoring provisions for this Biodiversity and E-flow Management Plan

Objective	Approach
Risk – based	Monitoring programmes to address material issues based on the use of the 'source pathway-receptor' approach in the ESIA. These are commensurate with: the scale and nature of the activity, the assessed potential level of impact (and uncertainty thereof), and the sensitivity of the local environment within the activity area of influence
Compliance - based	Additional monitoring programmes to meet specific regulatory needs

Following this approach, the proposed monitoring plans should meet the requirements of both MWE's to understand and manage the Project's potential impacts for each construction activity/ location and any specific requirements of the Uganda authorities. The specific monitoring requirements for this Biodiversity and E-flow Management Plan are presented herein.

9.4.3 Management System Verification Monitoring

Management System verification monitoring requirements, as detailed in the framework for ESMPs Documents, are divided into three levels as shown **in Table** 9-6 below.

Table 9-6: Management System verification monitoring requirements

Tier	Objective	Responsibility	Description
Tier 1	MWE	MWE & NEMA Management System Audits	These audits are aimed at assessing the MWE HSES management system elements and assessing their continued suitability throughout the project life cycle.
Tier 2:	MWE	MWE	These audits are undertaken by the MWE team or consulting firm on behalf of MWE to confirm

	ESMPs Audits		compliance by the Kabuyanda ICRP manager and its contractors with the ESMPs.
Tier 3:	Contractor self-audits	Contractor	These audits are to be undertaken by contractors to confirm compliance by themselves and their sub-contractors with the ESMPs and their own HSE management systems. The managing contractors shall ensure that audit reports are provided to MWE

9.4.4 Key Performance Indicators

Both the general monitoring and the management system verification processes require robust Key Performance Indicators (KPI) to be developed. These are quantitative or qualitative measurements used to gauge performance over time and can be used to assess the effectiveness of control measures. The initial KPIs considered relevant to this Biodiversity CESMP (and to be developed further and supplemented by the EPC contractor as part of the detailed contractor management plans) for the construction phase are shown in **Table** 9-7 below. Those derived from the Ecosystems Services Survey **Section 4.4** are summarised in **Annex 8.**

Table 9-7: Biodiversity and Environmental flow KPIs

Identification	KPI	Target/Action Threshold	Monitoring Measure	Associated Mitigation Controls	KPI Threshold
KPI-01	Instances of non-compliance with the requirements of this plan.	Minimise and continued improvement	See verification in Annex 7	All measures in Annex 7	Target for no non compliance issues
KPI-02	Instances of non-compliance with project standards identified during monitoring for specific species and valuable habitats	Minimise and continued improvement	See Annex 7	See Annex 7	Target for no non compliance issues
KPI-03	Timely reporting of biodiversity and e-flows information to prevent unnecessary mortally	Weekly to fortnightly reporting with sufficient information to inform the construction or operation team i.e., to change	To be recorded the weekly compliance report	All measures in Annex 7	Reports of quality biodiversity data during construction

		working area or to move species ahead of the construction or operation activity			
KPI-04	Timely reporting of biodiversity information to feed into the BAP	Fortnightly to reporting with sufficient information to inform the BAP	To be recorded in BAP and e-flow Management Plan.	All measures in Annex 7	Reports of quality biodiversity data during Construction or Operation.

The specific auditing requirements for the verification of each management and mitigation controls measure described within this plan are identified in ESMPs. This includes identification of the relevant audit tier level (1 to 3) to be undertaken.

9.5 Training

The contractor is required to ensure that all employees receive appropriate training in relation to biodiversity issues, so that the activities do not generate impacts on biodiversity.

MWE should also develop Internal Biodiversity and E-flow Management training protocol to train project staff to support and supervise the contractors.

The Safeguards Supervising Consultant to be hired by MWE will provide more support in E-flow monitoring and management.

The surviving vegetation along River Mishumba in the midstream (irrigable area)

10 ENVIRONMENTAL FLOW REQUIREMENT (EFR) MANAGEMENT SYSTEM

10.1 Overview

Kabuyanda Irrigation Scheme Development Environmental Flow Management Plan (EFMP) sets in place the EFR, a monitoring system, evaluation, and adjustment based on the information generated during the ESIA development and outcome of the additional surveys and sampling in the project area. It covers the pre-construction, construction, dam filling and operation and maintenance phases of the project. It provides guidance for integrating the acquired information into the management of River Mishumba in lieu of the planned development (construction) and operationalization of the Kabuyanda Irrigation Scheme. The assessment has indicated that the damming of River Mishumba will certainly significantly alter the natural water flows of the river for development and operation of irrigation scheme.

The plan stipulates ways and means of cooperation and communication among the dam operators, MWE as the organization responsible for monitoring, and MAAIF, DLGs and LLGs that will be responsible for coordinating the different aspects of the Kabuyanda ICRP project with the implementers including the contractors and operators of the project. These key actors have to broadly agree on the baseline condition, the expected condition of the river, the e-Flows predicted to maintain the expected condition, and the indicators and targets that will be used to measure whether these are being achieved. Implementation of e-Flows will be accompanied by an e-Flows monitoring program that provides the necessary data to inform each step, and supported by transparent reporting and independent auditing, provisions of which are made in this plan.

Kabuyanda irrigation scheme environmental flow management plan (EFMP) is a set of management actions and guidelines related to all regulation of water flow and mitigating the consequent impacts as they relate to the proposed irrigation scheme and associated infrastructure development and operationalization. The Kabuyanda EFMP focuses on the e-flows aspects. It describes the activities needed to implement, monitor, and review of the e-flows and clearly defines the responsibilities and key performance indicators. Figure 10-1 provides the schematic representation of the EFMP set up and linkages.

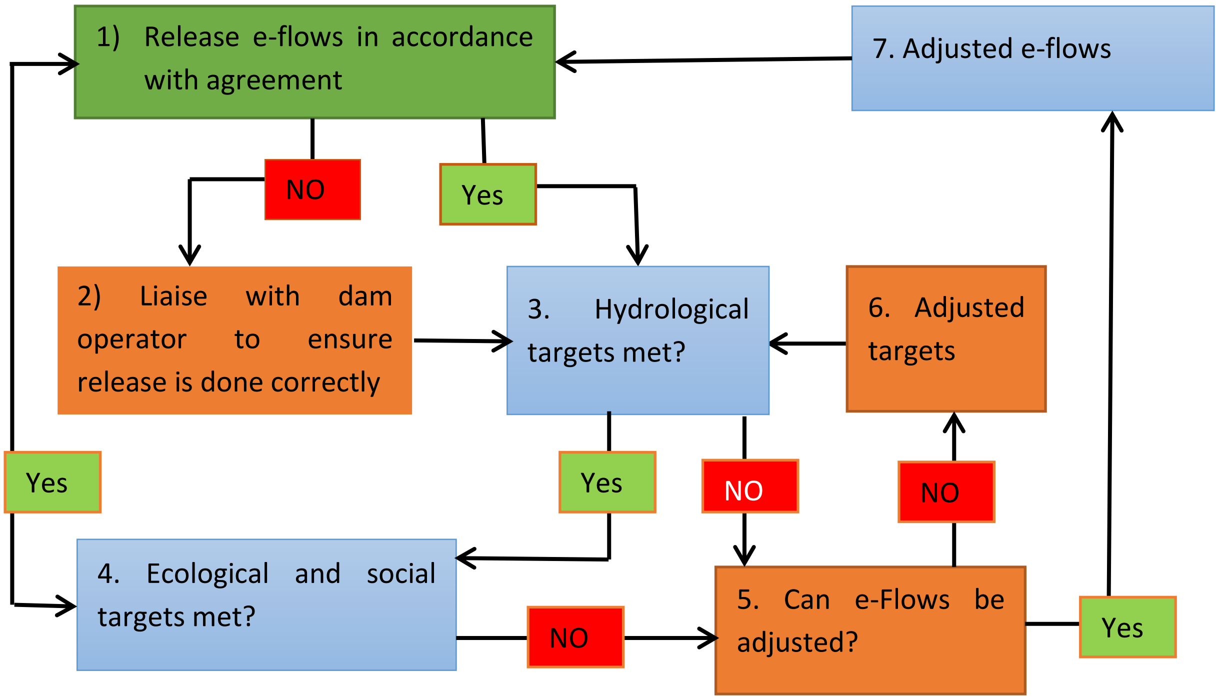

Figure 10-1: Environmental Flow Management Plan - Adaptive Management System as envisaged for Kabuyanda Irrigation Scheme

10.2 Implemeting the e-flow plan

Environmental Management Plan for Kabuyanda Irrigation Scheme must be based on the set e-flow as per set levels (Table 6-26) in this report which sets the water release from the reservoir or in case of adjustment following technical assessment and consultations with the concerned stakeholders from farmers to District Local Government and comprised of representatives of the farmers, the Civil Society Organisations (CSOs) operating in the area, Community-Based Organisations (CBOs) in support of farmers in the scheme, lower Local Government (Parish and Subcounty) and technical representatives from the district. Decisions on the any changes in set water flows should be made by the above multi-stakeholder committee approved by District Local Council endorsed by MWE to which the Irrigation Scheme Management reports to in case of need for changes in the set e-flows. In case of disagreement, the Ministry's level coordination mechanism will take up the issue and resolve it accordingly.

10.3 Specifics of the EFMP

10.3.1 Objectives

The Kabuyanda ICRP project EFMP plan's main objective is to provide guidance for environmental flow releases, adjustments in the flows, regulation of the e-flows, and management of the processes for the e-flow releases so as to ensure that the adjustments in water flow with the damming of River Mishumba does not adversely impact the ecosystem and socioeconomic activities below the dam in Mishumba catchment. The plan also provides a framework for regular monitoring of the impacts of the set and adjusted e-flows, for the maintenance or improvement of the ecological condition of the downstream areas. The specific objectives of the plan are;

a) to define and set the environmental flow requirements for the key ecosystem services, aquatic and associated terrestrial biodiversity, and for existing socioeconomic activities in different reaches of River Mishumba and the catchment at different times of the year;
b) propose a management system for setting, implementing, monitoring, research and adjusting the environmental flows to suit the e-flow requirements of downstream ecological components and socioeconomic activities of the Mishumba ecosystem.
c) to put in place a system for proposing/assessing measures to mitigate, as much as technically and economically feasible, any detrimental impact on key ecosystem services, aquatic biodiversity (such as fish, macro-invertebrate and amphibians' species) and the downstream users as a result of regulated e-flows associated with dam construction and operation of the irrigation infrastructure;
d) Allocate responsibility (including financial) for implementation of the EFMP/ESMP

10.3.2 The spatial scope

This EFMP plan spatially covers the Mishumba catchment, which is the project area for Kabuyanda ICRP project as detailed in **Chapter 1** - **Section 1.4.**

10.3.3 The dates of initialization, duration and provisions for revision

This Kabuyanda EFMP will enter into force after clearance and approval by the client and initialization and endorsement by both the Client and the Contractors at the different stages of the project, principally at the construction stage and also at the operational phase. This plan is drafted as an adaptive management plan, meaning it is amenable to adjustment with monitoring and research on e-flows and impact on different aspects of the ecosystem. This plan therefore is for duration of the Kabuyanda Irrigation project, implemented in phases.

The plan will be revised on demand/initiation by the Client or suggestion by the contractors and approval by the Client, but as a standard this plan will reviewed comprehensively every after three years, and will be adjusted to suit the changes in e-flow requirements and changing biodiversity and geomorphological conditions of the rivers and streams in project area whenever necessary with the recommendation of the biodiversity specialist and or the Hydrologist and approval of the Client.

10.3.4 Values to be protected / trade-offs

The e-flows as set currently were based mainly on technical evaluation analysis of the ecological and socioeconomic survey as well as the information that was generated during the ESIA development (2019). Focus of the assessment was put on the biodiversity where the assessment uncovered the requisite information and had the required expertise to set the e-flow requirements, and based on ecosystem components or species that would serve as ecological indicators in monitoring the impact of the set e-flows on the general biodiversity available in Mishumba catchment. In this regard, the e-flow values set were based on key fisheries groups in River Mishumba river considered representative of the aquatic biodiversity and key ecological indicators in their response to alterations in e-flows.

Key values to be protected in the EFPM include:

1) The physical resource base in the basin including demand and availability of surface and ground water, and water quality
2) Sensitive ecosystems and critical portions of the natural environment within a watershed context and assess the effects of water quality on the ecosystems.
3) Social issues, vulnerabilities, challenges (including gender issues, vulnerable groups, etc.) related to water resources development and management.
4) Swamps and watersheds within the Mishumba catchment
5) Inventory of matters related to the physical resource base including the effects of water development on the environment

Some of key trade-offs considered in setting of the current e-flows include:

1) Natural distribution and use of the River Mishumba by different organisms and the damming and diversion of water would limit the areas in which such biodiversity occurs.
2) Natural timing and cues for ecological and physiological processes of the biodiversity.
3) Effects of Water Development on the Environment, Sources and causes of degradation of land and water, Riparian ecosystems, Wetland ecosystems, other ecosystems and Natural Resources, Environmental issues and watershed conditions, their use and associated values
4) Decentralised water management potential as an alternative to an expansive dam across River Mishumba.
5) Future use and values of water resources,
6) Future use and values of environmental resources (ecosystems and natural resources) Protection of the biodiversity.
7) Existing socioeconomic activities including the extensive smallholder crop production enterprises, cottage brewery and mining industries, pond fish farming and others.

10.3.4.1 The agreed target ecological and social conditions across each season

The wide stakeholders will need to review and agree to the above trade-offs as well as consider the target ecological and social conditions across the wet and dry seasons that formed the basis for the set e-flow requirements as part of this EFPM. The key set ecological and social conditions set up are as indicated below:

A. Ecological conditions – Wet season

1) Ensure continued upstream migration of rheophilic fish for breeding, spawning and nursing.
2) Allow for overbank flow and flooding of floodplains, natural poodles and ditches to provide for lateral movement of limnophilic fish for breeding, spawning, nursing and feeding purposes, and habitats respectively.
3) Vegetated riparian areas along the river for refugee of the young fish, feeding of invertebrates, buffering of the river against pollutants and siltation.
4) Swamps will have to be maintained in the catchment as pockets and preserves of biodiversity including breeding and feeding birds, breeding and feeding fish, reptiles and amphibians, and invertebrates. Swamps are also need to serve as buffers.

B. Ecological conditions – Dry season

1) Allow for limited flow downstream for spent females and young of the rheophilic fishes to migrate downstream for feeding and growth.
2) Preserve ditches and swamps as they serve as refuges or haven for the limnophilic fish species, amphibians in the dry season
3) Limit and control the reclamation of swamps as they serve as refugees for limnophilic species and invertebrates

C. Socioeconomic conditions

1) The livelihoods of the attendant communities must be considered if they depend on River Mishumba by offering alternative livelihoods, compensation and or retooling.
2) All activities regarding the EFMP must take in consideration the need for building the resilience to the attendant communities especially during periods of prolonged drought.
3) The set e-flows in both wet and dry season must take in consideration the interests and challenges faced by different gender.
4) In setting and releasing the e-flows, the indigenous knowledge and local innovations and technologies must be taken in consideration.
5) Construction and or operation of the dam and associated irrigation infrastructure should not disfranchise communities of their due livelihoods and means of production without alternatives or compensations.

10.3.5 Dam designing to meet the target conditions

The dam's cofferdam is designed to allow the design flood to pass in the diversion structure without overtopping. Its embankment will be realized with excavation material from the diversion gallery, with a crest elevation of RL+1338.50m and a length of about 47 m. U/S coffer dam is designed with the design flow of 4.90 m^3/s corresponding to return period of 20 years. The slopes of the coffer dam proposed are 1:2.0 V/H on upstream, 1:2 V/H on downstream. The downstream cofferdam is designed in order not to be overtopped by the tail water level corresponding to the maximum design flow. According to the hydrological study the discharge with a 20-year Return Period is Q_{20} = 4.9 m^3/s. In this case, the intake gallery is overestimated as a diversion work, since it is designed to host the intake pipeline and its appurtenant structures. In terms of the dam body, the design of the Kabuyanda Dam the properties of foundation strata and Seismic coefficient parameters have been adopted as suggested by the Dam Safety Panel. According to the Final Design Report - MWE (2019), these properties have been determined by SP and the Geotechnical reports furnished by them are enclosed as **Annex 4.1** to **4.3**. In case of barrow area soil properties, MATEST CONSULT LTD investigated additional sources of materials as suggested by MWE. These construction material investigation reports are given under **Annex 4.4** of the same report. The properties have been assessed judiciously to adopt for the most economic design of the zoned earth dam section. The spillway structure of Kabuyanda Dam will be located on the left side of the dam, in order to reduce the interference of the concrete structure with the embankment dam. A side channel spillway has been selected, since it is particularly well-suited for embankment dams. The conventional side channel spillway consists of an overflow weir discharging into a narrow channel in which the direction of the flow is approximately parallel to the weir crest. Two road bridges are proposed on the side channel spillway and at stilling basin to access the earth dam and control building respectively.

In regards to the intake, Intake gallery of 154 m long barrel located on the left side of the natural river at a lower level to divert water from the river bed in the stretch between the temporary upstream and downstream cofferdams. The Intake gallery after the first phase will host the intake pipeline which will feed the irrigation system. The cofferdams were designed in order to allow the maximum discharge which can be evacuated by the intake gallery to pass without overtopping the upstream cofferdam and avoiding damage to the work area. An excavated channel upstream of the intake gallery will convey the water of the natural river into the gallery. Tail channel on downstream of the intake gallery will convey the water from the intake gallery to the natural river

10.3.6 The measures adopted for restoration, or preventing or mitigating impacts

Among the key measures in the EFMP for preventing impacts, mitigating impacts and or restoration following impacts include the following:

- Provision for a passage for upstream migration of rheophilic upstream breeding and spawning fish species.
- Setting and operating rules for e-flows releases and/or water quality targets
- Initiatives to restore and/or offset impacts.
- Maintain vegetated buffers wherever possible along River Mishumba and adjoining streams and tributaries banks
- Preserve, maintain and restore swamps

10.4 Organisation for the implementation of the EFMP

10.4.1 Organization principles

The organizational structure for the Kabuyanda ICRP project environmental flows and biodiversity management plan is given in **Figure** 10-2. The proposed structure was based on the following principles:

1) The closer the management to the ecosystem, the greater the responsibility, ownership, accountability, participation and use of local knowledge. For Kabuyanda ICRP the environmental flow assessment and management will be decentralized to the lowest appropriate level (Local Government, if possible).
2) Environmental flow managers will have to consider the effects (actual or potential) of the planned e-flow releases and regulation on the adjacent and other close related ecosystems. This includes upstream and downstream impacts and the impacts discussed (Chapter 6 i.e., Section 6.4 and Chapter 8) of other land management practices.
3) Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, shall be a priority target of environmental flows, particularly in the face of climate change and the need for resilient and adaptable ecosystems.
4) Environmental flows will take into consideration that ecosystems must be managed within the limits of their functioning. Realistic management objectives will be set based on environmental conditions and sustainability objectives.

5) Environmental flows will be undertaken at the appropriate spatial and temporal scales for the objectives to account for the needs of connectivity and interactions between hydrology and ecology.
6) Environmental flows need to reflect the varying temporal scales and lag-effects that characterize ecosystem processes, with objectives for ecosystem management set for the long term, which may conflict with short-term gains.
7) Adaptive management will be used to refine environmental flows to manage aquatic ecosystems within their limits to be resilient and sustainable and to achieve the change in desired outcomes.
8) Environmental flow management must recognize that change is inevitable. Ecosystems change, environmental conditions, such as rainfall, temperature and geomorphology change, and social values and objectives change.
9) Environmental flows will support the balance between conservation and use of biological diversity and ecosystem services. Rather than having some resources protected and some not protected, the management and use of ecosystems should integrate both desired outcomes.
10) All information used must be documented to understand the basis of decisions and support adaptive management as ecosystems or objectives change.
11) Setting environmental flows shall involve all relevant sectors of society and scientific disciplines, recognizing the complex nature of hydrology/ecology relationships and the potential interactions and outcomes.

10.4.2 Organizational Structure

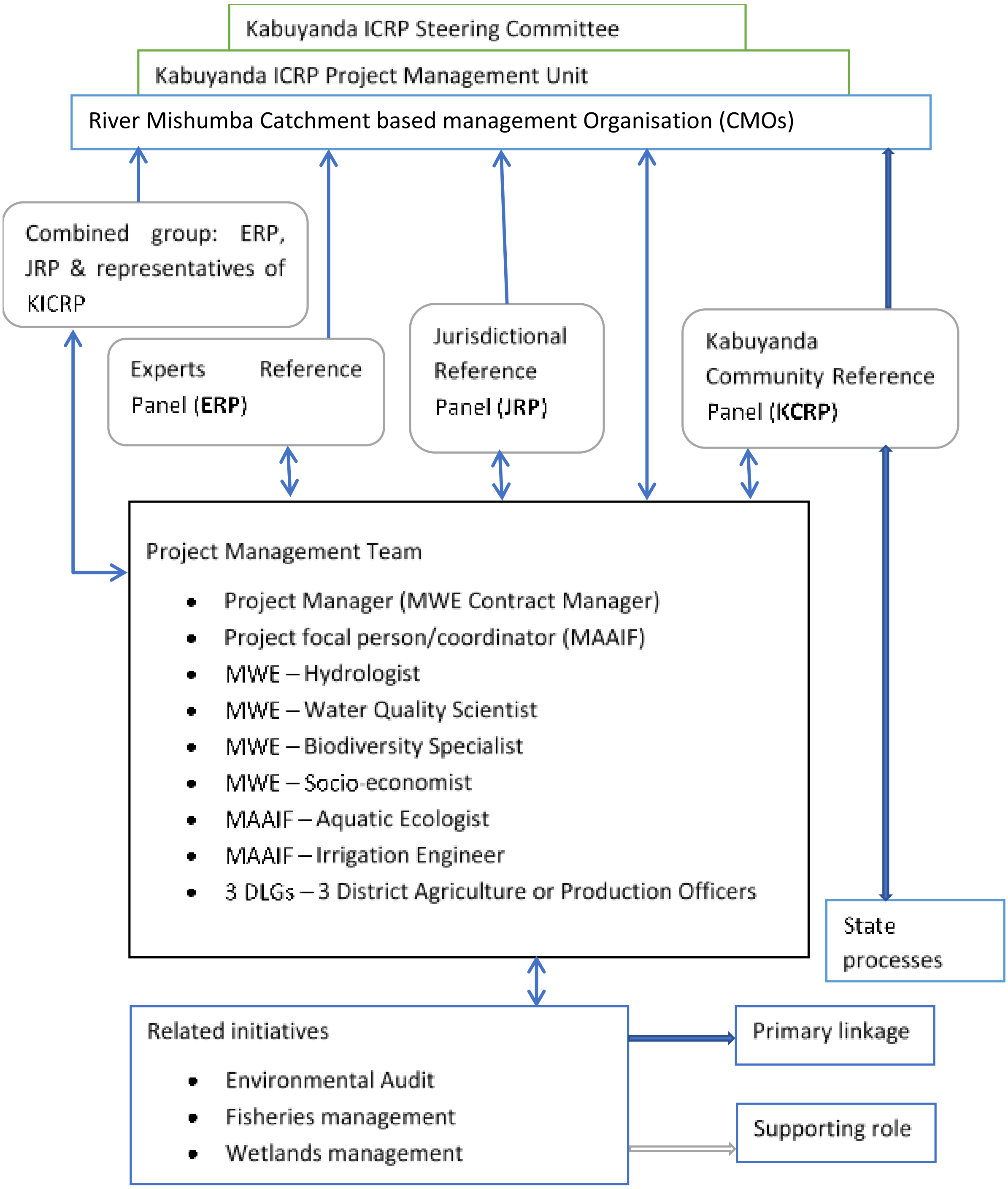

Figure 10-2: Organizational structure for Environmental flows and Biodiversity Management Plan.

10.4.3 Role of the different Actors

10.4.3.1 National level

- Monitoring and assessment;
- Planning and regulation advice and facilitation;
- Quality assurance and guidance;
- Capacity development; and

- Financial assistance and funding.

a) Project Steering Committee comprised of national stakeholders from public and private sector.
  - ✓ Guidance to the Project Management Unit in terms of implementation decisions as to the setting, implementing monitoring and adjusting of e-flows.
  - ✓ Follow up and monitoring of the performance and coordination of the project activities related to e-flows
  - ✓ Consideration and approval of project activity workplans and set budgets for EFMP.

b) Project Technical Committee/Project Management Unit
  - ✓ Technical planning and coordination of implementation activities related to setting of environmental flows, release and regulation of e-flows, and adjustment and monitoring of the impact of e-flows.
  - ✓ Monitoring and Supervision of the project constructors, operators, consultants and service providers as to their roles in EFMP.
  - ✓ Technical support and backup to DLGs and LLGs in supervision of the local contractors and service providers in scheduled activities in the EFMP.
  - ✓ Mobilization and coordination of stakeholders in the setting of environmental flow requirements

c) The NEMA is the apex body for environmental law enforcement in Uganda. NEMA in respect for the EFMP is in charge of:
  - ✓ Review and administrative clearance of environmental evaluations, in conjunction with other lead agencies
  - ✓ Delivery of permits (for instance, permits for activities within the legal buffer zones of waterbodies). The responsibility of delivering permits is vested into the different lead institutions
  - ✓ Monitoring compliance whose responsibility of control is distributed over 375 gazetted inspectors (2014) distributed in many Ugandan institutions (including the MWE). Only 30 of them belong to NEMA.

10.4.3.2 Regional level (District Local Governments and Lower Local Governments)

- Monitoring of assessment
- Planning and Regulation Advice and Facilitation
- Quality assurance and guidance
- Capacity development
- Financial assistance and funding

a) District Local Governments and Lower Local Governments Technical Staff
  - ✓ Coordination, supervision and monitoring of technical EFMP activities at local government level.
  - ✓ Mobilization and guiding of local stakeholders in setting and adjusting of e-flows.
  - ✓ Supervision of contractors to ensure that the e-flows releases follow the set e-flow requirements and commitments.

10.4.3.3 Community level

- Coordination of management and development activities
- Implementation of infrastructure project and programmes
- Operations and maintenance
- Community mobilisation and stakeholders' participation ensuring demand- driven implementation
- Communications and awareness raising

a) Mishumba Catchment Community Based Organization.

- ✓ Participating in the generation of information and engaging with National and Local Governments Technical Teams in setting of e-flow requirements
- ✓ Monitoring and following the e-flows releases and reporting on the impacts of such releases to biodiversity and socioeconomic activities

10.4.3.4 Service Providers (Constructors, Consultants, Technicians, Business Support Services Providers and others)

- Implementation, servicing and maintenance of the planned project (infrastructure, supplies of irrigation equipment, farming implements, machinery and inputs; providers of irrigation support services (technical and business), and others at national regional and community levels

10.4.3.5 Civil Society Organizations and Community Based Organizations

- Monitoring and reporting on the impact of damming, impact of damming on community and environment
- Providing of information for setting and monitoring of e-flow releases
- Mobilization and sensitization of communities in setting of and following e-flow releases and regulations.

10.5 Adaptive management

The adaptive management system will be central to utilization of the monitoring results as the EFMP is based on setting-checking-implementing-monitoring-re/planning design with the replanning informed by the outcome of the monitoring, and aimed at adjusting the e-flows so as to meet the e-flow requirements in a way that mitigates the observed impacts and addresses the failings of the previous e-flow settings. The recommended interval and basis for e-flows reviews is 3 years. The decision to adjust or not will be technical and will considered and taken by Technical Committee for the project at National level but with consultation and involvement of key stakeholders starting at farmer community level. The monitoring programme outcome and guidance, disclosures and consultations should be made on any altered/updated plan where necessary.

10.6 A framework for implementing and monitoring the EFMP

The monitoring activity shall be guided by the following steps:

1) Review of EFMP, study the project documents and technical reports, and review existing data.

2) Conduct a pilot monitoring study
3) Consult with stakeholders as to size of the data required to prove that the set e-flows and release plan and implementation are working.
4) Refine the monitoring study design
5) Establish the rationale of the study design

10.7 Reporting, record keeping and auditing/quality control arrangements.

Any monitoring of the performance of the EFMP including at that by the community will need review and clearance at the national level by the PMU so as to harmonize processes and agree on the type of data to be collected against the set objectives.

10.7.1 Delegation of institutional responsibility

The project will be implemented through existing Government structures, relying mainly on Government staff. The PMU will comprise Government staff and individual consultants recruited for the purpose of ensuring efficient project implementation. While each Ministry may have staff already engaged in these activities, the individual consultants under the PMU will provide additional support to the extensive additional work that the project will bring along, an additional work-load that may end once the project ends. This set-up strengthens and is aligned with Government structures and ensures sustainability. It also promotes cooperation between two ministries which have to keep working in close alignment when it comes to irrigation development, building on their respective mandates (Source: ICRP Project Appraisal Document, 2020).

The monitoring programme at national, regional and community level will be the remit of the Project PMU, and where in house, the PMU may seek the services of an independent consultant or firm. Monitoring at project site will be responsibility of respective organizations, whose monitoring programme and design will have to be considered and approved by MWE to whom the findings will be reported. The requirement and schedule for monitoring by the constructors and operators will be stated within the contracts and will be as specified above a weekly with captured in set and agreed format following the guidance of the MWE hydrologist and Biodiversity specialist.

Highly modified section of River Mishumba in the upstream (before reservoir area)

11 DAM OPERATION AND MAINTENANCE PLAN

Dams are complex structures subject to several forces that can cause failure. These forces are active over the entire life of the dam, and the fact that a dam has stood safely for years is not necessarily an indication that it will not fail. Therefore, Kabuyanda Irrigation dam must not be thought of as part of the natural landscape, but as man-made structure, which must be designed, inspected, operated, and maintained accordingly. A dam failure can be a disastrous event with catastrophic consequences to the downstream area and the surrounding environment. Inundation from dam failures have the potential for immense damage to property, the economy, the environment, and possibly fatalities as thousands of lives may be lost. There are many causes of dam failures and incidents, each depending on the dam's material, design, surrounding environment, construction methods, etc. In addition, there are enabling causes that are deficiencies in the dam structure and triggering causes that are outside factors which can adversely affect the safety of a dam.

According to the World Bank good practice note on safety of dams[14], dam safety plans are required for certain dams. Therefore, the Operation and Maintenance Plan (O&MP) is a requirement that outlines the general operation and maintenance (O&M) requirements of the dam and associated facilities to allow the users to define such requirements in the context of their projects. The following four dam safety reports were prepared, as required by OP4.37: Plan for Construction Supervision and Quality Assurance; Instrumentation Plan; Operation and Maintenance Plan; and Emergency Preparedness Plan. The above plans were reviewed by the Bank's Dam Safety Specialist and found satisfactory and along with the design progress, the Instrumentation Plan will be updated before bidding; the OM plan will be updated 6 months before reservoir impoundment starts; the Emergency Preparedness Plan will be updated 12 months before the reservoir impoundment starts.

11.1 Main Characteristics of Dam and Appurtenant Structures

Kabuyanda dam under the Kabuyanda Irrigation Scheme will impound water to develop 3,300 ha of irrigated agriculture extending southwards from the dam along the R. Mishumba banks. It will be a 33 m high zoned earth-fill dam, located at E233602 and N9899313 at the border of Katooma I (Rwakakwenda Parish), Kyamazinga I & II (Kagara Parish) and Rwoho CFR (Rwoho Parish) villages. The reservoir will operate at minimum and maximum storage capacity of between 1.5Mm^3 and 8.8Mm^3 respectively, beyond which the excess will be discharged through a spillway with a design discharge of 57m^3/s (10,000-year return period). It will drain a catchment area of about 90km^2 with its minimum drawdown level of +1347.0m and full reservoir level of +1359.00m across the 314m crest

It will have conventional side channel spillway with an overflow weir discharging into a narrow channel in which the direction of the flow is approximately parallel to the weir crest. The spillway system will comprise the following hydraulic elements:

[14] https://openknowledge.worldbank.org/bitstream/handle/10986/35484/Appendix-3-Operation-and-Maintenance-Plan-Sample-Framework.pdf?sequence=6&isAllowed=y

a. an ogee crest with sill elevation at RL +1359.00m;
b. a side channel about 78.50m long, characterized by a rectangular section 8.5m wide and by a variable flow in the first stretch in correspondence of the spillway crest;
c. a side channel about 30.00 m long, characterized by a variable rectangular section from 8.5m to 7.215m width;
d. a steep chute about 40m long characterized by a rectangular section of progressively narrowing width (from 7.215m to 5m); and
e. a chute about 110m long and 5m wide with stilling basin for energy dissipation is located at the end of the chute.

The spillway crest is designed to discharge;

a. the peak of the routed flood for 10,000 years' return period, Q10000 = 58.20m^3/s, considering the routing effects of the flood into the reservoir; and
b. the routed Probable Maximum exceptional Flood QPMF, = 270m^3/sec

While discharging the 10,000 years return flood the reservoir level will rise up to 0.8m over the Max Operating Level (FRL/FTL) up to an elevation of RL+1359.80m, providing a moderate routing of the peak discharge while maintaining an adequate freeboard even considering the waves due to the reservoir exposure to storm winds. While discharging the PMF, the reservoir level will reach the elevation RL+1361.25 m. This is commonly accepted in the engineering practice, due to the exceptionality of the event. The height of the spillway chute is H = 19.60m (H = 1351.60 – 1332.0), while the slope is 1 in 7.65. The spillway structure will end with a stilling basin to dissipate the water energy by means of a hydraulic jump and reduce scouring of the river bed. The stilling basin has been designed for routed flood with 10,000 years return period, Q10000 = 58.20 m^3/s. Tail channel of about 100m long protected with stone pitching, will convey the spilled flow from the stilling basin to the natural riverbed.

11.2 Potential Hazards of Kabuyanda Dam and Surrounding Areas

A dam hazard is source of potential harm or a situation with the potential to cause loss whose threat or condition may result from either an external cause (for example, earthquake, floods, or human activity) or an internal vulnerability with the potential to initiate a failure mode. In dam safety, a hazard is often seen as a measure of the consequences of dam failure in the downstream area of the dam in the event of dam failure or mis-operation, resulting in an uncontrolled release of flood waters. Dam failure is an uncontrolled release of water, sediment, or other stored contents of a reservoir through partial or complete collapse of the impounding dam, or the inability of a dam to fulfil the intended design purposes[15]

Kabuyanda Irrigation dam is located on a raised elevation (surrounded by hills) compared to the irrigable (downstream environment) where water will be utilised. This subjects the proposed dam to a hazard or threats that may cause dam failure. These can be loads and threats (flooding from high precipitation, landslides), dam failure or uncontrolled release of water, earthquakes and internal threats. Therefore, failure may occur due to both enabling and triggering causes which

[15] World Bank - Good Practice Note on Dam Safety (2020)

are both nature and man-made hence consequences/impacts in the downstream areas (i.e., nature and occupation of the valley downstream, or of valley use upstream).

Potential causes of dam failure

These include:

a. ***Overtopping***: this may occur when the water level surpasses the height of the dam crest, causing it to spill over the dam to the surrounding settings;
b. ***Seepage and piping***: This cause erosion and saturation in the embankment or foundation material and causes it to lose strength thereby allowing water to seep through;
c. ***Instability issues****:* Instability of a dam can be a serious problem and can cause sliding and movement of the embankment or foundation thereby weakening infrastructure stability and integrity;
d. ***Lack of maintenance****:* Dams also fail due to maintenance concerns and inadequate slope protection, surface run-off erosion, inappropriate vegetative growth and animal burrowing;
e. ***Foundation or abutment weakness*****:** Any weakness or deficiency in the foundation or abutments can be detrimental to a concrete dam;
f. ***Poor concrete strength or deterioration:*** inadequate or degraded concrete can lead to the inability of the dam to sustain large loads and result in failure; and
g. ***Cracking***: caused by movements e.g., the natural settling of a dam hence resulting into failure.

Triggering causes of dam failure

These include:

a. ***Extreme weather***: Extreme weather conditions such as sudden weather changes can compromise dam structural integrity occasioned by raise in reservoir water to problematic levels and thereby increasing seepage and piping;
b. ***Deterioration or poor condition***: can be through aging of a dam or a lack of proper maintenance regime. Deterioration of a dam's material can cause cracking, instability, and creating "paths" for internal erosion though which, water can break through;
c. ***Equipment malfunction or human error****:* Malfunction of dam facility alongside events arising from human error for instance, improper management of operational functions such as opening and closing of hydraulic gates, lack of adherence to both O&M as well as Emergency Action Plan (EAP) schedules and other similar actions can result in unpredictable forces that can cause failure to a dam facility all by itself; and
d. ***Animal activity or unchecked vegetation growth***: when animals burrow through dam embankments or vegetation within the embankment grows to unsafe levels and impacts of its roots, all these can occasion seepage and piping on the embankment leading to eventual dam failure.

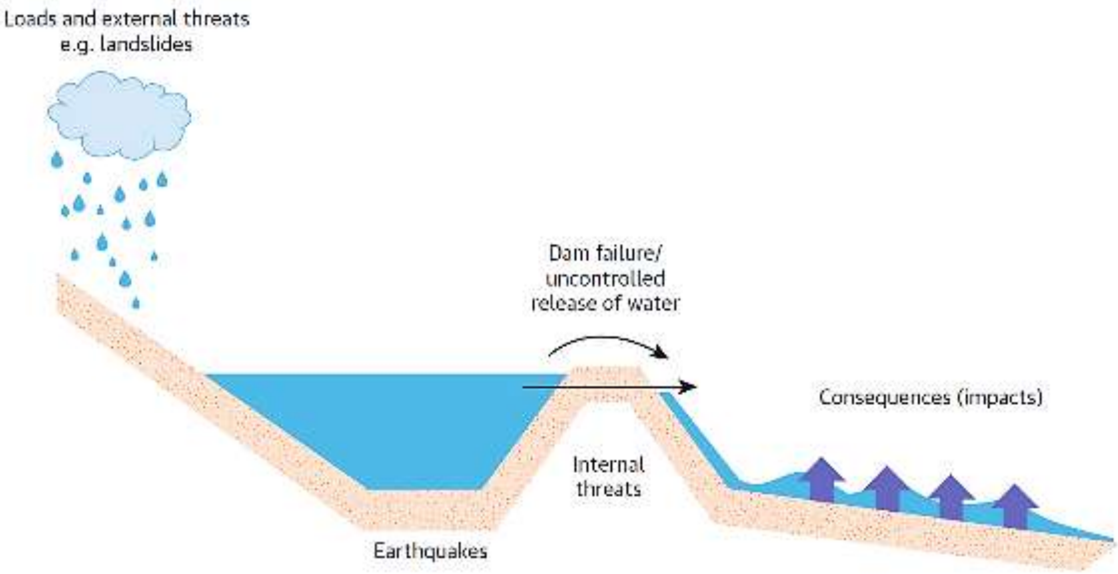

Figure 11-1: Conceptual Diagram of Threats/Loads, Dam Response/Performance, and Consequences[16]

11.2.1 Risk Classification of Kabuyanda Dam

According to the World Bank - Good Practice Note on Dam Safety (2020), the main criteria for classifying dams is based on either geometrical parameter (typically dam height and reservoir capacity, sometimes including dam type), incremental consequences or hazard potential that would occur as a result of a dam failure, or a combination of these.

Risk matrices are derived from four categories i.e. red (high) for dams with greatest risk (higher dam safety requirements); orange (substantial risk); light green (moderate risk); and green (low risk) for dams with lowest risk (lower dam safety requirements) as in Table 11-1. These can conceptualize the risk classification using two elements:

a. structural dimensions, such as the dam height and reservoir capacity, and
b. downstream consequences (the number of people affected and other consequences) in case of dam failure.

In addition, unusually high loads and threats, such as intensive floods, high seismicity, and structural vulnerabilities of dams as a result of a structure's type (such as embankment dam in comparison with concrete gravity dam), geological conditions amongst others should also be considered given their potential uncertainties.

Table 11-1: Typical risk classification of Kabuyanda Irrigation Dam

	Magnitude of downstream consequences				
Potential hydraulic force of failure and vulnerability (Dam's features and		**Low**	**Moderate**	**Substantial**	**High**
	High				
	Substantial				

[16] World Bank - Good Practice Note on Dam Safety (2020)

potential vulnerability)	Moderate				
	Low				

The International Commission on Large Dams (ICOLD) Bulletin 72 provides a simple concept of risk classification using four (4) parameters i.e., (a) dam height (b) reservoir capacity (c) number of people potentially affected, and (d) other potential consequence Table 11-2

Table 11-2: ICOLD Dams Classification System[17]

Dam's dimensional features	Reservoir capacity (million m^3)	<0.1	0.1–1	**1 - 120**	>120
	Points	0	2	4	6
	Dam height (m)	<15	15–30	**30 - 45**	>45
	Points	0	2	4	6
Downstream consequence in case of dam failure	Evacuation requirements (number of people)	None	1–100	**100 - 1,000**	>1,000
	Points	0	4	8	12
	Potential damage downstream	None	Low	**Moderate**	High
	Points	0	4	8	12
Total risk points (summation of the 4 factors' points)		<6	7–18	**19 - 30**	31–36
Class		I (low)	II (moderate)	**III (substantial)**	IV (high)

Therefore, Kabuyanda Irrigation Dam and surrounding areas is rated to have substantial hazard.

11.3 Management Structure

Management of safety of dams is an integral part of the overall sustainable management of dams (ICOLD-Bulletin "Dam Safety Management". ICOLD Preprint, B154). In this project, the management of the dam, its dam safety assurance, as well as the reservoir is the responsibility of the Directorate of Water Resources Management (DWRM) under the Ministry of Water and Environment (MoWE) as provided in the Ministry's Dam Safety Guidelines of 2014[18]. The Directorate has a unit responsible of all dam safety issues in Uganda. Therefore, like any other infrastructure water resource management project, the Dam Safety Unit (DSU) is comprised of a committee of administrative and technical expertise to execute the processes as defined under dam safety regulations. In compliance with the triggered OP 4.37, a Dam Safety Panel of experts has been constituted to provide the necessary oversight. Therefore, it puts regulations for the processes to enable effective operation of all dimensions of the organisation both under normal and abnormal conditions including emergencies. It is also responsible for making all organizational

[17]World Bank - Good Practice Note on Dam Safety (2020)
[18] MoWE/DWRM Dam Safety Guidelines August 2014-Republic of Uganda, Kampala

and management arrangements to perform activities within the constraints of government regulation.

In this regard, the role of the DSU under the Directorate is crucial in ensuring proper dam management and regulation. In addition, the DSU acts as a link of communication/information source among the actors including the public or stakeholders impacted by the dam.

The dam operations and maintenance team will have the following roles;

a. Data collection and processing for the dam;
b. Assessment of dam construction and management;
c. Dam inspection;
d. Providing technical advice on dam construction;
e. Dissemination and guidance on dam safety;
f. Drafting regulations, guidelines, technical instructions on dam safety;
g. Monitoring the implementation of dam construction safety aspects;
h. Inventories and registration of dam as well as its hazard classification;
i. Dam archive management.

11.3.1 Overall Management Structure

The Dam Safety Unit (DSU) under MWE/DWRM will be formed of the following staff.

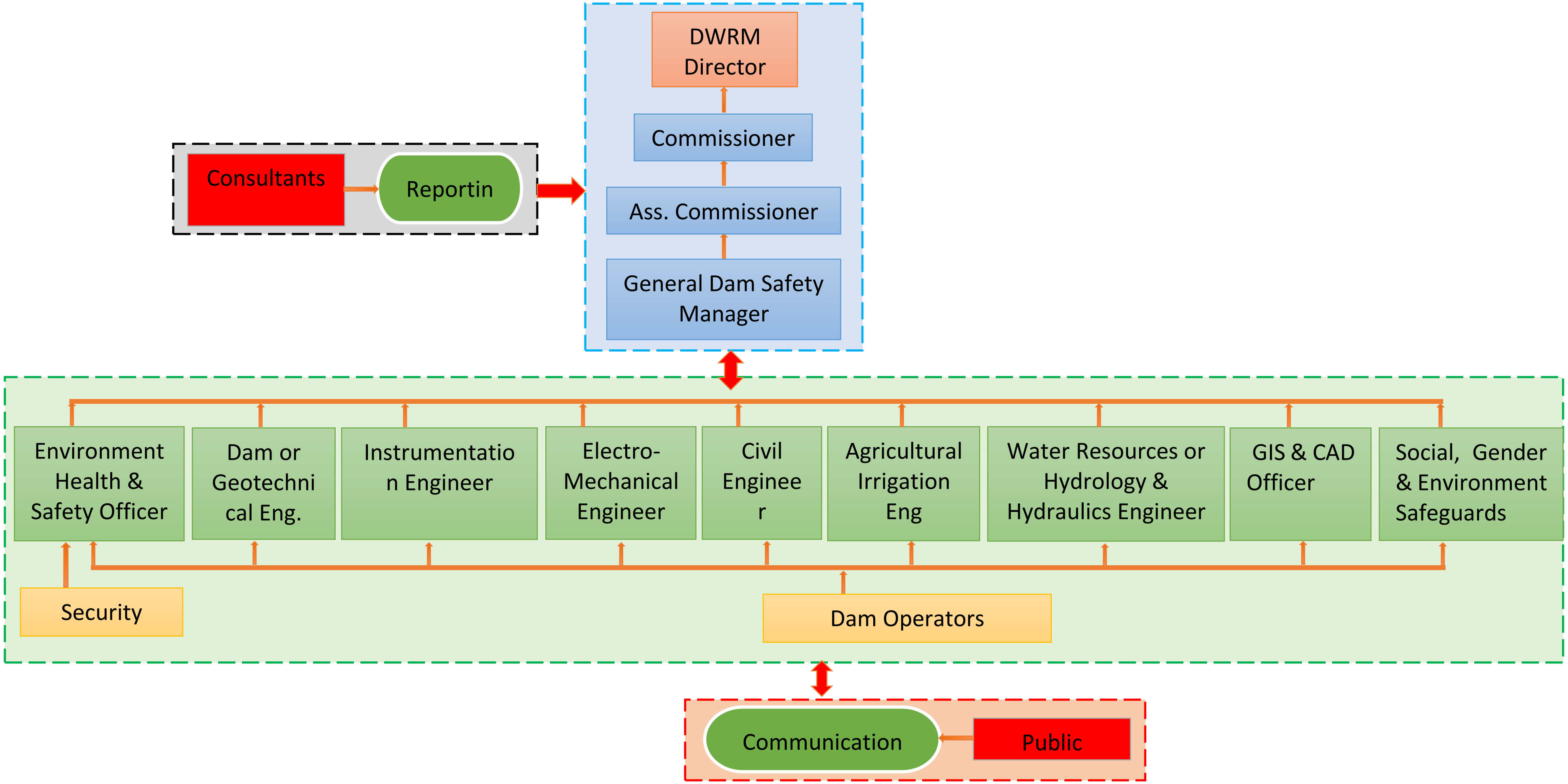

Figure 11-2: Overall organizational structure of the dam operation and maintenance team

11.3.2 Key Staff Qualification and Training

Key Technical	N°. of Staff	Level of qualifications and training	Roles and Responsibilities	Reporting to:
General Dam Safety Manager	01	Advanced degree in Geotechnical Engineering, Geology or Dam Engineering, Hydropower Engineering, Civil and Building Engineering or Water Engineering with Management Skills	Overall Management of the Staff Reporting to the MoWE	
Environment, Health and Safety Officer	01	Degree in Environmental Engineering, Environmental Sciences or Occupational Health and Safety	Heading all Occupational Health and Safety Services including	General Dam Safety Manager
Dam or Geotechnical Engineer	01	Advanced degree in Geotechnical Engineering, Geology or Dam Engineering or related field with knowledge in Hydropower projects	Geotechnical Services	General Dam Safety Manager
Instrumentation Engineer	01	Diploma in Instrumentation Engineering (Minimum) with good knowledge in flow, concrete related equipment	Overall supervision of Surveillance Instruments	General Dam Safety Manager
Electro-Mechanical Engineer	01	Degree in Mechanical or Electrical Engineering with knowledge in Hydropower Engineering	All electrical and mechanical works	General Dam Safety Manager
Civil Engineer	01	Degree in Civil and Building Engineering with knowledge in Water Engineering	All civil works (concrete)	General Dam Safety Manager

Agricultural Engineer	01	Advanced degree in Agricultural or Irrigation Engineering, Water Engineering or Related	Agriculture or irrigation services	General Dam Safety Manager
Water Resources or Hydrology and Hydraulic Engineer	01	Advanced degree in Hydrology, Hydropower Engineering, Water Engineering or Related	Hydrological and hydraulic aspects	General Dam Safety Manager
GIS and CAD Officer	01	Degree in Geographic Information Systems, Geomatics, Land Surveying or related filed with knowledge in CAD software and IT	GIS and CAD Services including IT Update of all project components in shapefiles	General Dam Safety Manager
Social, Gender & Environment Safeguards	01	Advanced degree in Sociology or Social Sciences	Social	General Dam Safety Manager

11.4 Maintenance Program

11.4.1 Maintenance Program Overview

Kabuyanda dam will impound a huge volume of water, that if it fails to hold it, the water will be release into the surrounding environment (especially downstream) thereby impacting on physical and human environment. Therefore, the dam should undergo routine and scheduled inspections, so that its maintenance team is able to timely discover and fix faults/risks early enough. Routine inspections on the dam are important, because they provide an input to preventive maintenance which keeps the dam and its appurtenant structures operating normally in line with its design and established standard and acceptable practices. The maintenance program is to indicate the components of Kabuyanda dam and its appurtenant structures that will require scheduled maintenance activities and a record of what is to be done, when and by who. This can be general and specific maintenance requirements for each operational component and all monitoring instruments and specific activities.

As such, dam maintenance program defines all tasks to be undertaken as scheduled to ensure;

a. reliable and safe operation;
b. regular inspection;
c. early detection of deterioration; and
d. repair or rehabilitation to be carried out in a timely manner to ensure all structures and facilities are kept in good condition.

The following maintenance program is proposed to be undertaken in the Kabuyanda dam;

a. vegetative maintenance involving mowing and overgrown bush removal;
b. debris removal that would impact on the flow near gates, spillways, channels;
c. animal control to guard against mainly in seepage pathways;
d. earth embarkments focusing on addressing any eroded paths, ruts, sloughs that could occur in the embankment;
e. Security or vandalism or public access to ensure safety of the investment;
f. Safety items installed to support and enhance safety of the dam and the public;
g. Slope protection to ensure the inclination is kept stable as design;
h. Concrete repairs to ensure its integrity;
i. Cleaning of drains to ensure efficient discharges flow throughs;
j. Refreshing staff gauges;
k. Instruments in terms of efficient use as prescribed; and
l. Exercise gates.

11.4.2 Civil Works and Electrical Mechanical Equipment Maintenance Program

Concrete is an inexpensive, durable, strong and basic building material often used in dams for core walls, spillways, stilling basins, control towers, and slope protection. However, poor workmanship, construction procedures, and construction materials may cause imperfections that later require repair. Long-term deterioration or damage caused by flowing water or other natural forces must be corrected.

Mechanical equipment includes spillway gates, sluice gates or valves, stoplogs, sump pumps, flashboards, relief wells, emergency power sources, siphons and other equipment associated with spillways, drain structures, and water supply structures.

Table 11-3: General maintenance plan

Component	Maintenance activity
Inlet structure	❖ Promptly repair or replace damaged lining and components.
	❖ Remove sediment that has accumulated to maintain capacity of the channel.
	❖ Vegetation shall be maintained and trees and brush controlled by chemical or mechanical means. Control noxious weeds.
	❖ Keep machinery away from steep side slopes. Keep equipment operators ❖ informed of all potential hazards
Inlet control device	❖ Promptly repair or replace damaged components.
	❖ Exercise gate valve regularly.
	❖ Lubricate in accordance with manufacturer's recommendations.
	❖ Repair deteriorated concrete as soon as possible.
Outlet	❖ Exercise regularly.
	❖ Lubricate in accordance with manufacturer's recommendations.
	❖ Promptly repair or replace damaged components.

Embankment	❖ Fill rills and gullies that occur on the embankment slopes and in the vegetated spillway and reseed the filled areas.
	❖ When animal burrows are found, remove the burrowing animals, replace ❖ embankment materials and reseed.
	❖ Maintain a vigorous sod in the emergency spillway and on embankment by regular mowing and fertilization. Remove excess growth. Do not burn or overgraze.
	❖ Prevent trees and brush from growing on embankment slopes, crest, or toe. ❖ Control tree and bush growth by hand cutting, mowing, or chemicals. Avoid damaging grass with herbicide sprays.
	❖ Maintain a fencing to keep livestock of embankment, where applicable.
	❖ Operate mowing and other equipment on slopes in accordance with machinery operation manual.
Spillway	❖ Fill rills and gullies that occur in the vegetated spillway and reseed the ❖ filled areas.
	❖ Maintain a vigorous sod in the spillway by regular mowing and fertilization. Remove excess growth. Do not burn or overgraze.
	❖ Do not graze livestock during establishment of vegetation and when soil conditions are wet.
	❖ Protect spillway from damage by farm equipment and vehicles. Do not ❖ use spillway as a road and practice care when crossing to prevent tillage ❖ marks or wheel tracks.
	❖ Prevent trees and brush from growing in the spillway. Control tree and bush growth by hand cutting, mowing, or chemicals. ❖ Avoid damaging grass with herbicide sprays.
	❖ Re-establish vegetative cover immediately where scour erosion has ❖ removed established seeding.
	❖ Where there is rock lining, replace any dislodged rock and fill back to ❖ grade if displacement or settlement occurs.
Staff gauges	❖ Promptly repair or replace damaged components.
Survey Monuments	❖ Promptly repair or replace damaged components.

Table 11-4: Types or categories of maintenance

Category of Maintenance	**Condition(s)**	**Frequency**

Critical Maintenance (require immediate repair or maintenance under the direction of a qualified engineer)	❖ Erosion, slope failure or other conditions which are endangering the integrity of the dam; ❖ Piping or internal erosion as evidenced by increasingly cloudy seepage or other symptoms; ❖ Spillway blockage or restriction; and ❖ Excessive or rapidly increasing seepage appearing anywhere near the dam sit.	❖ Anytime there is need to address the specific conditions
Periodic Maintenance (whenever they are noted during Operation Inspections or Periodic Inspections)	❖ Remove bushes and trees from the embankment and abutments; ❖ Repair erosion gullies; ❖ Repair defective gates or valves; ❖ Repair deteriorated concrete or metal components; and ❖ Maintain riprap or other erosion protection.	❖ at least annually
Continuous Maintenance	❖ Test, clean and lubricate gates and valves; ❖ Inspect and maintain instrumentation and gauging equipment; ❖ Remove debris from dam area and emergency spillway approach and exit channel; ❖ Remove debris from embankment face and from areas around the intake structures; and ❖ Clean and remove debris from seepage weirs and small drainage ditches.	❖ Semi-annually ❖ Anytime there is need to address the specific conditions
Embarkment Maintenance	❖ Fill erosion gullies with properly compacted cohesive soil material; Seed or riprap repaired area to stabilize from future erosion; ❖ Fill rodent burrows with slurry of soil, cement and water. Remove the rodents; ❖ Maintain grass cover by spraying weeds, fertilizing and watering as needed; ❖ Remove brush, bushes and trees from embankment and from within 7.62m of the groins and 15.24m of the toe of embankment; Remove tree roots, fill with compacted soil and re-seed area;	

	❖ Add or repair riprap where displacement or other damage occurs. ❖ Maintain grading of the embankment crests to prevent potholes, rutting or other potential for standing water to accumulate. ❖ Maintain fences to provide site security and to exclude livestock from the embankments. ❖ Repair and revegetate damaged embankment surfaces. ❖ Perform regular inspections of the embankments and abutments to identify potential maintenance items.	
	❖ Test gates and valves	❖ Semi-annually
	❖ Repair defective gates and valves to ensure smooth operation and prevent leakage. ❖ Repair deteriorated concrete or metalwork. ❖ Repair and verify calibration of water measurement equipment.	❖
	❖ Lubricate gates and valves	❖ annually or as recommended by the manufacturer.
	❖ Remove debris from the outlet channels, inspect and repair erosion protection.	❖ annually

11.5 Surveillance Program

Surveillance of Kabuyanda dam will help to avoid/reduce chances of dam failure by giving early warning of any potential issues that may impact on its performance for the irrigation purposes. Dam surveillance helps to:

a. compile an accurate history of observations relevant to the assessment of dam safety;
b. allow the safety performance of the dam to be regularly assessed and reported; and
c. facilitate the early detection and reporting of potential deficiencies or adverse trends.

Therefore, the surveillance program for Kabuyanda dam will consider instrumentation for the dam and its environment. This will help to measure, collect, and analyze data of key physical parameters of a dam and associated structures in order to assess their performance and behavior, detect potential defects and deficiencies at an early stage, and verify that those structures perform according to the design.

11.5.1 Surveillance Types and Schedule

Kabuyanda Irrigation Dam embankments can easily be monitored by using the following devices. devices mentioned in Table 11-5 below. The surveillance program provides visual details inspections and instrumentation monitoring. The plan provides elements for the surveillance program of the dam and reservoir. Table 11-5 show the proposed typical surveillance instruments for Kabuyanda Irrigation Dam.

Table 11-5: Proposed instrumentation for Kabuyanda Irrigation Dam

Key indicator	Instrumentation type	Parameter to measure	Location of instrumentation
Pore pressure	❖ Open standpipes ❖ Twin tube hydraulic Piezometers ❖ Vibrating wire piezometers	❖	❖ Dam body ❖ Dam foundation ❖ Abutment
Leakage or seepage losses	❖ Weirs (v-notch) or flumes ❖ Turbidity meter	❖ Measure flow rates of seepage	❖ Dam downstream ❖ Abutment
Deformation	❖ Deformation survey ❖ Surface movements survey ❖ Settlement gauges ❖ Yardstick or Folding Rule ❖ Inclinometers	❖ Measure cracks, scarps, erosion gullies, settlement, trees, wet areas, and slab or wall movement	❖ Dam crest ❖ Abutments
Vandalism	❖ Camera (CCTV)	❖ Dated and labelled provide an excellent record of existing conditions, and if taken periodically from the same location, which can be used for comparison	❖ Dam crest ❖ Fence ❖ Gates
Ground-water level	❖ Observation wells	❖ Determine the ground-water level.	❖ Embankment or foundation
Reservoir water levels	❖ Automatic water level gauge ❖ Rainfall gauges	❖ To the rise and fall in water levels in the dam; and ❖ Precipitation.	❖ Dam crest ❖ Upstream inlet ❖ At the dam

11.5.2 Periodic Dam Safety Inspection

The Kabuyanda irrigation dam surveillance program is to put in place, the frequency and regular inspections of the dam and its associated structures and instrumentation monitoring, data analyses, evaluation, and storage. However, the frequency of inspections and monitoring data analyses will vary depending on their specific tasks, complexity of the system, and the potential risks of the dam.

The Kabuyanda dam having been ranked as a substantial potential hazard, it will retain a huge volume of water, that if it fails, it will release the water into the surrounding environment with attendant impacts on the environment and host community. The dam is therefore to undergo routine inspections to enable the maintenance team establish faults before the dam fails. The routine inspections are important as they help in timely identification of deficiencies, affected sections/parts, causes and indicators which sets in a schedule for preventive maintenance to allow the dam operate normally.

It is crucial that the dam be inspected regularly for any instances or signs of seepage, cracks, instability and maintenance concerns occasioned vegetation, rodent activities etc.). This will help to take proper maintenance measures when needed. Therefore, emphasis will have to be on the following areas as illustrated in Figure 11-3 and explained in Table 11-6. Details of some of the checklists to be used are in **Annex 12**.

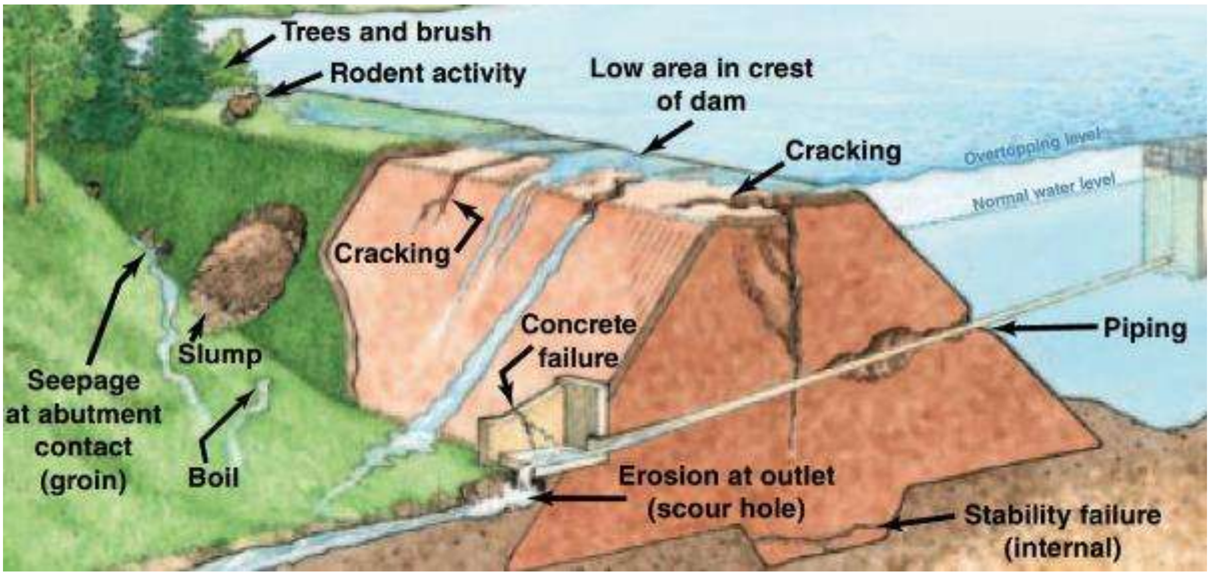

Figure 11-3: Schematic illustration of typical deficiencies in dam captured in inspection

Table 11-6: Potential risk, deficiencies and defects of the dam to be inspected

Areas of Inspection (deficiency)	Affected Sections or Structures	Causes	Indicators
Seepage	❖ Embankment ❖ Foundation ❖ Conduits ❖ Abutments	❖ internal pressures on structure ❖ cracks	❖ Exterior wet area or like a flowing spring ❖ Sand boils ❖ Noticeable changes in vegetation ❖ Changes in drainage flow
Cracking (longitudinal and transverse)	❖ Crest or slopes of the dam ❖ Foundation ❖ Conduits	❖ Poor Materials used ❖ internal pressures on structure	❖ leakages ❖ observation ❖ flowing spring
Instability	❖ Embankment ❖ Foundation	❖ seepage or surface runoff	❖ Change of position

		❖ settlement of the dam foundation ❖ varying forms of erosion	❖ Depressions or low spots in the embankment
Maintenance concerns	❖ Dam crest ❖ Embankment	❖ poor slope protection ❖ surface runoff erosion ❖ vegetative growth ❖ animal burrows	❖ Surface runoff ❖ deep erosion gullies ❖ animal burrows

Therefore, the DSU shall depend on the purpose of the inspection and carry out the following types of dam safety inspections as in Table 11-7

Table 11-7: Type of inspection or monitoring and frequency for Kabuyanda Dam

Inspection/Monitoring Type	Frequency	Items to Inspect, Monitor, Record	Personnel
Informal unscheduled (e.g., storm event, earthquake)	As needed	Spillway and Embankment: water levels, unusual conditions	DWRM
Informal	Quarterly	Spillway and Embankment: water levels, spillway debris, seepage, slides, rodent activity, vegetation, vandalism	DWRM
Maintenance	Annually	In addition to above items: slope protection condition, maintenance of operating and safety equipment	DWRM
Technical	5 Years	Safety Inspection	Engineer

11.5.3 Instrumentation and Monitoring

Various monitoring devices such as weirs, piezometers, and settlement monuments will be used to monitor dam embankment structures. They are used to determine if the structure is performing as designed, to detect signs of serious problems, or to provide further information after a problem has been detected. Due to expense, the use of extensive instrumentation to ensure safety is usually limited to large dams where failure would result in loss of life and significant damage. A full-scale monitoring and instrumentation program requires professional design and will not be discussed here.

Table 11-8 shows the instruments for dam monitoring while Table 11-9 shows the monitoring frequency for Kabuyanda irrigation dam.

Table 11-8: Instrumentation for Kabuyanda Dam

S. No.	Description of item of work	Purpose
1	Standpipe Piezometer model EPP-10SP or Water level sounder model EPP-10/6	Monitoring ground water level and its variation with time
2	VW type piezometer model EPP-30V	Monitoring pore water pressure in soil, earth/rockfills, foundations and concrete structures
3	V-notch Weir	Monitoring water flowrates, by measuring the head of water over the v-notch crest
4	Targets model EBS-16	Measuring vertical settlement of any dam structure due to nearby excavation and construction activities or movements.
5	Vertical movement devices (Magnetic settlement devices) model EDS-91	Monitoring vertical settlement or heave of soft ground (soil and rock movement in embankments and dams)
6	Automatic weather station model EAWS-101	Allows remote monitoring of meteorological data
7	Control Buildings	

Table 11-9: Proposed reading frequency of monitoring instruments

Monitoring activity	Risk classification		
	Low	**Medium**	**High**
Routine surveillance	Monthly	Weekly	Daily – weekly
Reservoir level	At routine inspection	Continuous	Continuous or telemetered
Seepage/leakage Phreatic surface/uplift pressure	At routine inspection	Monthly – daily	Daily
Deformation survey	Minimum 10-yearly	5-yearly	Yearly
Rainfall	Typically, not required at site	Daily	Daily – hourly
Seismic motion	Typically, not required at site	As required	As required
Turbidity of seepage	As required	Six months – yearly	Monthly

11.5.4 Reporting and Archiving Procedure

The MoWE specifically its DSU will be accountable of most important information on every structure under the responsibility of DWRM. This includes compliance with the proposed plans and following records/inventory of reservoir operations which should be maintained:

a. Rainfall record on daily basis throughout the year;
b. Reservoir levels on daily basis during dry season and hourly basis during wet season;
c. Depth of outflow over the spillway on hourly basis during wet season;
d. Estimated spillway outflows during wet season on hourly basis;
e. Irrigation releases;
f. Water audit register to be maintained for estimating the inflows on hourly basis during wet season and daily basis during dry season by accounting all the releases/outflows and the incremental change in storage in the reservoir;
g. All operating procedures;
h. Environmental Flow Management Plan; and
i. Biodiversity and Environmental Management Plan; among others.

Use of Records: The records will be part of the monitoring system for the reservoir, and findings will be shared both internally and externally, where appropriate to enable stakeholder engagements. The records are part of the instrumentation plan. However, the DSU will further take up the responsibility of updating the database about the dams.

A culvert (road) washed away by the flash flood downstream of the dam

12 MONITORING PROGRAM

The development of this monitoring program was based on Mishumba river monitoring system. This was through review and assessment of the monitoring system and procedures for the Mishumba River, especially downstream the proposed dam, conduct a gap analysis of the need for improvements to the monitoring system and management and propose the team needed for effective monitoring plan, sites for installing flow monitoring stages, field equipment needed and local capacity needed for implementing this monitoring plan, among others.

12.1 Gap Analysis

A rapid assessment of the monitoring system was done and it established key gaps existing (and anticipated) in the environmental monitoring of the environmental flow, bio-diversity and ecosystem services across the River Mishumba. Among the key gaps identified included:

A. ***Need for Readiness Assessment before and/or during implementation:*** The readiness assessment is justifiable because there is substantial preparatory work required to be done before the actual construction of a results-based M&E system that encompasses river flow monitoring can be completed. The readiness assessment will provide:

ii) Review of information needs of stakeholders (esp. MDAs and DLGs) that are present as well as anticipated in relation to River Mishumba catchment. It should be noted that all monitoring processes provide answers to information needs. The nature of information and data is not clearly defined at present, in particular it’s indicators, indicator definitions, data structures, data flow charts, data models, river flow measurement monitoring systems, information flow requirements, etc.;

iii) Agree on the appropriate type and model of the monitoring system that integrates key functions such as process monitoring, compliance monitoring, implementation monitoring against result monitoring, context monitoring, financial monitoring, organizational and grievance monitoring;

iv) Assess the community and organizational roles, responsibilities, capabilities and incentives;

- Who will own the system?
- Who will benefit from the system?
- How much information do they really want?
- How will the system directly support better resource allocation and the achievement of program goals?
- How will the organization, the champions, and the staff react to negative information generated by the monitoring system?
- How will the monitoring plan/system link with project, program, sector, and national goals?

B. ***Need to harmonize on desired outcomes of monitoring plan vis-a-vis scenarios and targets of stakeholders (ICRP, MDAs, DLGs & community).*** The existing documentations (e.g., design report and appraisal document) do not clearly define the overall M&E plan for river flow, biodiversity and ecosystem services. This is critical because establishing outcomes will illustrate what success looks like. In addition, it’s quite insufficient to directly set indicators before harmonizing the overall outcomes vis-a-vis the agreed scenarios. Setting the outcomes is crucial before identifying and defining indicators for which data will be captured. The current situation shows that there is not yet collaborative effort on harmonizing the outcomes of the monitoring plan. Outcomes refer to changes in relationships, actions, activities, behaviors within the R. Mishumba flow regime.

Some of the key issues to be harmonized will include:

- what are the strategic priorities?
- what are the desired outcomes?
- who is to participate? identify and/or review major concerns of stakeholder groups;
- translate problems into shared outcome statements among key players;
- disaggregate to capture key desired outcome e.g., improved habitats for fauna by size and conditions and species.

C. ***Needs to develop and define Key Performance Indicators (KPIs) to monitor outcomes:*** At present, the KPI for monitoring river flow, biodiversity and ecosystem services are not very clear. The KPI are intended to help understand if the desired outcomes are achieved. The SMART indicators (SMART - Specific, Measurable, Achievable, Realistic and Time bound) are not yet developed. At same time, the definition of KPIs is required, as well as determining the data structures, baseline values and target values. The indicators will cover Inputs (what is needed), output (what has been done), outcomes (desired situation), risks and assumptions. This is a critical gap that has been identified. However, pre-defined indicators from previous projects and best practices could be of use. The indicators will have to be in tandem with national environmental monitoring frameworks including the MoWE Standard National Climate Change Indicators (MoWE, 2016).

D. ***Need to set baseline Setting Baselines and Gather Data on Indicators:*** The previous studies clearly describe the baseline conditions along the river Mishumba. However, in order to effectively monitor, the baseline values for KPIs need to be developed. The baseline is the first measurement of an indicator that sets the current condition against which future change can be tracked. It is essential to establish the baseline data, identify data sources, define data collection methods, tools and devices; collect data, and establish all data information flow protocols (capture, storage, processing, reporting, knowledge management).

E. ***Need to set targets*** for the monitoring plan: The target setting is not yet clear in relation to overall ICRP performance framework, funding and resource levels, capacity, budgets, facilities, and the like - throughout the target period (daily, weekly, monthly, quarterly, bi-annual, annual, etc.).

F. ***Need to develop comprehensive monitoring plan for river flow, biodiversity and ecosystem services:*** Under the EFR report, a monitoring plan has been presented to give an overview. There is need to have a detailed monitoring plan. This could be a stand-alone document to guide all the ICRP actors. Presently, there is gap in linking Implementation Monitoring and Results Monitoring. The detailed monitoring plan will clearly stipulate this at all monitoring levels (input, activity, output, outcome, impact). It will also define outcomes and targets link to annual work plans, as well as the continuous flow of information up and down the system.

G. ***Need to strengthen the plan to report monitoring results***: The current proposal on reporting requirements is contained in the design report, dam operation plan, instrumentation plan, among others. The major cross-cutting gap is that, there are many contributing specialties that seem to be parallel to each other, and these need to be harmonized. At same time, reporting templates are required. The target audience of the reporting is majorly tied to internal ICRP users, not external audiences.
   - ❖ There is need to redefine who consumes what information, at what level, what is the purpose? In what format will information be disseminated?
   - ❖ Who will receive what information?
   - ❖ When?
   - ❖ Who will prepare the information?
   - ❖ Who will deliver the information?

H. ***Need to integrate Information, Education and Communication (IEC):*** In order to achieve the desired outcomes, reporting should integrate IEC needs of communities and is critical. An IEC plan could be integrated into the ESMP and EFR plan as well. It should also relate to other national IEC frameworks e.g., Uganda National Climate Change Communication Strategy (UNCCS, 2017).

I. ***Review on how to use the monitoring results/reports***: The uses of performance findings and their additional benefits need to be clearly defined at all levels. What is known is that internal use of findings at ICRP is fairly well laid out. However, for sustainability there is need to expound on the how finding of monitoring reports could be used by external and auxiliary actors e.g., DLGs, civil society, academia, etc. Also, the aspect of knowledge management, learning, feedback and organizational memory are essential and need to be addressed / planned for.

J. ***Consideration on sustaining the monitoring plan during operations phase is inadequate:*** There critical aspects that need to be refined especially during operations, namely: a) will demand for monitoring results be continuous? b) What incentives to the monitoring actors after construction? What data quality assurance plan? What capacity is needed in terms of skills, resources and infrastructures?

12.2 Scope of the Monitoring Programme and its overall objective

A monitoring programme is to preserve and to achieve habitat structure and availability; ensure supply of natural food resources in key habitats; maintain the natural breeding, spawning and migration cues and pathways of key fish species in relation to the annual hydrograph of River Mishumba. The Kabuyanda ICRP EFMP is about ensuring that the e-flows recommendations meet the e-flow requirements for key aquatic assets of River Mishumba, and that once the e-flows implemented they do address not only the requirements for fish species but the other biodiversity within or dependent on River Mishumba flow regimes. Monitoring and assessment programme for Kabuyanda EFMP will generate the information to answer clear and precise management and scientific questions on the success of the set e-flows in fulfilling the EFMP objectives. This framework is based on the fact that the relationship between flow regime and river conditions for River Mishumba were extensively examined through detailed field surveys and sampling, in both wet and dry seasons, and also based on historical data and information gathered during the ESIA development for the Kabuyanda ICRP project. This formed the basis for setting of the environmental flow recommendations and the establishing the need to protect or modifying the flow regime with damming of River Mishumba in order to meet the identified ecological and socioeconomic e-flow requirements (**Chapter 6** above and **Annex 5)**.

12.3 Conceptual understanding of flow–ecology relationships and the questions (hypotheses) to be tested

This monitoring programme is based on the concept that alteration of water flow in River Mishumba, a largely an ephemeral river whose flow is generally considered low, may impact the biodiversity in the areas of the project thereby affecting other ecological services and functions of River Mishumba. Under circumstances of limited or controlled loss of riparian vegetation, poodles/pools, reclamation of swamps, change in morphology of the river channel, reduction of flows and changed course of water in River Mishumba, the ecology will not be affected hence continuous ecosystem services provision by the River Mishumba.

However, if the flow is not properly adapted to address the above concerns, possibly it may result into reduced channel riparian vegetation due to encroachment, filling with sedimentation; succession of plants leading to dominance of the waters with unpalatable filamentous algae that is much more suited to the harsh conditions; reduced flow results in armoring, reduced flushing of detritus, nutrients, settling of fine sediment, all which add to reducing the capacity of the river; reduction in habitat space for macroinvertebrates and fish in the substratum because of armoring and infilling with fine sediments. Also, some parts of the bottom may be exposed with reduction in flow and the fact that sediments and organic matter may enter the channel directly from adjacent valley slopes and may not be flushed by low flows in the main channel.

12.4 Timing and monitoring schedules

The monitoring programme for the EFMP will commence before the commencement of construction of the dam and associated infrastructure. This responsibility is entirely for the technical team under MoWE/DWRM. However, this team can be supported by CSOs, CBOs, the Kabuyanda Catchment based Community organization, the local governments, technical committee from central governments and Consultants. Within the plan, monitoring and reporting will be fortnightly for the contractors, monthly for the biodiversity specialist and Hydrologist, and annually for MoWE and NEMA where MoWE takes the lead of every step **(Annex 7, Annex 8 and Annex 9)**.

12.5 Information and Data Variables for the Monitoring Programme

The monitoring plan aims at tracking progress of implementing BEMP and capturing data that is helpful in decision making throughout the project cycle. **Table** 12-1 indicates the information/data needs under key parameters or response variables, location of such variables, location of application and comments about the variable (**Annex 7, Annex 8 and Annex 9**).

Table 12-1: Environmental variables with established causal links with changes to the flow regime

Ecosystem component	Response variable	Location of application	Comments	Period of Monitoring
River fisheries production and productivity	❖ Fish occurrence and production	Survey points 6, 8, 14, 15, 18, 20 & 24 Upstream the dam	Short-term responses to specific flow events as predicted	At least twice a year i.e., every season – dry and wet
Vegetation (details in Annex 5)	❖ Riverbank understory vegetation (species composition, distribution, abundance, survival, growth, reproduction)	Nearly all 24 survey points	Survival and total biomass responded predictably to flow events in lower reaches	Twice a year (once in dry and once in wet season)
Dragonflies	❖ Abundance, diversity	Selected swamps within the Mishumba catchment	Easily communicated and can assess effect of watering quickly	Twice a year (once in dry and once in wet season)
Fish	❖ Larval fish (occurrence, relative abundance, community composition)	The six survey sites where fish was caught (6, 8, 14, 15,18, 20, & 23) Upstream the dam	Preliminary results suggest good response to flow stress	At least twice a year i.e., every season – dry and wet
Frogs	❖ Abundance, diversity and breeding occurrence in swamps	Sites close to flood prone areas of the river	Easily communicated and can assess effect of watering quickly	Twice a year (once in dry and once in wet season)
Birds	❖ No. of species occurring in the catchment	Nearly all 24 survey points considering the upstream, midstream and downstream	Easily communicated and can assess effect of watering quickly	Twice a year (once in dry and once in wet season)
Flow and water stage	❖ Water levels	❖ At the damsite ❖ The Existing River gauging station downstream of the dam	The variation in expected flows based on the season of the year	❖ Daily ❖ When there is need e.g., in case of any occurrence eve heavy downpour

		❖ Proposed gauging station at the last sampling site (outlet) – Point 24		

An access road to Rwoho CFR destroyed by heavy trucks carrying timber from the forest in the upstream

13 IMPLEMENTATION ARRANGEMENTS AND PROCEDURES

13.1 Institutional arrangements

13.1.1 Ministry's' level coordination mechanism

The project will be implemented through existing Government structures, relying mainly on Government staff. Individual consultants – where necessary - will be recruited where the Ministry has inadequate capacity. The PMU will comprise Government staff and individual consultants recruited for the purpose of ensuring efficient project implementation. The implementation of proposed irrigation project will be done under the overall ICRP implying that, its implementation (during both construction and operation phases) will be guided under the broader Multi-sectoral Steering Committee. A multi-sectoral Project Steering Committee (PSC) will be set up to provide high-level operational and policy guidance to ensure that the Project component and its activities are implemented as planned. The PSC will be chaired by the Permanent Secretary of MWE and will comprise Permanent Secretaries (or their representatives at high technical level) of the Ministries and stakeholder statutory agencies as well as Isingiro district. The PSC will meet quarterly to review work plans, budgets and progress of implementation and operation, and ensure adherence to relevant Government policies and strategies during implementation of the Project.

13.1.2 The Project Support Team - PST

The Permanent Secretary of the MWE will be the Accounting Officer for all Project's funds. MWE through its Water for Production Department will have overall responsibility for Components 1 in which the project falls. As the Lead implementing agency for the Project, MWE will be responsible for planning, procurement, budgeting, Financial Management (FM), Monitoring and Evaluation (M&E), and reporting, among others. A Project Support Team (PST) will be constituted within the Water for Production Department of MWE will oversee selected activities, in addition to key hired technical specialists (procurement, accountant, environmental, social, and M&E specialists). The PST will also be responsible for preparing plans, developing budgets, monitoring results, compiling reports, and disseminating outputs and outcomes.

13.1.3 Roles of other ministries in the project

The role of other stakeholder ministries can be summed up as follows:

a. Ministry of Trade, Industry and Co-operatives (MoTIC) will be responsible amongst others, for developing, coordinating, regulating, promoting and facilitating domestic and external trade with particular emphasis on value addition drives in the project as well as export promotion and access to regional and international markets for the commodities under this project;
b. Ministry of Gender, Labor and Social Development (MoGLSD) will be key with respect to the supervision of implementation of livelihood restoration programs as well as providing guidance in mitigation of risks of sexual exploitation and abuse, and employment of children. The Ministry will be key in aspects of HIV/AIDS mainstreaming, occupational health and safety as well as gender issues in the project; and
c. Ministry of Agriculture Animal Industry and Fisheries (MAAIF) will be one of the key implementing partner of the Project's activities that fall within its mandate especially

implementation processes for the agri-business development component, which is important for value addition on crop products from the project. They will take lead in provision of the required agricultural technical support, farmer training and sensitisation, guidance on good quality inputs, safe farming practices, etc.,

13.1.4 Role of National Environment Management Authority-NEMA

National Environment Management Authority (NEMA) will review and approve the Project ESIA and any subsequent Environmental Assessments that will be prepared for project infrastructures not covered under this study as well as monitoring records submitted in accordance with the National Environment Act and its respective Regulations. They will approve and monitor implementation of Operational ESMP.

13.1.5 Isingiro District local government administration

The Isingiro District on its part, will designate a Project Support Officer (PSO) amongst its staff, who will head the District Technical Support Team to support the implementation and technical supervision of the Project, including sensitization of farmers, training, and monitoring and evaluation in the respective local governments. In addition, the DEO and CDO are all key in the implementation of the project with respect to observance of environmental and social safeguards during project implementation (during both construction and operation phases). At District Local Government level, staff will be designated from the relevant implementing departments, chaired by the Chief Administrative Officer, to provide technical oversight on implementation. The Isingiro District staff will consist of the District Production Coordinator, District Engineer, District Community Development Officer, District Natural Resources Officer, District Agricultural Officer, District Water Officer, Senior Agricultural Engineer and District Commercial Officer. The District and Sub- County Officials will take lead in engagements with the Communities and Local Authorities. They will lead in mobilization of communities to take part of project implementation activities including implementation of catchment management activities, sensitization and information dissemination, formation of Grievance Redress Committees and ensure satisfactory resolution of grievances received during project implementation.

13.1.6 Role of the contractors

Contractors hired to undertake project civil works shall be required to develop their own Contractor’s ESMP which will include among others; the project ESIA approved by both NEMA and World Bank, Health and Safety Management Plan, Traffic Management Plan, Waste Management Plan, Construction Camp and Equipment Yard Management Plan, Labor Force Management Plan which shall also include Code of Conduct for Workers, Construction Materials Acquisition Due Diligence Procedure, etc. The Contractors shall hire the following key staff to undertake project implementation: Project Manager, Environmental Specialist, Sociologist, Health and Safety Officer.

13.1.7 Role of the supervising consultant

The Engineer/Supervising Consultant will be responsible for the technical and contractual implementation of the works to be undertaken. The responsibilities of the Engineer/Supervising Consultant will include:

a. Ensure that, the requirements as set out in the ESMP and any other conditions stipulated by the relevant Authorities are implemented;
b. Assist the Contractor in ensuring that the conditions for ESMP are adhered to and promptly issue instructions to the Contractor;
c. Support the Contractor in the preparation of monthly site meetings and that, such meetings have their agenda embody aspects of environmental and social compliance; and
d. Review and approve work method statements by the contractor to ensure environmental and social safeguards are fully addressed in works to be undertaken.

13.1.8 Project implementation support

The World Bank task teams will support implementation of the Project, especially during the construction phase and during the initial operations phase, until project closure (30-Apr-2026) or as may be extended. The type and level of support will be guided by the scope of the Project, the activities in each component, relative risks involved, and the institutional capacity of the government counterpart. Implementation support by the World Bank will consist of at least semi-annual Implementation Support Supervision missions, short technical missions, meetings and audio conferences between the World Bank and relevant implementing agencies. Field visits to key construction and rehabilitation sites will be conducted during supervision missions. Additional support will also be provided by the World Bank's procurement, FM, and safeguards specialists, most of whom will be based in the Kampala office, on Project contracts and overall compliance with Environmental and Social safeguards and fiduciary requirements. In addition, the Project will support international technical experts to advise the GoU and to provide technical support to the implementing agencies as they develop ToRs, design and feasibility studies. This Implementation Support Plan is indicative and may be revised during Project implementation based on emerging Project challenges and field conditions.

13.2 Implementation procedures

The Biodiversity and Ecological Flow Management Plan along with the Environmental and Social Management Plan (ESMP) propose preparation of specific plans that will address the management of specific media, areas and aspects of the environment and community. The Implementation Procedures proposed here specify how mitigation measures and monitoring actions in the Biodiversity and Ecological Flow Management Plan will be thematically implemented along the given time frames and specific responsibility assignments. The proposed thematic plans also define frameworks for follow-up actions in order to check progress and the resulting effects on the environment during construction and operation phases of the project. The plans refer to each phase of the project cycle and will contain actions and programs for their implementation, related to the requirements of the respective regulatory framework.

Each plan, as a basis, will have the following content: a) objectives of the plan; b) management actions; c) responsibilities in carrying out activities; d) monitoring over the implementation of the activities; e) reporting; f) criteria, objectives to be achieved and monitoring indicators; g) timeframe for implementation. Each plan will propose a way of control and communication, as well as topics for employee training. Part of each plan will be checklists for the purpose of keeping records/monitoring the compliance of the measures and activities of the plans and their implementation with the legal requirements and requirements defined in each plan. Informing about the level of implementation of each particular plan will be through regular reports. The form of the reports will be proposed by appropriate experts (and will be defined in each plan). For this purpose, preparation of the following plans, in addition to the Biodiversity and Ecological Flow Management Plan, Environmental Flow Requirement Management System, Dam Operation Plan and Monitoring Plan, is required.

1. Quality Management Plan;
2. Auxiliary sites Acquisition and Management Plan;
3. Decommissioning Plan (for contractor's facilities after construction phase);
4. Waste Management Plan;
5. Erosion and Pollution Control Plan;
6. Security Management Plan;
7. Labour Force Management Plan;
8. Occupational Health and Safety (OHS) Plan;
9. Emergency Response Plan;
10. Community Health and Safety Plan;
11. Cultural Heritage Management Plan;
12. Grievance Redress Mechanism; and
13. Stakeholder Engagement Plan.

Regenerating riparian vegetation along River Mishumba after the Flash floods of May 2020

14 CONCLUSIONS AND RECOMMENDATIONS

Eco-Hydraulics: The estimated monthly runoff for R. Mishumba at the proposed dam location indicates a bi-modal variation with two peak flows in April and October of $0.8m^3/s$ and $0.89m^3/s$, respectively, and a MAF is $0.51m^3/s$. The month with the lowest flow is July with a flow of 0.12 m^3/s. June, July and August record flows representing 24% of the MAF. Based on the data series, the river sometimes dries up in the dry months of July and August, and February and September. Flow in the months of September-November is more variable than during the other months. The maximum flows, that lead to flooding, are most likely to occur during the months of September - December. Rweibara (Kasharira) tributary joins R. Mishumba immediately downstream of the Kabuyanda dam while Chezho, Rwemango and Kyabaganda join Mishumba at about 5km. The Rweibara River contributes about 18% of the $0.61m^3/s$ AAF of R. Mishumba at the confluence, and the combined flow of Rweibara and Rwemango Rivers is about 43.3% of the total flow to the confluence. The contribution of 56.7% from the three tributaries of Chezho, Rwemango and Kyabaganda can fully sustain the ecosystem down of this main confluence.

Fish biodiversity: The additional surveys established existence of ecologically significant and critical fish biodiversity including relics of previous highlights of Lake Victoria fishery, Singida tilapia (*Oreochromis esculentus*) and Victoria carp (*Labeo victorianus*), both of which are currently considered as critically endangered and are Redlisted by IUCN. Other fish species found in Mishumba catchment are Zilli's tilapia (*Coptodon tilapia*); Albert tilapia (*Oreochromis leucostictus*); African catfish (*Clarias gariepinus*); Mudfish (*Clarias cassonii*); and Haplochromines (*haplochromis spp.*). In conclusion the additional survey and study found that the project will not have adverse effects on the aquatic biodiversity, and in many instances will instead provide a life line for this fish biodiversity by creating conditions to boost the numbers of fish such as the resultant reservoir and creation of special conservation areas recommended as part of the management options for aquatic biodiversity in BMP. Recommendations and guidelines have been given in here for sustenance and development of all the identified fish species for the different stages of the project development and operation. Key recommendations are as follows:

- Limnophilic fishes, especially the relatively large bodied fishes such as Singida tilapia, will required the e-flows to provide and maintain a minimum depths of >0.15m at the lower end of Mishumba River with water flow rates of not more than 1.4 m/s and seasonal overbank flow and inundation of adjoining areas so as to refresh and or create feeding, spawning and nursing grounds for such fish species found in the catchment.
- The rheophilic species in the catchment including Victoria tilapia, require seasonal flushes or pulses coupled with marked increase in water depths to stimulate spawning and creation of spawning, nursing and feeding grounds for such species. It is also recommended that selected sections of Mishumba River or sections of adjoining rivers with pockets of rheophilic species be maintained as relatively fast flowing (> 06 m/s) sections for purposes of sustaining the ecological requirements of such fishes.
- That two special conservation areas need to be created at specially selected sites on adjoining rivers Chezho and Kyabaganda for the preservation and breeding of the critically endangered Victoria carp (Ningu). This is meant to compensate for the interruption of the upstream

migration on River Mishumba for Ningu's breeding and spawning by the damming of River Mishumba.

Flora and Fauna: The habitats were found to be greatly modified and non-critical for floral biodiversity. Large chunks of the area were under cultivation for subsistence, with farmlands, and pasturelands. Even the protected Rwoho CFR was had only the exotic tree species, notably Eucalyptus spp., Pinus spp. and Grevillia Robusta. All plant species were of Least Concern (in agreement with the ESIA). All habitats in Mishumba are non-critical for biodiversity, though it is home to some species of fauna and as such, caution be taken to ensure that, observance of minimal water flows and guided opening up of the areas should take into account, requirements set out in this study for sustaining the habitats. The additional survey established that there is less in-stream vegetation cover inform affecting water movement processes. However, it's projected that the impoundment/damming of Mishumba River will increase the resident time of the water which will allow for transformation of some of these chemical species. The chemical species input will be majorly anthropogenic, linked to the cottage industries and agricultural practices in the catchment. In terms of fauna, the additional surveys established that Mishumba catchment has no vulnerable, threatened or endangered fauan. The faunal species identified in the Mishumba catchment were common snakes, otters, water ducks and water insects including water skates, water bugs, dragon flies, earth worms.

Although the conclusion is that the Kabuyanda ICRP based on damming of River Mishumba will have no effect on existing fauna and floral since the area is already highly disturbed owing to the farming and mining activities in the area, cutting and clearing of the natural vegetation, and high level of siltation as shown by the level of turbidity and TDS at the different sampling sites, is likely to affect the provisional of ecological services by Mishumba River. It is therefore the recommendation of this study that:

- The water release schedule from the reservoir be $0.1m^3/s$ during the dry season (lowest) and $0.24\ m^3/s$ during the rainy season, and for maintenance purposes, and the floods be based on the return periods of 2 years and 5 years.
- Agricultural production and socioeconomic activities within Kabuyanda Irrigation Scheme be properly planned and controlled to significantly cut out the unnatural supply and entry of such chemical species in the water course.
- Water flow be set and regulated to maintain the existing flora and fauna, and limit the entry and establishment of invasive species.
- The Biodiversity and Ecological Flow Management Plan (BEFMP) has been developed in response to the identified potential impacts herein and those in the ESIA, and must funded and implemented as part of the Kabuyanda ICRP Project.

Social-economic: The catchment is an active site with planted forests in Rwoho CFR, extensive subsistence, pastoral livestock keeping, timber felling and chain sawing and cottage brewery. Change of purpose and use of water will certainly require transforming the communities into crop producers. There is a need to consider the cultural attachments, traditions and indigenous knowledge of these communities in the catchment plan as most households surveyed grow some bananas (matooke). This was not provided for in the agriculture development plan under the irrigable area, neither is the livestock production and existing cottage industries. Therefore, measures to allow for such communities to be transformed through training, exposure and demonstration have been captured as means of helping them adopt to the new plan for use of the area. In addition, suggestions to keep some of the traditional and cottage enterprises sustained is encouraged.

Underground water: The underground water level was assessed and found to be flacuate between rainy and dry seasons, and the variation to be also highly correlated to the level of water in the Mishumba River channel. Our conclusion is that the institution or change in hydrological regime for Mishumba Catchment to support the Kabuyanda ICRP project has to mimic the natural flow regime so as not to constrain the underground water sources and supply. Flooding or overbank releases will raise the water tables if not properly timed while over drawing in periods of low levels may result in drawing down the underground water resources. It is therefore the recommendation of the additional survey and study, that e-flows be done in a way that avoids excessive water supply or draw down so as to protect the underground water sources.

Environmental flow assessment and monitoring: The development of e-flow requirements for various species was based on species whose water requirements are dominated by others and would not require further analysis. This is based on the understanding that by satisfying the requirements of those that require more water, the requirements of other species will by ecological relation (shared habitats and effects) be realized. Therefore, flow requirements concentrated on the requirement for fish and for the papyrus for fauna and flora respectively. The e-flows were superimposed with the flow required for flushing or maintenance of the river reaches. It has already been indicated that the floods for the return period of 2 years and 5 years will be maintained for this purpose. In conclusion it was established that the overall discharge in the river reaches under consideration are quite small, therefore, there is very limited room for manipulation of flows to provide meaningful variations. From this perspective and the fact that the only investment using significant water in the catchment is the proposed irrigation scheme, only three (3) scenarios were studied. These include:

- Scenario one (1) represents the water required for the e-flows as deduced from the analysis of flows from sampling points 3, 6, 8, 14 and 15 including the maintenance of the high and low floods.
- Scenario two (2) comprises the proposed releases by the ESIA study report but with an addition of releasing low and high floods as in the previous scenario.
- Scenario three (3) is when the releases are increased in by twenty percent (20%) and forty percent (40%) of the Mean Annual Flow (MAF) during the dry and wet season respectively. It also includes the maintenance of the high and low floods.

Scenario 3 seemed the more appropriate scenario for the Mishumba Catchment based Kabuyanda ICRP project e-flow management.

Adjustments to the dam design and O&M plans: In the hydrolauic assessment it was established that Kabuyanda dam will impound and hold back a huge volume of water creating a reservoir. It was however concluded on analysis that the dam as designed and its operation and maintenance plan, are adequate and require no adjustments. As a point of emphasis however makes the following recommendations:

- The dam should undergo routine and scheduled inspections so as to enable discovery and attendance to any engineering and operational problem that may arise in a timely manner.
- Preventive maintenance programme for the components of Kabuyanda dam and its appurtenant structures be adopted and incorporated in the Kabuyanda ICRP project.

Cummulative Impacts: Kabuyanda ICRP project with its associated dam and irrigation infrastructure were found to have appropriately designed, and if operated as per design will have minimal and reversible cumulative impacts. It is a largely a positive project to both natural and the human environments. However key areas of concern leading to cumulative impacts are those regarding the impact of water reservoir and irrigation scheme on water quality, soil salinity, floral and faunal biodiversity, and underground water. To that effect the following conclusions are made concerning cumulative impact assessments carried out:

- Kabuyanda will transform the eixisting socioeconomic activities into organized irrigable crop production and associated downstream economic activities, and will have minimal or no resettlement of people as they ordinary do not reside in the catchment.
- Kabuyanda ICRP will involve land take for the dam and irrigation infrastructure as well as the irrigable area but this land is already under crop production and will not involve displacing peoples' other socioeconomic activities apart from a few cottage industries that in themselves related to agricultural production and products.
- The project is not in competition with other major socioeconomic or production activities as the site is majorly public land with a forest reserve based on planted trees with no prisitine vegetation.
- Does not significantly alter flows downstream apart from the period of daming and creation of the water reservoir.
- The resevior will allow for development a fishery to support the fishing livelihoods and perhaps act as a key conservation area for the limnophilic species and other aquatic bidoversity including water birds, terrestrial animals and aquatic plants.
- The project will have a moderate impact on habitat fragmentation and reduced connectivity of the rivers and habitats in the Mishumba catchment.
- There are no risks of opening and disturbing pristine areas, as the area is already highly disturbed and modified. However there will be additional cumulative impacts from clearing of vegetation for the dam and irrigation infrastructure construction as well establishment of a reservoir.

Key cumulative impacts were assessed and linked to issues of water quality, soil salinity, floral and faunal biodiversity, and underground water levels. However all the impacts if handled as per the project design are manageable and reversible.

It is clear that save for the month of January, the recommended flows within the ESIA are sufficient to protect the fish and fauna. The impact of these floods is assumed negligible and therefore, no further analysis of the same has been conducted. Therefore, the recommended water release schedule from the reservoir is 0.05m^3/s during the dry season (lowest) and 0.1 m^3/s during the rainy season. For maintenance purposes, the floods with the return periods of 2 years and 5 years should be imposed on this flow.

The study concludes that no hinderance in the environmental or social findings can stop the implementation of the Kabuyanda ICRP, hence recommending that the proposed mitigation/enhancement measures of identified impacts and several the proposed plans be implemented accordingly for the success of the project.

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APPENDIX

Annex 1: List of sampled water quality parameters

Parameters	Units	Measurement recurrence
In-situ parameters		
Temperature	℃	Seasonally and in every sampling site and every sampling time
Dissolved Oxygen	mg/l and %	
Conductivity	µS/cm	
pH	-	
Laboratory analyzed parameters		
Turbidity	NTU	Seasonally and in every sampling site and every sampling time
COD	mg/l	
Alkalinity	mg/l	
Calcium	mg/l	
Magnesium	mg/l	
Chloride	mg/l	
Nitrogen as Nitrate and Ammonia	mg/l	
Sulphate	mg/l	
Phosphate	mg/l	
Iron	mg/l	
Manganese	mg/l	
Fluoride	mg/l	
Aluminum	mg/l	
Total dissolved solids	mg/l	
Coliform bacteria, Total coliforms	100 ml/number of colonies	
Phenols		Seasonally and in every sampling site and every sampling time
Vanadium		
Nickel		
Cobalt		
Cyanide		
Cadmium		
Mercury		
Lead		
Copper		
Selenium		
Zinc		
DDT and other toxic agrochemicals used in the area (consultant to proposed indicators)		

Annex 2: Laboratory water quality analysis certificates

Water Quality Analysis - Laboratory Results for the Wet Season

November 2020

Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 19th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	H1	H2	H3	E1	E2	E3	C1	C2	C3	G1	G2	G3	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Laboratory Number	E43704	E43705	E43706	E43707	E43708	E43709	E43710	E43711	E43712	E43713	E43714	E43715	
Chemical Oxygen Demand (mg/L)	104	139	119	48	51	59	37	39	43	121	110	127	100
Electrical Conductivity (µS/cm)	113200	107300	105200	108400	108300	134400	89300	94700	101900	98700	145100	132900	2500
TDS (mg/L)	79240	75110	73640	75880	75810	94080	62510	66290	71330	69090	101570	93030	1500
Turbidity (NTU)	14.3	11.8	12.1	143	136	135	37.2	40.3	45	13	12.4	12.6	25
Iron (mg/L)	1.82	1.74	1.57	5.23	4.75	4.89	1.98	1.74	2.04	0.38	0.41	0.46	1
Aluminium (mg/L)	1.80	2.30	1.90	3.60	3.90	4.20	0.08	0.09	0.12	4.81	4.46	5.01	–
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	–
Total Hardness (mg/L)	480	495	475	495	510	500	468	458	479	420	458	530	600
Calcium Hardness (mg/L)	203	198	239	215	250	269	189	198	210	247	250	270	600
Magnesium Hardness (mg/L)	277	297	236	280	260	231	279	260	269	173	208	260	600
Calcium (mg/L)	81	79	96	86	100	108	76	79	84	99	100	108	150
Magnesium (mg/L)	66	71	57	67	62	55	67	62	65	42	50	62	100
E. Coli (CFU/100mls)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.03
Phosphates (mg/L)	<0.01	0.28	0.06	0.41	0.51	0.45	0.28	0.24	0.20	0.02	<0.01	<0.01	0.7
Chlorides (mg/L)	42	44	44	17	30	22	28	19	25	59	36	39	250
Nitrates as N (mg/L)	1.50	1.40	1.60	3.50	3.50	3.50	1.50	1.60	1.60	2.00	1.60	1.80	10
Ammonium as N(mg/L)	0.72	0.68	0.72	<0.01	<0.01	0.08	0.37	0.37	0.39	<0.01	<0.01	<0.01	0.5
Sulphate (mg/L)	274	265	271	1015	1027	1026	1053	1057	1054	1088	1100	1033	400

Notes;

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Checked by

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MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 19th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	F1	F2	F3	D1	D2	D3	A1	A2	A3	A minerals	A Plankton	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Laboratory Number	E43716	E43717	E43718	E43719	E43720	E43721	E43722	E43723	E43724	E43725	E43726	
Chemical Oxygen Demand (mg/L)	81	80	82	74	70	70	60	67	64	58	49	100
Electrical Conductivity (µS/cm)	197000	97600	117200	177100	186500	189600	1200	881	861	894	883	2500
TDS (mg/L)	137900	68320	82040	123970	130550	132720	840	617	603	626	618	1500
Turbidity (NTU)	32	29	31	140	129	132	3.5	2.44	2.8	1.8	2.2	25
Iron (mg/L)	5.87	5.23	5.64	5.57	4.84	5.34	0.24	0.38	0.28	0.41	0.76	1
Aluminium (mg/L)	3.34	3.41	3.50	0.68	0.61	0.59	3.14	2.94	2.83	3.19	3.21	-
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	
Total Hardness (mg/L)	676	430	487	590	558	600	444	315	307	320	316	600
Calcium Hardness (mg/L)	174	180	155	305	268	264	207	148	145	151	149	600
Magnesium Hardness (mg/L)	502	250	332	285	290	336	237	167	162	169	167	600
Calcium (mg/L)	70	72	62	122	107	106	83	59	58	60	60	150
Magnesium (mg/L)	120	60	80	68	70	81	57	40	39	41	40	100
E. Coli (CFU/100mls)	<1	<1	<1	<1	<1	<1	5	13	9	21	33	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	<0.01	<0.01	<0.01	0.04	0.05	0.01	4.90	2.60	7.30	2.70	2.50	<0.01
Phosphates (mg/L)	<0.01	0.07	0.71	0.77	0.84	0.72	0.02	0.10	0.01	<0.01	<0.01	0.7
Chlorides (mg/L)	43	32	37	15	21	13	78	61	92	63	63.2	250
Nitrates as N (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.29	0.32	0.45	0.53	0.52	10
Ammonium as N(mg/L)	0.63	0.48	0.57	<0.01	<0.01	<0.01	1.28	1.40	1.30	0.70	0.72	0.5
Sulphate (mg/L)	1030	1039	1046	786	747	803	318	338	327	286	273	400

Notes;

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MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 19th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	L Phyto/zoo	S1	V phyto/zoo 1 260	U Phyto 8 200	W Mineral	Z mineral	V mineral	O minerals	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Laboratory Number	E43593	E43594	E43595	E43596	E43597	E43598	E43599	E43600	
Chemical Oxygen Demand (mg/L)	167	90	73	606	37	21	51	148	100
Electrical Conductivity (µS/cm)	1376	65500	1269	1029	628	1356	1169	1428	2500
TDS (mg/L)	963	45850	888	720	440	949	818	1000	1500
Turbidity (NTU)	5.22	2.09	97.4	50.7	91.4	5.67	51.5	0.86	25
Iron (mg/L)	0.33	0.12	0.8	2.34	0.58	0.66	0.69	0.02	1
Aluminium (mg/L)	7.48	0.47	5.54	0.10	0.23	0.75	5.82	2.31	-
Total Alkalinity (mg/L)	<2	<2	<2	29.8	25.4	4	<2	<2	
Total Hardness (mg/L)	565	720	511	388	208	520	404	561	600
Calcium Hardness (mg/L)	276	145	216	181	103	216	199	284	600
Magnesium Hardness (mg/L)	289	575	295	207	105	304	205	277	600
Calcium (mg/L)	110	58	86	72	41	86	80	114	150
Magnesium (mg/L)	69	138	71	50	25	73	49	66	100
E. Coli (CFU/100mls)	18	<1	23	32	24	29	9	23	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	5.60	<0.01	2.60	2.60	0.03	2.20	2.10	6.10	<0.01
Phoshates (mg/L)	0.38	1.36	0.09	0.01	0.05	0.01	0.01	0.04	0.7
Chlorides (mg/L)	157	40	125	131	30	206	109	181	250
Nitrates as N (mg/L)	1.49	1.36	6.94	0.45	18.00	2.83	7.46	0.33	10
Ammonium as N(mg/L)	0.34	0.47	0.17	0.27	0.23	0.16	0.17	0.11	0.5
Sulphate (mg/L)	410	1448	386	280	143	335	383	398	400

Notes;

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NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 19th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	H Phyto/zoo	S2	R Phyto/zoo	R3	J Phyto/zoo	P Migera minerals River	C2 minerals	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Laboratory Number	E43601	E43602	E43603	E43604	E43605	E43606	E43607	
Chemical Oxygen Demand (mg/L)	26	91	47	96	622	57	376	100
Electrical Conductivity (µS/cm)	1398	5860	1464	75100	923	1697	832	2500
TDS (mg/L)	979	4102	1025	52570	646	1188	582	1500
Turbidity (NTU)	41.1	2.6	10.1	3.2	33.7	1.03	156	25
Iron (mg/L)	1.55	0.34	0.08	<0.01	3.38	3.34	2.54	1
Aluminium (mg/L)	1.30	0.73	0.51	2.80	3.42	3.21	0.12	-
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	17.4	-
Total Hardness (mg/L)	469	303	644	690	332	646	295	600
Calcium Hardness (mg/L)	230	106	260	288	156	299	139	600
Magnesium Hardness (mg/L)	239	197	384	402	176	347	156	600
Calcium (mg/L)	92	42	104	115	62	120	56	150
Magnesium (mg/L)	57	47	92	96	42	83	37	100
E. Coli (CFU/100mls)	15	18	8	21	16	14	12	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	4.70	<0.01	7.10	<0.01	2.60	2.30	0.07	<0.01
Phoshates (mg/L)	0.08	0.15	0.05	0.03	<0.01	<0.01	0.03	0.7
Chlorides (mg/L)	160	39	195	85	92	143	105	250
Nitrates as N (mg/L)	3.20	2.45	1.91	0.41	1.27	5.40	3.80	10
Ammonium as N(mg/L)	0.46	0.27	0.28	1.19	0.55	0.32	0.46	0.5
Sulphate (mg/L)	412	1686	404	432	259	508	226	400

Notes;

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NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 19th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	N minerals	H minerals	J minerals	U minerals	C phyto/zoo plankton	O phyto/zoo	Q phyto/zoo	Z Phyto/zoo	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Laboratory Number	E43608	E43609	E43610	E43611	E43612	E43613	E43614	E43615	
Chemical Oxygen Demand (mg/L)	29	21	132	71	1402	160	95	202	100
Electrical Conductivity (µS/cm)	1589	1384	936	975	971	1448	1744	1412	2500
TDS (mg/L)	1112	969	655	683	680	1014	1221	988	1500
Turbidity (NTU)	2.53	12	10.2	45.6	89.7	3.65	22.6	13.4	25
Iron (mg/L)	<0.01	1.51	1.29	1.01	4.84	0.02	1.36	0.05	1
Aluminium (mg/L)	<0.001	1.60	3.78	0.13	0.16	1.98	16.00	0.82	-
Total Alkalinity (mg/L)	21	<2	<2	8.8	<2	<2	<2	<2	
Total Hardness (mg/L)	602	519	337	353	351	545	665	531	600
Calcium Hardness (mg/L)	279	241	159	166	165	253	308	247	600
Magnesium Hardness (mg/L)	323	278	179	187	186	292	357	284	600
Calcium (mg/L)	112	97	63	66	66	101	123	99	150
Magnesium (mg/L)	78	67	43	45	45	70	86	68	100
E. Coli (CFU/100mls)	3	43	51	65	25	36	42	17	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	4.40	3.40	2.60	3.20	0.04	7.80	3.70	1.80	<0.01
Phoshates (mg/L)	0.46	<0.01	0.24	<0.01	<0.01	0.01	0.16	0.03	0.7
Chlorides (mg/L)	203	155	72	138	128	197	165	217	250
Nitrates as N (mg/L)	2.10	2.00	9.00	0.78	0.38	1.44	5.16	5.88	10
Ammonium as N(mg/L)	0.17	0.49	0.86	0.15	0.95	0.21	0.39	0.16	0.5
Sulphate (mg/L)	422	406	260	284	255	400	569	353	400

Notes;

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LABORATORY MANAGER

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Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	Y phyto/zoo	G phyto/zoo	R1	A phyto	L minerals	S phyto/zoo	P phyto/zoo Kaganji	Q minerals	F minerals	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Laboratory Number	E43616	E43617	E43618	E43619	E43620	E43621	E43622	E43623	E43624	
Chemical Oxygen Demand (mg/L)	908	289	51	96	177	321	1486	118	75	100
Electrical Conductivity (µS/cm)	1022	1312	70400	999	1377	762	1367	1771	1227	2500
TDS (mg/L)	715	918	49280	699	964	533	957	1240	859	1500
Turbidity (NTU)	160	28.2	1.71	28.9	0.44	98.3	118	5.35	53.4	25
Iron (mg/L)	2.38	2.47	0.09	2.17	0.33	5.76	2.18	0.52	4.76	1
Aluminium (mg/L)	<0.001	5.1	2.45	3.14	6.54	0.76	2.34	19	3.38	–
Total Alkalinity (mg/L)	55	<2	<2	<2	<2	96.8	81.4	<2	<2	–
Total Hardness (mg/L)	372	490	722	363	516	267	512	676	455	600
Calcium Hardness (mg/L)	174	228	258	170	240	126	238	313	212	600
Magnesium Hardness (mg/L)	198	262	464	193	276	140	274	363	243	600
Calcium (mg/L)	70	91	103	68	96	51	95	125	85	150
Magnesium (mg/L)	47	63	111	46	66	34	66	87	58	100
E. Coli (CFU/100mls)	19	24	<1	21	4	23	9	2	34	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	0.02	3.10	7.80	2.40	3.40	6.80	7.50	3.90	5.30	<0.01
Phoshates (mg/L)	<0.01	<0.01	<0.01	0.01	0.07	0.01	0.07	0.11	<0.01	0.7
Chlorides (mg/L)	176	150	113	92	143	72	153	165	63	250
Nitrates as N (mg/L)	1.54	3.10	1.54	1.00	3.20	0.12	0.32	7.30	1.70	10
Ammonium as N(mg/L)	0.67	0.35	0.88	0.59	0.19	1.93	1.71	0.54	0.91	0.5
Sulphate (mg/L)	280	376	1050	232	393	155	292	587	355	400

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TEST RESULTS

Sample Name	I Minerals	P migera River Phyto/zoo	K Minerals	R2	E phyto/zoo	C minerals	W Phyto and Zoo	S3	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Laboratory Number	E43625	E43626	E43627	E43628	E43629	E43630	E43631	E43632	
Chemical Oxygen Demand (mg/L)	103	64	48	73	83	47	74	59	100
Electrical Conductivity (µS/cm)	1605	1709	1376	80200	1163	912	689	72000	2500
TDS (mg/L)	1124	1196	963	56140	814	638	482	50400	1500
Turbidity (NTU)	1	13.4	0.63	3.69	244	117	191	1.75	25
Iron (mg/L)	<0.01	2.7	1.07	0.02	8.24	2.21	1.14	1.82	1
Aluminium (mg/L)	0.08	2.94	0.63	2.65	3.5	0.14	0.27	0.53	-
Total Alkalinity (mg/L)	11.6	<2	<2	<2	<2	<2	74.6	<2	-
Total Hardness (mg/L)	609	651	516	602	429	328	237	326	600
Calcium Hardness (mg/L)	282	302	240	252	201	154	113	114	600
Magnesium Hardness (mg/L)	327	350	276	350	229	173	124	212	600
Calcium (mg/L)	113	121	96	101	80	62	45	46	150
Magnesium (mg/L)	78	84	66	84	55	42	30	51	100
E. Coli (CFU/100mls)	5	14	16	8	26	34	23	<1	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	5.00	2.30	2.80	<0.01	3.10	3.50	0.87	<0.01	<0.01
Phoshates (mg/L)	<0.01	0.06	0.08	0.02	0.03	<0.01	0.20	0.23	0.7
Chlorides (mg/L)	214	151	154	86	67	77	78	37	250
Nitrates as N (mg/L)	0.20	3.69	3.15	0.33	0.34	0.47	2.87	0.16	10
Ammonium as N(mg/L)	0.07	0.29	0.39	0.00	1.38	0.95	0.76	0.89	0.5
Sulphate (mg/L)	426	495	403	1112	364	238	141	1023	400

Notes;

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28 DEC 2020 NWQRL
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

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NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
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TEST RESULTS

Sample Name	GI B minerals	I Phyto and zoo	D Zoo plankton	P Minerals Kagonji	K phyto and zoo	I phyto-zoo	F phyto and zoo	R Minerals	N Zoo/Phyto	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Laboratory Number	E43633	E43634	E43635	E43636	E43637	E43638	E43639	E43640	E43641	
Chemical Oxygen Demand (mg/L)	41	172	1035	42	35	98	79	39	68	100
Electrical Conductivity (µS/cm)	1463	1636	1032	1311	1387	429	1203	1426	1431	2500
TDS (mg/L)	1024	1138	764	918	971	300	842	998	1002	1500
Turbidity (NTU)	2.23	20.1	235	69.8	25.6	26.7	112	3.89	36.4	25
Iron (mg/L)	0.49	0.12	5.36	0.76	1.07	1.01	5.44	0.05	0.8	1
Aluminium (mg/L)	4.67	0.06	0.45	0.23	0.71	0.57	3.21	2.71	<0.001	–
Total Alkalinity (mg/L)	<2	16	<2	20	<2	54.2	<2	<2	<2	–
Total Hardness (mg/L)	551	617	401	490	520	131	446	536	538	600
Calcium Hardness (mg/L)	256	286	187	228	242	65	208	249	250	600
Magnesium Hardness (mg/L)	295	331	213	262	278	67	238	287	288	600
Calcium (mg/L)	102	114	75	91	97	26	83	100	100	150
Magnesium (mg/L)	71	80	51	63	67	16	57	69	69	100
E. Coli (CFU/100mls)	37	54	21	16	6	36	34	29	12	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	4.10	7.90	2.80	0.74	4.60	0.03	4.70	6.10	1.20	<0.05
Phoshates (mg/L)	0.07	0.05	0.09	0.08	0.10	0.23	<0.01	<0.01	0.04	0.7
Chlorides (mg/L)	128	230	81	191	168	77	77	181	168	250
Nitrates as N (mg/L)	3.61	0.25	1.59	11.00	3.80	4.20	3.40	2.30	0.71	10
Ammonium as N(mg/L)	0.25	0.35	0.84	0.13	0.48	0.55	1.14	0.17	0.28	0.5
Sulphate (mg/L)	474	421	335	300	399	32	344	403	400	400

Notes;

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Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 19th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	C2 Phyto	T Minerals	N Phyto/zoo	S minerals	Y Minerals	M Minerals	E minerals	D minerals	G Minerals	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Laboratory Number	E43642	E43643	E43644	E43645	E43646	E43647	E43648	E43649	E43650	
Chemical Oxygen Demand (mg/L)	72	17	83	65	73	57	84	35	21	100
Electrical Conductivity (µS/cm)	970	377	1611	685	975	1420	1135	1216	1360	2500
TDS (mg/L)	679	264	1128	480	683	994	795	851	952	1500
Turbidity (NTU)	212	1.58	18.7	83.5	186	1.99	225	149	18.7	25
Iron (mg/L)	5.74	0.1	0.05	1.9	0.65	0.30	4.85	5.18	1.04	1
Aluminium (mg/L)	0.10	0.53	<0.001	0.64	0.36	2.6	4.1	0.52	3.98	–
Total Alkalinity (mg/L)	90.4	50	25.2	22.2	9.6	<2	<2	<2	<2	–
Total Hardness (mg/L)	351	110	611	235	353	534	418	451	509	600
Calcium Hardness (mg/L)	165	55	283	112	166	248	195	210	237	600
Magnesium Hardness (mg/L)	186	55	328	123	187	286	223	241	272	600
Calcium (mg/L)	66	22	113	45	66	99	78	84	95	150
Magnesium (mg/L)	45	13	79	30	45	69	53	58	65	100
E. Coli (CFU/100mls)	19	6	53	11	33	8	4	32	15	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	6.70	0.56	6.80	<0.01	0.05	0.18	5.20	3.30	2.70	<0.05
Phoshates (mg/L)	0.04	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.7
Chlorides (mg/L)	112	126	220	65	143	98	115	137	142	250
Nitrates as N (mg/L)	1.60	2.10	1.90	0.10	16.00	2.70	0.49	0.40	3.00	10
Ammonium as N(mg/L)	1.57	0.05	0.24	0.67	0.11	0.09	0.81	0.94	0.53	0.5
Sulphate (mg/L)	223	27	415	206	286	409	304	335	390	400

Notes;

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TEST RESULTS

Sample Name	Z1	Z2	Z3	N1	N2	N3	U1	U2	U3	T1	T2	T3	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Laboratory Number	E43651	E43652	E43653	E43654	E43655	E43656	E43657	E43658	E43659	E43660	E43661	E43662	
Chemical Oxygen Demand (mg/L)	110	113	95	48	36	43	81	32	31	147	31	31	100
Electrical Conductivity (µS/cm)	125400	110000	130800	136400	117600	125900	128200	116600	116300	146200	112000	108100	2500
TDS (mg/L)	87780	77000	91560	95480	82320	87430	89740	81620	81410	102340	78400	75670	1500
Turbidity (NTU)	5.68	5.1	3.75	2.44	5.81	4.79	26.2	2.13	26.7	2.65	4.24	5.1	25
Iron (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	0.11	0.17	<0.01	<0.01	<0.01	1
Aluminium (mg/L)	0.94	0.85	0.88	<0.001	<0.001	0.003	0.21	0.24	0.19	0.64	0.71	0.77	-
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	498	458	479	492	510	490	500	505	497	480	446	458	600
Calcium Hardness (mg/L)	354	360	300	378	298	280	194	210	217	350	300	349	600
Magnesium Hardness (mg/L)	144	98	179	114	212	210	306	295	280	130	146	109	600
Calcium (mg/L)	142	144	120	151	119	112	78	84	87	140	120	140	150
Magnesium (mg/L)	35	24	43	27	51	50	73	71	67	31	35	26	100
E. Coli (CFU/100mls)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	0.07	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phoshates (mg/L)	<0.01	0.03	<0.01	<0.01	0.29	0.31	0.09	0.12	0.11	<0.01	<0.01	<0.01	0.7
Chlorides (mg/L)	65	68	60	63	70	74	42	89	83	19	25	33	250
Nitrates as N (mg/L)	4.10	3.50	3.60	1.80	2.30	1.30	3.30	3.87	3.64	0.15	0.18	0.21	10
Ammonium as N(mg/L)	0.20	0.24	0.26	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Sulphate (mg/L)	1009	1013	1004	1001	993	998	971	964	968	989	993	1002	400

Notes;

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Certificate of Analysis

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Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	P1 kagonji	P2 Kagonji	P3 kagonji	P1 migeera	P2 Migeera	P3 Migeera	J1	J2	J3	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Laboratory Number	E43663	E43664	E43665	E43666	E43667	E43668	E43669	E43670	E43671	
Chemical Oxygen Demand (mg/L)	42	72	67	59	64	60	73	40	52	100
Electrical Conductivity (μS/cm)	129900	106100	145400	126200	153900	108900	115100	120800	145900	2500
TDS (mg/L)	90930	74270	101780	88340	107730	76230	80570	84560	102130	1500
Turbidity (NTU)	36.3	35.1	38	3.05	2.9	3.4	6.6	7.2	5.8	25
Iron (mg/L)	0.14	0.19	0.15	0.18	0.21	0.27	0.02	0.03	0.02	1
Aluminium (mg/L)	2.14	2.43	2.31	2.91	2.75	3.18	3.70	3.45	3.76	-
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	512	498	503	510	502	506	471	478	475	600
Calcium Hardness (mg/L)	358	351	304	298	313	246	238	230	225	600
Magnesium Hardness (mg/L)	154	147	199	212	189	260	233	248	250	600
Calcium (mg/L)	143	140	122	119	125	98	95	92	90	150
Magnesium (mg/L)	37	35	48	51	45	62	56	60	60	100
E. Coli (CFU/100mls)	<1	<1	<1	<1	<1	<1	<1	<1	<1	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>300	0
Manganese (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phoshates (mg/L)	0.06	0.30	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.7
Chlorides (mg/L)	63	74	61	48	52	58	35	33	36	250
Nitrates as N (mg/L)	10.00	5.60	7.40	3.30	2.40	2.90	<0.01	<0.01	<0.01	10
Ammonium as N(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Sulphate (mg/L)	897	904	899	1028	1038	1035	1017	1025	1018	400

Notes;

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TEST RESULTS

Sample Name	K1	K2	K3	L1	L2	L3	M1	M2	M3	I1	I2	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Laboratory Number	E43672	E43673	E43674	E43675	E43676	E43677	E43678	E43679	E43680	E43681	E43682	
Chemical Oxygen Demand (mg/L)	233	187	148	38	32	26	35	38	43	59	40	100
Electrical Conductivity (µS/cm)	158900	151000	176000	135800	104400	143300	181300	154200	1565	184500	144200	2500
TDS (mg/L)	111230	105700	123200	95060	73080	100310	126910	107940	1096	129150	100940	1500
Turbidity (NTU)	3.03	3.6	3.5	1.7	2.1	2.3	8.07	11	7.8	2.86	3.2	25
Iron (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.38	0.16	0.32	[illegible]
Aluminium (mg/L)	0.59	0.68	0.72	6.34	7.80	7.40	2.80	2.40	2.90	0.07	0.08	-
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	498	485	482	450	438	444	587	610	593	657	580	600
Calcium Hardness (mg/L)	223	217	220	208	211	228	346	321	275	303	248	600
Magnesium Hardness (mg/L)	275	268	262	242	227	216	241	289	318	354	332	600
Calcium (mg/L)	89	87	88	83	84	91	138	128	110	121	99	150
Magnesium (mg/L)	66	64	63	58	54	52	58	69	76	85	80	100
E. Coli (CFU/100mls)	<1	<1	<1	<1	<1	<1	<1	<1	3	<1	<1	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	1.30	<0.01	12	<0.01	<0.01	<0.01
Phoshates (mg/L)	0.02	0.03	0.03	0.09	0.08	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	0.7
Chlorides (mg/L)	47	44	43	48	68	52	50	47	187	56	68	250
Nitrates as N (mg/L)	<0.01	<0.01	<0.01	2.40	2.10	2.00	0.40	0.48	0.26	0.29	0.31	10
Ammonium as N(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Sulphate (mg/L)	892	894	887	1007	997	999	927	944	515	928	937	400

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Analysis Completion data	: 28th December 2020

TEST RESULTS

Sample Name	V1	V2	V3	Y1	Y2	Y3	W1	W2	W3	Q1	Q2	Q3	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Laboratory Number	E43683	E43684	E43685	E43686	E43687	E43688	E43689	E43690	E43691	E43692	E43693	E43694	
Chemical Oxygen Demand (mg/L)	53	18	28	47	52	54	39	41	30	72	65	63	100
Electrical Conductivity (µS/cm)	115600	111500	112800	115200	130100	122500	193200	105300	183400	108000	130000	114900	2500
TDS (mg/L)	80920	78050	78960	80640	91070	85750	135240	73710	128380	75600	91000	80430	1500
Turbidity (NTU)	38.2	53	43	154	190	287	70.7	91	65	13	11.9	14	25
Iron (mg/L)	2.7	0.98	1.3	0.34	0.28	0.39	0.43	0.51	0.69	0.64	0.58	0.47	1
Aluminium (mg/L)	6.10	5.60	5.80	0.38	0.41	0.36	0.31	0.29	0.28	18.00	21.00	23.00	-
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	
Total Hardness (mg/L)	511	490	507	495	487	476	502	496	634	454	477	487	600
Calcium Hardness (mg/L)	219	227	208	256	237	247	205	211	290	246	240	254	600
Magnesium Hardness (mg/L)	292	263	299	239	250	229	297	285	344	208	237	233	600
Calcium (mg/L)	88	91	83	102	95	99	82	84	116	98	96	102	150
Magnesium (mg/L)	70	63	72	57	60	55	71	68	83	50	57	56	100
E. Coli (CFU/100mls)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphates (mg/L)	0.05	0.08	0.18	0.21	0.14	0.23	0.29	0.33	0.31	<0.01	<0.01	<0.01	0.7
Chlorides (mg/L)	43	47	38	42	45	41	37	34	40	48	53	58	250
Nitrates as N (mg/L)	5.60	5.80	5.80	6.50	4.30	4.90	2.40	1.80	2.20	3.20	2.50	2.70	10
Ammonium as N(mg/L)	<0.01	<0.01	<0.01	0.32	0.26	0.43	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Sulphate (mg/L)	990	1000	997	1032	1023	1030	921	947	931	1034	1047	1036	400

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TEST RESULTS

Sample Name	O1	O2	O3	B1	B2	B3	B minerals	B zoo plankton	B Physo	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Laboratory Number	E43695	E43696	E43697	E43698	E43699	E43700	E43701	E43702	E43703	
Chemical Oxygen Demand (mg/L)	26	39	46	39	53	72	58	52	62	100
Electrical Conductivity (µS/cm)	108600	161500	153300	74300	104000	92400	1213	877	869	2500
TDS (mg/L)	76020	113050	107310	52010	72800	64680	849	614	608	1500
Turbidity (NTU)	4	2.72	3.4	5	3.32	4.5	1.5	0.41	0.93	25
Iron (mg/L)	0.04	0.06	0.02	3.89	3.74	3.95	3.36	4.79	4.44	1
Aluminium (mg/L)	2.20	2.60	2.00	0.92	0.89	0.95	0.79	0.85	0.88	-
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	
Total Hardness (mg/L)	506	530	531	521	491	488	450	313	310	600
Calcium Hardness (mg/L)	287	238	249	251	228	217	210	148	146	600
Magnesium Hardness (mg/L)	219	292	282	270	263	271	240	166	164	600
Calcium (mg/L)	115	95	100	100	91	87	84	59	58	150
Magnesium (mg/L)	53	70	68	65	63	65	58	40	39	100
E. Coli (CFU/100mls)	<1	<1	<1	<1	<1	<1	8	11	14	0
Total Coliforms (CFU/100mls)	>200	>200	>200	>200	>200	>200	>200	>200	>200	0
Manganese (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	1.90	2.60	2.70	2.90	<0.01
Phoshates (mg/L)	<0.01	<0.01	<0.01	0.06	0.07	0.08	0.15	0.28	0.01	0.7
Chlorides (mg/L)	71	52	56	35	38	36	60	79	64.5	250
Nitrates as N (mg/L)	1.30	1.10	0.98	1.50	2.10	1.80	0.25	0.28	1.70	10
Ammonium as N(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	0.12	0.64	0.5
Sulphate (mg/L)	983	985	979	988	992	999	1163	302	254	400

Notes;

Samples are analyzed on as received basis.

The client does bear sampling responsibility as to the representative characters of the sample delivered. Results are therefore based on the sample delivered and analyzed. mg/l-stands for milligrams per liter

Checked by

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23 DEC 2020

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Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Soil Samples from River Mishumba Isingiro District
Date Sampled	: 28th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Laboratory Number	E43735	E43736	E43737	E43738	E43739	E43740	E43741	E43742
Sample/Source Name	E AFTER BRIDGE	M	I **	A	CI	T	Z	3
Cadmium (mg/kg)	<0.2	<0.2	<0.2	0.2	0.2	0.2	<0.2	0.3
Lead (mg/kg)	23	84	82	13	14	5.2	42	15
Copper (mg/kg)	42	115	166	15	15	7.9	78	17
Zinc (mg/kg)	30	79	87	22	30	16	36	38
Cobalt (mg/kg)	7.0	16	8.3	0.9	5.1	4.3	7.6	6.2
Nickel (mg/kg)	12	29	27	13	14	7.7	15	14
Selenium (mg/kg)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vanadium (mg/kg)	62	176	239	51	33	11	105	32
Mercury (mg/kg)	<1	<1	<1	<1	<1	<1	<1	<1

Notes;

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Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Soil Samples from River Mishumba Isingiro District
Date Sampled	: 28th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Laboratory Number	E43743	E43744	E43745	E43746	E43747	E43748	E43749	E43750	E43751
Sample/Source Name	L	H	Q	E	D	U/N	X	O	B
Cadmium (mg/kg)	<0.2	0.2	0.2	0.4	0.2	<0.2	<0.2	0.3	0.8
Lead (mg/kg)	49	13	41	11	11	88	73	65	21
Copper (mg/kg)	116	16	28	14	7.1	198	203	98	31
Zinc (mg/kg)	78	19	39	29	11	26	34	87	18
Cobalt (mg/kg)	13	1.7	17	1.6	5.1	19	12	26	1.4
Nickel (mg/kg)	26	8.6	16	11	3.7	21	17	38	24
Selenium (mg/kg)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vanadium (mg/kg)	66	28	65	28	12	240	217	83	69
Mercury (mg/kg)	<1	<1	<1	<1	<1	<1	<1	<1	<1

Notes;

Samples are analyzed on as received basis.

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Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Soil Samples from River Mishumba Isingiro District
Date Sampled	: 28th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Laboratory Number	E43727	E43728	E43729	E43730	E43731	E43732	E43733	E43734
Sample/Source Name	V	R	E BEFORE BRIDGE	K	C2	G	I	P
Cadmium (mg/kg)	<0.2	0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2
Lead (mg/kg)	80	22	38	48	3.1	30	36	10
Copper (mg/kg)	209	33	42	193	2.4	20	71	8.3
Zinc (mg/kg)	17	21	63	77	3.7	20	60	15
Cobalt (mg/kg)	14	1.5	11	11	1.1	8.3	19	5.5
Nickel (mg/kg)	16	14	24	36	1.1	11	30	5.8
Selenium (mg/kg)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vanadium (mg/kg)	200	70	108	29	7	86	139	18
Mercury (mg/kg)	<1	<1	<1	<1	<1	<1	<1	<1

Notes;

Samples are analyzed on as received basis.

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Republic of Uganda

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NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Soil Samples from River Mishumba Isingiro District
Date Sampled	: 28th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Laboratory Number		E43727	E43728	E43729	E43730	E43731	E43732
Sample/Source Name	Units	V	R	E BEFORE BRIDGE	K	C2	G
Organochlorine Pesticides							
BHC	µg/g	ND	ND	ND	ND	ND	ND
Lindane (g-B)	µg/g	ND	ND	ND	ND	ND	ND
Heptachlor	µg/g	ND	ND	ND	ND	ND	ND
Aldrin	µg/g	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	µg/g	ND	ND	ND	ND	ND	ND
Oxychlordane	µg/g	ND	ND	ND	ND	ND	ND
Gamma-chlordane	µg/g	ND	ND	ND	ND	ND	ND
Alfa-chlordane	µg/g	ND	ND	ND	ND	ND	ND
Dieldrin	µg/g	ND	ND	ND	ND	ND	ND
Endrin	µg/g	ND	ND	ND	ND	ND	ND
Endosulfan	µg/g	ND	ND	ND	ND	ND	ND
DDT	µg/g	ND	ND	ND	ND	ND	ND
Organophosphorous Pesticides							
Dichlorvos	µg/g	ND	ND	ND	ND	ND	ND
Methacrifos	µg/g	ND	ND	ND	ND	ND	ND
Diazinon	µg/g	ND	ND	ND	ND	ND	ND
Etrimfos	µg/g	ND	ND	ND	ND	ND	ND
Phosphamidon	µg/g	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	µg/g	ND	ND	ND	ND	ND	ND
Fenitrothion	µg/g	ND	ND	ND	ND	ND	ND
Primiphosmethyl	µg/g	ND	ND	ND	ND	ND	ND
Malathion	µg/g	ND	ND	ND	ND	ND	ND
Chlorpyrifos	µg/g	ND	ND	ND	ND	ND	ND
Parathionethyl	µg/g	ND	ND	ND	ND	ND	ND
Pirimiphosethyl	µg/g	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	µg/g	ND	ND	ND	ND	ND	ND

Notes;

Samples are analyzed on as received basis. ND means Not Detected

The client does bear sampling responsibility as to the representative characters of the sample delivered. Results are therefore based on the sample delivered and analyzed. mg/l-stands for milligrams per liter

PRINCIPAL ANALYST LABORATORIES 28 DEC 2020

LABORATORY MANAGER 28 DEC 2020 NWQRL NATIONAL WATER QUALITY REFERENCE LABORATORY -ENTEBBE

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NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Soil Samples from River Mishumba Isingiro District
Date Sampled	: 28th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Laboratory Number		E43739	E43740	E43741	E43742	E43743	E43744
Sample/Source Name	**Units**	**C1**	**T**	**Z**	**3**	**L**	**H**
Organochlorine Pesticides							
BHC	µg/g	ND	ND	ND	ND	ND	ND
Lindane (g-B)	µg/g	ND	ND	ND	ND	ND	ND
Heptachlor	µg/g	ND	ND	ND	ND	ND	ND
Aldrin	µg/g	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	µg/g	ND	ND	ND	ND	ND	ND
Oxychlordane	µg/g	ND	ND	ND	ND	ND	ND
Gamma-chlordane	µg/g	ND	ND	ND	ND	ND	ND
Alfa-chlordane	µg/g	ND	ND	ND	ND	ND	ND
Dieldrin	µg/g	ND	ND	ND	ND	ND	ND
Endrin	µg/g	ND	ND	ND	ND	ND	ND
Endosulfan	µg/g	ND	ND	ND	ND	ND	ND
DDT	µg/g	ND	ND	ND	ND	ND	ND
Organophosphorous Pesticides							
Dichlorvos	µg/g	ND	ND	ND	ND	ND	ND
Methacrifos	µg/g	ND	ND	ND	ND	ND	ND
Diazinon	µg/g	ND	ND	ND	ND	ND	ND
Etrimfos	µg/g	ND	ND	ND	ND	ND	ND
Phosphamidon	µg/g	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	µg/g	ND	ND	ND	ND	ND	ND
Fenitrothion	µg/g	ND	ND	ND	ND	ND	ND
Primiphosmethyl	µg/g	ND	ND	ND	ND	ND	ND
Malathion	µg/g	ND	ND	ND	ND	ND	ND
Chlorpyrifos	µg/g	ND	ND	ND	ND	ND	ND
Parathionethyl	µg/g	ND	ND	ND	ND	ND	ND
Pirimiphosethyl	µg/g	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	µg/g	ND	ND	ND	ND	ND	ND

Notes;

Samples are analyzed on as received basis. ND means Not Detected

The client does bear sampling responsibility as to the representative characters of the sample delivered. Results are therefore based on the sample delivered and analyzed. mg/l-stands for milligrams per liter

LABORATORY MANAGER
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NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Soil Samples from River Mishumba Isingiro District
Date Sampled	: 28th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Laboratory Number		E43733	E43734	E43735	E43736	E43737	E43738
Sample/Source Name	Units	I	P	E AFTER BRIDGE	M	I **	A
Organochlorine Pesticides							
BHC	µg/g	ND	ND	ND	ND	ND	ND
Lindane (g-B)	µg/g	ND	ND	ND	ND	ND	ND
Heptachlor	µg/g	ND	ND	ND	ND	ND	ND
Aldrin	µg/g	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	µg/g	ND	ND	ND	ND	ND	ND
Oxychlordane	µg/g	ND	ND	ND	ND	ND	ND
Gamma-chlordane	µg/g	ND	ND	ND	ND	ND	ND
Alfa-chlordane	µg/g	ND	ND	ND	ND	ND	ND
Dieldrin	µg/g	ND	ND	ND	ND	ND	ND
Endrin	µg/g	ND	ND	ND	ND	ND	ND
Endosulfan	µg/g	ND	ND	ND	ND	ND	ND
DDT	µg/g	ND	ND	ND	ND	ND	ND
Organophosphorous Pesticides							
Dichlorvos	µg/g	ND	ND	ND	ND	ND	ND
Methacrifos	µg/g	ND	ND	ND	ND	ND	ND
Diazinon	µg/g	ND	ND	ND	ND	ND	ND
Etrimfos	µg/g	ND	ND	ND	ND	ND	ND
Phosphamidon	µg/g	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	µg/g	ND	ND	ND	ND	ND	ND
Fenitrothion	µg/g	ND	ND	ND	ND	ND	ND
Primiphosmethyl	µg/g	ND	ND	ND	ND	ND	ND
Malathion	µg/g	ND	ND	ND	ND	ND	ND
Chlorpyrifos	µg/g	ND	ND	ND	ND	ND	ND
Parathionethyl	µg/g	ND	ND	ND	ND	ND	ND
Pirimiphosethyl	µg/g	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	µg/g	ND	ND	ND	ND	ND	ND

Notes;

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Water Quality Management Department
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NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Soil Samples from River Mishumba Isingiro District
Date Sampled	: 28th November 2020
Date received	: 2nd December 2020
Analysis Completion data	: 28th December 2020

TEST RESULTS

Laboratory Number		E43745	E43746	E43747	E43748	E43749	E43750	E43751
Sample/Source Name	Units	Q	E	D	U/N	X	O	B
		Organochlorine Pesticides						
BHC	µg/g	ND	ND	ND	ND	ND	ND	ND
Lindane (g-B)	µg/g	ND	ND	ND	ND	ND	ND	ND
Heptachlor	µg/g	ND	ND	ND	ND	ND	ND	ND
Aldrin	µg/g	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	µg/g	ND	ND	ND	ND	ND	ND	ND
Oxychlordane	µg/g	ND	ND	ND	ND	ND	ND	ND
Gamma-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND
Alfa-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND
Dieldrin	µg/g	ND	ND	ND	ND	ND	ND	ND
Endrin	µg/g	ND	ND	ND	ND	ND	ND	ND
Endosulfan	µg/g	ND	ND	ND	ND	ND	ND	ND
DDT	µg/g	ND	ND	ND	ND	ND	ND	ND
		Organophosphorous Pesticides						
Dichlorvos	µg/g	ND	ND	ND	ND	ND	ND	ND
Methacrifos	µg/g	ND	ND	ND	ND	ND	ND	ND
Diazinon	µg/g	ND	ND	ND	ND	ND	ND	ND
Etrimfos	µg/g	ND	ND	ND	ND	ND	ND	ND
Phosphamidon	µg/g	ND	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	µg/g	ND	ND	ND	ND	ND	ND	ND
Fenitrothion	µg/g	ND	ND	ND	ND	ND	ND	ND
Primiphosmethyl	µg/g	ND	ND	ND	ND	ND	ND	ND
Malathion	µg/g	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	µg/g	ND	ND	ND	ND	ND	ND	ND
Parathionethyl	µg/g	ND	ND	ND	ND	ND	ND	ND
Pirimiphosethyl	µg/g	ND	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	µg/g	ND	ND	ND	ND	ND	ND	ND

Notes;

Samples are analyzed on as received basis. ND means Not Detected

The client does bear sampling responsibility as to the representative characters of the sample delivered. Results are therefore based on the sample delivered and analyzed. mg/l-stands for milligrams per liter

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LABORATORY MANAGER
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Water Quality Analysis - Laboratory Results for the Dry Season

February 2021

Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number	E46435	E46436	E46437	E46438	E46439	E46440	E46441	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Sample Name	6Phytoo	6s	6zoo	7D	7L	7Minerals	7S	
Electrical Conductivity (µS/cm)	808	232000	805	215000	223000	1270	198900	2500
TDS (mg/L)	565.6	162400	563.5	150500	156100	889	139230	1500
Turbidity (NTU)	27	17	14	3	35	26	17	25
Chlorides (mg/L)	225	122	249	97	290	302	292	250
Manganese (mg/L)	2.8	2.51	2.4	<0.01	<0.01	1.96	0.28	<0.01
Ammonium (mg/L)	1.52	1.34	1.29	<0.01	<0.01	0.32	<0.01	0.5
Nitrates (mg/L)	3.15	2.12	1.93	<0.01	<0.01	<0.01	0.21	10
Sulphate (mg/L)	200	210	206	1233	1166	376	1256	400
Phoshates (mg/L)	0.49	0.38	0.15	<0.02	<0.02	0.38	<0.02	0.7
Aluminium (mg/L)	0.82	0.96	0.55	0.42	0.59	0.68	0.65	-
Chemical Oxygen Demand (mg/L)	104	22	53	36	41	84	38	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	280	790	315	830	831	276	782	600
Calcium Hardness (mg/L)	120	340	135	357	357	119	336	600
Magnesium Hardness (mg/L)	160	450	180	473	474	157	446	600
Calcium (mg/L)	48	136	54	143	143	47	135	150
Magnesium (mg/L)	38	108	43	114	114	38	107	100
E. Coli (CFU/100mls)	13	<1	4	<1	<1	15	<1	0
Total Coliforms (CFU/100mls)	>200	<1	>200	<1	<1	>200	<1	0
Iron (mg/L)	4.8	0.89	0.76	0.34	0.28	0.45	0.65	1

Notes;

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NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number	E46442	E46443	E46444	E46445	E46446	E46447	E46448	E46449	E46450	E46451	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	7Zoo	AD	AL	Aminerals	Aphyto	Azoo	CD	CL	Cminerals	Cphytoo	
Electrical Conductivity (µS/cm)	1297	122000	ND	874	664	712	162000	170300	557	987	2500
TDS (mg/L)	907.9	85400	ND	611.8	464.8	498.4	113400	119210	389.9	690.9	1500
Turbidity (NTU)	9	1	ND	2	3	2	2	1	1	0	25
Chlorides (mg/L)	318	178	ND	319	135	267	180	190	278	220	250
Manganese (mg/L)	2.18	1.89	ND	1.94	2.29	1.99	2.28	2.13	1.98	2.38	<0.01
Ammonium (mg/L)	1.32	1.21	ND	1.27	1.19	1	1.56	1.66	1.45	1.93	0.5
Nitrates (mg/L)	5	3	ND	0.04	0.03	0.03	0.57	0.78	0.99	0.98	10
Sulphate (mg/L)	368	379	ND	278	236	246	275	259	220	204	400
Phoshates (mg/L)	0.84	0.78	ND	0.089	0.045	0.063	0.98	0.95	1.4	1.75	0.7
Aluminium (mg/L)	0.60	3.92	ND	3.97	3.86	3.62	3.48	0.97	1.08	1.05	-
Chemical Oxygen Demand (mg/L)	93	41	ND	65	173	92	55	48	67	98	100
Total Alkalinity (mg/L)	<2	<2	ND	<2	<2	<2	<2	<2	24	106	-
Total Hardness (mg/L)	238	710	ND	211	198	376	847	822	211	378	600
Calcium Hardness (mg/L)	102	305	ND	91	85	162	364	353	91	163	600
Magnesium Hardness (mg/L)	136	405	ND	120	113	214	483	469	120	215	600
Calcium (mg/L)	41	122	ND	36	34	65	146	141	36	65	150
Magnesium (mg/L)	33	97	ND	29	27	51	116	112	29	52	100
E. Coli (CFU/100mls)	<1	<1	ND	6	16	22	<1	<1	1	7	0
Total Coliforms (CFU/100mls)	>200	<1	ND	>200	>200	>200	<1	<1	>200	>200	0
Iron (mg/L)	2.8	0.52	ND	0.58	2.89	1.3	0.98	0.76	0.88	1.8	1

Notes;

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Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number	E46426	E46427	E46428	E46429	E46430	E46431	E46432	E46433	E46434	Drinking water standards (DEAS 12:2018 Maximum permissible for Natural potable Water)
Sample Name	6	1D	1L	1Minerals	1Phyto	1Zoo	6D	6L	6minerals	
Electrical Conductivity (µS/cm)	50600	128200	ND	699	748	589	151400	267000	823	2500
TDS (mg/L)	35420	89740	ND	489.3	523.6	412.3	105980	186900	576.1	1500
Turbidity (NTU)	148	224	ND	10	4	4	3	2	34	25
Chlorides (mg/L)	289	67	ND	78	167	156	79	128	197	250
Manganese (mg/L)	<0.01	1.8	ND	1.4	1.7	1.5	<0.01	<0.01	2.14	<0.01
Ammonium (mg/L)	0.74	1.4	ND	1.9	1.45	1.67	<0.01	<0.01	0.86	0.5
Nitrates (mg/L)	3.5	0.44	ND	2.4	2.6	2	6	5	3	10
Sulphate (mg/L)	1350	1740	ND	245	280	168	1467	1400	208	400
Phoshates (mg/L)	0.08	0.11	ND	0.13	0.14	0.13	0.05	0.07	0.05	0.7
Aluminium (mg/L)	0.50	0.44	ND	1.01	1.16	1.05	1.08	0.91	0.69	
Chemical Oxygen Demand (mg/L)	57	43	ND	78	146	87	33	58	77	100
Total Alkalinity (mg/L)	<2	<2	ND	<2	<2	<2	<2	<2	<2	
Total Hardness (mg/L)	650	700	ND	200	257	240	840	790	300	600
Calcium Hardness (mg/L)	280	301	ND	86	111	103	361	340	129	600
Magnesium Hardness (mg/L)	371	399	ND	114	146	137	479	450	171	600
Calcium (mg/L)	112	120	ND	34	44	41	144	136	52	150
Magnesium (mg/L)	89	96	ND	27	35	33	115	108	41	100
E. Coli (CFU/100mls)	<1	<1	ND	4	<1	7	<1	<1	21	0
Total Coliforms (CFU/100mls)	<1	<1	ND	>200	<1	>200	<1	<1	>200	0
Iron (mg/L)	3.2	0.43	ND	0.56	2.4	0.12	0.57	0.76	0.68	1

Notes;

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Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number	E46562	E46563	E46564	E46565	E46566	E46567	E46568	E46569	Drinking water standards (DEAS12:2018 Maximum permissible for Natural potable Water)
Sample Name	WS	XD	XL	Xminerals	Xphytoo	XS	Xzoo	Yphyto	
Electrical Conductivity (µS/cm)	70300	80500	63500	1333	1767	76200	2240	1634	2500
TDS (mg/L)	49210	56350	44450	933.1	1236.9	53340	1568	1143.8	1500
Turbidity (NTU)	71	149	55	71	51	145	125	120	25
Chlorides (mg/L)	198	189	179	346	387	210	358	367	250
Manganese (mg/L)	2.43	1.5	1.67	2.15	2.31	1.91	3.39	3.63	<0.01
Ammonium (mg/L)	0.43	0.51	0.21	0.176	2.5	2.1	<0.01	2.16	0.5
Nitrates (mg/L)	0.56	0.21	0.22	3.45	0.1	0.16	0.36	<0.01	10
Sulphate (mg/L)	1000	1239	1109	337	416	1320	420	398	400
Phoshates (mg/L)	0.38	0.4	0.43	0.3	0.99	1.2	1.14	0.77	0.7
Aluminium (mg/L)	0.28	0.33	0.38	0.36	0.34	0.44	<0.001	0.47	
Chemical Oxygen Demand (mg/L)	56	45	51	38	54	38	78	102	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	
Total Hardness (mg/L)	746	800	763	356	398	751	433	365	600
Calcium Hardness (mg/L)	321	344	328	153	171	323	186	157	600
Magnesium Hardness (mg/L)	425	456	435	203	227	428	247	208	600
Calcium (mg/L)	128	138	131	61	68	129	74	63	150
Magnesium (mg/L)	102	109	104	49	54	103	59	50	100
E. Coli (CFU/100mls)	<1	<1	<1	<1	<1	<1	<1	2	0
Total Coliforms (CFU/100mls)	<1	<1	<1	<1	<1	<1	<1	>200	0
Iron (mg/L)	0.45	0.23	0.31	0.24	1.8	0.33	0.27	1.4	1

Notes;

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Certificate of Analysis

Client Name : JBN Consults and Planners Ltd
Client Address : Plot 48 Mbago Road, Najjera 1
Sample type & Location : Surface water from River Mishumba Isingiro District
Date Sampled : 7th April 2021
Date received : 7th April 2021
Analysis Completion data : 3rd May 2021

TEST RESULTS

Laboratory Number	E46554	E46555	E46556	E46557	E46558	E46559	E46560	E46561	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	VL	Vminerals	Vphyto	VS	Vzoo	WD	WL	Wminerals	
Electrical Conductivity (µS/cm)	88500	1357	685	91500	1571	82300	100800	1324	2500
TDS (mg/L)	61950	949.9	479.5	64050	1099.7	57610	70560	926.8	1500
Turbidity (NTU)	20	2	21	40	76	30	41	34	25
Chlorides (mg/L)	383	400	389	280	403	273	307	353	250
Manganese (mg/L)	0.45	1.14	1.4	0.98	1.32	2.67	2.38	2.62	<0.01
Ammonium (mg/L)	0.31	0.51	0.63	0.47	0.56	0.49	0.36	0.477	0.5
Nitrates (mg/L)	33	0.35	0.28	0.11	0.14	0.34	0.41	4.7	10
Sulphate (mg/L)	1087	312	165	1509	380	1299	1389	331	400
Phoshates (mg/L)	0.44	0.23	0.19	0.1	0.12	0.14	0.12	0.32	0.7
Aluminium (mg/L)	0.26	0.30	0.23	7.16	6.81	7.50	6.89	7.13	-
Chemical Oxygen Demand (mg/L)	45	67	57	38	89	23	26	48	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	753	311	287	689	412	743	866	351	600
Calcium Hardness (mg/L)	324	134	123	296	177	319	372	151	600
Magnesium Hardness (mg/L)	429	177	164	393	235	424	494	200	600
Calcium (mg/L)	130	53	49	119	71	128	149	60	150
Magnesium (mg/L)	103	43	39	94	56	102	118	48	100
E. Coli (CFU/100mls)	<1	3	1	<1	<1	<1	2	<1	0
Total Coliforms (CFU/100mls)	<1	>200	>200	<1	<1	<1	>200	<1	0
Iron (mg/L)	7.9	7.8	5.4	5.9	6.8	0.56	0.87	0.99	1

Notes;

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TEST RESULTS

Laboratory Number	E46528	E46529	E46530	E46531	E46532	E46533	E46534	E46535	E46536	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	Qphyto	QS	Qzoo	RD	RL	Rminerals	Rphyto	RS	Rzoo	
Electrical Conductivity (µS/cm)	1185	196000	1188	71600	48900	1290	ND	64900	2810	2500
TDS (mg/L)	829.5	137200	831.6	50120	34230	903	ND	45430	1967	1500
Turbidity (NTU)	27	2	30	3	4	18	ND	9	11	25
Chlorides (mg/L)	276	176	289	220	211	320	ND	198	276	250
Manganese (mg/L)	1.98	0.56	2.45	0.34	0.29	2.43	ND	0.35	1.94	<0.01
Ammonium (mg/L)	0.2	0.04	0.32	<0.001	<0.001	0.24	ND	0.05	0.087	0.5
Nitrates (mg/L)	4.4	3.2	5.6	2.9	3.1	5.72	ND	3.6	5.9	10
Sulphate (mg/L)	380	1400	400	1289	1328	390	ND	1427	523	400
Phosphates (mg/L)	0.67	0.21	0.66	0.04	0.08	0.04	ND	1.1	1.3	0.7
Aluminium (mg/L)	2.99	3.38	2.84	3.91	23.37	19.68	ND	25.83	28.29	-
Chemical Oxygen Demand (mg/L)	53	32	68	39	38	47	ND	23	65	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	ND	<2	<2	-
Total Hardness (mg/L)	254	783	265	587	523	341	ND	673	412	600
Calcium Hardness (mg/L)	109	337	114	252	225	147	ND	289	177	600
Magnesium Hardness (mg/L)	145	446	151	335	298	194	ND	384	235	600
Calcium (mg/L)	44	135	46	101	90	59	ND	116	71	150
Magnesium (mg/L)	35	107	36	80	72	47	ND	92	56	100
E. Coli (CFU/100mls)	22	<1	6	<1	<1	31	ND	<1	1	0
Total Coliforms (CFU/100mls)	>200	<1	>200	<1	<1	>200	ND	<1	>200	0
Iron (mg/L)	32	27	16	0.48	0.54	1.78	ND	0.65	0.35	1

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TEST RESULTS

Laboratory Number	E46492	E46493	E46494	E46495	E46496	E46497	E46498	E46499	E46500	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	KS	Kzoo	LL	Lminerals	Lphyto	LS	Lzoo	MD	ML	
Electrical Conductivity (µS/cm)	154200	817	71800	790	1233	92300	1286	93700	25100	2500
TDS (mg/L)	107940	571.9	50260	553	863.1	64610	900.2	65590	17570	1500
Turbidity (NTU)	8	26	5	6	5	0	20	2	3	25
Chlorides (mg/L)	176	215	140	289	310	138	289	98	292	250
Manganese (mg/L)	2.4	2.28	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01
Ammonium (mg/L)	0.23	2.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.741	0.5
Nitrates (mg/L)	0.94	0.54	8.1	7.4	7.9	5.2	9.1	8.3	35	10
Sulphate (mg/L)	175	174	1400	158	219	538	230	1390	1100	400
Phoshates (mg/L)	0.09	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.79	0.7
Aluminium (mg/L)	4.65	4.21	4.55	4.24	4.62	0.77	0.87	0.73	0.84	-
Chemical Oxygen Demand (mg/L)	33	69	32	56	36	28	64	44	38	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	722	312	763	334	412	873	278	723	265	600
Calcium Hardness (mg/L)	310	134	328	144	177	375	120	311	114	600
Magnesium Hardness (mg/L)	412	178	435	190	235	498	158	412	151	600
Calcium (mg/L)	124	54	131	57	71	150	48	124	46	150
Magnesium (mg/L)	99	43	104	46	56	119	38	99	36	100
E. Coli (CFU/100mls)	<1	1	<1	3	4	<1	7	<1	<1	0
Total Coliforms (CFU/100mls)	<1	>200	<1	>200	>200	<1	>200	<1	<1	0
Iron (mg/L)	0.09	0.25	<0.01	0.45	0.52	<0.01	<0.01	<0.01	<0.01	1

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TEST RESULTS

Laboratory Number	E46482	E46483	E46484	E46485	E46496	E46487	E46488	E46489	E46490	E46491	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	IS	JD	Jminerals	Jphyto	Js	Jzoo	KD	KL	Kminerals	Kphyto	
Electrical Conductivity (µS/cm)	ND	115000	543	671	84800	552	146000	229000	675	784	2500
TDS (mg/L)	ND	80500	380.1	469.7	59360	386.4	102200	160300	472.5	548.8	1500
Turbidity (NTU)	ND	9	32	11	9	9	1	16	2	2	25
Chlorides (mg/L)	ND	190	128	135	95	159	89	92	216	220	250
Manganese (mg/L)	ND	1.34	2.52	2.38	<0.01	3.75	3.14	2.45	1.65	2.19	<0.01
Ammonium (mg/L)	ND	0.09	0.57	0.49	<0.01	2.25	2.9	1.98	0.41	0.38	0.5
Nitrates (mg/L)	ND	0.23	2.94	3.4	8.2	0.11	1.3	1.43	1.48	1.6	10
Sulphate (mg/L)	ND	1200	71	122	1186	64	1240	1589	162	163	400
Phoshates (mg/L)	ND	0.48	0.35	0.33	0.39	0.47	<0.01	<0.01	0.07	0.04	0.7
Aluminium (mg/L)	ND	1.97	1.60	2.21	2.83	2.34	0.10	0.07	0.09	0.10	-
Chemical Oxygen Demand (mg/L)	ND	35	67	62	48	103	25	28	57	48	100
Total Alkalinity (mg/L)	ND	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	ND	650	218	251	727	253	719	983	277	264	600
Calcium Hardness (mg/L)	ND	280	94	108	313	109	309	423	119	114	600
Magnesium Hardness (mg/L)	ND	371	124	143	414	144	410	560	158	150	600
Calcium (mg/L)	ND	112	37	43	125	44	124	169	48	45	150
Magnesium (mg/L)	ND	89	30	34	99	35	98	134	38	36	100
E. Coli (CFU/100mls)	ND	<1	18	14	<1	11	<1	<1	12	4	0
Total Coliforms (CFU/100mls)	ND	<1	>200	>200	<1	>200	<1	<1	>200	>200	0
Iron (mg/L)	ND	1.5	4.2	0.09	0.08	0.33	0.03	0.04	0.98	0.79	1

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TEST RESULTS

Laboratory Number	E46462	E46463	E46464	E46465	E46466	E46467	E46468	E46469	E46470	E46471	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	Fminerals	Fphyto	Fphyto	FS	Fzoo	FZoo	GD	GD	GL	Gminerals	
Electrical Conductivity (µS/cm)	673	364	724	156600	403	383	86600	247000	201000	655	2500
TDS (mg/L)	471.1	254.8	506.8	109620	282.1	268.1	60620	172900	140700	458.5	1500
Turbidity (NTU)	116	183	109	101	103	176	190	112	106	105	25
Chlorides (mg/L)	191	153	167	128	175	180	89	92	101	196	250
Manganese (mg/L)	1.83	0.69	0.78	0.83	0.59	0.64	0.89	0.76	0.555	1.682	<0.01
Ammonium (mg/L)	0.183	1.93	1.7	2.01	1.99	2.2	0.1	0.13	0.12	0.19	0.5
Nitrates (mg/L)	0.56	0.14	0.08	0.12	2.7	2.4	0.09	0.05	0.12	0.8	10
Sulphate (mg/L)	166	24.7	200	218	31	35	130	127	134	157	400
Phoshates (mg/L)	0.56	0.39	0.27	0.17	0.13	0.09	0.05	0.08	0.12	0.11	0.7
Aluminium (mg/L)	0.64	0.55	0.84	0.75	0.73	5.04	4.31	4.43	4.80	5.17	-
Chemical Oxygen Demand (mg/L)	58	73	82	26	64	69	29	38	46	73	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	279	135	309	856	164	120	698	930	920	253	600
Calcium Hardness (mg/L)	120	58	133	368	71	52	300	400	396	109	600
Magnesium Hardness (mg/L)	159	77	176	488	93	68	398	530	524	144	600
Calcium (mg/L)	48	23	53	147	28	21	120	160	158	44	150
Magnesium (mg/L)	38	18	42	117	22	16	95	127	126	35	100
E. Coli (CFU/100mls)	6	19	22	<1	18	21	<1	<1	<1	4	0
Total Coliforms (CFU/100mls)	>200	>200	>200	<1	>200	>200	<1	<1	<1	>200	0
Iron (mg/L)	0.678	5.23	0.92	0.73	0.81	0.79	0.44	0.53	3.4	3.8	1

Notes;

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Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number	E46472	E46473	E46474	E46475	E46476	E46477	E46478	E46479	E46480	E46481	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	Gphyto	GS	Gzoo	HD	HL	Hminerals	Hphyto	Hs	Hzoo	ID	
Electrical Conductivity (µS/cm)	701	202000	709	228000	184600	705	743	209000	531	124000	2500
TDS (mg/L)	490.7	141400	496.3	159600	129220	493.5	520.1	146300	371.7	86800	1500
Turbidity (NTU)	42	87	25	23	24	15	22	10	2	10	25
Chlorides (mg/L)	201	97	301	68	73	184	212	76	289	178	250
Manganese (mg/L)	1.8	0.77	1.45	<0.01	0.34	1.66	2.09	<0.01	<0.01	4.5	<0.01
Ammonium (mg/L)	0.09	0.13	0.18	<0.01	<0.01	0.344	1.47	<0.01	<0.01	<0.01	0.5
Nitrates (mg/L)	0.9	0.14	0.19	<0.01	<0.01	2.7	0.88	<0.01	<0.01	0.32	10
Sulphate (mg/L)	161	142	152	1401	1350	184	185	1371	1390	740	400
Phoshates (mg/L)	0.05	0.07	0.04	<0.02	<0.02	0.05	0.4	0.003	0.02	<0.01	0.7
Aluminium (mg/L)	4.16	3.95	4.11	4.19	4.31	4.90	6.27	5.92	5.74	5.49	-
Chemical Oxygen Demand (mg/L)	120	51	98	33	27	64	78	36	89	44	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	8.4	-
Total Hardness (mg/L)	376	879	300	800	970	298	281	867	234	690	600
Calcium Hardness (mg/L)	162	378	129	344	417	128	121	373	101	297	600
Magnesium Hardness (mg/L)	214	501	171	456	553	170	160	494	133	393	600
Calcium (mg/L)	65	151	52	138	167	51	48	149	40	119	150
Magnesium (mg/L)	51	120	41	109	133	41	38	119	32	94	100
E. Coli (CFU/100mls)	7	<1	2	<1	<1	1	1	<1	3	<1	0
Total Coliforms (CFU/100mls)	>200	<1	>200	<1	<1	>200	>200	<1	>200	<1	0
Iron (mg/L)	0.49	0.38	2.7	2.1	1.9	2.3	2	1.7	1.8	0.03	1

Notes;

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Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number	E46452	E46453	E46454	E46455	E46456	E46457	E46458	E46459	E46460	E46461	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	Cs	Czoo	DD	DL	Dminerals	Dphyto	DS	Dzoo	FD	FL	
Electrical Conductivity (µS/cm)	273000	621	220000	173100	1058	509	131600	897	209000	176800	2500
TDS (mg/L)	191100	434.7	154000	121170	740.6	356.3	92120	627.9	146300	123760	1500
Turbidity (NTU)	4	3	4	91	70	29	31	122	165	35	25
Chlorides (mg/L)	190	210	178	240	290	225	189	289	134	146	250
Manganese (mg/L)	1.99	1.78	1.1	1.3	1.9	2.1	2.5	2.4	1.94	1.78	<0.01
Ammonium (mg/L)	2.1	2.4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.13	0.15	0.5
Nitrates (mg/L)	0.87	0.75	2.5	2.8	2.6	2.9	3.5	2.1	0.05	0.09	10
Sulphate (mg/L)	207	219	277	267	283	278	260	265	127	153	400
Phoshates (mg/L)	1.6	0.94	0.04	0.07	0.08	0.06	0.04	0.05	<0.01	<0.01	0.7
Aluminium (mg/L)	1.13	1.09	1.17	0.17	0.20	0.10	0.11	0.15	0.12	0.15	-
Chemical Oxygen Demand (mg/L)	48	146	37	44	76	89	27	78	31	34	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	900	265	890	751	288	167	678	266	846	809	600
Calcium Hardness (mg/L)	387	114	383	323	124	72	292	114	364	348	600
Magnesium Hardness (mg/L)	513	151	507	428	164	95	386	152	482	461	600
Calcium (mg/L)	155	46	153	129	50	29	117	46	146	139	150
Magnesium (mg/L)	123	36	122	103	39	23	93	36	116	111	100
E. Coli (CFU/100mls)	<1	12	<1	<1	8	3	<1	1	<1	<1	0
Total Coliforms (CFU/100mls)	<1	>200	<1	<1	>200	>200	<1	>200	<1	<1	0
Iron (mg/L)	1.3	0.98	1.8	1.5	1.9	5.87	0.98	1.34	0.64	0.71	1

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Certificate of Analysis

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Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
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Analysis Completion data	: 3rd May 2021

TEST RESULTS

Sample Number	RSediment	Sediment	TSediment	Usediment	VSediment	WSediment
Laboratory Number	E46609	E46610	E46611	E46612	E46613	E46614
Cadmium (ppm)	0.20	0.32	0.32	0.28	<0.2	<0.2
Lead (ppm)	25	37	8	93	91	100
Copper (ppm)	35	53	7	180	220	198
Zinc (ppm)	24	41	18	31	21	43
Cobalt(ppm)	2	4	5	24	19	32
Nickel (ppm)	13	34	9	28	12	9
Selenium (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vanadium(ppm)	74	110	19	275	250	320
Mercury (ppm)	<1	<1	<1	<1	<1	<1

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Client Address : Plot 48 Mbago Road, Najjera 1
Sample type & Location : Surface water from River Mishumba Isingiro District
Date Sampled : 7th April 2021
Date received : 7th April 2021
Analysis Completion data : 3rd May 2021

TEST RESULTS

Laboratory Number	E46607	E46608	E46609	E46610	E46611	E46612	E46613	E46614
Sample/Source Name	PSediment	QSediment	RSediment	Sediment	TSediment	Usediment	VSediment	WSediment
Organochlorine Pesticides								
BHC	ND	ND	ND	ND	ND	ND	ND	ND
Lindane (g-B)	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND	ND	ND	ND
Gamma-chlordane	ND	ND	ND	ND	ND	ND	ND	ND
Alfa-chlordane	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan	ND	ND	ND	ND	ND	ND	ND	ND
DDT	ND	ND	ND	ND	ND	ND	ND	ND
Organophosphorous Pesticides								
Dichlorvos	ND	ND	ND	ND	ND	ND	ND	ND
Methacrifos	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND	ND	ND	ND	ND
Etrimfos	ND	ND	ND	ND	ND	ND	ND	ND
Phosphamidon	ND	ND	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	ND	ND	ND	ND	ND	ND	ND	ND
Fenitrothion	ND	ND	ND	ND	ND	ND	ND	ND
Primiphosmethyl	ND	ND	ND	ND	ND	ND	ND	ND
Malathion	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ND	ND	ND	ND	ND	ND	ND	ND
Parathionethyl	ND	ND	ND	ND	ND	ND	ND	ND
Pirimiphosethyl	ND	ND	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	ND	ND	ND	ND	ND	ND	ND	ND

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TEST RESULTS

Laboratory Number	E46510	E46511	E46512	E46513	E46514	E46515	E46516	E46517	E46518	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	Nzoo	OD	OL	Ominerals	Ophyto	OS	Ozoo	PD	PL	
Electrical Conductivity (µS/cm)	1291	95400	75200	1680	914	77100	1087	78200	120300	2500
TDS (mg/L)	903.7	66780	52640	1176	639.8	53970	760.9	54740	84210	1500
Turbidity (NTU)	6	2	15	28	2	5	4	1	3	25
Chlorides (mg/L)	320	289	276	301	310	267	256	214	189	250
Manganese (mg/L)	2.99	<0.01	<0.01	1.1	1.4	0.56	0.23	0.11	0.15	<0.01
Ammonium (mg/L)	0.38	<0.01	<0.01	0.1	<0.01	<0.01	<0.01	1.1	1.3	0.5
Nitrates (mg/L)	0.12	40	37	3.8	4.2	12	4.5	1.3	1.4	10
Sulphate (mg/L)	378	1479	1600	416	375	1489	349	1230	1472	400
Phoshates (mg/L)	0.24	0.33	0.29	0.34	<0.01	<0.01	<0.01	0.23	0.42	0.7
Aluminium (mg/L)	3.57	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	2.84	2.44	-
Chemical Oxygen Demand (mg/L)	98	25	31	38	36	26	52	33	24	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	317	598	547	325	297	655	309	612	673	600
Calcium Hardness (mg/L)	136	257	235	140	128	282	133	263	289	600
Magnesium Hardness (mg/L)	181	341	312	185	169	373	176	349	384	600
Calcium (mg/L)	55	103	94	56	51	113	53	105	116	150
Magnesium (mg/L)	43	82	75	44	41	90	42	84	92	100
E. Coli (CFU/100mls)	14	<1	<1	12	9	<1	8	<1	<1	0
Total Coliforms (CFU/100mls)	>200	<1	<1	>200	>200	<1	>200	<1	<1	0
Iron (mg/L)	<0.01	0.08	0.06	0.06	0.04	0.07	0.03	2.8	3.6	1

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TEST RESULTS

Laboratory Number	E46501	E46502	E46503	E46504	E46505	E46506	E46507	E46508	E46509	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	Mphyto	Ms	Mzoo	ND	NL	Nminerals	Nphyto	Nphyto	NS	
Electrical Conductivity (µS/cm)	1749	99000	1325	82000	76600	1295	1155	742	85500	2500
TDS (mg/L)	1224.3	69300	927.5	57400	53620	906.5	808.5	519.4	59850	1500
Turbidity (NTU)	3	0	4	1	2	2	2	6	9	25
Chlorides (mg/L)	188	294	186	96	112	330	300	316	189	250
Manganese (mg/L)	1.07	0.13	1.8	0.98	0.78	2.96	2.45	2.78	1.84	<0.01
Ammonium (mg/L)	2.12	<0.01	1.73	0.45	0.43	0.44	0.34	0.41	0.48	0.5
Nitrates (mg/L)	5.4	41	3	0.08	0.06	0.04	0.28	0.24	0.09	10
Sulphate (mg/L)	516	1403	447	980	1044	368	350	180	1580	400
Phoshates (mg/L)	0.68	0.19	0.29	0.18	0.13	0.25	0.26	0.28	0.26	0.7
Aluminium (mg/L)	0.89	8.04	9.20	7.80	9.59	9.10	3.20	3.44	2.95	-
Chemical Oxygen Demand (mg/L)	56	27	78	33	38	46	65	58	41	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	288	673	215	732	609	257	248	318	690	600
Calcium Hardness (mg/L)	124	289	92	315	262	111	107	137	297	600
Magnesium Hardness (mg/L)	164	384	123	417	347	146	141	181	393	600
Calcium (mg/L)	50	116	37	126	105	44	43	55	119	150
Magnesium (mg/L)	39	92	29	100	83	35	34	44	94	100
E. Coli (CFU/100mls)	9	<1	15	<1	<1	31	22	28	<1	0
Total Coliforms (CFU/100mls)	>200	<1	>200	<1	<1	>200	>200	>200	<1	0
Iron (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.18	0.26	<0.01	<0.01	1

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TEST RESULTS

Laboratory Number	E46519	E46520	E46521	E46522	E46523	E46524	E46525	E46526	E46527	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	Pphyto	Pphyto	Pphytoo	PS	Psediment	Pzoo	QD	QL	Qminerals	
Electrical Conductivity (µS/cm)	1144	934	1782	76400	1118	1049	169600	137000	1306	2500
TDS (mg/L)	800.8	653.8	1247.4	53480	782.6	734.3	118720	95900	914.2	1500
Turbidity (NTU)	3	2	3	1	10	54	92	28	2	25
Chlorides (mg/L)	317	332	356	367	297	270	180	195	266	250
Manganese (mg/L)	1.8	1.89	1.74	0.98	1.144	1.4	0.76	0.56	2.06	<0.01
Ammonium (mg/L)	1.67	2.1	2.05	1.34	0.9	0.75	0.06	0.09	0.18	0.5
Nitrates (mg/L)	1.9	2.2	2.3	1.6	9.1	6.2	5.3	4.9	4.6	10
Sulphate (mg/L)	412	378	439	1230	300	290	980	1060	407	400
Phoshates (mg/L)	0.84	0.72	0.77	0.32	0.28	0.63	0.11	0.14	0.54	0.7
Aluminium (mg/L)	2.71	3.20	2.46	3.95	3.62	0.28	2.88	2.63	3.58	-
Chemical Oxygen Demand (mg/L)	37	43	48	31	45	65	23	43	48	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	278	317	398	648	363	298	736	717	267	600
Calcium Hardness (mg/L)	120	136	171	279	156	128	316	308	115	600
Magnesium Hardness (mg/L)	158	181	227	369	207	170	420	409	152	600
Calcium (mg/L)	48	55	68	111	62	51	127	123	46	150
Magnesium (mg/L)	38	43	54	89	50	41	101	98	37	100
E. Coli (CFU/100mls)	2	<1	<1	<1	<1	3	<1	<1	12	0
Total Coliforms (CFU/100mls)	>200	<1	<1	<1	<1	>200	<1	<1	>200	0
Iron (mg/L)	3.8	3.1	1.8	2.2	2.5	1.65	13	16	24	1

Notes;

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NWQRL 04 MAY 2021 NWQRL
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MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number		E46590	E46591	E46592	E46593	E46594	E46595	E46596	E46597	E46598	E46599
Sample/Source Name	Units	HA	HB	HSediment	IA	IB	ISediment	JA	JB	JSediment	KA
Organochlorine Pesticides											
BHC	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lindane (g-B)	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Oxychlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gamma-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alfa-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Organophosphorous Pesticides											
Dichlorvos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrifos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Etrimfos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphamidon	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fenitrothion	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Primiphosmethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Malathion	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Parathionethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pirimiphosethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes;

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Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Sample Number	HA	HB	HSediment	IA	IB	ISediment	JA	JB	JSediment	KA	KB	KSediment
Laboratory Number	E46590	E46591	E46592	E46593	E46594	E46595	E46596	E46597	E46598	E46599	E46600	E46601
Cadmium (ppm)	0.24	0.32	0.29	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Lead (ppm)	17	23	55	43	56	69	100	120	142	40	44	68
Copper (ppm)	19	25	42	78	101	125	445	534	632	178	196	303
Zinc (ppm)	17	23	25	59	77	94	213	255	302	85	94	145
Cobalt(ppm)	2	3	16	24	31	38	58	69	82	23	25	39
Nickel (ppm)	7	10	22	34	44	54	103	123	146	41	45	70
Selenium (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vanadium(ppm)	22	29	135	150	195	240	53	63	75	21	23	36
Mercury (ppm)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Notes;

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Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number	E46537	E46538	E46539	E46540	E46541	E46542	E46543	E46544	E46545	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	SL	Sminerals	Ss	Szoo	TD	TL	Tminerals	Tphyto	TS	
Electrical Conductivity (µS/cm)	95600	1549	96600	1510	64200	70900	1489	1547	87200	2500
TDS (mg/L)	66920	1084.3	67620	1057	44940	49630	1042.3	1082.9	61040	1500
Turbidity (NTU)	2	8	1	3	2	65	77	2	2	25
Chlorides (mg/L)	307	325	330	340	310	330	342	372	289	250
Manganese (mg/L)	<0.01	2.03	0.51	2.4	0.34	<0.01	1.86	2.3	2.1	<0.01
Ammonium (mg/L)	<0.01	0.13	<0.01	2.02	1.67	<0.01	<0.01	1.92		0.5
Nitrates (mg/L)	40	5.3	35	2.6	28	31	3.5	2.1	22	10
Sulphate (mg/L)	1449	386	1168	407	1453	1365	362	440	1690	400
Phoshates (mg/L)	1.25	0.18	0.19	0.83	0.16	0.2	0.39	0.81	0.82	0.7
Aluminium (mg/L)	3.33	0.63	3.01	3.26	3.44	0.79	0.93	0.58	0.90	
Chemical Oxygen Demand (mg/L)	78	98	45	167	54	45	78	86	56	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	
Total Hardness (mg/L)	844	365	922	353	682	716	297	301	871	600
Calcium Hardness (mg/L)	363	157	396	152	293	308	128	129	375	600
Magnesium Hardness (mg/L)	481	208	526	201	389	408	169	172	496	600
Calcium (mg/L)	145	63	159	61	117	123	51	52	150	150
Magnesium (mg/L)	115	50	126	48	93	98	41	41	119	100
E. Coli (CFU/100mls)	<1	8	<1	3	<1	<1	56	31	<1	0
Total Coliforms (CFU/100mls)	<1	>200	<1	>200	<1	<1	>200	>200	<1	0
Iron (mg/L)	0.32	1.4	0.56	0.34	<0.01	<0.01	0.24	0.13	<0.01	1

Notes;

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Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Sample Number	LA	LB	LSediment	MSediment	OSediment	PSediment	QSediment
Laboratory Number	E46602	E46603	E46604	E46605	E46606	E46607	E46608
Cadmium (ppm)	<0.2	<0.2	<0.2	<0.2	1.40	0.38	0.42
Lead (ppm)	53	74	83	99	78	23	48
Copper (ppm)	120	168	187	110	91	16	33
Zinc (ppm)	70	98	109	67	74	30	42
Cobalt(ppm)	18	25	28	21	33	10	14
Nickel (ppm)	33	46	51	22	45	6	18
Selenium (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vanadium(ppm)	74	104	115	198	88	26	82
Mercury (ppm)	<1	<1	<1	<1	<1	<1	<1

Notes;

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Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number		E46600	E46601	E46602	E46603	E46604	E46605	E46606
Sample/Source Name	Units	KB	K Sediment	LA	LB	LSediment	MSediment	OSediment
Organochlorine Pesticides								
BHC	µg/g	ND	ND	ND	ND	ND	ND	ND
Lindane (g-B)	µg/g	ND	ND	ND	ND	ND	ND	ND
Heptachlor	µg/g	ND	ND	ND	ND	ND	ND	ND
Aldrin	µg/g	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	µg/g	ND	ND	ND	ND	ND	ND	ND
Oxychlordane	µg/g	ND	ND	ND	ND	ND	ND	ND
Gamma-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND
Alfa-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND
Dieldrin	µg/g	ND	ND	ND	ND	ND	ND	ND
Endrin	µg/g	ND	ND	ND	ND	ND	ND	ND
Endosulfan	µg/g	ND	ND	ND	ND	ND	ND	ND
DDT	µg/g	ND	ND	ND	ND	ND	ND	ND
Organophosphorous Pesticides								
Dichlorvos	µg/g	ND	ND	ND	ND	ND	ND	ND
Methacrifos	µg/g	ND	ND	ND	ND	ND	ND	ND
Diazinon	µg/g	ND	ND	ND	ND	ND	ND	ND
Etrimfos	µg/g	ND	ND	ND	ND	ND	ND	ND
Phosphamidon	µg/g	ND	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	µg/g	ND	ND	ND	ND	ND	ND	ND
Fenitrothion	µg/g	ND	ND	ND	ND	ND	ND	ND
Primiphosmethyl	µg/g	ND	ND	ND	ND	ND	ND	ND
Malathion	µg/g	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	µg/g	ND	ND	ND	ND	ND	ND	ND
Parathionethyl	µg/g	ND	ND	ND	ND	ND	ND	ND
Pirimiphosethyl	µg/g	ND	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	µg/g	ND	ND	ND	ND	ND	ND	ND

Notes;

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MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number		E46570	E46571	E46572	E46573	E46574	E46575	E46576	E46577	E46578	E46579
Sample/Source Name	Units	1Sediment	2A	2B	2Sediment	4A	4B	4Sediment	6A	6B	6Sediment
Organochlorine Pesticides											
BHC	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lindane (g-B)	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Oxychlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gamma-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alfa-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Organophosphorous Pesticides											
Dichlorvos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrifos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Etrimfos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphamidon	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fenitrothion	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Primiphosmethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Malathion	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Parathionethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pirimphosethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes;

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Certificate of Analysis

Client Name : JBN Consults and Planners Ltd
Client Address : Plot 48 Mbago Road, Najjera 1
Sample type & Location : Surface water from River Mishumba Isingiro District
Date Sampled : 7th April 2021
Date received : 7th April 2021
Analysis Completion data : 3rd May 2021

TEST RESULTS

Sample Number	7A	7B	7Sediment	AA	AB	ASediment	CA	CB	CSediment	GSediment
Laboratory Number	E46580	E46581	E46582	E46583	E46584	E46585	E46586	E46587	E46588	E46589
Cadmium (ppm)	1.35	1.76	2.23	0.28	0.34	0.42	<0.2	<0.2	<0.2	0.20
Lead (ppm)	58	75	95	18	22	27	5	7	9	38
Copper (ppm)	30	39	50	22	26	33	2	3	3	29
Zinc (ppm)	110	143	182	19	23	29	4	6	8	17
Cobalt(ppm)	24	31	39	1	1	2	2	3	4	11
Nickel (ppm)	48	62	78	12	14	18	4	5	6	15
Selenium (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vanadium(ppm)	120	156	198	65	78	98	5	8	10	93
Mercury (ppm)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Notes;

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Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number		E46580	E46581	E46582	E46583	E46584	E46585	E46586	E46587	E46588	E46589
Sample/Source Name	Units	7A	7B	7Sediment	AA	AB	ASediment	CA	CB	CSediment	GSediment
Organochlorine Pesticides											
BHC	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lindane (g-B)	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Oxychlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gamma-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alfa-chlordane	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Organophosphorous Pesticides											
Dichlorvos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrifos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Etrimfos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphamidon	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloropyrifos methyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fenitrothion	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Primiphosmethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Malathion	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Parathionethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pirimiphosethyl	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorfenvinphos	µg/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes;

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NWQRL 04 MAY 2021 NWQRL
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Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
NATIONAL WATER QUALITY REFERENCE LABORATORY - ENTEBBE

Certificate of Analysis

Client Name	: JBN Consults and Planners Ltd
Client Address	: Plot 48 Mbago Road, Najjera 1
Sample type & Location	: Surface water from River Mishumba Isingiro District
Date Sampled	: 7th April 2021
Date received	: 7th April 2021
Analysis Completion data	: 3rd May 2021

TEST RESULTS

Laboratory Number	E46546	E46547	E46548	E46549	E46550	E46551	E46552	E46553	Drinking water standards (DEAS12:2018 Maximum permisible for Natural potable Water)
Sample Name	Tzoo	UD	UL	Uminerals	Uphyto	Us	Uzoo	VD	
Electrical Conductivity (µS/cm)	1461	125800	107500	1350	2180	139500	1547	118300	2500
TDS (mg/L)	1022.7	88060	75250	945	1526	97650	1082.9	82810	1500
Turbidity (NTU)	4	1	21	2	3	4	36	40	25
Chlorides (mg/L)	343	314	318	344	360	303	374	330	250
Manganese (mg/L)	2.18	<0.01	<0.01	1.94	2.12	<0.01	2.33	<0.01	<0.01
Ammonium (mg/L)	1.84	<0.01	<0.01	1.53	1.67	<0.01	2.72	0.2	0.5
Nitrates (mg/L)	2	36	42	1.73	1.94	38	2.2	7.5	10
Sulphate (mg/L)	408	1488	1409	342	620	1442	400	1023	400
Phoshates (mg/L)	0.83	0.45	0.23	0.09	<0.01	0.905	0.84	0.33	0.7
Aluminium (mg/L)	0.65	0.65	0.70	0.79	0.87	0.95	0.16	0.12	-
Chemical Oxygen Demand (mg/L)	114	54	45	67	73	43	89	34	100
Total Alkalinity (mg/L)	<2	<2	<2	<2	<2	<2	<2	<2	-
Total Hardness (mg/L)	353	921	900	376	387	826	329	892	600
Calcium Hardness (mg/L)	152	396	387	162	166	355	141	384	600
Magnesium Hardness (mg/L)	201	525	513	214	221	471	188	508	600
Calcium (mg/L)	61	158	155	65	67	142	57	153	150
Magnesium (mg/L)	48	126	123	51	53	113	45	122	100
E. Coli (CFU/100mls)	21	<1	<1	22	<1	<1	2	<1	0
Total Coliforms (CFU/100mls)	>200	<1	<1	>200	<1	<1	>200	<1	0
Iron (mg/L)	<0.01	0.98	0.56	1.6	1.8	0.78	0.66	8.6	1

Notes;

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Certificate of Analysis

Client Name : JBN Consults and Planners Ltd
Client Address : Plot 48 Mbago Road, Najjera 1
Sample type & Location : Surface water from River Mishumba Isingiro District
Date Sampled : 7th April 2021
Date received : 7th April 2021
Analysis Completion data : 3rd May 2021

TEST RESULTS

Sample Number	1Sediment	2A	2B	2Sediment	4A	4B	4Sediment	6A	6B	6Sediment
Laboratory Number	E46570	E46571	E46572	E46573	E46574	E46575	E46576	E46577	E46578	E46579
Cadmium (ppm)	1.40	0.54	0.81	1.01	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Lead (ppm)	28	23	35	43	52	64	70	104	146	177
Copper (ppm)	43	12	18	22	63	78	85	126	176	214
Zinc (ppm)	28	44	66	82	89	110	120	178	249	303
Cobalt(ppm)	4	9	14	18	32	40	43	64	90	109
Nickel (ppm)	34	19	29	36	42	52	57	84	118	143
Selenium (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vanadium(ppm)	100	48	72	90	190	236	257	380	532	646
Mercury (ppm)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Notes;

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Annex 3: Vegetation and Flora

Point	*Vegetation*	*Land use/cover*	*Vegetation Cover (%)*	*Bare Ground or Bog (%)*	*Water Cover (%)*	*Pics*
1	Cyperus-Persicaria riverine vegetation along the river in the valley that has Eucalyptus sp woodland in Rwoho CFR	Plantation farming, Apiculture, Charcoal burning	70	15	15	3441-3442
2	Cyperus-Persicaria-Phoenix riverine vegetation in Rwoho CFR	Eucalyptus planting	80	15	5	3447-3452
3	Cyperus riverine vegetation and bushed fallow in valley with Eucalyptus sp and Pinus sp for Rwoho CFR on hill slopes	Plantation farming, Apiculture	50	40	10	3444-3451
4	Lepistemon-Commelina wetland fallow derived from Cyperus-Typha-Ludwigia riverine vegetation; This is in the middle of Eucalyptus sp woodland of Rwoho CFR	Cultivation and Apiculture	90	5	5	3568-3571
5	Eucalyptus sp woodland in a swamp	Cultivation	98	2	0	3572-3575
6	Cyperus riverine vegetation and bushed fallow in valley with Eucalyptus sp and Pinus sp for Rwoho CFR on hill slopes	Plantation farming, Apiculture	40	50	10	3454-3458
7	Cyperus-Bridelia-Melanthera riverine vegetation with patch of Eucalyptus woodland	Cultivation	100	0	0	3576-3583
8	Cyperus wetland in valley with Musa-Coffea- gardens contiguous with Eucalyptus woodland in Rwoho CFR	Plantation and subsistence farming	75	15	10	3462-3468
9	Typha-Cyperus-Melanthera streamline vegetation with moderately bushed grassland patch	Livestock grazing and subsistence cultivation	100	0	0	3476-3481
10	Cyperus-Typha-Leersia riverine vegetation with Eucalyptus-caffea Garden on hill slopes	Cultivation	87	3	10	3482-3487
11-A	Cyperus-Typha streamline vegetation in valley with Musa-Coffea gardens on hill slopes	Cultivation, Settlement and livestock grazing	90	7	3	3492-3503
11-B	Cyperus-Typha riverine vegetation	Cultivation, settlements	75	15	10	3504-3507
12	Eucalyptus sp woodland with patches of Sorghum-Ipomoea-gardens through which passes a stream	Cultivation	83	7	10	
13	Typha riverine vegetation with patches of Eucalyptus woodlots	Cultivation	90	0	10	3552-3554
13	Typha-Cyclosorus-Cyperus riverine vegetation fringed by Eucalyptus sp plantation	Livestock grazing and subsistence cultivation	99	0	1	
14	Cyperus riverine vegetation with Eucalyptus sp woodland on hill slopes	Plantation farming and Distillation	60	25	15	3471-3473
15	Cyperus riverine vegetation with patches of bare ground and short bushes	Cultivation and Distillation	60	25	15	3512-3517

16	Cyperus-Typha-Persicaria riverine vegetation with patches of cultivated Eucalyptus sp and Zea mays	Cultivation	75	15	10	3519-3522
17	Cyperus community surrounding open water patch	Cultivation	40	55	5	3524-3527
18	Cyperus riverine vegetation	Cultivation and Livestock grazing	55	10	35	3531-3537
19	Cyperus-Typha-Leersia riverine vegetation	Cultivation	75	20	5	3538-3541
20	Typha riverine vegetation with patches of Eucalyptus sp and a grassland	Cultivation	85	5	10	3545-3548
22	Typha riverine vegetation; There are fish ponds surrounded by Cynodon dactylon	Fish farming, cultivation	70	0	30	3559-3567
23	Typha-Cyclosorus-Leersia riverine vegetation	Cultivation	82	3	15	3587-3589
24	Typha-Leersia-Persicaria riverine vegetation with fields of cultivation	Cultivation	50	0	50	3590-3598

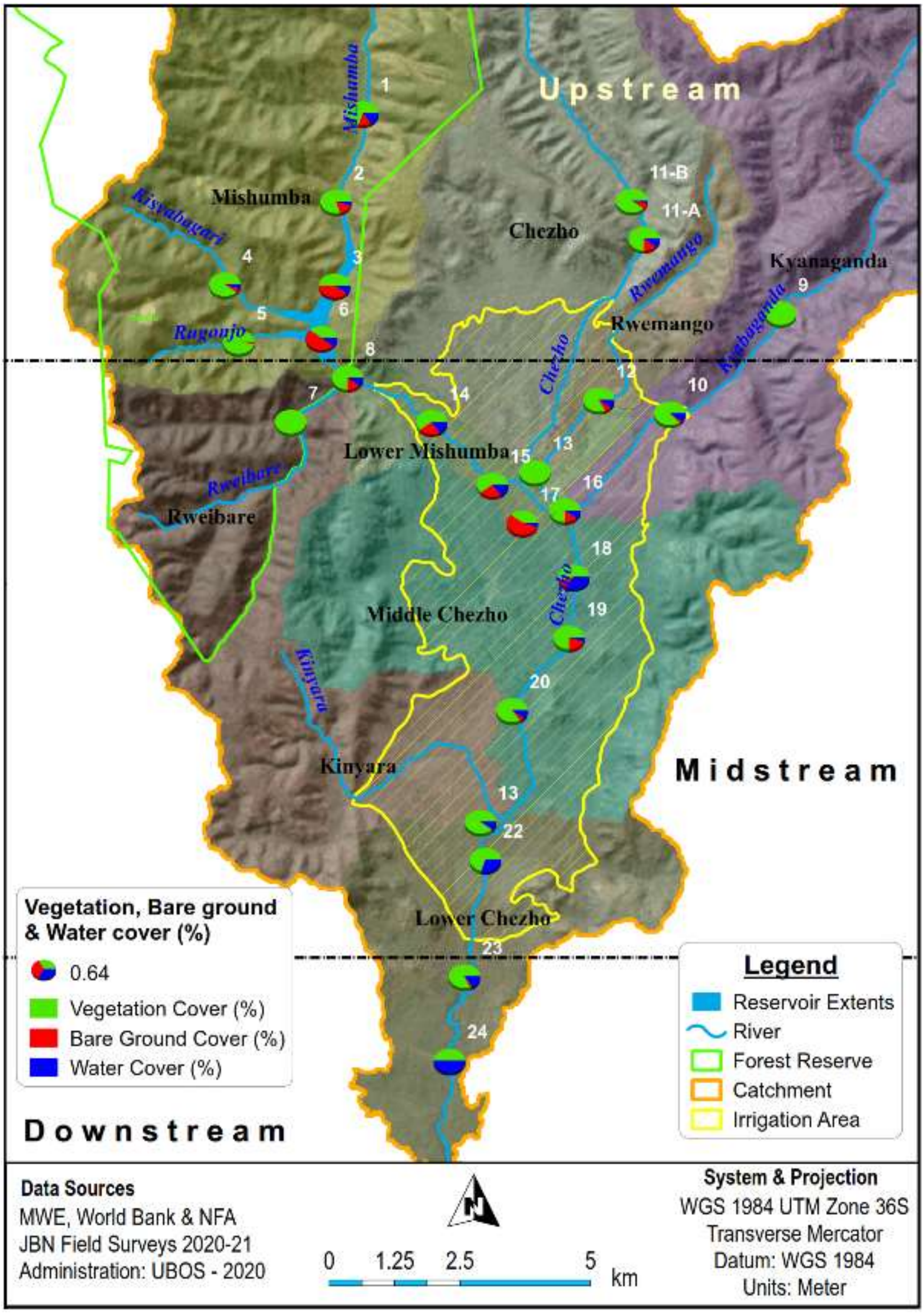


Figure 14-1: Land use/cover, vegetation, bare ground or bog and water coverage in Mishumba

Family	***Species***	***Life form***	***Global conservation status by IUCN***	***Percentage cover***																							
Acanthaceae	Acanthospermum hispidum DC.	Herb	NE																								
Acanthaceae	Acanthus polystachius Delile	Shrub	NE	20	7	3			2														3	2	45	2	
Acanthaceae	Asystasia gangetica (L.) T. Anderson	Herb	NE	1	8				2	2		8			1	2			4	5		25	3				5
Acanthaceae	Barleria ventricosa Hochst. ex Nees	Herb	NE				2					1				1		1	1				1	1			
Acanthaceae	Dyschoriste radicans Hutch. & Dalziel	Herb	NE						2			7		2	5	30			3	2		25	1	15			
Acanthaceae	Hygrophila auriculata Heine	Herb	NE													7	10		6	3		20					
Acanthaceae	Thunbergia alata Bojer ex Sims	Climber	NE									2															
Amaranthaceae	Achyranthes aspera L.	Herb	NE	2	2	5		3	2	2		2	1		1				8	8	10	2	3		10	10	2
Amaranthaceae	*Aerva lanata* (L.) Juss. ex Schult.	Herb	NE		1																				2	2	
Amaranthaceae	Alternanthera pungens Kunth	Herb	NE											1						1							
Amaranthaceae	Alternanthera sessilis (L.) R.Br. ex DC.	Herb	LC							1								2				5					
Amaranthaceae	Amaranthus dubius Mart. ex Thell.	Herb	NE				2		2					3					2								
Amaranthaceae	Amaranthus graecizans L.	Herb	NE						1	2																	
Amaranthaceae	Amaranthus lividus L.	Herb	NE	1	2	2	2		5	2		2	1						2			2	1			2	
Amaranthaceae	Cyathula achyranthoides (Kunth) Moq.	Herb	NE							1	1			1													
Amaryllidaceae	Scadoxus multiflorus (Martyn.) Raf	Herb	NE												3												
Apiaceae	Centella asiatica (L.) Urb.	Herb	LC									2	2	2	1					2		2		3			

Apocynaceae	Mondia whitei (Hook. f.) Skeels	Climber	NE	7		2			1																		
Apocynaceae	Secamone sp.	Herb		2		2	1		1	2	1			2													
Araliaceae	Hydrocotyle ranunculoides L. f	Herb	LC			3																					
Arecaceae	Phoenix reclinata Jacq.	Tree/Fn	NE		10	2												2									
Asparagaceae	Asparagus falcatus L.	Shrub	NE			3							1		1	3			3	5			1				
Asparagaceae	Dracaena fragrans (L.) Ker Gawl.	Shrub/Ud	NE																								1
Asparagaceae	Sansevieria dawei Stapf.	Herb	NE													2											
Asteraceae	Acmella caulirhiza Del.	Herb/	NE			1	1						3							1	2	2				4	
Asteraceae	Acmella uliginosa (Sw.) Cass.	Herb	LC						1			3										10					
Asteraceae	Ageratum conyzoides L.	Herb	NE	2	8	2	2	2	2		2		5	2		2	5	5	2		5	8	3	4		5	4
Asteraceae	Aspilia africana (Pers.) C.D. Adams	Herb	NE	5	7	5		3				4															
Asteraceae	Bidens pilosa L.	Herb	NE	2	15	3		5	10		2	5		1		2	2	5	2	2		7	5		2	10	3
Asteraceae	Bidens sp.	Herb											3														
Asteraceae	Blumea alata (D. Don) DC.	Herb	NE		1									1										1		2	
Asteraceae	*Bothriocline longipes* (Oliv. & Hiern) N.E. Br.	Shrub	NE			1						15									2		2				
Asteraceae	Conyza floribunda Kunth	Herb	NE			3						2		2		2	1		2			1		3	2	2	2
Asteraceae	Crassocephalum crepidioides (Benth.) S. Moore	Herb	NE	2	5	1				2			1				1								2		2
Asteraceae	Crassocephalum paludum C. Jeffrey colekiti	Herb	LC														1							1			2
Asteraceae	Crassocephalum vitellinum (Benth.) S. Moore	Herb	NE						1		1								1			2					
Asteraceae	Dichrocephala integrifolia (L. f.) Kuntze	Herb	NE						2				1								2	1				3	3
Asteraceae	*Emilia discifolia* (Oliv.) C. Jeffrey	Herb	NE																			1					

Asteraceae	*Erlangea tomentosa* (Oliv. & Hiern) S. Moore	Shrub	NE													1	1				2						
Asteraceae	Galinsoga parviflora Cav.	Herb	NE		8	1		2	4			2		1				2	1	3	2	5	1		3		
Asteraceae	Gynura scandens O. Hoffm.	Herb	NE						2												2		4				
Asteraceae	Lactuca sp.	Herb																	1			1					
Asteraceae	*Melanthera scandens* (Schumach. & Thonn.) Roberty	Herb	NE				3		3	7	7	20				2	5	2	2		30		40	10	5	3	2
Asteraceae	Sonchus sp.	Herb														1											
Asteraceae	Synedrella nodiflora (L.) Gaertn.	Herb	NE						1					1					2			1					1
Asteraceae	Tagetes minuta L.	Herb	NE		8	2	1			1		1					1	2	1	2		2				2	1
Asteraceae	Tridax procumbens	Herb	NE																	1							
Asteraceae	Vernonia amygdalina Delile	Tree	NE	10		3									1	2	1		2	8			6	4	5	2	
Asteraceae	Vernonia auriculifora Hiern	Shrub/Ud	NE							1						5	1		2		2			3			
Asteraceae	Vernonia cinerea (L.) Less.	Herb	NE					1																			
Bignoniaceae	*Markhamia lutea* (Benth.) K. Schum.	Shrub	NE		4	5		1		3		3									2			2		2	
Bignoniaceae	Stereospermum kunthianum Cham.	Tree	LC																						3		
Boraginaceae	Cordia africana Lam.	Tree	NE		10																						
Brassicaceae	Cardamine africana L.	Herb	NE		1	1	2		1			2										2					
Cannaceae	Canna indica L.	Herb	NE						2	1																	
Capparaceae	Capparis fascicularis DC.	Shrub	NE												2	1		1									
Celestraceae	*Maytenus heterophylla* (Eckl. & Zeyh.) N. Robson	Shrub	NE		1	1									5			1	2	2	2	2	1	2	2	1	
Colchicaceae	Gloriosa superba L.	Herb	LC							1														2	1		
Commelinaceae	Commelina africana L.	Herb	LC			2																					
Commelinaceae	Commelina benghalensis L.	Herb	LC	7	5	3	5	2	1	8	7	3	7			10	2	20		10		30	15	10	10	5	3
Commelinaceae	Commelina subulata Roth	Herb	NE																					2			

Commelinaceae	Polyspatha paniculata Benth.	Herb	NE																					35		
Convolvulaceae	*Dichondra repens* J.R. Forst. & G. Forst.	Herb	NE												2						2						
Convolvulaceae	Ipomea rubens Choisy	Climber	NE						4		2	4						10			10	5			2		
Convolvulaceae	Ipomoea cairica (L.) Sweet	Climber	NE			7	2		10	3	3		2		2	4	10	20	4	20		5		10			
Convolvulaceae	Ipomoea involucrata P. Beauv.	Climber	NE							2	2													2	15	15	
Convolvulaceae	Ipomoea purpurea (L.) Roth	Climber	NE						1	2		2									2				10		
Convolvulaceae	Ipomoea sp.	Climber		2																							
Convolvulaceae	*Lepistemon owariense* (P. Beauv.) Hallier f.	Climber	NE	7	8	5																	3		50	25	
Cucurbitaceae	Cucumis sp	Climber				1																		2			
Cucurbitaceae	Zehneria sp.	Climber		2	2	1																					
Curcubitaceae	Diplocyclos palmatus (L.) C. Jeffrey	Climber	NE			2				3									2								
Curcubitaceae	Momordica foetida Schumach.	Climber	NE	10		5		2	2	10														2	10	5	10
Curcubitaceae	Mukia maderespatana (L.) M. Roem.	Climber	NE	7						2			2					15		2							
Curcubitaceae	*Zehneria thwaitesii* (Schweinf.) C. Jeffrey	Climber	NE				1																				
Cyperaceae	Cyperus articulatus L.	Herb	LC														1		7								
Cyperaceae	Cyperus cyperoides (L.) Kuntze	Herb	NE		1	1			2			1				2	1		1	1		3	2	5			
Cyperaceae	Cyperus denudatus L. f.	Herb	NE	50	80	80	45	25	10	55	45		5	10	50		10			5	3	5		10			80
Cyperaceae	Cyperus difformis L.	Herb	NE							3									3			2					
Cyperaceae	Cyperus digitatus Roxb.	Herb	LC		30	15	10	20	3		2		2		4												

Cyperaceae	Cyperus dives Delile	Herb	NE	7	10			65	30	20	15	65	50	15	20	3	10	15	20		10	10	25		8		10
Cyperaceae	Cyperus dubius Rottb.	Herb	LC											3													
Cyperaceae	Cyperus exaltatus Retz.	Herb	LC	35						30	20			50	40				10		20						
Cyperaceae	Cyperus latifolius (Peter) Kük.	Herb	NE	20	15	5	2	10					5			2		20	8				2				10
Cyperaceae	Cyperus papyrus L.	Herb	LC			20	20	15	5	5	5			2	10												
Cyperaceae	Cyperus sp.	Herb		5	1																						
Cyperaceae	Kyllinga alba Nees	Herb	NE												3	1			5	2		2	3	1			
Cyperaceae	Kyllinga elatior Kunth	Herb	NE																1	1							
Cyperaceae	Kyllinga sp.	Herb																			10						
Euphorbiaceae	Acalypha bipartita Müll. Arg.	Shrub	NE		1	2						1								2	8				10	10	
Euphorbiaceae	Acalypha crenata Hochst. ex A. Rich.	Herb	NE																			1					
Euphorbiaceae	*Acalypha ornata* Hochst. ex A. Rich.	Herb/Fn	NE			1															15			4	50		
Euphorbiaceae	Cascabela thevetia (L.) Lippold	Shrub	LC											2													
Euphorbiaceae	Erythrococca bongensis Pax	Shrub	NE												2												
Euphorbiaceae	Euphorbia heterophylla L.	Herb	NE									3				1		3	1	2							1
Euphorbiaceae	Euphorbia indica Lam.	Herb	NE																	3							
Euphorbiaceae	Euphorbia tirucalii L.	Tree	NE									2	1	5						4		10					
Euphorbiaceae	*Flueggea virosa* (Roxb. ex Willd.) Royle	Shrub	NE			1	1									4		1	2	8		1		1			
Euphorbiaceae	Macaranga schweinfurthii Pax	Tree/Fg	NE	8	2																						
Euphorbiaceae	Ricinus communis L.	Shrub	NE		2	1	1		1	2	1									4				1	8		

Euphorbiaceae	Shirakiopsis elliptica (Hochst.) Esser	Shrub	NE	5	5		2		2																5		
Euphorbiaceae	Tragia brevipes Pax	Herb	NE			2						1							1			4					
Fabaceae	Acacia brevispica Harms	Climber	LC							1										2							
Fabaceae	Acacia hockii De Wild.	Shrub	NE												1												
Fabaceae	Acacia polyacantha Willd.	Tree	NE														2			1							
Fabaceae	Acacia sieberiana DC.	Shrub	NE			2											1		1	2							
Fabaceae	Aeschynomene indica L.	Tree/r	LC		2																						
Fabaceae	Albizia schimperiana Oliv.	Tree	LC	2	2	2																		2	5	3	
Fabaceae	Alysicarpus glumaceus (Vahl) DC.	Herb	NE														2		1								
Fabaceae	Calliandra calothyrsus Meisn.	Shrub	NE													8											
Fabaceae	Crotalaria brevidens Benth.	Herb	NE														1										
Fabaceae	Crotalaria pallida Aiton	Herb	NE													1								1			
Fabaceae	Crotalaria spinosa Benth.	Herb	NE														2		1	1							
Fabaceae	*Desmodium canum* (J.F. Gmel.) Schinz & Thell.	Herb	NE			2													1	5							
Fabaceae	Desmodium salicifolium Mart. ex Benth.	Herb	LC																2								
Fabaceae	Erythrina abyssinica Lam.	Shrub	NE			5									3						10				6	3	
Fabaceae	Indigofera arrecta Benth. ex Harv.	Shrub	NE														1			1							2
Fabaceae	Indigofera spicata Forssk.	Herb	NE													1	3		1								
Fabaceae	Mimosa pigra L.	Shrub	NE						5	8	2			1						2							
Fabaceae	*Neonotonia wightii* (Wight & Arn.) J.A. Lackey	Herbaceous Climber	LC		4	10						10				10			3		20	10	8			30	
Fabaceae	Rhynchosia viscosa (Roth) DC.	Climber	NE													5	10										
Fabaceae	*Senna didymobotria* (Fresen.) Irwin & Barneby	Shrub	LC	5	2	3		3	15	3	3	2									15			2	2		
Fabaceae	*Senna spectabilis* (Vogel) H.S. Irwin & Barneby	Tree	LC																3								

Fabaceae	Sesbania sesban (L.) Merr.	Shrub/r	NE			1		2	1	3	1								2								
Fabaceae	Teramnus labialis (L. f.) Spreng.	Herb	NE							3		1				10		3	5	7				8			
Fabaceae	Vigna sp.	Climber	NE														3										
Lamiaceae	Hoslundia opposita Vahl	Shrub	NE			1						1				2			1	1		2			3		
Lamiaceae	Leonotis nepetifolia (L.) R. Br.	Herb	NE	1		1		2		3	3	4		2			5	2	2	7		7	3	2			3
Lamiaceae	Leucas martinicensis (Jacq.) R. Br.	Herb	NE						1	5		1		1				1	1			1					1
Lamiaceae	Ocimum gratissimum L.	Shrub	NE																3	1							2
Lamiaceae	Plectranthus sp.	Herb			1																2	1				3	
Lauraceae	Persea americana Mill.	Tree	NE				4																			3	
Malvaceae	Abutilon mauritianum (Jacq.) Medik.	Herb	NE			5			1			2				3			5		5		2	1		2	
Malvaceae	Dombeya dawei Sprague	Shrub	NE																						2		
Malvaceae	Grewia mollis Juss.	Shrub	NE													2		1		5							
Malvaceae	Grewia similis K. Schum.	Shrub	NE												1				2	3		1					
Malvaceae	Hibiscus fuscus Garcke	Herb	NE													2											
Malvaceae	Hibiscus micrantha L. f.	Shrub	NE		10																						
Malvaceae	Hibiscus sp.			5	5	2		1	2	1	2				1	2	2		3						1		
Malvaceae	Sida acuta Burm. f.	Herb	NE	2							1	2		1	1				3	1	3				2		
Malvaceae	Sida cuneifolia A. Gray	Herb	NE												3				2	1		2	2				
Malvaceae	Sida rhombifolia L.	Herb	NE		1	1										1			1	1		3		1			
Malvaceae	Sida sp.	Herb							1			2		1					1			1		1			
Malvaceae	Sida urens L.	Herb	NE		5				3					1					2		7			1			
Malvaceae	Triumfetta annua L.	Herb	NE		1														2	1	2					3	1
Malvaceae	Triumfetta rhomboidea Jacq.	Shrub	NE			1								1								1	2				
Malvaceae	Triumfetta sp.	Shrub										2														1	
Malvaceae	Urena lobata (L.) Miq.	Herb	NE																							5	
Malvaceae	Wissadula rostrata (Schumach.) Planch.	Herb	NE													2			2			3					
Meliaceae	Trichilia emetica (Forsk.) Vahl	Shrub	NE		4																						
Menispermaceae	Cissampelos mucronata A. Rich.	Climber	NE	5		3			1			2			1	5		2	2	3	3	3	2	4	3		2
Moraceae	Ficus elastica Roxb. ex Hornem.	Tree	NE							1									1								

Moraceae	Ficus natalensis Hochst.	Tree	NE																			5					
Myrsinaceae	Maesa lanceolata Forssk.	Shrub	NE	2	5																10				5	4	
Myrtaceae	Eucalyptussp.	Tree	NE													50		15	15	15	30					100	
Myrtaceae	Psidium guajava L.	Shrub	NE													1				1						1	
Myrtaceae	*Syzygium cordatum* Hochst. in C. Krauss	Tree	NE	20	5					4																	
Nymphaeaceae	Nymphaea nouchali Burm.f.	Herb	NE								2			2			2	2									
Oleaceae	Jasminum eminii Gilg	Climber	NE													2			3	2							
Oleaceae	Jasminum sp.	Climber																		1							
Onagoraceae	Ludwigia abyssinica A. Rich.	Herb	NE	10	15	7	10	10	5		2	20		1	2	5	2	2	15		15	1		10	1		
Onagoraceae	Ludwigia adscendens (L.) H. Hara	Herb	NE							5									6	5							
Onagoraceae	*Ludwigia octovalvis* (Jacq.) P.H. Raven	Herb	LC				1				2												2	2			
Oxallidaceae	Oxalis corniculata DC.	Herb	NE		2	2								1		1			1	1	20	2	2	10	10	30	
Phyllanthaceae	Bridelia micrantha (Hochst.) Baill.	Shrub	LC	5	5	2	1		1												35			4	1		
Phyllanthaceae	Phyllanthus ovalifolius Forssk.	Shrub	NE	1	1	1			3		1					1			1				2	1		1	1
Phytolaccaceae	Phytolacca dodecandra L'Hér.	Herb	NE			3	2					1		3	1	1				4				3	4		
Phytolaccaceae	Phytolacca sp.	Herb																								2	
Poaceae	Brachiaria decumbens Stapf	Grass	NE													2											
Poaceae	Brachiaria leersioides (Hochst.) Stapf	Grass	NE																			2					
Poaceae	Chloris gayana Kunth	Grass/Og	NE																				20				
Poaceae	Chloris pycnothrix Trin.	Grass	NE											1	1												1

Poaceae	Cynodon dactylon (L.) Pers.	Grass	NE			2			5	5	2	10	15	8	40	40	30	10	10	15		10		20		6	2
Poaceae	Digitaria longiflora (Retz.) Pers.	Grass	NE												5	5	5		20	5							
Poaceae	Digitaria velutina (Forssk.) P. Beauv.	Grass	NE			2					2	5					1				10					5	6
Poaceae	Echinochloa colona (L.) Link	Grass	LC										10							3		10					
Poaceae	Echinochloa haploclada (Stapf) Stapf	Grass	NE						2																		
Poaceae	Echinochloa pyramidalis (Lam.) Hitchc. & Chase	Grass	LC							2	10		2		10												
Poaceae	Eleusine africana Kenn. -O'Byrne	Grass	LC		2	2	1	1	1			2	2	2					2			1			1		
Poaceae	*Eriochloa fatmensis* (Hochst. & Steud.) Clayton	Grass	NE							2		5															
Poaceae	Leersia hexandra G.C. Tucker	Grass	NE			2	20	5	10	10	10	20		3	20	30	15	35	30	20	5	40					20
Poaceae	Oplismenus hirtellus (L.) P. Beauv.	Grass	NE																						3		
Poaceae	Panicum brevifolium L.	Grass	NE																						5		
Poaceae	Panicum hymeniochilum Nees	Grass	LC	5	7	2	1				2																
Poaceae	Panicum maximum (Steud.) Oliv.	Grass	NE									2							10	4							
Poaceae	Panicum sp.	Grass		5																							
Poaceae	Paspalum scrobiculatum L.	Grass	LC											1		5	2		5				3				
Poaceae	Paspalum sp	Grass				1	1							10					1					2			
Poaceae	Pennisetum purpureum Schumach.	Grass	NE			2		5	1	2	1								2	5	5	3	2	1	10		
Poaceae	Phragmites mauritianus Kunth	Grass	NE									1															
Poaceae	Setaria poiretiana (Schult.) Kunth	Grass	NE		2	3	2		3			5	2					3	2	2		4	2		15		
Poaceae	*Setaria sphacelata* (Schumach.) Stapf & C.E. Hubb. ex M.B. Moss	Grass	NE									2					4						5				
Poaceae	Setaria verticillata (Guss.) B. Boivin	Grass	NE		1		1		2			1	1					3	1	5						3	

Poaceae	Sorghum bicolor (L.) Moench	Grass	NE																	15							
Poaceae	Sporobolus agrostoides Chiov.	Grass	NE																			3			8	3	
Poaceae	Sporobolus festivus Hochst. ex A. Rich.	Grass	NE				1		2						1	5			3	5		1					
Poaceae	Sporobolus pyramidalis P. Beauv.	Grass	NE																2	2		1	4				
Poaceae	Zea mays L.	Grass	NE															10		5							
Polygonaceae	*Oxygonum sinuatum* (Hochst. & Steud. ex Meisn.)	Herb	NE																	1							1
Polygonaceae	Persicaria madagascariensis (Meisn.) S. Ortíz & Paiva	Herb	NE		4	2	4			3			2	1		8	4	4	7	3	5						
Polygonaceae	Persicaria senegalensis (Meisn.) Soják	Herb	LC			1			2	3	4		20									3					
Polygonaceae	*Persicaria setosula* (A. Rich.) K.L. Wilson	Herb	NE	20	30	15	10	10	20	20	15	10	10	2	10	2		2	8	5	20	10	3	8		1	3
Polygonaceae	Rumex bequaertii De Wild.	Herb	NE						2	1	1	2	4				2			5	5	1			3	1	5
Portulaccaceae	Portulaca oleracea L.	Herb	NE																	1							
Proteaceae	Grevillea robusta A. Cunn. ex R.Br.	Tree	NE													3											
Rhamnaceae	Ziziphus sp.	Tree			7																						
Rosaceae	Rubus steudneri Schweinf.	Shrub	NE	1															1				2	3		1	
Rubiaceae	Pavetta lanceolata Eckl.	Shrub	NE		1																						
Rubiaceae	Rubia cordifolia L.	Climber	NE							2					1	2			2			3		1			
Rubiaceae	Spermacocce sp.	Herb					1																				
Rubiaceae	Spermacoce ocymoides Burm. f.	Herb	NE	1																							
Rubiaceae	Spermacoce princeae (K. Schum.) Verdc.	Herb	NE											2													
Rubiaceae	Tricalysia niamniamensis Schweinf. ex Hiern	Shrub	NE																			2					
Rubiaceae	Vangueria apiculata K. Schum.	Tree	NE																					2		2	
Rutaceae	*Clausena anisata* (Willd.) Hook. f. ex Benth.	Tree	NE		3																						

Rutaceae	*Vepris nobilis* (Delile) Mziray	Shrub	NE													1											
Salviniaceae	Azolla pinnata R.Br.	Herb	LC													1	3							2			
Sapindaceae	Allophylus abyssinicus (Hochst.) Radlk.	Shrub	NE															1		3				2			
Sapindaceae	Allophylus africanus P. Beauv.	Shrub	NE													2											
Sapindaceae	Blighia unijugata Baker	Shrub	NE																						4		
Sapindaceae	Paullinia pinnata L.	Climber	NE	2	3	2	1			1									1	1							
Scrophulariaceae	Scoparia dulcis L.	Herb	NE																					2			
Solanaceae	Capsicum frutescens L.	Shrub	LC													1											
Solanaceae	Nicandra physalodes (L.) Gaertn.	Shrub	NE										3							2							
Solanaceae	Physalis peruviana L.	Herb	NE	1	2	1						1												2		1	
Solanaceae	Solanum aethiopicum L.	shrub	NE																		1						
Solanaceae	Solanum anguivi Lam	shrub	NE			2	1			1														1			
Solanaceae	Solanum campylacanthum Hochst. ex A. Rich.	Shrub	NE											3						3		2					
Solanaceae	Solanum dasyphyllum Schumach. & Thonn.	Shrub	NE			1			1	1		2		5	1				1	1		2					2
Solanaceae	Solanum lycopersicum L.	Herb	NE							1																	
Solanaceae	Solanum macrocarpon L.	Shrub	NE											3					1			1					
Solanaceae	Solanum nigrum L.	Herb	NE	1	2	1			1	2									1			1	1		6		1
Sphenocleaceae	Sphenoclea zeylanica Gaertn.	Herb	LC																		2					5	
Thelyptelidaceae	Cyclosorus interraptus (Willd.) H. Itô	Fern	LC	20	5	2				2	3				1	15	35	25			10			60	5	4	5
Typhaceae	Typha capensis (Rohrb.) N.E.Br.	Herb	LC			2			1		30			3	40	50	50	80	65	45	2		90	70			75
Typhaceae	Typha domingensis Pers.	Herb	LC							10		15													4		
Verbanaceae	Clerodendrum johnstonii Oliv.	Herb	NE		2	6	2	1		2		6			2			10	5	5	10	5	8	10		8	
Verbanaceae	*Clerodendrum myricoides* (Hochst.) Steane & Mabb.	Herb	NE												2												
Verbanaceae	Lantana camara (L.) L.H. Bailey	Shrub	NE			4	2			3		5		2	1	4		2	7	8	4		2	1		2	2

Verbanaceae	Lantana trifolia L.	Shrub	NE											1		2				1	1			1			
Verbanaceae	Stachytarpheta urticifolia Sims	Shrub	NE											1													
Vitaceae	Cissus petiolata Hook. f.	Climber	NE			1																					
Vitaceae	Cissus quadrangularis L.	Climber	NE	5	10	1	1					2			2	1			3	5				15			
Vitaceae	*Cyphostemma adenocaule* (Steud. ex A. Rich.) Desc. ex Wild & R.B. Drumm.	Climber	NE			4		2		10		1						10	2	10		2		6			
Vitaceae	Cyphostemma cyphopetallum Fresen.	Climber	NE																						2		
Vitaceae	*Cyphostemma serpens* (Hochst. ex A. Rich.) Desc.	Climber	NE			2										2		1	2	2							
Zingiberaceae	Aframomum alboviolaceum (Ridl.) K. Schum.	Herb	NE																	3							

Annex 4: Species check list of bird species recorded during the survey both seasons combined

Family	***Species***	***No. counted (Wet Season)***	***No. counted (Dry Season)***	***IUCN Red List Status***
Accipitridae	119 - *Aquila spilogaster* African Hawk-Eagle	2	-	LC
Accipitridae	122 - *Lophaetus occipitalis* Long-Crested Eagle - F	2	1	LC
Accipitridae	124 - *Stephanoaetus coronatus* Crowned Eagle - FF	-	1	R-VU, U-EN
Accipitridae	125 - Polemaetus bellicosus Martial Eagle	2	2	NT, R-VU
Accipitridae	75 - Milvus migrans Black Kite - pA	4	2	PM
Accipitridae	76 - *Haliaeetus vocifer* African Fish Eagle - W	1	-	LC
Accipitridae	90 - *Polyboroides typus* African Harrier Hawk	4	1	LC
Accipitridae	93 - *Circus ranivorus* African Marsh Harrier - W	1	3	R-NT
Alcedinidae	375 - Halcyon senegalensis Woodland Kingfisher - A	7	14	LC
Alcedinidae	378 - Ispidina picta African pygmy Kingfisher - fw	1	-	LC
Alcedinidae	383 - *Ceryle rudis* Pied Kingfisher - W	2	1	LC
Anatidae	57 - *Anas undulata* Yellow-Billed Duck - W	4	3	LC
Anhingidae	7 - Anhinga rufa African Darter - W	3	2	R-VU, U-VU
Apodidae	367 - *Tachymarptis melba* Alpine Swift - p	23	22	PM
Ardeidae	17 - *Bubulcus ibis* Cattle Egret - G	-	3	Least Concern
Ardeidae	22 - *Ardea intermedia* Intermediate Egret - W	-	1	Least Concern
Ardeidae	26 - *Ardea melanocephala* Black-Headed Heron - w	3	6	-
Charadriidae	211 - *Charadrius hiaticula* Common Ringed Plover - PW	2	-	PM
Charadriidae	221 - *Vanellus senegallus* African Wattled Lapwing - W	-	5	LC
Charadriidae	223 - *Vanellus spinosus* Spur-Winged Lapwing - WG	-	2	LC
Charadriidae	227 - *Vanellus crassirostris* Long-Toed Lapwing - W	-	2	LC
Cisticolidae	657 - *Cisticola ayresii* Wing-Snapping Cisticola - G	6	4	LC
Colliidae	369 - *Colius striatus* Speckled Mousebird	11	29	LC
Columbidae	270 - Turtur tympanistria Tambourine Dove - F	2	21	-
Columbidae	271 - *Turtur afer* Blue-Spotted Wood Dove - F	-	2	LC
Columbidae	283 - Streptopelia semitorquata Red-Eyed Dove - f	2	3	LC
Columbidae	284 - Streptopelia decipiens African Mourning Dove	18	58	-
Columbidae	289 - Streptopelia senegalensis Laughing Dove	5	10	LC
Corvidae	855 - *Corvus albus* Pied Crow	1	14	LC
Corvidae	858 - Ptilostomus afer Piapiac	5		LC
Cuculidae	309 - *Cuculus solitarius* Red-Chested Cuckoo - AF	9	2	LC
Cuculidae	323 - *Centropus superciliosus* White-Browed Coucal	6	33	LC

Estrilididae	959 - *Lagonosticta senegala* Red-Billed Firefinch	14		LC
Estrilididae	963 - *Lagonosticta rubricata* African Firefinch	-	7	LC
Estrilididae	966 - *Estrilda paludicola* Fawn-Breasted Waxbill	6	-	LC
Estrilididae	980 - Spermestes cucullata Bronze Mannikin	1	39	-
Estrilididae	981 - *Spermestes bicolor* Black-and-White Mannikin - f	20	17	LC
Gruidae	185 - *Balearica regulorum* Grey Crowned Crane - WG	21	57	VU, R-NT, U-EN
Hirundinidae	501 - *Neophedina cincta* Banded Martin - AG	-	21	LC
Hirundinidae	512 - *Hirundo angolensis* Angola Swallow	19		LC
Hirundinidae	513 - *Hirundo rustica* Barn Swallow - Pw	13	16	PM
Indicatoridae	456 - *Indicator minor* Lesser Honeyguide - f	6		LC
Laniidae	812 - Lanius collaris Common Fiscal - G	2	5	LC
Laniidae	815 - *Lanius excubitoroides* Grey-Backed Fiscal - Afw	6	9	LC
Leiothrichidae	764 - Turdoides sharpei Black-Lored Babbler	2	-	-
Malaconotidae	843 - Laniarius erythrogaster Black-Headed Gonolek - f	9	9	-
Meropidae	392 - Merops persicus Blue-Cheeked Bee-Eater - P	-	43	PM (LC)
Motacillidae	516 - Motacilla capensis Cape Wagtail - W	23	8	
Motacillidae	520 - Motacilla aguimp African Pied Wagtail - w	2	5	
Muscicapidae	576 - *Cossypha heuglini* White-Browed Robin-Chat - f	4	5	LC
Muscicapidae	592 - *Saxicola torquatus* African Stonechat	4	8	LC
Muscicapidae	601 - Myrmecocichla nigra Sooty Chat	1	1	LC
Muscicapidae	725 - *Muscicapa comitata* Dusky-Blue Flycatcher - F	1		LC
Muscicapidae	730 - *Ficedula semitorquata* Semi-Collared Flycatcher - P	-	1	NT, PM
Musophagidae	302 - *Musophaga rossae* Ross's Turaco - F	-	4	Least Concern
Musophagidae	376 - *Crinifer zonurus* Eastern Grey Plantain Eater	-	2	Least Concern
Nectariniidae	783 - *Cyanomitra alinae* Blue-Headed Sunbird - FF	-	5	RR, R-RR
Nectariniidae	787 - *Chalcomitra senegalensis* Scarlet-Chested Sunbird - f	-	4	Least Concern
Nectariniidae	790 - Nectarinia kilimensis Bronze Sunbird - f	7	4	LC
Nectariniidae	803 - Cinnyris erythrocercus Red-Chested Sunbird - W	2	-	R-RR
Passeridae	881 - Passer griseus Northern Grey-Headed Sparrow	6	21	-
Ploceidae	897 - Ploceus ocularis Spectacled Weaver - f		2	LC
Ploceidae	903 - Ploceus intermedius Lesser Masked Weaver	223	3	-
Ploceidae	908 - *Ploceus cucullatus* Black-Headed Weaver (some constructing nests)	75	134	LC
Ploceidae	910 - *Ploceus melanocephalus* Yellow-Backed Weaver - W	-	76	LC
Ploceidae	923 - Quelea cardinalis Cardinal Quelea - A	3	-	R-RR

Ploceidae	930 - *Euplectes franciscanus* Northern Red Bishop - G		5	Least Concern
Ploceidae	932 - Euplectes axillaris Fan-Tailed Widowbird - w	18	17	LC
Ploceidae	937 - Amblyospiza albifrons Grosbeak Weaver - fW	3	15	LC
Psittacidae	292 - *Poicephalus meyeri* Brown Parrot	1	4	LC
Pycnonotidae	543 - *Baeopogon indicator* Honey Guide Greenbul - FF	8	-	LC
Pycnonotidae	547 - Atimastillas flavicollis Yellow-Throated Greenbul - f	-	40	LC
Pycnonotidae	732 - Pycnonotus barbatus Common Bulbul	41	74	LC
Rallidae	171 - Crex egregia African Crake - AwG		2	R-NT, U-NT
Rallidae	178 - *Zapornia flavirostra* Black Crake - W	29	32	LC
Rhamphastidae	443 - *Pogonornis bidentatus* Double-Toothed Barbet - f	1	-	LC
Scopidae	28 - Scopus umbretta Hamerkop - w	5	1	LC
Stenostiridae	732 - Elminia longicauda African Blue-Flycatcher - f	2	-	-
Sturnidae	872 - *Lamprotornis purpuroptera* Ruppell's Long-tailed Starling	12	6	LC
Threskiornithidae	39 - *Bostrychia hagedash* Hadada Ibis - w	17	26	LC
Threskiornithidae	42 - Threskiornis aethiopicus Sacred Ibis - W	-	2	LC
Turdidae	612 - *Turdus pelios* African Thrush - f	1	1	LC
Viduidae	985 - *Vidua macroura* Pin-Tailed Whydah - G	-	2	LC
Zosteropidae	811 - Zosterops senegalensis Northern Yellow White-Eye - f	4	-	LC

Annex 5: Biology and flow-related ecological requirements of plant species most sensitive to hydrology in River Mishumba

Table 14-1 shows the flora most dependent on water. From the five attributes about these plant species which determine their distribution, the dominant flora was established to be herbs (74.1%) with only a few grasses and one species of tree (*Syzygium cordatum*) that are heavily dependent on ground water for their survival (Orwa *et al.,* 2009, Maroyi 2018, Mbanze *et al.,* 2019, Dixon *et al.,* 2020). Most (81.5%) of the plant species have a perennial growth cycle, and survive through the growing seasons. This means that environmental flow rates that ensure their continued growth and reproduction through the growing seasons can support their survival (Table 6-11)

Only a single species (3.7%), *Nymphaea nouchali*, is favoured by presence of open water conditions. This species was recorded from sites 8, 14 and 15. It has floating leaves with long petioles (leaf stalks) that arise directly from the rhizome by which it gets anchored for support. The species requires presence of water throughout the year and is favoured by slow-flowing water. It grows between 30 and 90 cm, with an average of 60 cm deep and requires an environmental flow rate as in Table 6-13.

With the exception of *Nymphaea nouchali*, survival of rest of plant species is not necessarily dependent on open water availability as they can still grow provided there is a regime of flooding (seasonal or permanent), marshy conditions in the vegetation or edges at the river. This is verified by the fact that the vast majority of plant species (92.6%) in Table 14-1 are hygrophytes (plants adapted to permanently damp - not wet - conditions) and can grow well under permanent conditions of moderate levels of soil moisture and are less dependent. The hygrophytic species of plant mostly (83.3%) grow emergent, anchored with roots, thus farther away from the open water. Most plant species therefore can survive under lower e-flow rates.

Table 14-1: Summary of the biology and flow-related ecological requirements of plant species most sensitive to hydrology in River Mishumba

Plant species	Attribute													
	Growth habit			Growth Cycle		Common microhabitat(s)					Water-loving affinity		If hydrophytic, then:	
	Tree	Grass	Herb	Annual	Perennial	Seasonally flooded	Permanently waterlogged	Water edge	Marshy ground	Abundant-water	Hydrophyte	Hygrophyte	Floating	Emergent, Rooted and anchored
Hygrophila auriculata	0	0	1	1	0	1					0	1	0	0
Cyperus papyrus	0	0	1	0	1		1				0	1	0	1

Cyperus articulatus	0	0	1	0	1	1					0	1	0	0
Cyperus denudatus	0	0	1	0	1	1					0	1	0	0
Cyperus difformis	0	0	1	1	0	1					0	1	0	0
Cyperus dives	0	0	1	0	1	1	1				0	1	0	0
Cyperus exaltatus	0	0	1	0	1	1					0	1	0	0
Cyperus latifolius	0	0	1	0	1	1					0	1	0	0
Hydrocotyle ranunculoides	0	0	1	1	0		1	1			0	1	0	1
Syzygium cordatum	1	0	0	0	1		1		1		0	1	0	0
Melanthera scandens	0	0	1	0	1			1			0	1	0	0
Nymphaea nouchali	0	0	1	0	1					1	1	0	1	1
Ludwigia abyssinica	0	0	1	0	1	1		1			0	1	0	1
Ludwigia octovalvis	0	0	1	0	1	1		1			0	1	0	1
Echinochloa colona	0	1	0	1	0	1					0	1	0	0
Echinochloa haploclada	0	1	0	0	1	1		1			0	1	0	0
Echinochloa pyramidalis	0	1	0	0	1		1	1	1		0	1	0	1
Leersia hexandra	0	1	0	0	1		1	1	1		1	0	0	1
Paspalum scrobiculatum	0	1	0	0	1	1			1		0	1	0	0
Phragmites m auritianus	0	1	0	0	1		1	1			0	1	0	0
Persicaria madagascarie nsis	0	0	1	0	1		1	1	1		0	1	0	1
Persicaria senegalensis	0	0	1	0	1	1			1		0	1	0	0
Persicaria setosula	0	0	1	0	1		1	1	1		0	1	0	1
Sphenoclea zeylanica	0	0	1	1	0	1					0	1	0	0
Cyclosorus interraptus	0	0	1	0	1		1		1		0	1	0	0

Typha capensis	0	0	1	0	1		1	1	1		0	1	0	1
Typha domingensis	0	0	1	0	1		1	1	1		0	1	0	1
Total number of species	1	6	20	5	22	14	12	12	10	1	2	25	2	10
Percentage number of species	**3.7%**	**22.2%**	**74.1%**	**18.5%**	**81.5%**	**51.9%**	**44.4%**	**44.4%**	**37.0%**	**3.7%**	**7.4%**	**92.6%**	**16.7%**	**83.3%**

Annex 6: Stakeholder Consultations (Attendance Lists) for Kabuyanda ICRP

Community meeting at Kyamazinga 1 village (upstream) held on 5th March 2021

JBN
Solutions that last

ATTENDANCE FORM

Project Name: Kabuyanda

Project Code: Kyamazinga I Village – LC1 Committee Date: 5/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	NAYABAHIKA FRANCIS	KYAMAZINGA I	C/MAN	0750432600	[illegible]
2.	TUMWEBAZE FRANCIS	KYAMAZINGA I	V/MAN	0753443229	[illegible]
3.	Muhangizi Innocent	Kyamazinga I	C/man youth	0751683[illegible]	[illegible]
4.	Twinomugisha Shumidyas	Kyamazinga I	C/man [illegible]	0751[illegible]313	[illegible]
5.	Kiconco Aleni	Kyamazinga I	C/Person	0759874917	Kiconco
6.	Kenneth Twikirize	Kyamazinga I			
7.	Mbabazi Lidia	Kyamazinga I			
8.	Mutungirehi Fiona	Kyamazinga I			
9.	Twinomuyambi Lasiton	Kyamazinga I		075818[illegible]	
10.	ARINIETWE MERODA	Kyamazinga I	Sec - Environment	0704969051	[illegible]
11	BARISIGARA FABIANO	Kyamazinga I	V.H.T.	0757019050	[illegible]

Community meeting at Kyamazinga 2 village (upstream) held on 8th March 2021

JBN
Solutions that last

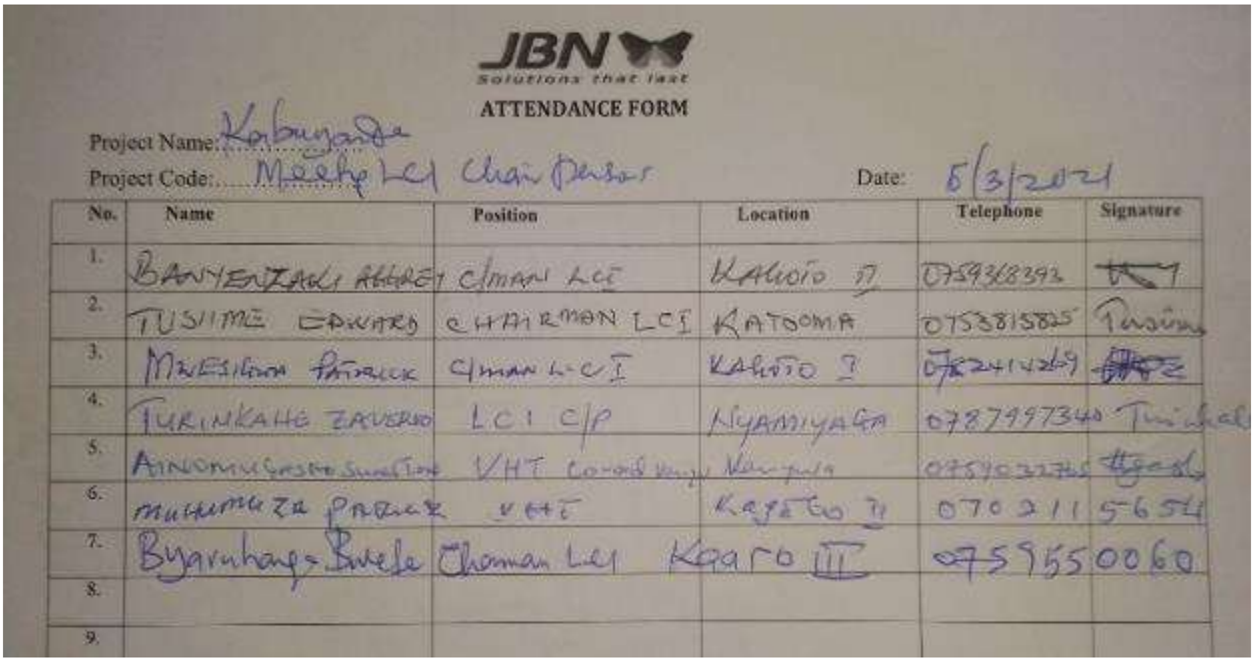
ATTENDANCE FORM

Project Name: Kabuyanda

Project Code: Kyamazinga II LC1 Committee Date: 8/2/2021

No.	Name	Position	Location	Telephone	Signature
1.	Kaliga Sitikini	Chairman LC1		0753531[illegible]	[illegible]
2.	Natukunda Silvia	Kyamazinga II	Finance [illegible]	075770[illegible]	Silvia
3.	Katushabe Evelyn	Kyamazinga II	Sec. Women	0756626603	Evelyn
4.	Kanyarutokye Zirimabagabo	Kyamazinga II			Zirimabagabo
5.	Muhumuza Marti	Kyamazinga II	Sec - Youth		Marti
6.	Julius Varisito	Kyamazinga II			Varisito
7.	Kyarungaba Vastera	Kyamazinga II	V/C Person		[illegible]
8.	Sanyu Silvia	Kyamazinga II	Sec. Environment		S. Livia
9.	Tumwebaze Kellen	Kyamazinga II	V.H.T / Sec. Info	0755879[illegible]	[illegible]
10.	Ainomukiriza Scovia	Kyamazinga II	V.H.T	0706751840	[illegible]

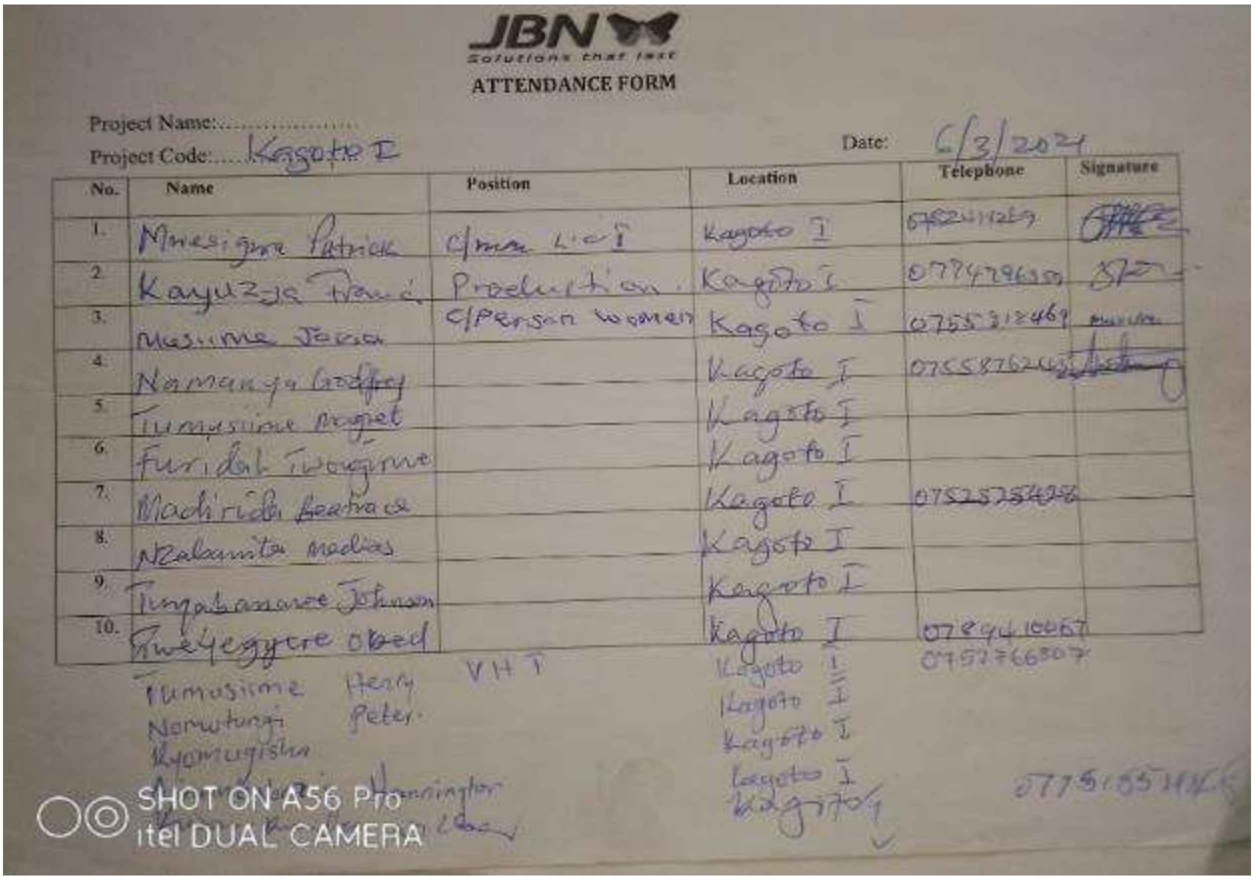
Meeting Village Chairpersons for dam site area on 6th March 2021


JBN
Solutions that last
ATTENDANCE FORM

Project Name: Kabuyanda
Project Code: Meeting LC1 Chairpersons
Date: 5/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	Banyenzaki Alfred	C/man LCI	Kahoio II	0759368393	
2.	Tusiime Edward	Chairman LCI	Katooma	0753815825	Tusiime
3.	Mwesigwa Patrick	C/man L-C I	Kagoto I	0782414269	
4.	Turinkahe Zaverio	LC1 C/P	Nyamiyaga	0787997340	
5.	Ainomugisha Sunstone	VHT coordinator	Kampala	0759032765	
6.	Muhumuza Patrick	VHT	Kagoto II	0702115654	
7.	Byaruhanga Swele	Chairman LC1	Kagoto III	0759550060	
8.					
9.					

Community meeting at Kagoto 1 village (dam site) held on 6th March 2021

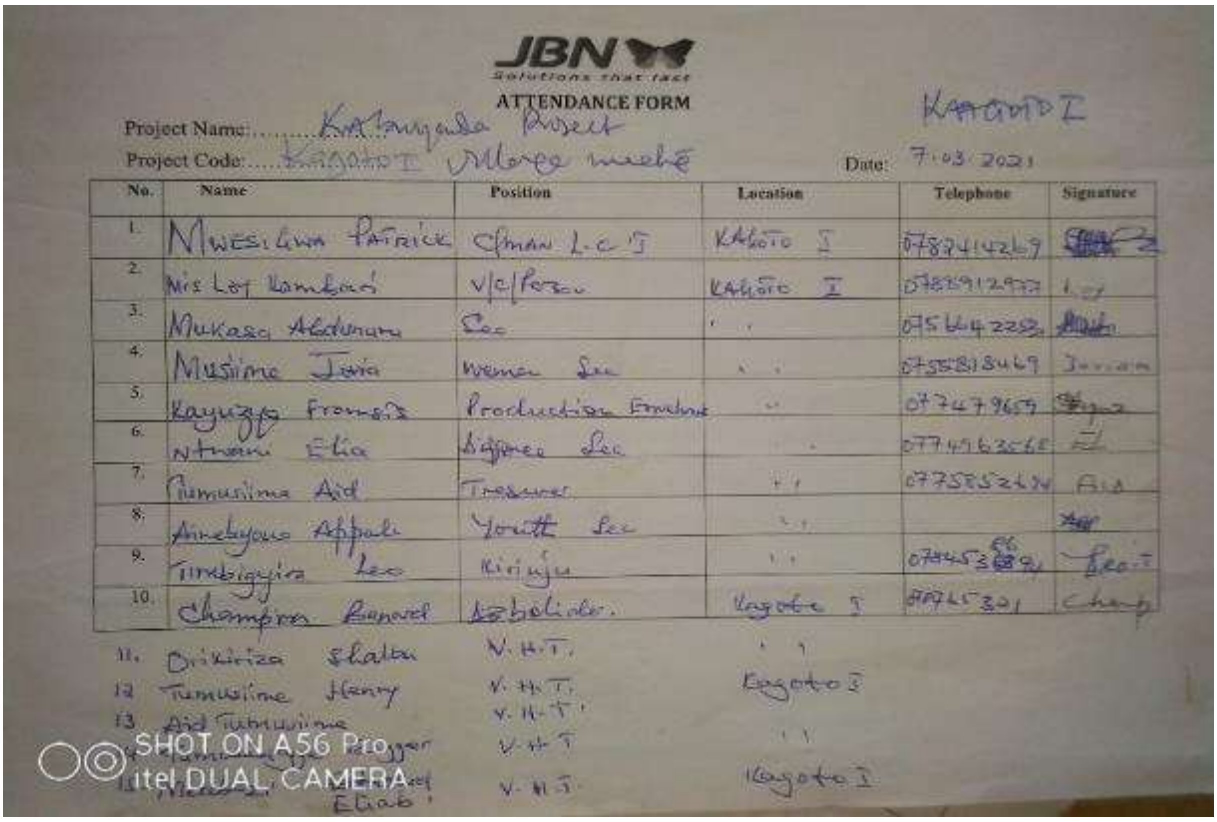

JBN
Solutions that last
ATTENDANCE FORM

Project Name:
Project Code: Kagoto I
Date: 6/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	Mwesigwa Patrick	C/man L-C I	Kagoto I	0782414269	
2.	Kayuzza Francis	Production	Kagoto I	0774296350	
3.	Musiime Jovia	C/Person women	Kagoto I	0755312469	
4.	Namanya Godfrey		Kagoto I	0755876244	
5.	Tumusiime Nyget		Kagoto I		
6.	Faridah Twongirwe		Kagoto I		
7.	Machirida Beatrace		Kagoto I	0752525498	
8.	Nzabamita Medias		Kagoto I		
9.	Tumwebaze Johnson		Kagoto I		
10.	Rweyeggyere Obed		Kagoto I	0789410067	

Tumusiime Henry VHT Kagoto I 0752766807
Nomwitungi Peter Kagoto I
Kyomugisha Kagoto I
Harrington Kagoto I
Kagoto I 0775165344

Meeting with Kagoto 1 Village committee leaders held on 7th March 2021


JBN
Solutions that last
ATTENDANCE FORM

Kagoto I

Project Name: Kabuyanda Project
Project Code: Kagoto I village meeting
Date: 7.03.2021

No.	Name	Position	Location	Telephone	Signature
1.	Mwesigwa Patrick	C/man L.C I	Kagoto I	0782414269	[illegible]
2.	Mrs Loy Kambasi	V/c/Person	Kagoto I	0785912977	Loy
3.	Mukasa Abdurum	Sec	"	0756442258	[illegible]
4.	Musiime Jovia	Women Sec	"	0755813469	Jovia
5.	Kayugo Francis	Production Finance	"	0774479659	[illegible]
6.	Ntwari Elia	Defence Sec	"	0774963565	[illegible]
7.	Tumusiime Aid	Treasurer	"	0775852434	Aid
8.	Ainebyona Appoli	Youth Sec	"		[illegible]
9.	Tinkabigira Leo	Kiringu	"	0784538896	Leo
10.	Champion Ronald	Lobelider	Kagoto I	0774530[illegible]	Champ
11.	Orikiriza Shallen	V.H.T.	"		
12	Tumusiime Henry	V.H.T.	Kagoto I		
13	Aid Tumusiime	V.H.T.			
14	[illegible]	V.H.T	"		
15	[illegible] Eliab	V.H.T.	Kagoto I		

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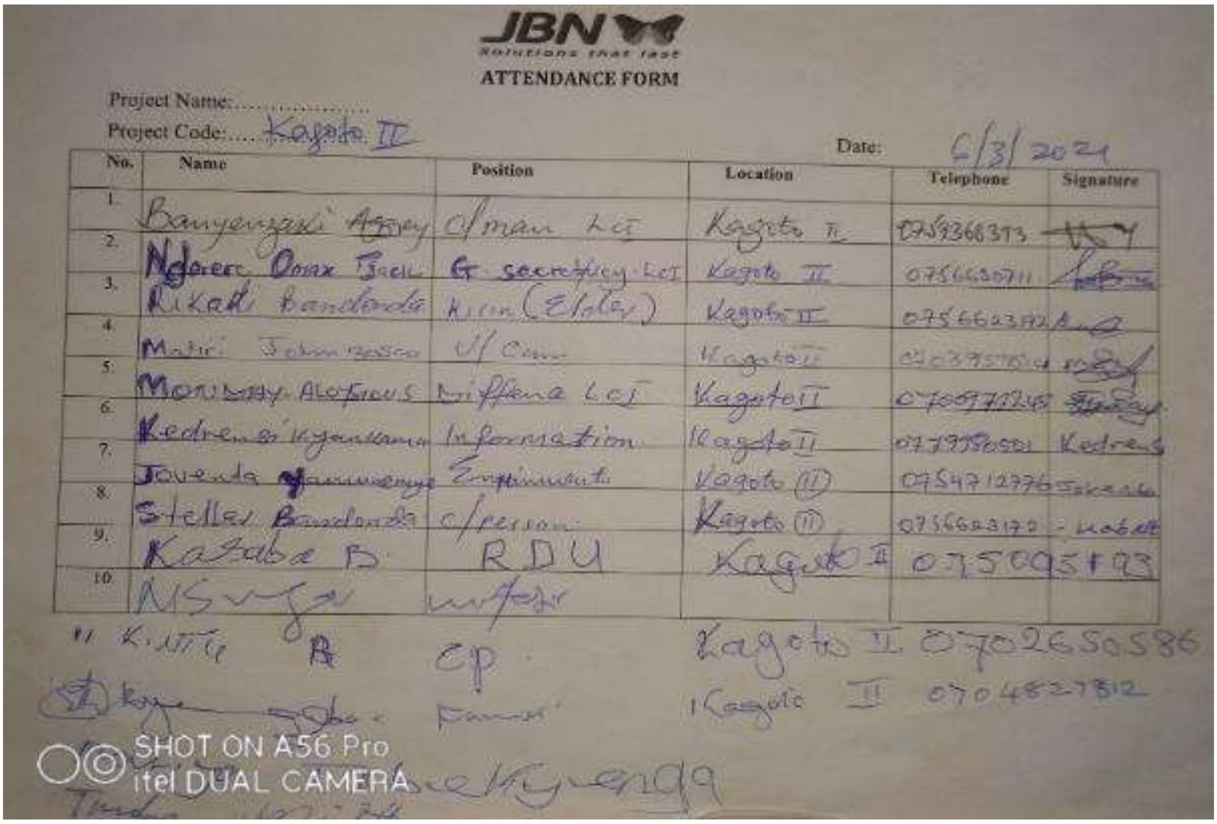
itel DUAL CAMERA

Meeting with Kagoto 2 village committee leaders held on 6th March 2021


JBN
Solutions that last
ATTENDANCE FORM

Project Name: ....
Project Code: Kagoto II
Date: 6/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	Banyenzaki Agrey	C/man LCI	Kagoto II	0759368373	[illegible]
2.	Ndaaro Omax Brian	G. secretary LCI	Kagoto II	0756630711	[illegible]
3.	Rikati Bandanda	Kirin (Elder)	Kagoto II	0756623972	[illegible]
4.	Mahir John Bosco	V/Chair	Kagoto II	0703957504	[illegible]
5.	Monday Aloysious	Diffence LCI	Kagoto II	0700977216	[illegible]
6.	Kedress Kyankama	Information	Kagoto II	0779958501	Kedress
7.	Jovenda Yamumenya	Engineering	Kagoto (II)	0754712776	[illegible]
8.	Steller Bandanda	C/person	Kagoto (II)	0756623170	[illegible]
9.	Kazaba B	RDU	Kagoto II	0750095793	
10.	Nsenga	Wife			
11	Kiiza B	CP	Kagoto II	0702650586	
	[illegible]	Farmer	Kagoto II	0704827812	
	[illegible] Kyenga				

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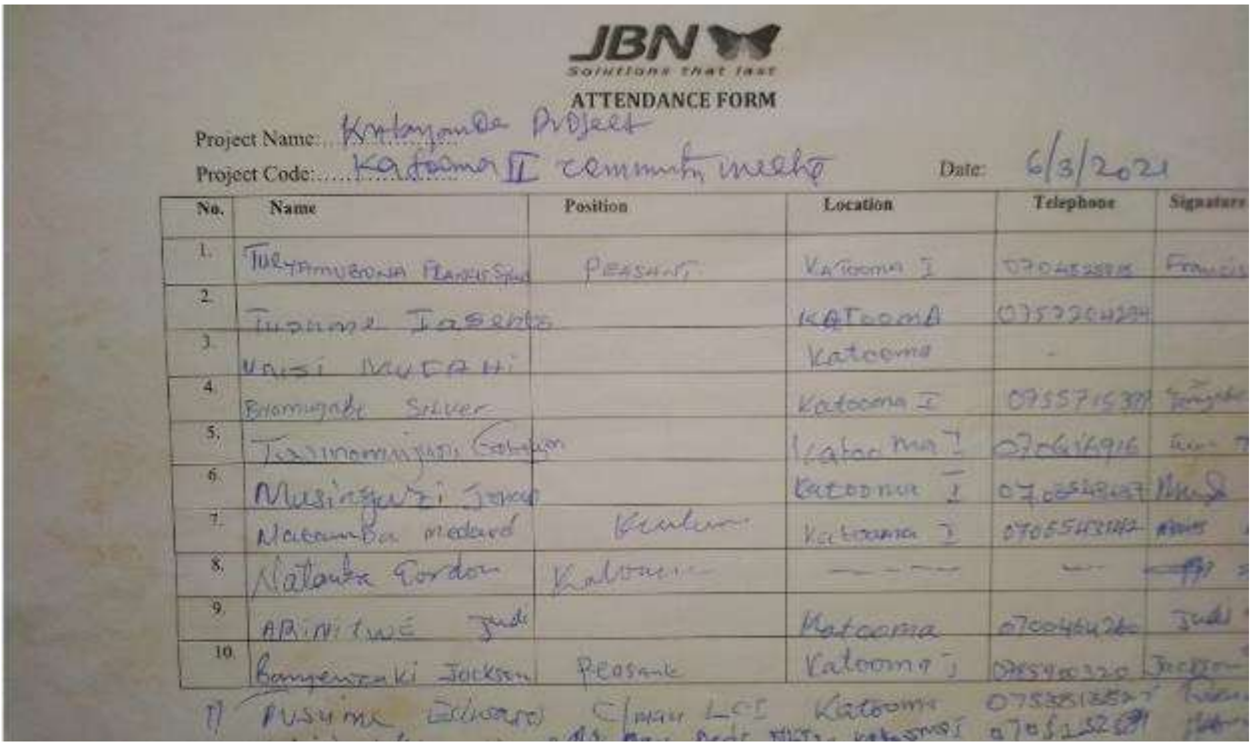
itel DUAL CAMERA

Community meeting at Katoma 2 village held on 6th March 2021



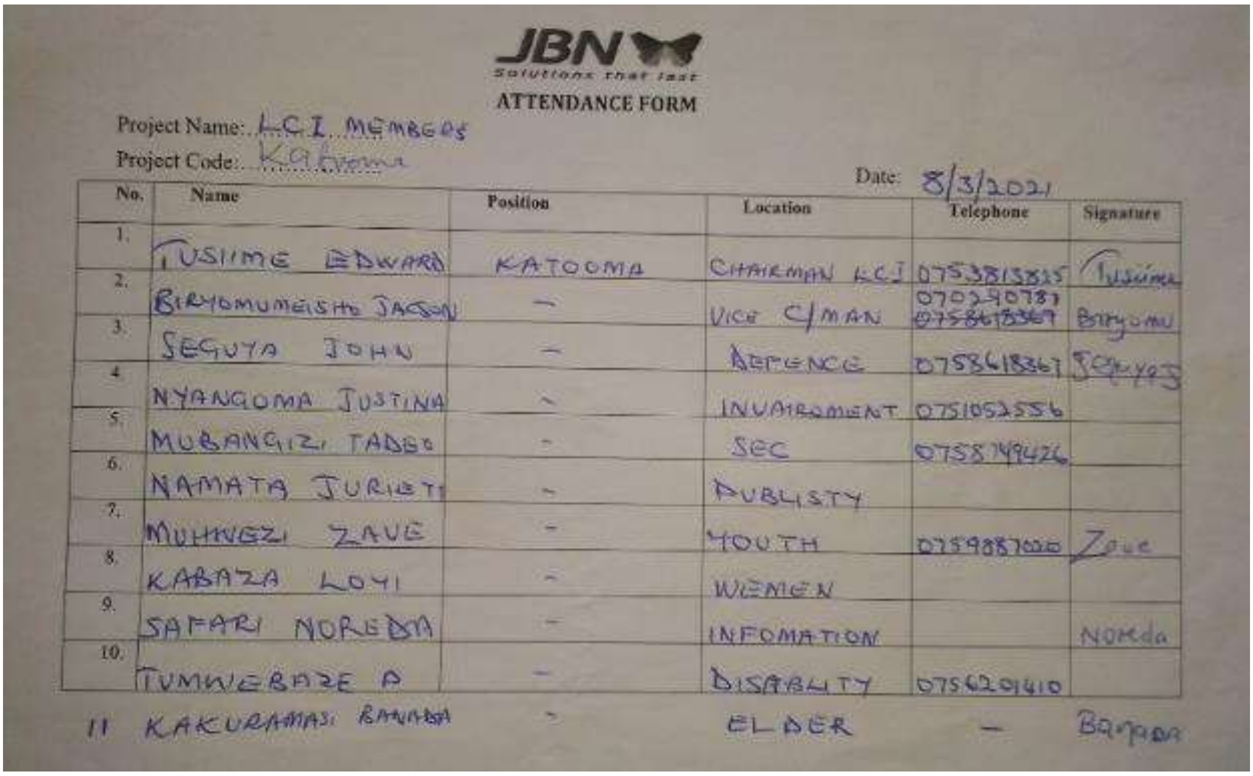
JBN
Solutions that last

ATTENDANCE FORM

Project Name: Kabuyanda Project
Project Code: Katooma II community meeting
Date: 6/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	Tumwamubona Francis	Peasant	Katooma I	0704652898	Francis
2.	Tusiime Jasento		Katooma	0757704294	
3.	Unisi Mugabi		Katooma	-	
4.	Byomugabe Silver		Katooma I	0755715378	[illegible]
5.	Tusiimomugisi Gordon		Katooma I	0706616916	[illegible]
6.	Musinguzi James		Katooma I	0706549497	[illegible]
7.	Nabamba medard	Kraalom	Katooma I	0705543142	[illegible]
8.	Natanda Gordon	Kabanen	———	—	[illegible]
9.	Arinitwe Jude		Katooma	0700464260	Jude
10.	Byenzanki Jackson	Peasant	Katooma I	0785980320	Jackson
11	Tusiime Edward	C/man LCI	Katooma	0753813825	[illegible]

Community meeting at Katooma village held on 8th March 2021



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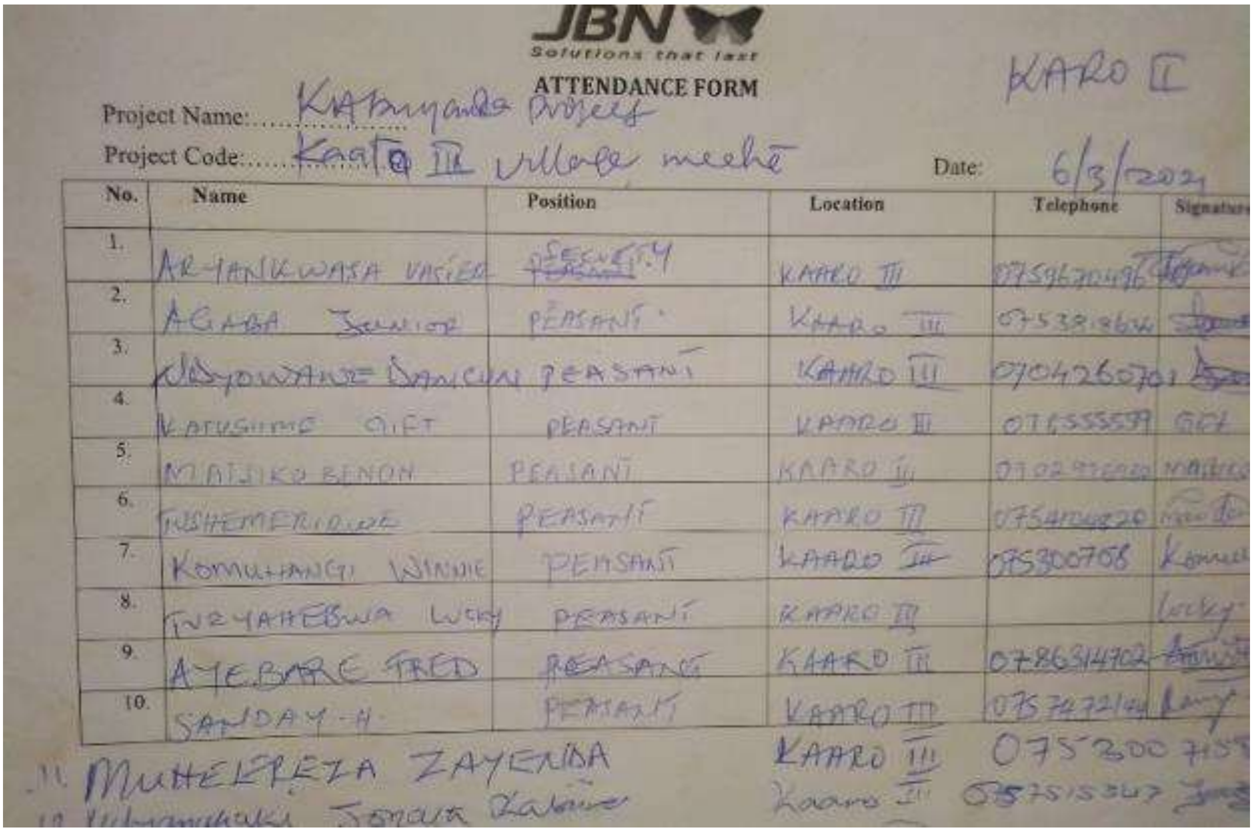
Solutions that last

ATTENDANCE FORM

Project Name: LC I MEMBERS
Project Code: Katooma
Date: 8/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	TUSIIME EDWARD	KATOOMA	CHAIRMAN LCI	0753813825	Tusiime
2.	BIRYOMUMEISHO JACSON	–	VICE C/MAN	0702907871 0758618367	Biryomu
3.	SEGUYA JOHN	–	DEFENCE	0758618367	Seguya
4.	NYANGOMA JUSTINA	–	INVAIROMENT	0751052556	
5.	MUBANGIZI TADEO	–	SEC	0758749426	
6.	NAMATA JURIETI	–	PUBLISTY		
7.	MUHWEZI ZAVE	–	YOUTH	0759887020	Zave
8.	KABAZA LOYI	–	WEMEN		
9.	SAFARI NOREDA	–	INFOMATION		Noreda
10.	TUMWEBAZE A	–	DISABLITY	0756201410	
11	KAKURAMASI BANABA	–	ELDER	–	Banaba

Meeting with Kaaro 3 village held on 6th March 2021



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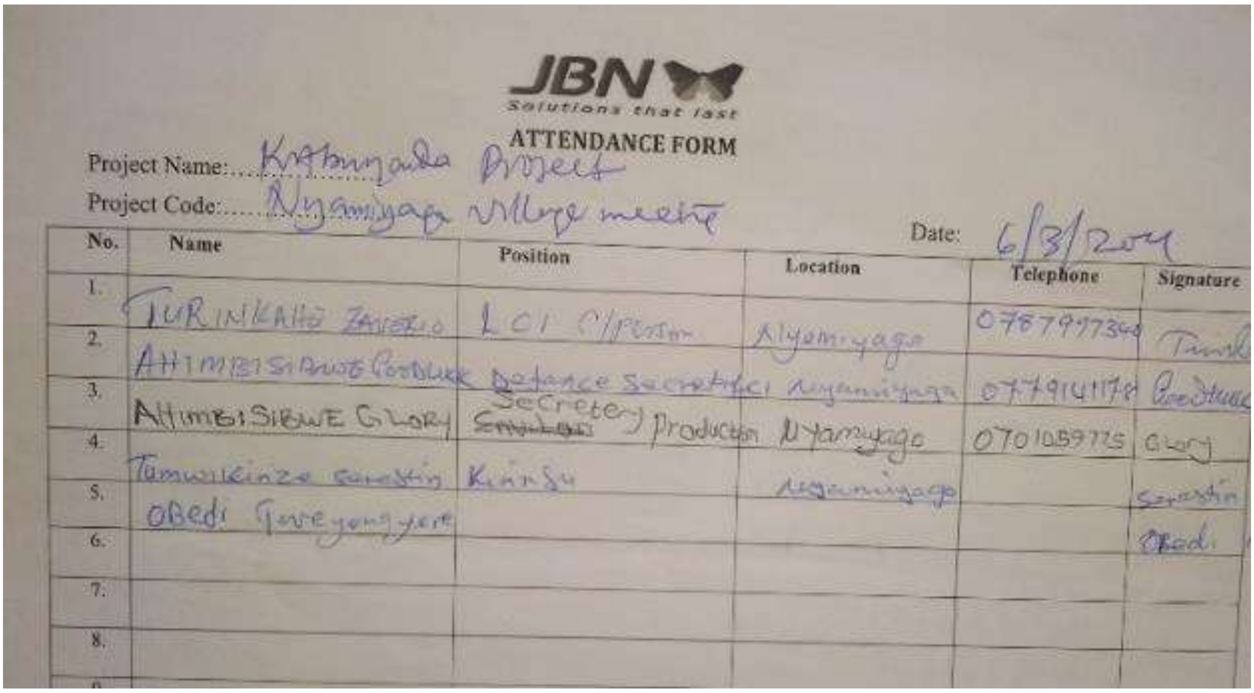
Solutions that last
ATTENDANCE FORM

KARO II

Project Name: Kabuyanda Project
Project Code: Kaaro III village meeting
Date: 6/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	ARYANKWASA VASIEA	~~PEASANT~~ SECURITY	KAARO III	0759670496	[illegible]
2.	AGABA JUNIOR	PEASANT	KAARO III	075381964	[illegible]
3.	NDYOWANZE DANIEL	PEASANT	KAARO III	0704260701	[illegible]
4.	KATUSHIME GIFT	PEASANT	KAARO III	0755555?9	GIFT
5.	MATSIKO BENON	PEASANT	KAARO III	[illegible]	MATSIKO
6.	TUSHEMERIRWE	PEASANT	KAARO III	07540[illegible]20	[illegible]
7.	KOMUHANGI WINNIE	PEASANT	KAARO III	0753007058	Komu[illegible]
8.	TWEYAHEBWA LUCKY	PEASANT	KAARO III		Lucky
9.	AYEBARE FRED	PEASANT	KAARO III	0786314702	[illegible]
10.	SANDAY H.	PEASANT	KAARO III	0757472144	[illegible]
11.	MUHEKEZA ZAYERIDA		KAARO III	075300 7[illegible]	
12.	[illegible] Jonah Kabwe		Kaaro III	0787515347	[illegible]

Community meeting at Nyamiyaga village held on 6th March 2021



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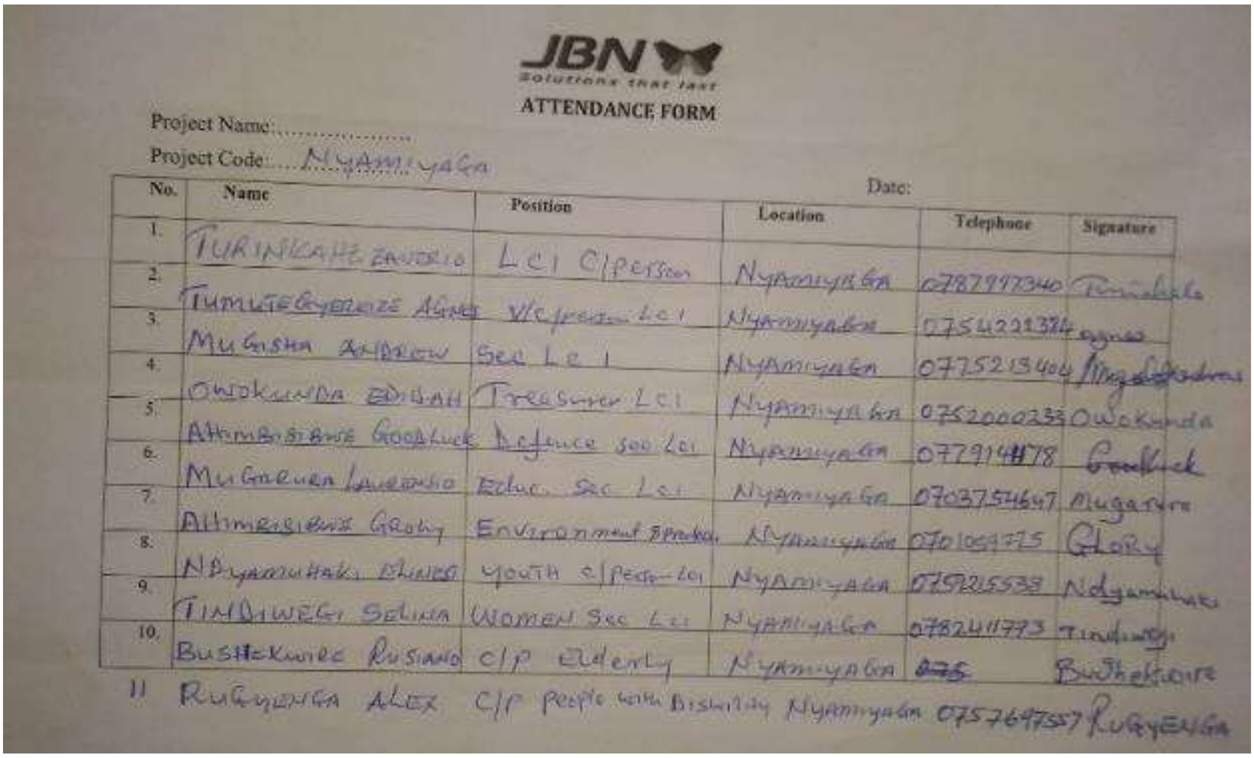
Solutions that last
ATTENDANCE FORM

Project Name: Kabuyanda Project
Project Code: Nyamiyaga village meeting
Date: 6/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	TURINKAHO ZAVERIO	LCI C/person	Nyamiyaga	0787997340	Turink[illegible]
2.	AHIMBISIBWE GOODLUCK	Defence secretary LCI	Nyamiyaga	0779141178	Goodluck
3.	AHIMBISIBWE GLORY	Secretary Production	Nyamiyaga	0701059725	Glory
4.	Tumwikinze Sarastin	Kiinju	Nyamiyaga		Sarastin
5.	OBedi Tweyongyere				Obed.
6.					
7.					
8.					



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Solutions that last
ATTENDANCE FORM

Project Name:....................
Project Code:....NYAMIYAGA
Date:

No.	Name	Position	Location	Telephone	Signature
1.	TURINKAHE ZAVERIO	LCI C/PERSON	NYAMIYAGA	0787997340	[illegible]
2.	TUMUTEGYEREIZE AGNES	V/C/person LCI	Nyamiyaga	0754221324	Agnes
3.	MUGISHA ANDREW	SEC LC I	NYAMIYAGA	0775213404	[illegible]
4.	OWOKUNDA EDINAH	Treasurer LCI	Nyamiyaga	0752000233	OWOKUNDA
5.	AHIMBISIBWE GOODLUCK	Defence sec LCI	Nyamiyaga	07791#4878	Goodluck
6.	MUGARURA LAURENSIO	Educ. Sec LCI	Nyamiyaga	0703754647	Mugarura
7.	AHIMBISIBWE GLORY	Environment [illegible]	Nyamiyaga	0701059775	GLORY
8.	NDYAMUHAKI BLINES	YOUTH C/PERSON LCI	NYAMIYAGA	0759215538	Ndyamuhaki
9.	TIMBIWEGI SELINA	WOMEN SEC LCI	NYAMIYAGA	0782411773	Timbiwegi
10.	BUSHEKWIRE RUSIANO	C/P Elderly	NYAMIYAGA	~~075~~	Bushekwire
11	RUGYENGA ALEX	C/P People with Disability	Nyamiyaga	0757647557	RUGYENGA

Community meeting at kabumba village (downstream) held on 12th March 2021

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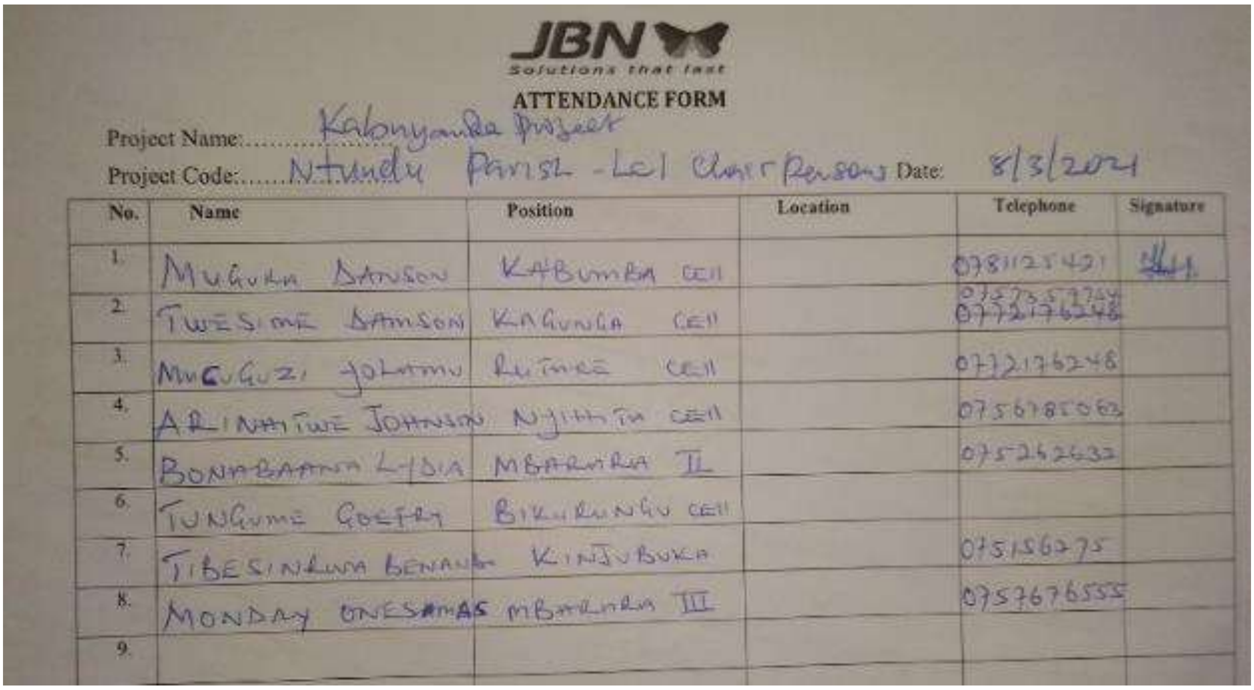
Solutions that last
ATTENDANCE FORM

Project Name:....................
Project Code:....Kabumba Village
Date: 12/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	MUGURA SANSON	C/MAN LCI	KABUMBA CELL	0781125421	[illegible]
2.	NGABIRANO HOPE	INVIROMENT	KABUMBA CELL	0705901809	
3.	MARION BAKEITHA	TURESURER	KABUMBA CELL	0773751023	
4.	KYOMUGENDO JOUMAS	INFORMATION	KABUMBA CELL		
5.	KIGUMBA JOHNSON	ELDER	KABUMBA CELL		
6.	TURYAHEBWE MERIAS	PUBULICITY	KABUMBA CELL	0700239448	
7.	MIDIAS KWERA	WOMEN C/PERSON	KABUMBA CELL	0753382510	
8.	MUGISHA JOSEPH	GENAL SEC	KABUMBA CELL	0703583354	
9.	KEMIREMBE UNITH	YOUTH	KABUMBA CELL	0755399720	
10.					

Meeting Village chairpersons in Ntundu parish (down stream) on 8th March 2021



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Solutions that last

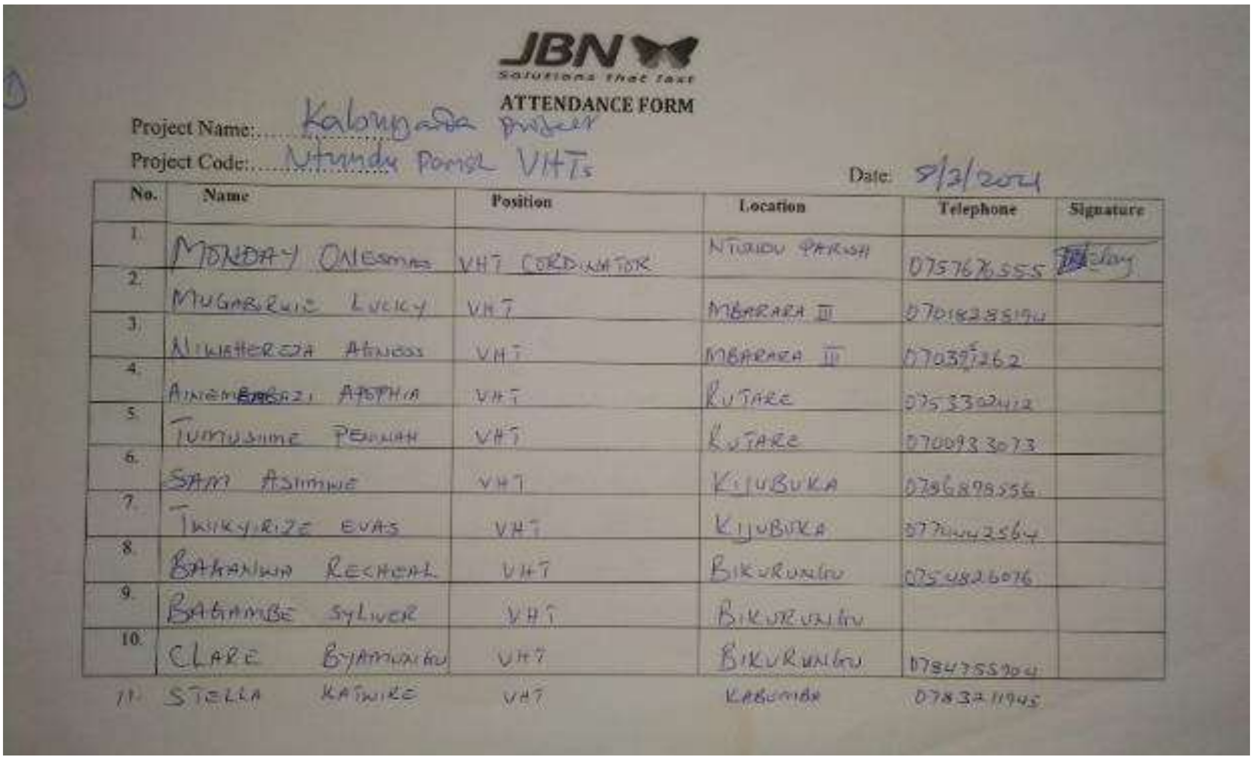
ATTENDANCE FORM

Project Name: Kabuyanda Project

Project Code: Ntundu Parish - LC1 Chair Persons Date: 8/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	MUGUHA DANSON	KABUMBA CELL		0781125421	[illegible]
2.	TWESIME SAMSON	KAGUNGA CELL		0757357754 ~~0772176248~~	
3.	MUGUZI JOHAMU	RUTARE CELL		0772176248	
4.	ARINAITWE JOHNSON	NYITHITA CELL		0756785063	
5.	BONABAANA LYDIA	MBARARA II		075262632	
6.	TUNGUME GODFREY	BIKURUNGU CELL			
7.	TIBESINDWA BENARD	KINJUBUKA		075156275	
8.	MONDAY ONESAMAS	MBARARA III		0757676555	
9.					

Meeting VHTs in Ntundu parish on 8th March 2021



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Solutions that last

ATTENDANCE FORM

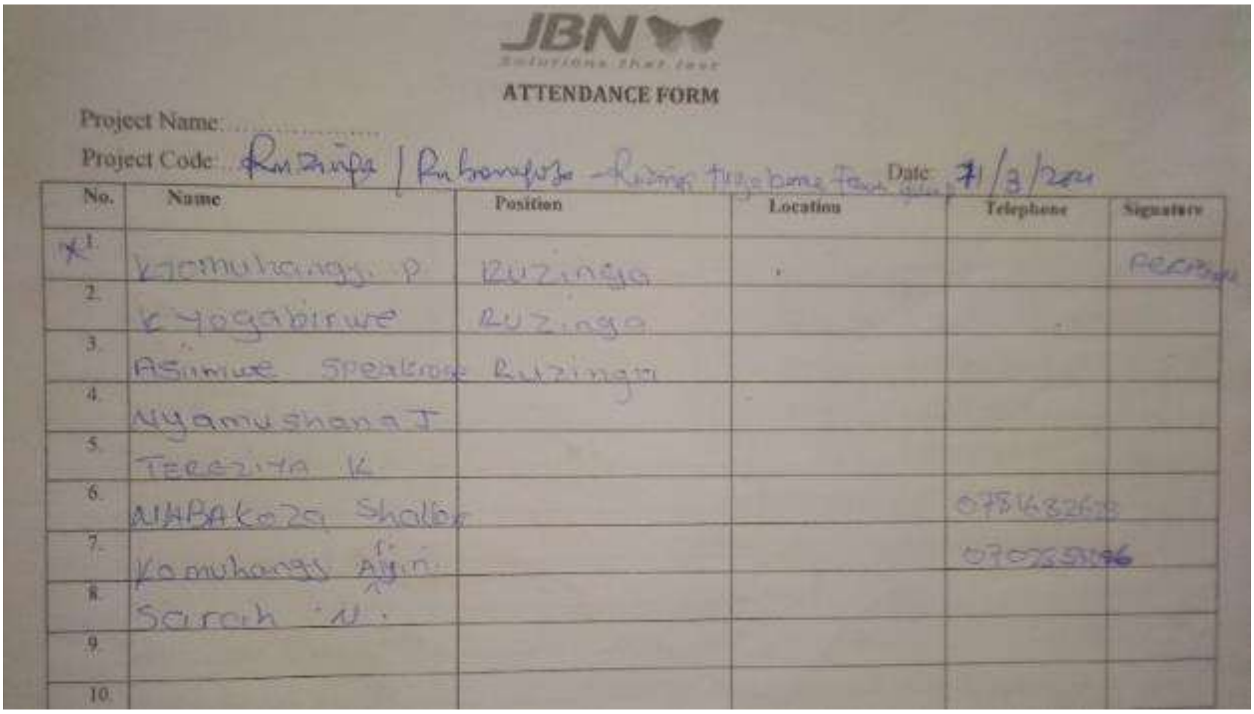
Project Name: Kabuyanda Project

Project Code: Ntundu Parish VHTs

Date: 9/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	MONDAY ONESMAS	VHT CORDINATOR	NTUNDU PARISH	0757676555	[illegible]
2.	MUGABIRWE LUCKY	VHT	MBARARA III	07018285194	
3.	NIWAHEREZA AGNESS	VHT	MBARARA III	0703971262	
4.	AINEMBABAZI APOPHIA	VHT	RUTARE	0753302412	
5.	TUMUSIIME PENINAH	VHT	RUTARE	0700933073	
6.	SAM ASIIMWE	VHT	KIJUBUKA	0786898556	
7.	TWIKIRIZE EVAS	VHT	KIJUBUKA	0770442564	
8.	BAKANWA RECHEAL	VHT	BIKURUNGU	0754826076	
9.	BAGAMBE SYLVER	VHT	BIKURUNGU		
10.	CLARE BYAMUNGU	VHT	BIKURUNGU	0784755904	
11.	STELLA KATWIRE	VHT	KABUMBA	0783211945	

Meeting women cultivators at Ruzinga village on 11th March 2021

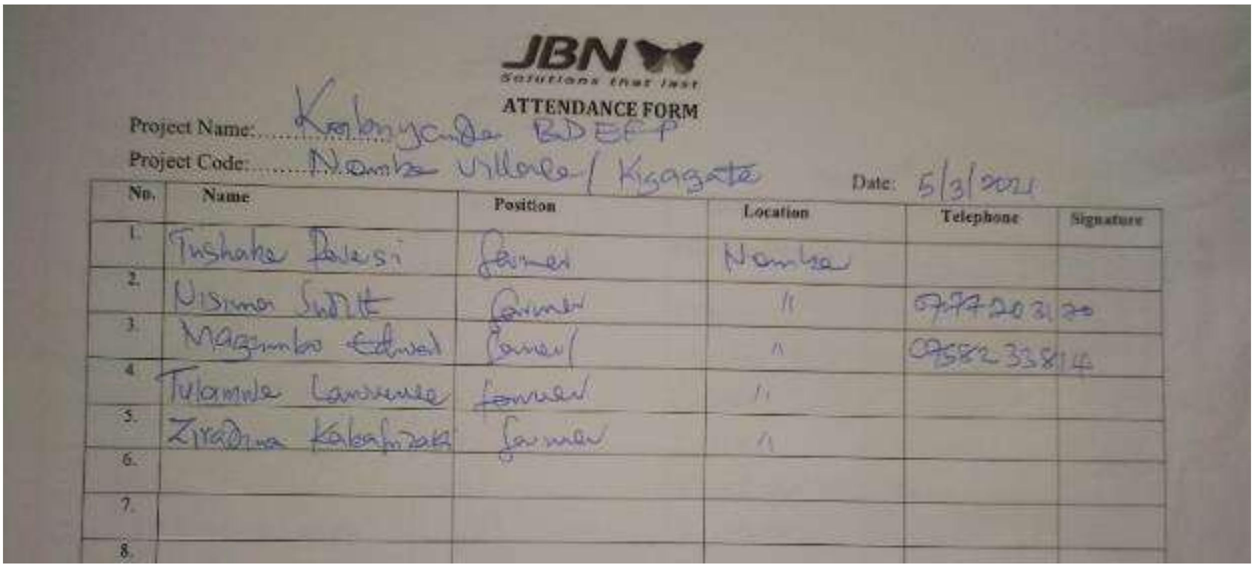


JBN
Solutions that last
ATTENDANCE FORM

Project Name: ....
Project Code: Ruzinga / Rubongozo – Ruzinga Nyabona Farm ... Date: 7/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	Kamuhangi P	Ruzinga			PECP...
2.	Kyogabirwe	Ruzinga			
3.	Asiimwe Speaker	Ruzinga			
4.	Nyamushana T				
5.	Terezia K				
6.	Ninbakaza Shallo			0781482628	
7.	Kamuhangi Ajun			0702253096	
8.	Sarah N.				
9.					
10.					

Meeting farmers at Nombe village on 5th March 2021

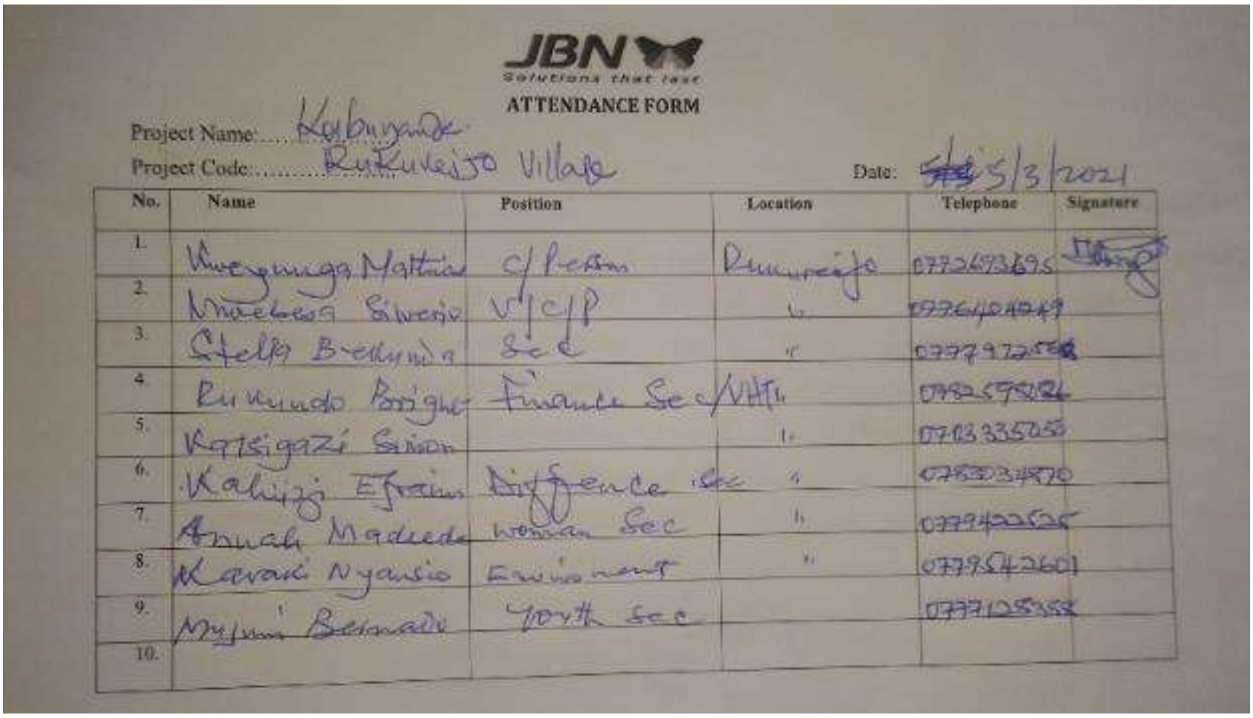


JBN
Solutions that last
ATTENDANCE FORM

Project Name: Kabuyanda BDEFP
Project Code: Nombe Village / Kigagate Date: 5/3/2021

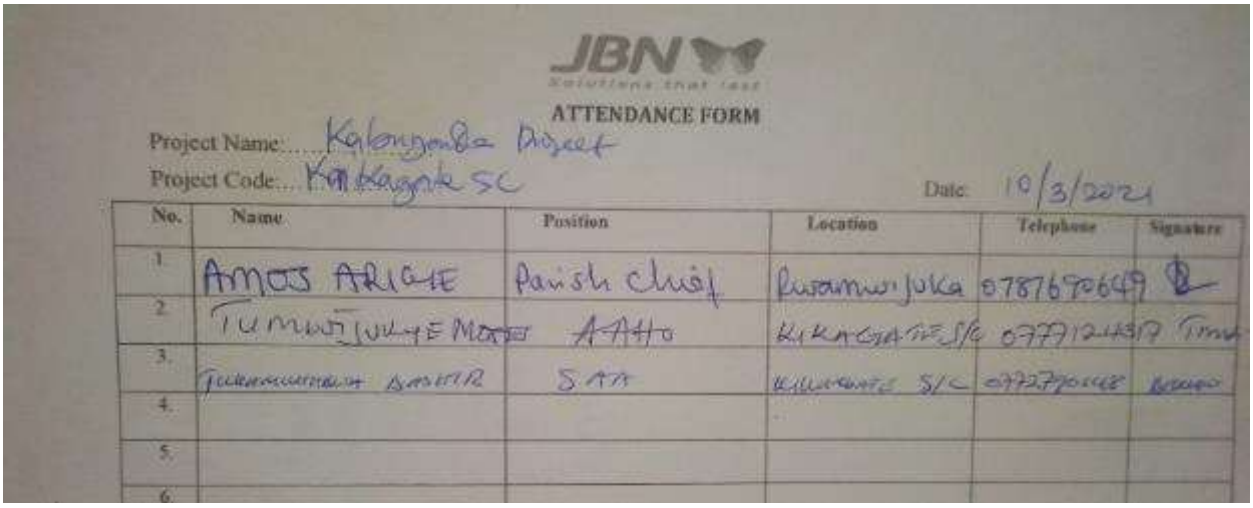
No.	Name	Position	Location	Telephone	Signature
1.	Tushabe Paresi	farmer	Nombe		
2.	Nimusiima Sudit	farmer	"	0774203120	
3.	Magambo Edward	farmer	"	0758233814	
4.	Tulamwe Lawrence	farmer	"		
5.	Ziradma Kabafunzaki	farmer	"		
6.					
7.					
8.					

Meeting with Rukureijo village committee leaders on 5th March 2021



No.	Name	Position	Location	Telephone	Signature
1.	Rwegyunga Mathias	C/Person	Rukurejo	0772693695	[illegible]
2.	Mwebesa Siverio	V/C/P	"	0776404249	
3.	Stella Bedinda	Sec	"	077797256	
4.	Rukundo Bright	Finance Sec/VHT		0782575286	
5.	Katsigazi Simon		"	0703335055	
6.	Kahigi Efrain	Difference Sec	"	0783034870	
7.	Anuah Madeeda	Woman Sec	"	0779422525	
8.	Karari Nyansio	Environment	"	0779542601	
9.	Mujuni Bernard	Youth Sec		0777125358	
10.					

Meeting Kikagate Sub County Technical Staff held on 10th March 2021



No.	Name	Position	Location	Telephone	Signature
1.	AMOS ARIGYE	Parish chief	Rwamwijuka	0787690649	[illegible]
2.	TUMWIJUKYE MOSES	AAHO	KIKAGATE S/C	0777124317	[illegible]
3.	[illegible] BASHIR	SAS	KIKAGATE S/C	0772770448	[illegible]
4.					
5.					
6.					

Meeting Kabuyanda Town Council Sub County Technical Staff held on 11th March 2021

JBN

ATTENDANCE FORM

Project Name: Kabuyanda Project

Project Code: Kabuyanda T/C meeting Technical Heads Date: 11/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	BYAKATONDA VICENT	TOWN CLERK	KABUYANDA T/C	0758816686	[illegible]
2.	WAKOKO INNOCENT	HEALTH INSPECTOR	Kabuyanda T/c	0759018685	[illegible]
3.	NAMBATYA HADIJAH	ACDO	Kabuyanda T/c	0701173705	[illegible]
4.	KAGONGO WILLIAS	Assistant E. officer	KABUYANDA T/c	0753973800	[illegible]
5.	KEKYIREMBO JESSICA	Town AGENT	CENTRA WARD KABUYANDA T/C	0752941827	[illegible]
6.	Sabiiti Francis	Day guard	Kabuyanda	0751044455	[illegible]
7.	Anyijukire [illegible]	[illegible]	Kabuyanda T/c	07593[illegible]	[illegible]
8.	Hakiri Dickson [illegible]	Irrigation [illegible]	Kabura II	0705[illegible]2581	[illegible]
9.	Ntambo Gyoc[illegible]	ASKARI	Kabuyanda	0702[illegible]068	[illegible]
10.	Dr. Collins Atwine	Incharge	Kabuyanda HC[illegible]	0779[illegible]152	[illegible]
	Arinaitwe Priscilla	EIN	Kabuyanda T/c	0779931353	[illegible]

JBN

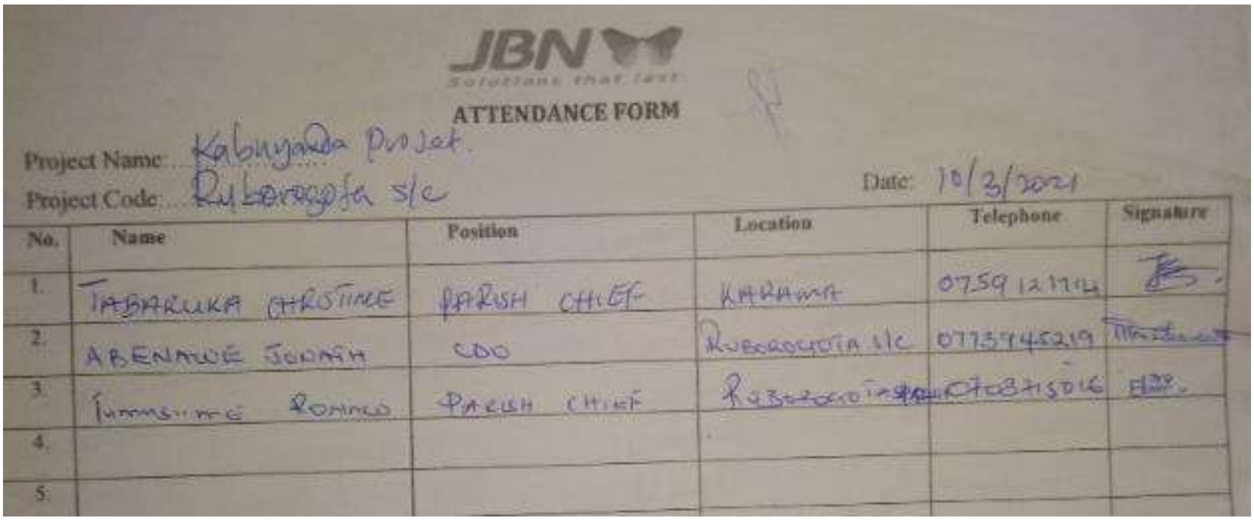
ATTENDANCE FORM

Project Name: Kabuyanda

Project Code: meeting Kikagate S/c Technical Heads Date: 12/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	AMOS ARIGYE	Parish chief	Kikagate S/c	0751463844	[illegible]
2.	TUMWIJUKYE MOSES	AAHO	KIKAGATE S/c	0752597[illegible]	[illegible]
3.					
4.					
5.					
6.					

Meeting Ruborogota Sub County Technical Staff held on 10th March 2021



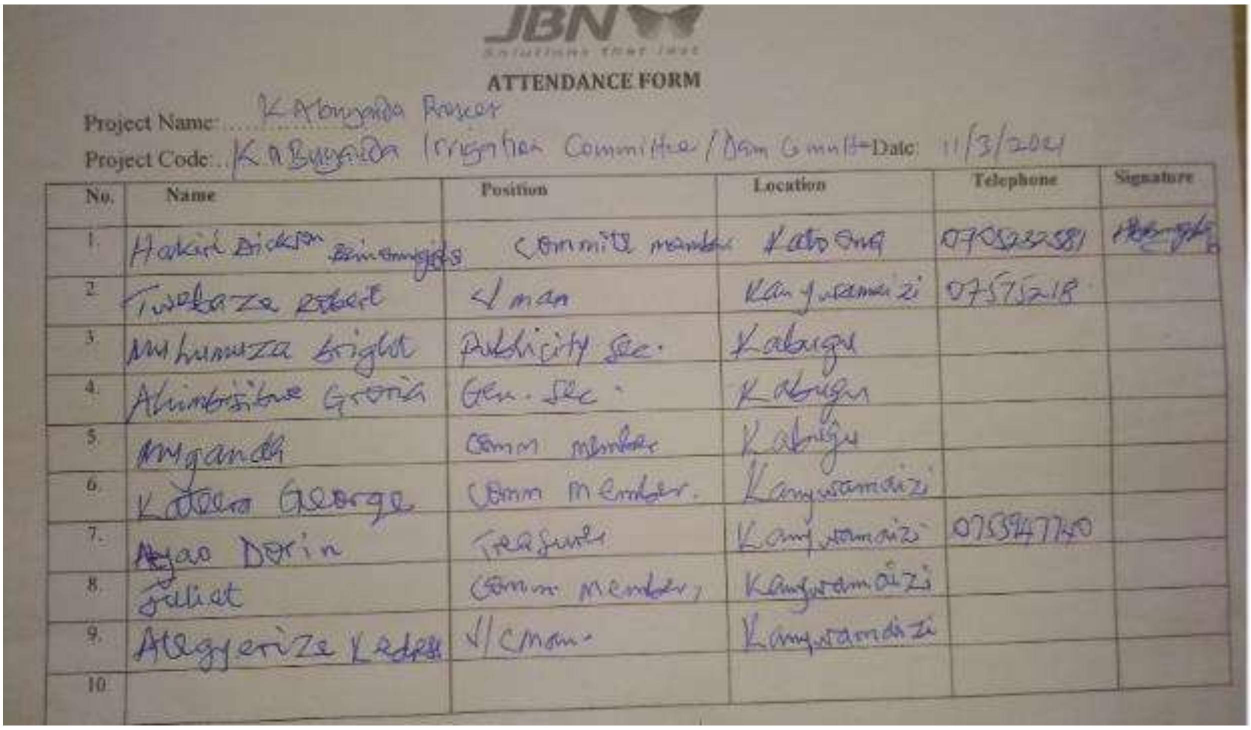
JBN
Solutions that last

ATTENDANCE FORM

Project Name: Kabuyanda Project
Project Code: Rubaregota s/c
Date: 10/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	TABARUKA CHRISTINE	PARISH CHIEF	KARAMA	0759121114	
2.	ABENAWE JONAH	CDO	RUBOROGOTA S/C	0773745219	
3.	Tumusiime Romano	PARISH CHIEF	Ruborogota [illegible]	0708715016	
4.					
5.					

Meeting Kabuyanda Dam Committee on 11th March 2021



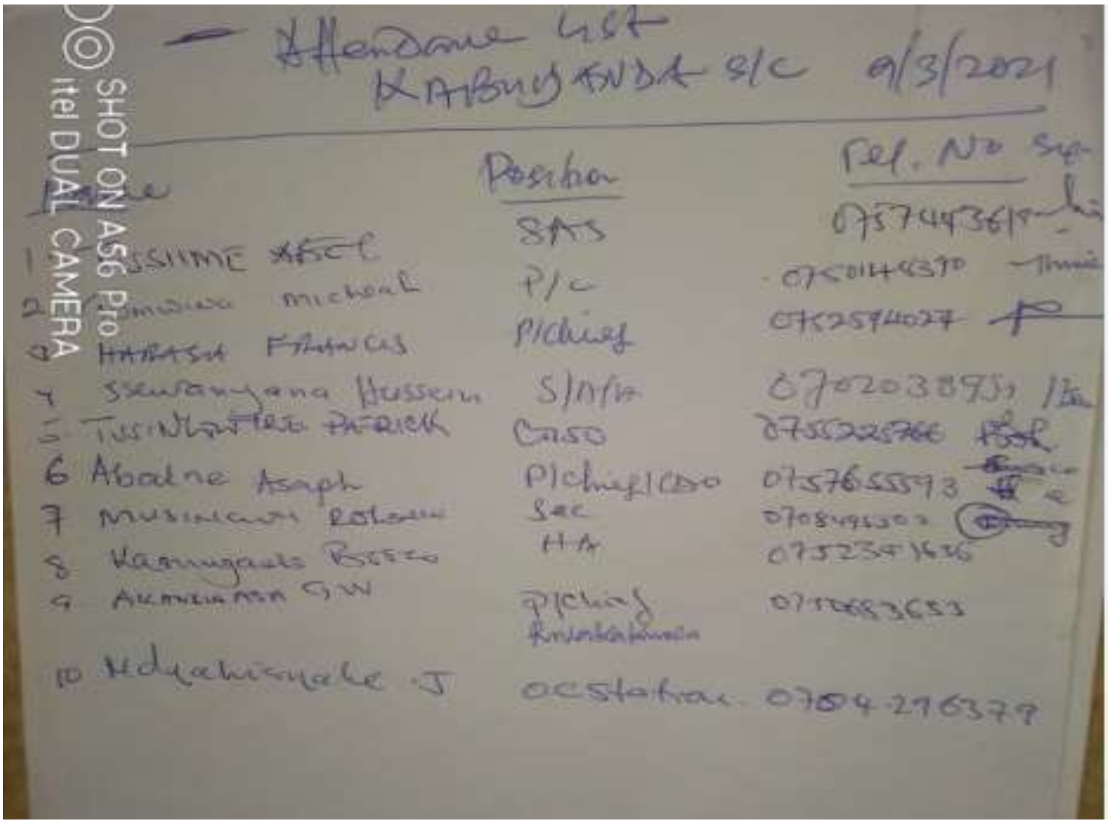
JBN
Solutions that last

ATTENDANCE FORM

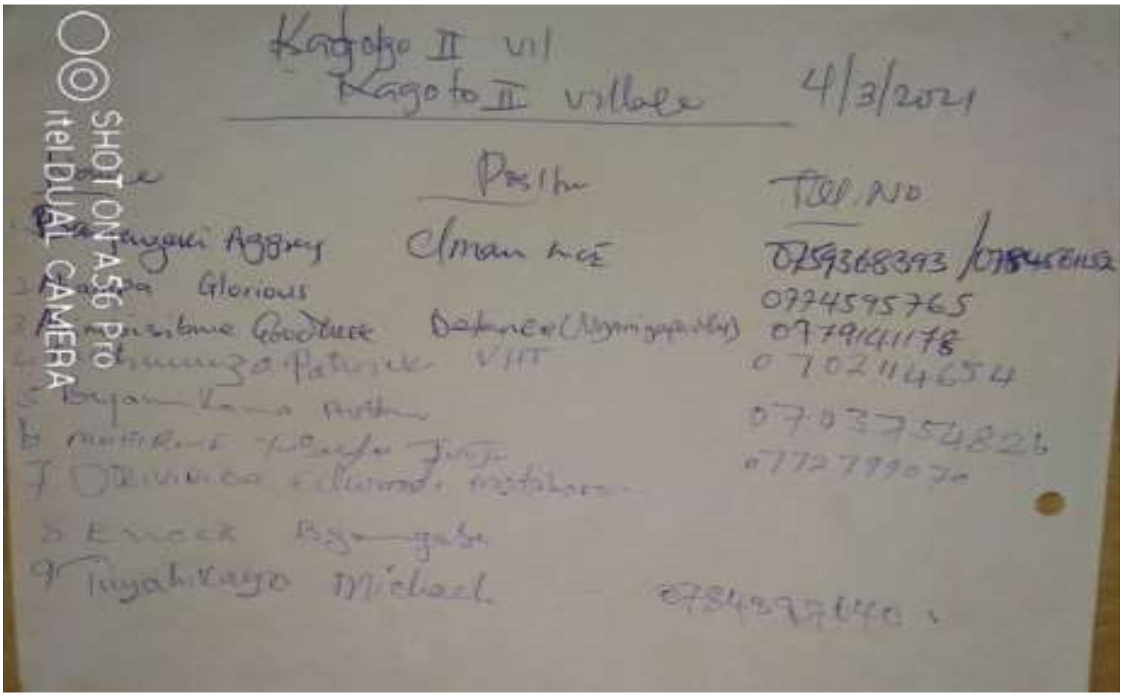
Project Name: Kabuyanda Project
Project Code: Kabuyanda Irrigation Committee / Dam Committee
Date: 11/3/2021

No.	Name	Position	Location	Telephone	Signature
1.	Hakiri Dickson Bainomugisha	Committee member	Katooma	0705232581	
2.	Twebaze robert	V/man	Kanyamaizi	0757521R	
3.	Muhumuza bright	Publicity Sec.	Kabuga		
4.	Ahimbisibwe Gloria	Gen. Sec.	Kabuga		
5.	Amganda	Comm member	Kabuga		
6.	Kateera George	Comm member.	Kanyamaizi		
7.	Ayao Dorin	Treasurer	Kanyamaizi	0755947740	
8.	Juliet	Comm member,	Kanyamaizi		
9.	Akegyerize Kedesi	V/Cman.	Kanyamaizi		
10.					

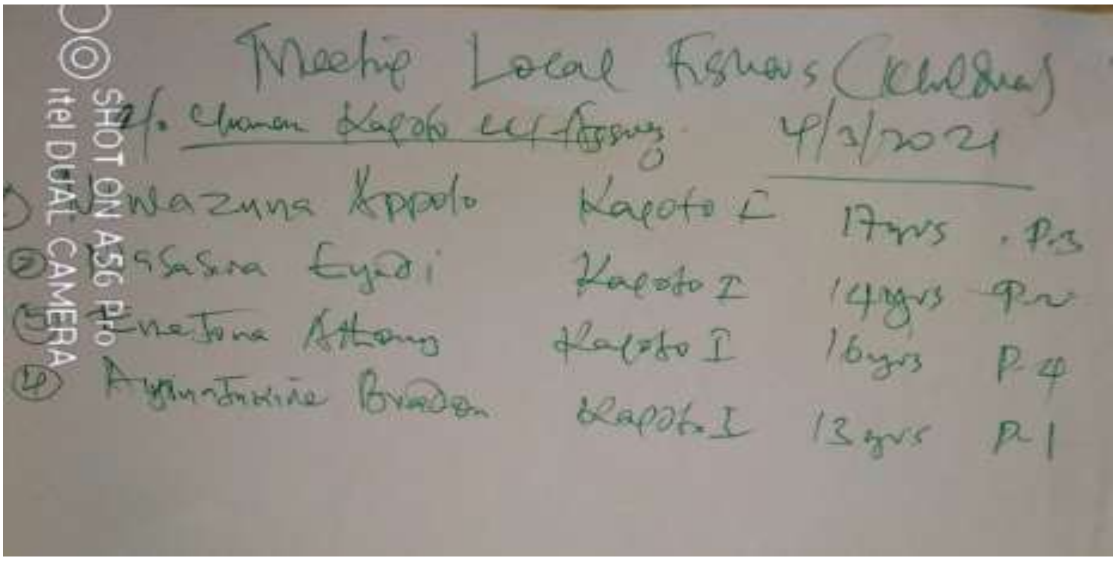
Meeting Kabuyanda Sub County Technical Staff on 9th March 2021



Meeting Kagoto 2 village leader on 4th March 2021



Meeting artianal fishermen at Kagoto 1 (dam site) on 4th March 2021


Meeting Local Fishers (Children)
C/o Chairman Kagoto LC1 ... 4/3/2021

1	Nwazuna Kapolo	Kagoto I	17yrs	P.3
2	Asasira Eyadi	Kagoto I	14yrs	P.[illegible]
3	Enatona Atthony	Kagoto I	16yrs	P.4
4	Ayamanyire Braden	Kagoto I	13yrs	P.1

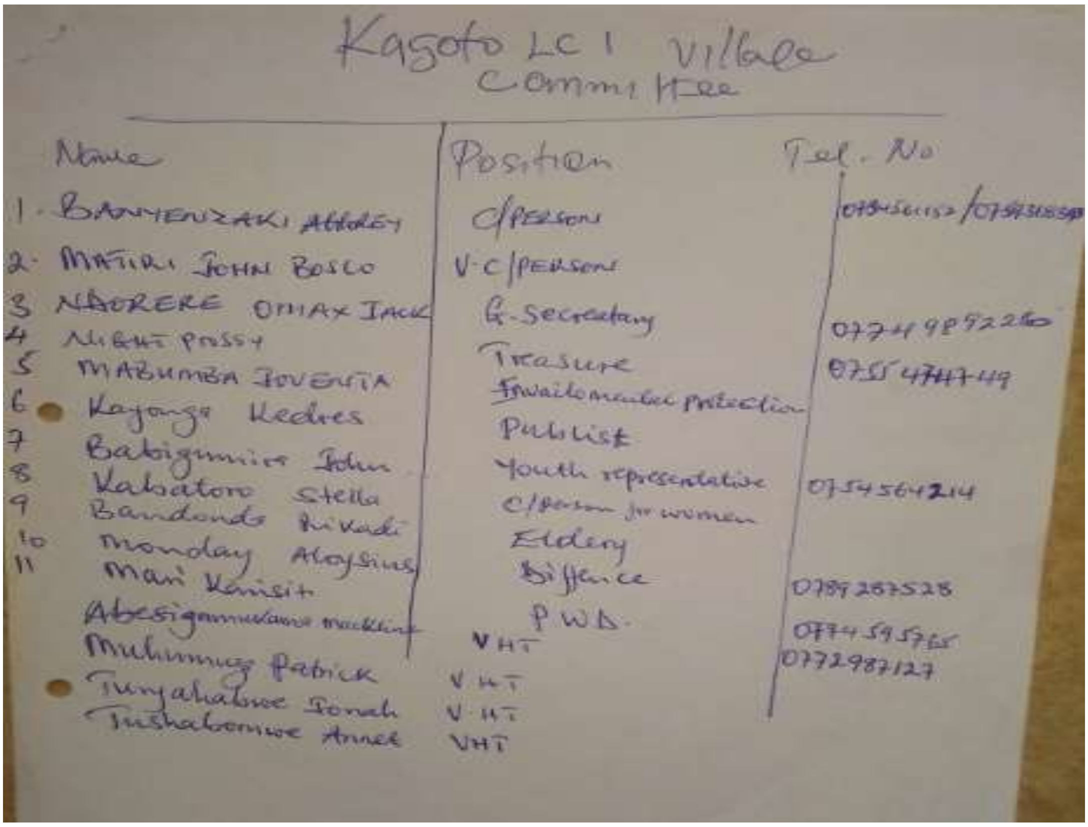
List of Village Envrionment Committe leaders in Rwamwijuka parish (irrigable area)


RWAMWIJUKA PARISE SECRETARIES FOR ENVIRONMENT

#	NAME		VILLAGE
1	ASIIMWE	LYDIA	Ruyonza
2	AKANKWASA	MICHEAL	Bobare
3	KYAKABALE	ASAPH	KIGANDO
4	KIRUNGA	JAMES	RWAMWIJUKA
5	NYAMBAKO	NZERA	KAMWOSYA
6	GAKYARO	TARASISIO	RWEMIZO
7	MWEBESA	MEDARD	KABURARA
8	CATHERINE	MANZI	KASHARIRA

LCII PARISH
* UNITH MUTABAZI
Compiled by
Amos ARIGYE
AREA PARISH CHIEF

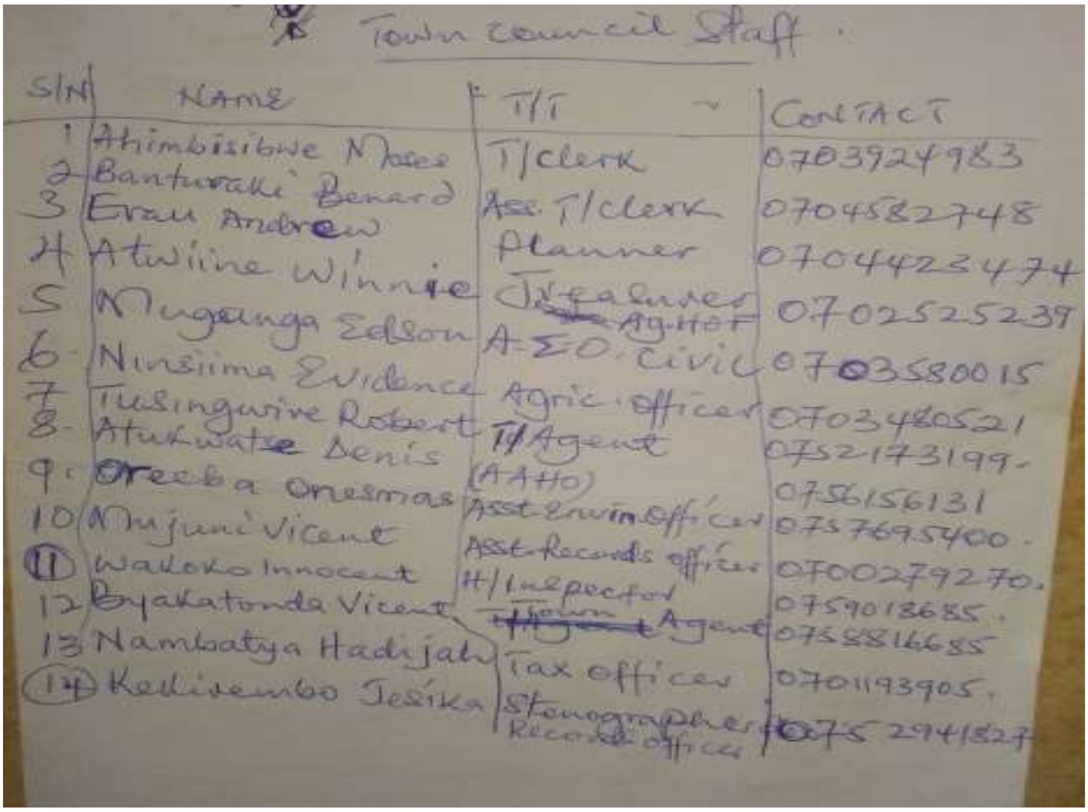
List of Kagoto 1 village council leaders



Kagoto LC I Village Committee

Name	Position	Tel. No
1. BANYENZAKI ALFRED	C/PERSON	[illegible]/[illegible]
2. MATIRI JOHN BOSCO	V.C/PERSON	
3 NAGERERE OMAX JACK	G-Secretary	0774 9892260
4 NIGHT PRISSY	Treasure	0755 474749
5 MABUMBA JOVENTA	Environmental protection	
6 Kajonga Kedres	Publicist	
7 Babigumira John	Youth representative	0754564214
8 Kabatoro Stella	C/person for women	
9 Bandonda Rikadi	Eldery	
10 Monday Aloysius	Difference	
11 Mani Kenisit	P.W.D.	0789287528
Abesigamukama Macklin	VHT	0774595765
Muhimuza Patrick	V.H.T	0772987127
Tumwebaze Jonah	V.H.T	
Tushabomwe Annet	VHT	

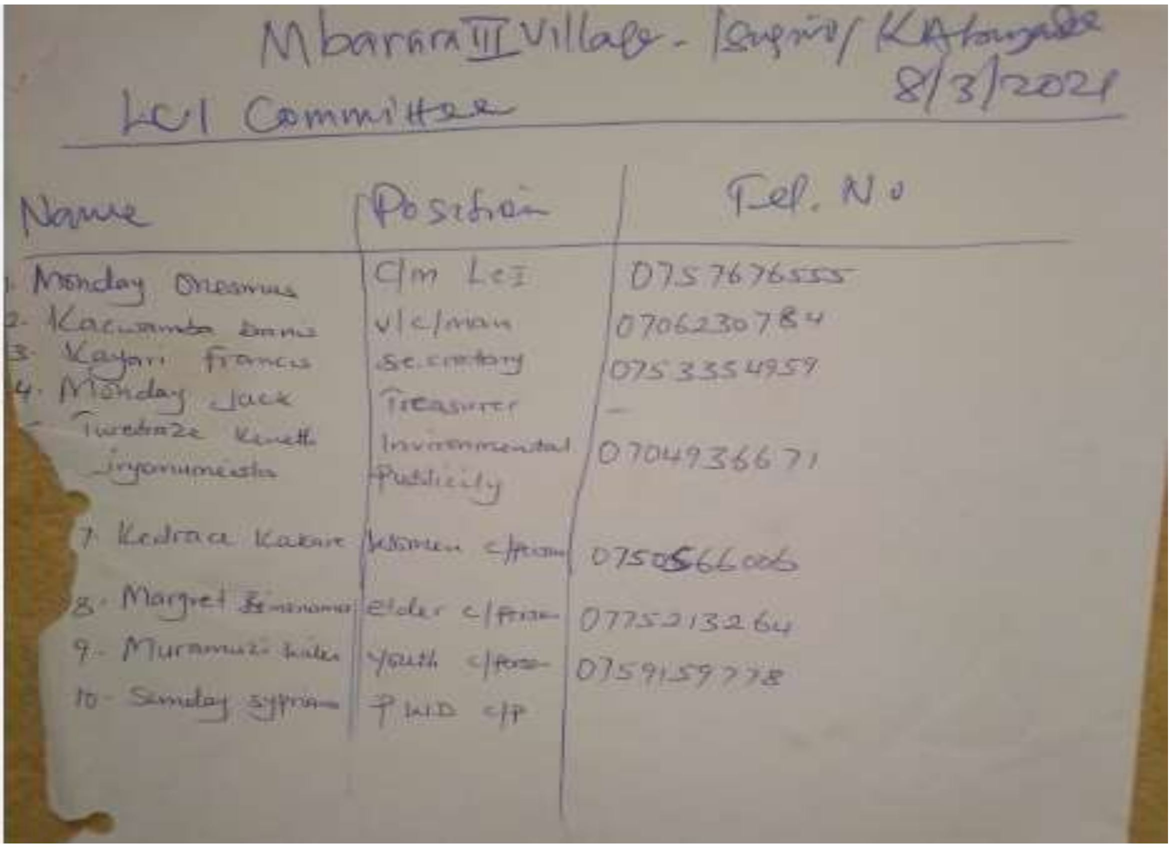
List of Kabuyanda town Council Technical staff



Town Council Staff

S/N	NAME	T/T	CONTACT
1	Ahimbisibwe Moses	T/clerk	0703924983
2	Banturaki Benard	Ass. T/clerk	0704582748
3	Evau Andrew	Planner	0704423474
4	Atwiine Winnie	~~Treasurer~~ Ag-HOF	0702525239
5	Mugeanga Edson	A.E.O. Civic	0703580015
6	Ninsiima Evidence	Agric. officer	0703480521
7	Tusingwire Robert	T/Agent	0752173199
8	Atukwatse Denis	(AAHO)	0756156131
9	Oreeba Onesmas	Asst. Envin Officer	0757695400
10	Mujuni Vicent	Asst. Records officer	0700279270
11	Wakoko Innocent	H/Inspector	0759018685
12	Byakatonda Vicent	~~Agent~~ T/own Agent	0758816685
13	Nambatya Hadijah	Tax officer	0701193905
14	Kedirembo Jesika	Stenographer Records officer	0775 2941827

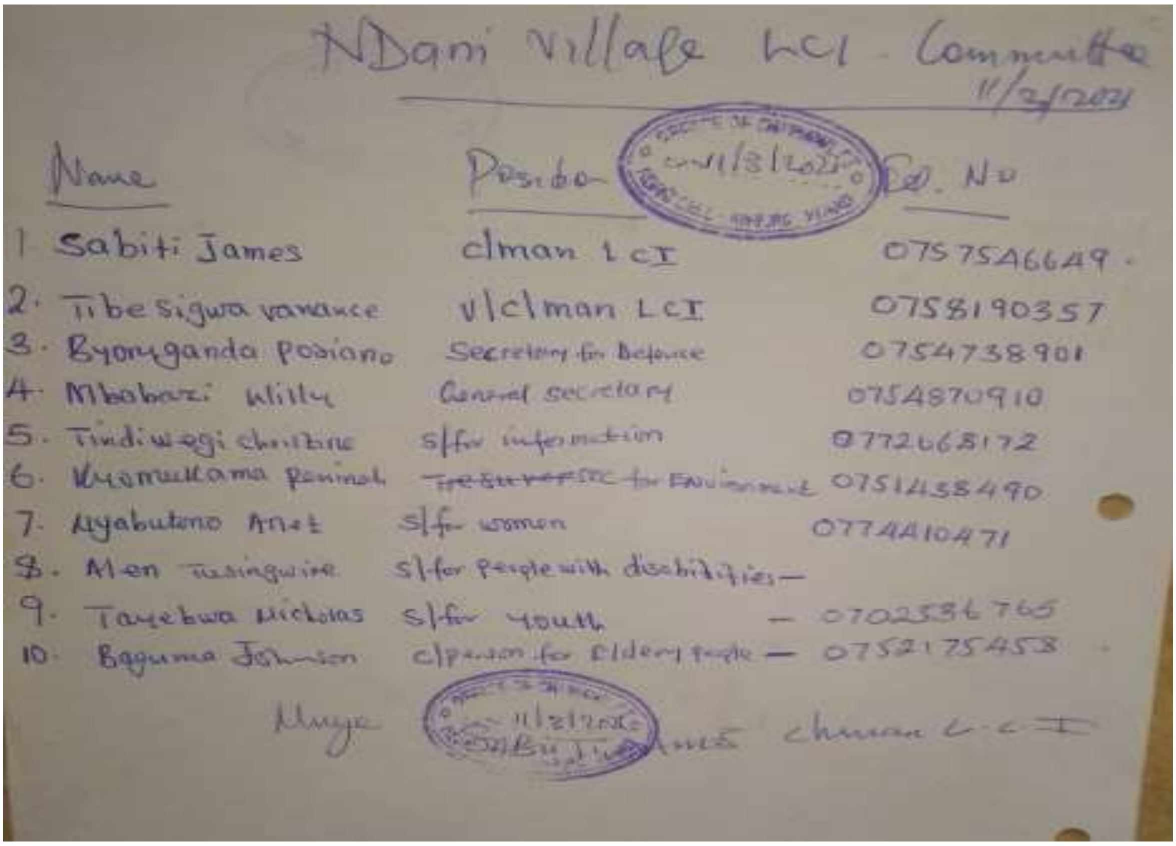
List of Village leaders at Mbarara 3 village (irrigable area)



Mbarara III Village - Engiri/ Katoogo
8/3/2021
LCI Committee

Name	Position	Tel. No
1. Monday Onesmus	C/m LcI	0757676555
2. Kacwamba Dani	v/c/man	0706230784
3. Kayari francis	Secretary	0753354957
4. Monday Jack	Treasurer	-
- Twetonze Kenneth	Invironmental	0704936671
Jyorumeesto	Publicity	
7. Kedrace Kakuru	Women c/person	0750566006
8. Margret [illegible]	Elder c/person	0775213264
9. Muramuzi [illegible]	youth c/person	0759159778
10. Sunday sylvian	PWD c/p	

List of community leaders for Ndani village



NDani Village LC1 Committee
11/3/2021

Name	Position	Tel. No
1. Sabiti James	c/man LcI	0757546649
2. Tibesigwa vanance	v/c/man LcI	0758190357
3. Byomuganda posiano	Secretary for Defence	0754738901
4. Mbabazi Willy	General secretary	0754870910
5. Tindiwegi christine	s/for information	0772663172
6. Kyomukama peninah	~~Treasurer~~ sec for Environment	0751458490
7. Ayabutono Annet	s/for women	0774410471
8. Allen Tusinguwire	s/for People with disabilities	—
9. Tayebwa Nicholas	s/for youth	— 0702336765
10. Bagyuma Johnson	c/person for Eldery people	— 0752175453

Mugye [illegible] chman L.C.I

Annex 7: Summary of BEMP consideration on biodiversity mitigation measures and management Actions

M- MWE; BT- Contracted Biodiversity Specialists; C-Constructor; O-Operator

Ref	Topic	Sub Topic	Location	Requirement (Collecting mode/treatment/evacuation/final disposal)	Owner (c/t)	Verification Process
B001	Biodiversity - General	Interaction with other plans	All	This Biodiversity CESMP will be applied in conjunction with all other relevant management plans, including, but not necessarily limited to those outlined in the CESMP.	M, BT, C	Biodiversity - General Internal audit program and record
B002	Biodiversity - General	Use of Biodiversity Specialists	All	The Project will seek to minimize impacts on notable species and loss, fragmentation, alteration, disturbance and disruption of sensitive habitats. The approach to be taken is outlined throughout this CESMP. A principal management tool in this will be the use of Biodiversity Specialists. All Biodiversity Specialists will be appropriately skilled for undertaking site supervision and species relocations where required.	M, BT	Monitoring report, Maps
B003	Biodiversity - General	Mapping of sensitive habitats and species.	Sensitive Habitats (Class 3 - 5)	The Biodiversity Specialists contracted will identify and map any sensitive habitats though in this study, no sesntive habitats were found. Habitats will be mapped in sufficient detail that the locations of notable plant. (And where practical animal) species (including Uganda Red List species) are clearly marked. Bespoke mitigation will be applied in all areas where sensitive habitats are identified (see specific below). The maps will be used to monitor mitigation effectiveness.	BT	Monitoring report, Maps
B004	Biodiversity - General	Mitigation for sensitive habitats and species.	Sensitive Habitats (Class 3 - 5)	Where any such habitats or species is present impacts will be mitigated as outlined in the ESIA for example by scheduling works to a less sensitive time of year or the use of appropriate species translocation to nearby suitable habitats. The resultant "hazard" mapping will be updated weekly with reports on any critical receptors.	BT, C	Monitoring report, Maps
B005	Biodiversity – General	Pre-construction checks	Sensitive Habitats (Class 3 - 5)	Before commencement of vegetation stripping the Biodiversity, Specialists will conduct pre-construction checks, to help avoid accidental injury or death to sensitive species such as ground nesting birds, reptiles, amphibians and bats. Checks will include within hollow trees and other places of shelter. The Biodiversity Specialists will prepare a weekly monitoring report and hazard map showing sensitive locations. This will be shared with workers in an appropriate manner (e.g., Toolbox talks) so that sensitive areas can be avoided or bespoke mitigation implemented.	BT, C	Monitoring report, Maps
B006	Biodiversity – General	Training	All	MWE will train internal staff to be able to provide advice to contractors with input and advice if required and enable an informed overview of the biodiversity input from the contractors. Workers will be made aware of the ecological sensitivities of the areas and will be trained in mitigation for unforeseen events, including the presence of uncommon habitats and species. Health and safety recommendations regarding poisonous or otherwise dangerous plants or animals will also be provided by the e.g., through toolbox talks Biodiversity Specialists. Emergency numbers will be provided for Ecologists should protected species be found on site in the absence of site supervision.	BT, C	Field verification, monitoring reports, record
B007	Biodiversity - General	Road signs	Roads	Areas of high wildlife use will be indicated through appropriate signage along access roads where potential exists for vehicle/wildlife collision.	BT, C	Field verification Field verification
B008	Biodiversity - General	Biodiversity Specialist	Forests, riparian habitats	Where works in forests, riparian habitats or in water are unavoidable, at least one Biodiversity Specialists should be deployed to work with the workforce during clearance to identify sensitive habitats and species present on site, in particular nests with eggs/chicks, dens, burrows, hibernacula and other places of shelter to prevent direct mortality. **In many locations two Biodiversity Specialists will be required.**	BT, C	Field verification, monitoring reports, record

B009	Biodiversity - General	Escape ramps	All	Pits and excavations will be filled in as soon as possible following works. Any that need to remain open for longer than 48 hr periods will have appropriate ramps (soil and not more than 45°) to allow fauna to escape should they fall in. Morning checks for fauna will be conducted for excavations left open overnight.	BT, C	Field verification, monitoring reports, record
B010	Biodiversity - General	Nesting birds	All	Active bird nests will not be damaged. As far as possible tree and scrub clearance will not be undertaken during the breeding bird season (March to August inclusive). Should clearance during this time be necessary a preclearance nesting bird check of the vegetation to be cleared will be undertaken by the Biodiversity Specialists and a decision on whether to move the nest or defer the clearance will be made by the Biodiversity Specialists.	BT, C	Field verification, monitoring reports, photo record
B011	Biodiversity - General	Translocation	All	Potential habitats for translocation will be identified in close proximity to project footprint (but outside of the works corridor) if required. Translocation location will vary depending on the species but should be located according to target habitat.	BT, C	Field verification, monitoring reports, photo record
B012	Biodiversity - General	Tree conservation	All	Wherever possible the felling of significant/mature trees will be avoided and connectivity between areas of forest habitats will be maintained. No trees over 100 mm in diameter will be felled without a pre-felling check by a Biodiversity Specialist.	BT, C	Field verification, monitoring reports, photo record
B013	Biodiversity - General	Laydown areas	All	Laydown areas and compounds will be sited to avoid unnecessary clearance of vegetation.	BT, C	Field verification, monitoring reports, photo record
B014	Biodiversity - General	Barriers and crossing points	All	Regular wildlife crossing points will be installed to enable wildlife to cross excavations, berms and drainage channels. Fencing will be minimized and no areas vital for wildlife will be isolated by the workforce activities but temporary barriers will be used to prevent wildlife from accessing waste disposal areas.	BT, C	Field verification, monitoring reports, photo record
B015	Biodiversity - General	Monitoring and management regimes	All	Restored areas will be monitored mowing regimes used to control growth of invasive species. The success of ecological restoration measures will be observed for a period of minimum 36 months so that they can validate the effectiveness of the solutions adopted, however 5 years monitoring is recommended.	BT	Field verification, monitoring reports, photo record
B016	Biodiversity - General		All	Careful management of networks of ditches and polders so as to provide alternative habitats for species; in order to bring the land to its original state	BT, C	Field verification, monitoring reports, photo record
B017	Biodiversity - General		All	Where necessary conditions will be created for recolonization of notable species in the affected habitat by providing a microhabitat that replies the initial state (pre-project). The success of the measures to restore the environment in areas affected will be evaluated according to the data collected by the Biodiversity Specialist and specified within the BAP.	BT	Field verification, monitoring reports, photo record
B018	Biodiversity - General		Entire Project	Maintain vegetated buffers wherever possible along River Mishumba and adjoining streams and tributaries banks	BT, C	Field verification, monitoring reports, photo record
B019	Biodiversity - General	Dead wood, boulders	Forested areas	Structures will be created within selected areas at a density of about 3-5 (stacks)/km, 3-5 mc material. These structures will ensure no net loss for amphibian and reptile species which utilize these features.	BT, C	Field verification, monitoring reports, photo record
B020	Biodiversity - General	Replanting	Forested areas	During the ecological restoration phase, a series of measures will be taken in selected areas within the Mishumba catchment in order to mitigate the impact of land clearing by regenerating the cleared vegetation cover	BT**, C**	Field verification, monitoring reports, photo record
B021	Biodiversity - General	Replanting	All	Replanting will be conducted according to the ESIA and restoration CSEMP and Operation ESMPs within the specified areas of irrigation command area.	BT, **C**	Field verification, monitoring reports, photo record
B022	Biodiversity - General		Access Roads	Access areas roads will be constructed in such a way that rain-water run-off is effective and puddles which could attract amphibians are avoided.	BT, C	

B023	Biodiversity - General	Vehicles	Sensitive Habitats (Class 3-5)	Use of low-impact vehicles (in terms of emissions and load bearing) where applicable.	C	Field verification, monitoring reports
B024	invasive species	All	A site wide ban on workers bringing vegetation or soil from outside the site area to prevent dispersion of non-native invasive species.	All vehicles and equipment will be washed down before entering the sensitive sites (see specific mitigation with regards to Japanese Knotweed)	BT, C	Field verification, monitoring reports
B025	Biodiversity - General	Bats	Within forested areas Within forested areas	200 bat boxes to be erected within forested areas. These will be monitored as a component of the BAP.	BT, C	Field verification, monitoring reports, photo record
B026	Biodiversity - General	Restoration	All	Ephemeral water bodies to be created along the route in line with the Environmental permit at a density of 1 per 3 – 5km.	BT, C	Field verification, monitoring reports, photo record

Annex 8: Summary of BEMP consideration on social risks and impacts regarding provisioning ecosystems services

No.	Impact & Risk	Area affected		Baseline condition (value)	Management Measures (Safeguards)	Key Performance Indicator (KPI)	BEMP Targets	Responsibility
		River stretch	Sub Catchments					
1	**Decrease in access to provisioning ecosystems services (river water, fishing etc.)**							
	a) Disruption of water collection points along river streams (dirty water due to construction of dam upstream and trenching of distribution networks)	• Upstream • Midstream • Downstream	• Mishumba • Lower Mishumba • Middle Chezho • Lower Chezho	• 97% of HHs collect fresh water	• Establish alternative clean water sources (extend free piped water) during construction phase in 6 parishes (Kagara, Kanywamizi, Central, Rwamwijuka, Kisyoro, Ntundu) • Conduct sensitization led by DHO/ Health Inspectors, Health Assistants & VHTs	• Provide alternative domestic water supply points (PSP) established before construction to serve 4,465 HHs in 6 parishes	All done before construction begins	• MWE/ICRP • WSDF-SW DWO, DHO • Contractor • Sub county • Parish • Community
	b) Disruption of watering points for livestock at dam site area (6 villages affected)	• Upstream (dam site)	• Mishumba	• 94% of HHs	• Create alternative watering points below dam site • Restrict livestock at dam site • Community dialogue on livestock watering & setting regulations	• Alternative sites for livestock watering selected and gazetted	Dialogue before construction	• Contractor • DLG • Sub County • Agriculture Extension • Community Livestock owners
	c) Disruption of crop farming livelihoods within floodplain and buffer zones	• Upstream • Midstream • Downstream	• All sub catchments	• 93% HHs cultivate within swamps & buffer zones	• Develop & implement 7 sub catchment protection action plans • Minimal eviction of encroachers in critical sampled points • Organize encroachers into groups and offer them casual jobs esp. women and youth (labour intensive public works)	• Minimum of 450 encroachers evicted before construction begins • Integrate evictees into livelihood restoration actions (alternative crops) • Atleast 18 active groups formed (maximum of 25 people each) and give casual jobs	Sensitization & dialogue before project roll-out especially with women	• MWE/ICRP • DLG • Sub county • Agriculture Extension • Parish • Community
	d) Disruption of artisanal fishing activities (for domestic & income uses) especially during dam construction in Mishumba & Lower Mishumba, Middle Chezho sub catchments	• Upstream (dam site) • Midstream	• Mishumba • Lower Mishumba • Middle Chezho	• 52% HHs (fish for domestic consumption) • 21% HHs (fish for sale)	• Adhere to Environmental safeguards, ESMP & sub catchment protection plans • Restrict fishing activities at dam site • Organize Mobilize artisanal fishermen into groups and offer them casual jobs (labour intensive public works) - contact lead fisher head called Ndyabahika to mobilize.	• 7 groups of fishermen formed (1 per sub catchment)	• Sensitization done before, during construction • Start with 3 groups in Mishumba & Lower Mishumba, Middle Chezho	• MWE/ICRP • DLG / DFO • Sub county • Agriculture Extension • Community

Annex 9: Summary of BEMP consideration on specific mitigation measures and actions for Sensitive Habitats and notable Species

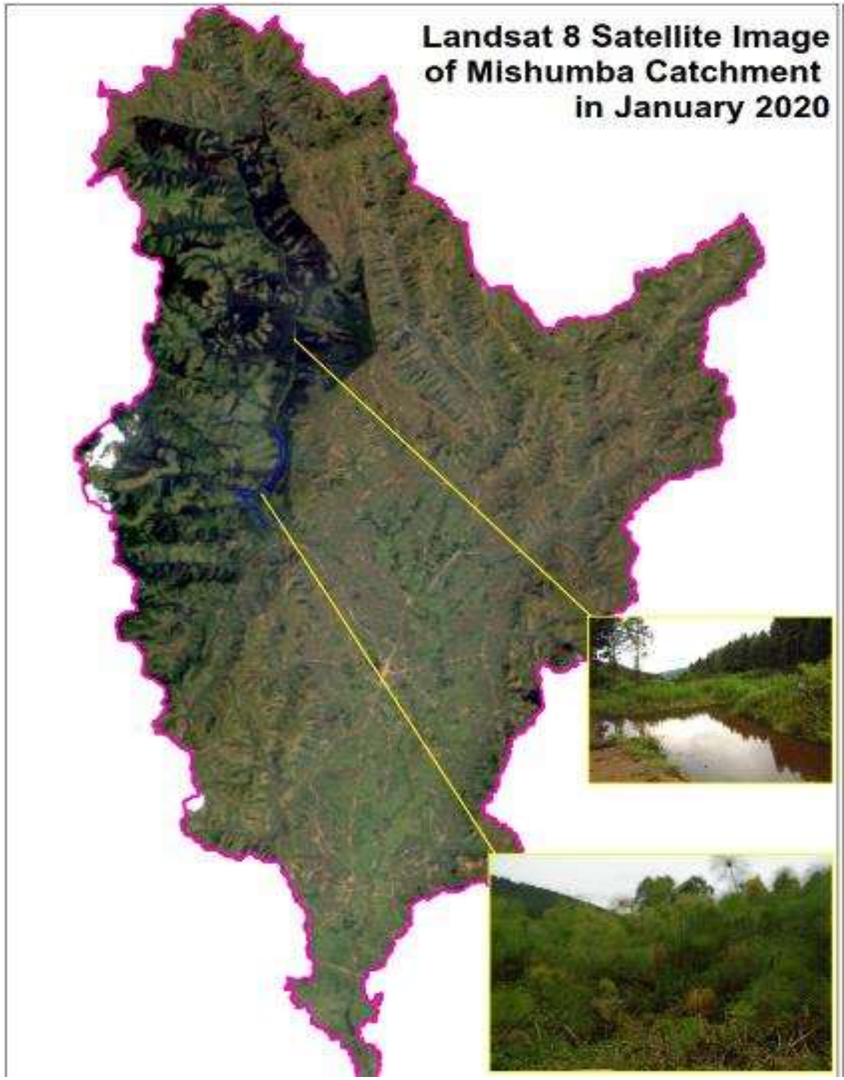
Habitat Type and location	Mitigation Method Description
Ponds / ephemeral water bodies	• Ponds in the irrigable area (downstream) along Mishumba should be mapped prior to demarcation of blocks. • If the ponds are to be destroyed, drainage should be conducted via pumping with a suitable pump filter (to prevent animals and debris being drawn into the pump). All animals present within the pond should be moved to appropriate habitats away from the works. • If possible, pond drainage should be avoided April – November. • Replacement of these ponds is required on a minimum of a 1 to 1 replacement, dug to mimic the size and location of the ponds lost and using liners to retain water where hydrologically required.
Riparian areas	• There are areas of riparian habitat that qualify as priority biodiversity features and may qualify as CH. The method of crossing has been determined by considering the width of the river, the composition of the river bed and the volume and the flow of the river. Crossings will either be directionally drilled avoiding the need to dig up the river bed or open cut (wet or dry depending on the status of the watercourse). Silt fences would be used in areas of wet open cut, strategically positioned to prevent sedimentation downstream. • Banks would be restored using either gabion cages or wooden revetments to ensure soil/integrity before vegetation matures to provide soil stability. There would be re-planting of scrub in some areas or vegetation would be allowed to colonise naturally as appropriate. • All riparian works and river crossing should follow the prescriptions of the water chapter of this ESIA.
Swamps	• Efforts should be made to protect and retain as much swamps as possible, and were destroyed or drained in construction, on completion of activity restoration of the swamps should conducted. • Any draining of the swamps should consider allowing the animals contained to move or to be moved to other habitats before reclamation starts.
Forested areas	• Felling of trees should be avoided during the breeding season of birds and reptiles. If required a check by the Biodiversity Specialist will be required. • Noisy work should also be avoided at such times • Dead wood should be retained on site. • Forest should be reinstated/ replanted as specified within the ESIA and impacts should be addressed within the offsetting strategy.

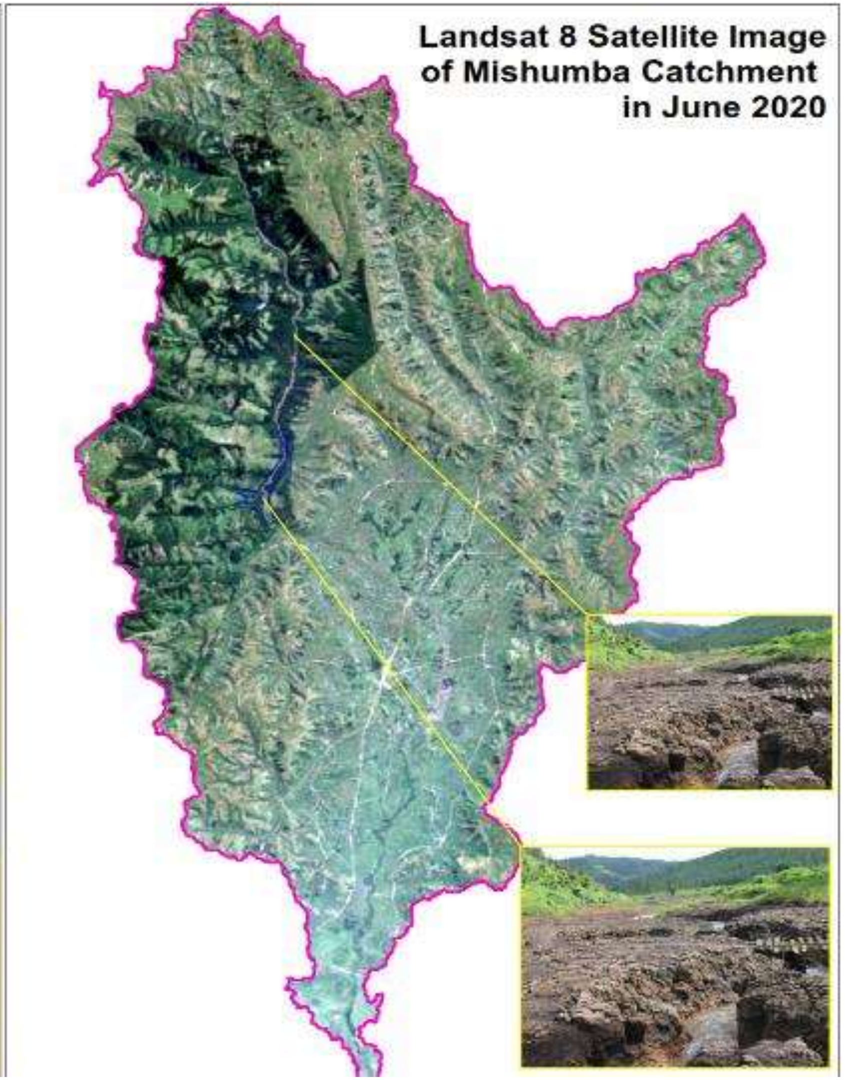
Annex 10: Monitoring Framework for Kabuyanda ICRP

Objectives / Targets (as per ToR)	Indicators	Means of Verification (Documented Evidence)	Frequency (Timeframe)	Assumptions	Responsible Entity
Defining the magnitude and extent of the impacts (environmental, social and ecological) of the planned operation of the Kabuyanda Dam, with an emphasis on key ecosystem services, aquatic and terrestrial biodiversity (such as fish, amphibians and macro-invertebrate species) and the downstream users	Total No. of persons / HHs accessing ecosystem services (provisioning & cultural benefits) at given time ***(Disaggregated by sex/ gender, river stretch, sub catchment, PAPs, magnitude & significance of impact, ecosystem services, coping mechanisms, project phase, fr)***	• Monitoring Tools (primary data collection) • BEMP MIS • DLG Department reports (Fisheries, Production, water, health, Roads, Agriculture Extension) • Social Safeguards Reports	• Monthly • Quarterly • Bi-annual • End of project phase (Construction)	The baseline conditions are taken into consideration as of January 2021	• MWE/ ICRP • DLG & LLGs • Community • CSOs
	No. of HHs collecting water from river streams (using clean, less dirty water) not affected by dam construction, operation & decommissioning	• Project committee reports • DLG Water Reports • Social Safeguards Reports	• Monthly • Quarterly • Bi-annual • End of project phase (Construction)	Access to safe water is very limited, and dependence open sources (river streams) is still dominant esp.	• MWE/ ICRP • DLG & LLGs • Community • NG
	No. of persons / HHs carrying out artisanal fishing for food & sale				
	No. of persons / HHs watering grazing livestock near rivers (watering points)				

Objectives / Targets (as per ToR)	Indicators	Means of Verification (Documented Evidence)	Frequency (Timeframe)	Assumptions	Responsible Entity
	No. of persons / HHs cultivating within swamps and buffer zones			upstream and downstream	
	No. of persons / HHs actively engaged in aquaculture (fish ponds)				
	No. of persons / HHs accessing firewood sources				
	No. of persons / HHs moving across river (bridge)				
	No. of homesteads / human settlements within irrigable area				
	Cultural good and other non-material benefits				
	Fauna				
	Number of fauna species	Biodiversity inventory reports	Twice a year (once in dry and once in wet season)		MWE / DLG / Hired Consultants
	Number of individuals of each species seen	Biodiversity inventory reports	Twice a year (once in dry and once in wet season)		MWE / DLG / Hired Consultants
	Number of fauna species using habitat	Biodiversity inventory reports	Twice a year (once in dry and once in wet season)		MWE / DLG / Hired Consultants
	Number of fauna species in 20m buffer per 1 Kilometre of distance along the Mushumba river and its tributaries	Biodiversity inventory reports	Twice a year (once in dry and once in wet season)		MWE / DLG / Hired Consultants

Annex 11: Past Current and Satellite Images (25th March 2021) of River Mishumba from Upstream (dam area) to downstream (River Kagera)





Past and Current Images of sections of River Mishumba Catchment (Before May 2020 and After May 2020

Annex 12: Screening of timeseries data

The screening of the data acquired from the main design report was done by undertaking trend analyses using both the Mann-Kendall and Sen's slope analyses. The Mann-Kendall non-parametric test (M-K) was conducted to investigate the presence of trends in the annual series. The M-K test statistic S is calculated using the formula:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k)$$

$$\operatorname{sgn}(x_j - x_k) = \begin{bmatrix} +1 \\ 0 \\ -1 \end{bmatrix} \begin{Bmatrix} x_j - x_k > 0 \\ x_j - x_k = 0 \\ x_j - x_k < 0 \end{Bmatrix}$$

Where x_j and x_k are the annual values in years j and k, j > k, respectively.

If n < 10, the value of S is compared directly to the theoretical distribution of S derived by Mann and Kendall. For n >= 10, the statistic S is approximately normally distributed with the mean and variance as follows:

$$E(S) = 0$$

$$VAR(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{a} t_p (t_p - 1)(2t_p + 5) \right]$$

Where q is the number of tied groups; tp is the number of data values in the pth group.

The standard test statistic Z is computed as follows:

$$Z = \begin{Bmatrix} \frac{S-1}{\sqrt{VAR(S)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & if\ S < 0 \end{Bmatrix}$$

Sen's Slope estimator test

Non-parametric method (Sen, 1968) was used to estimate the magnitude of trends in the data series. The slope of "n" pairs of data w:

$$\beta_i = Median \left[\frac{X_j - X_k}{i - k} \right] \forall (k < j)$$

In this equation, Xj and Xk denote values of data at time j and k, respectively, and time j is after time k. The median of "n" values of the bi is the Sen's slope estimator. A negative bi value represents a decreasing ternd, a positive bi represent an increasing trend over time.

If "n" is an even number, then the slope Sen's estimator is computed by using the following equation:

$$\beta_{med} = \frac{1}{2} \beta_{n/2} + \beta_{(n+2)/2}$$

If "n" is an odd number, then the estimated slope by using the Sen's method can be computed as follows:

$$\beta_{med} = \beta_{(n+1)/2}$$

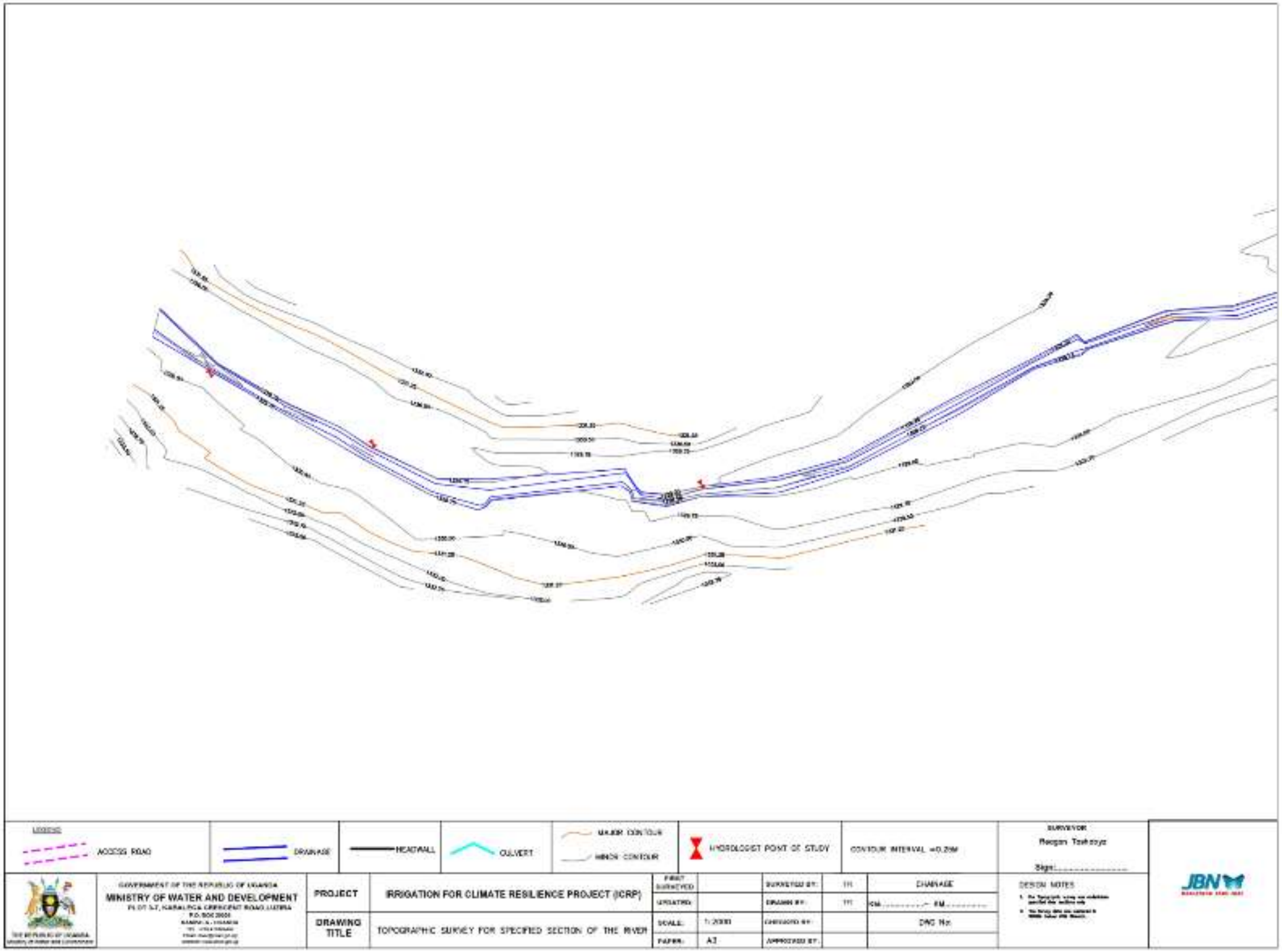
β_{med} was then tested by a two tailed test at 100(1-α) % confidence level, and the true slope of monotonic trend is confirmed or not to be significant.

Annex 13: Topographic Survey

Topographic Surveys

February 2021

Topographic Maps for the River section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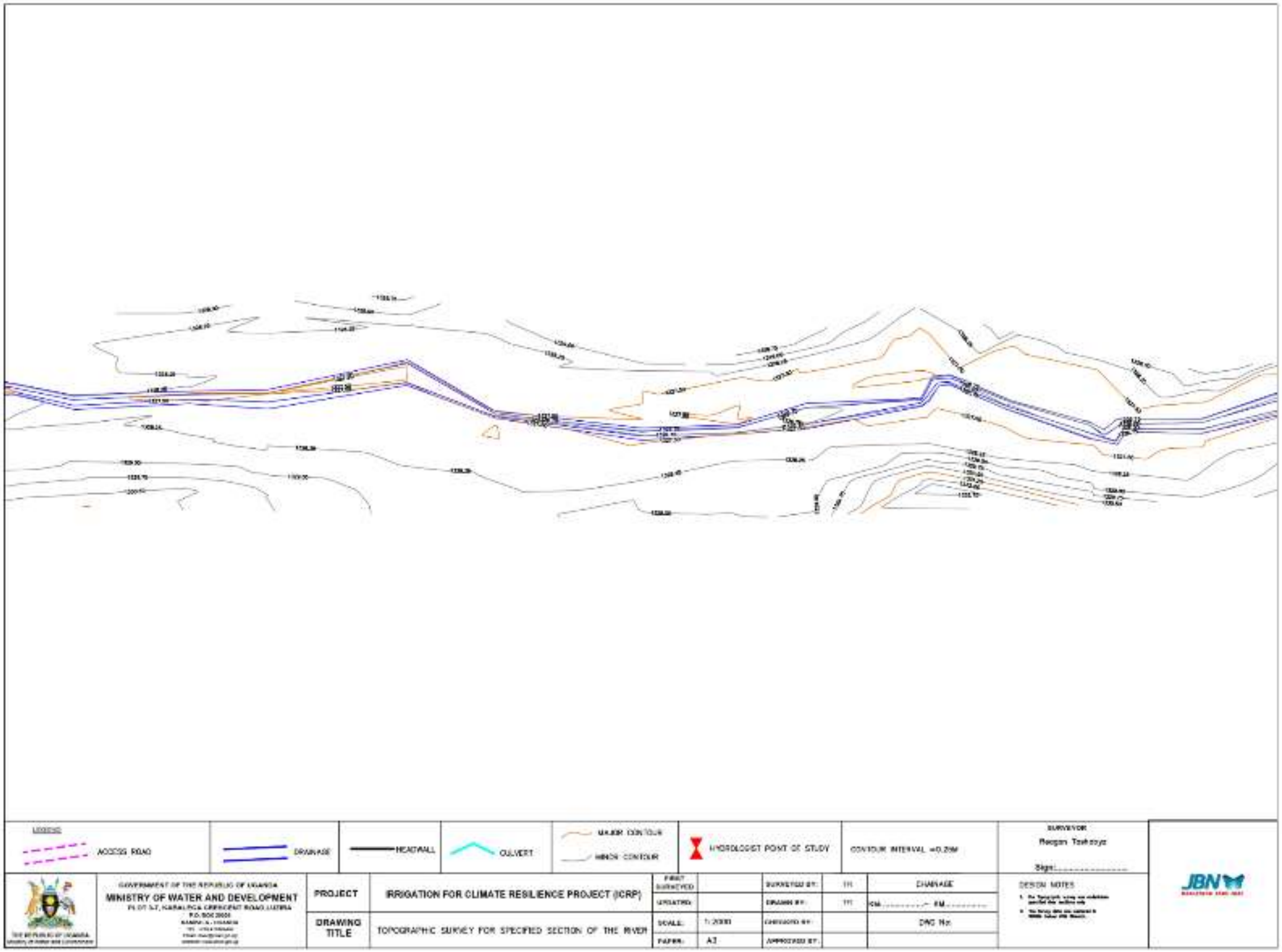
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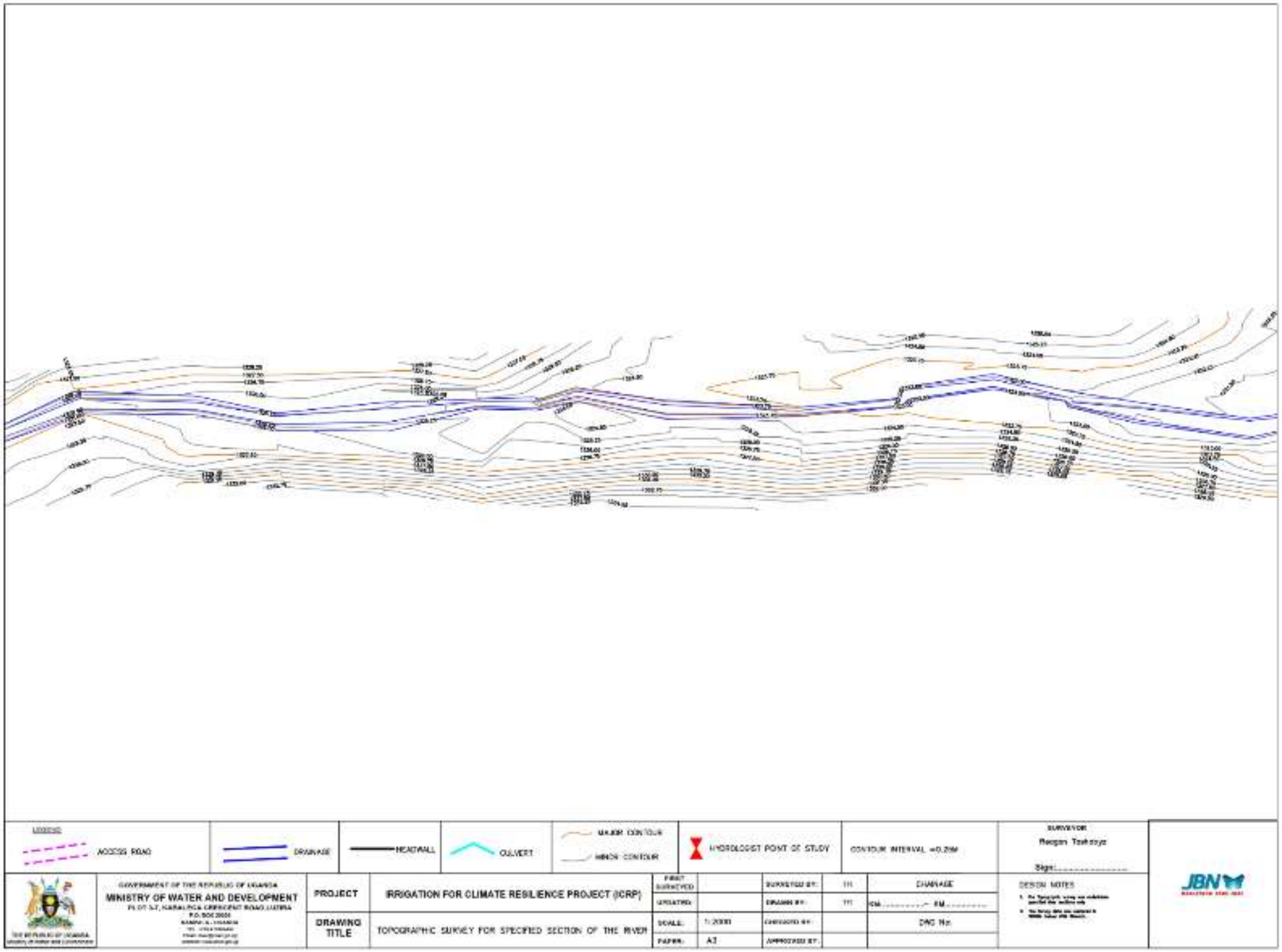
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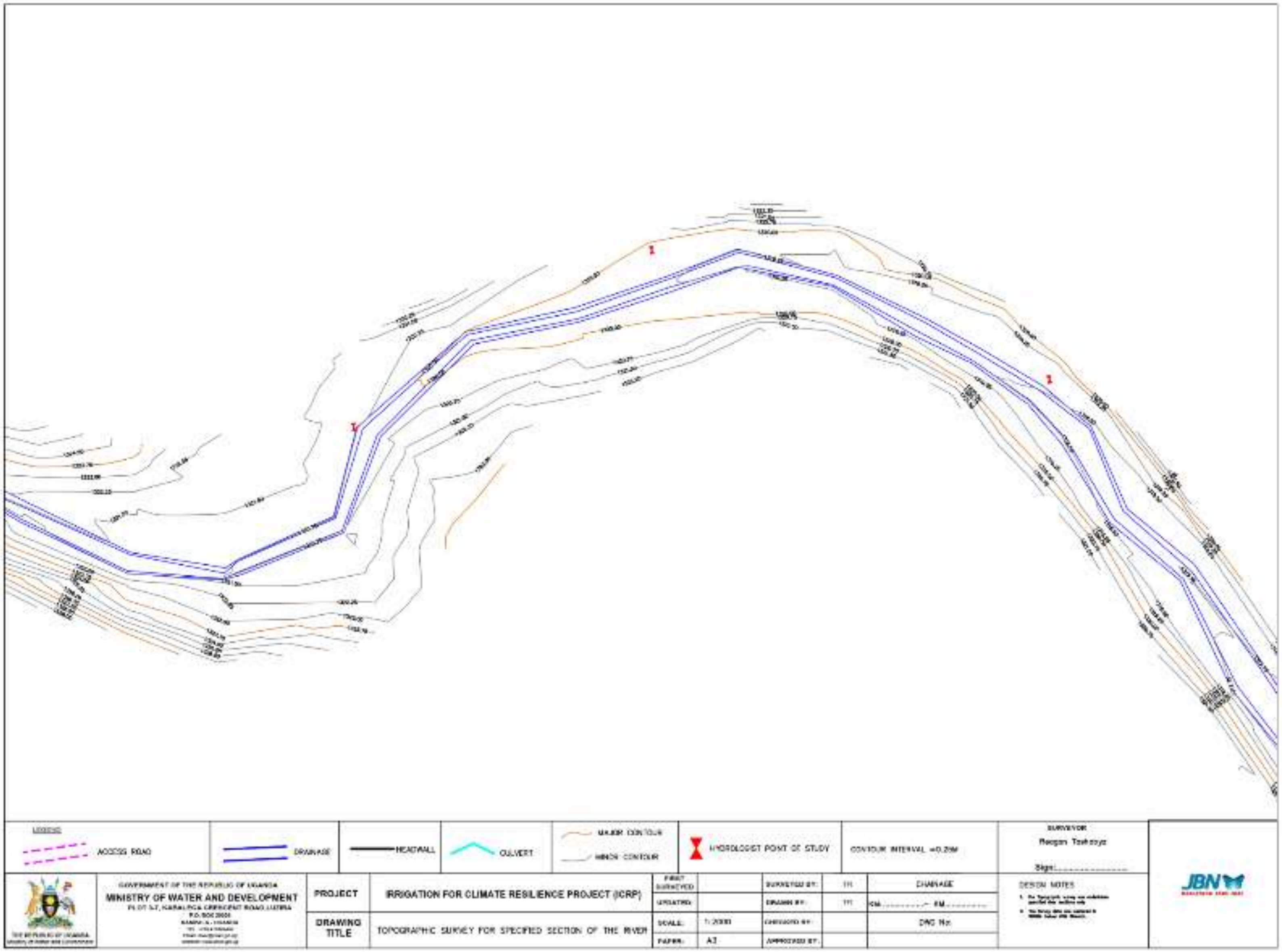
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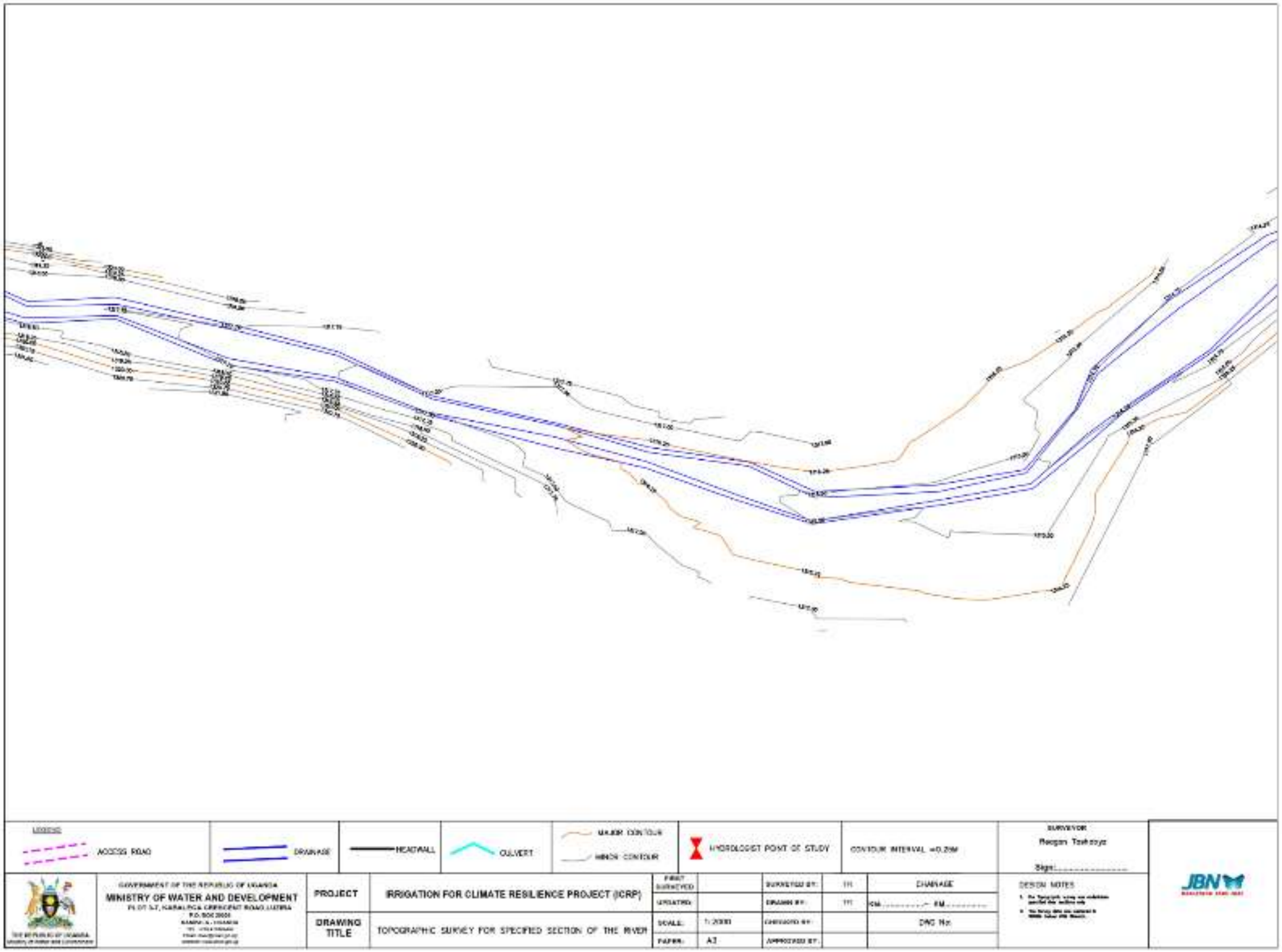
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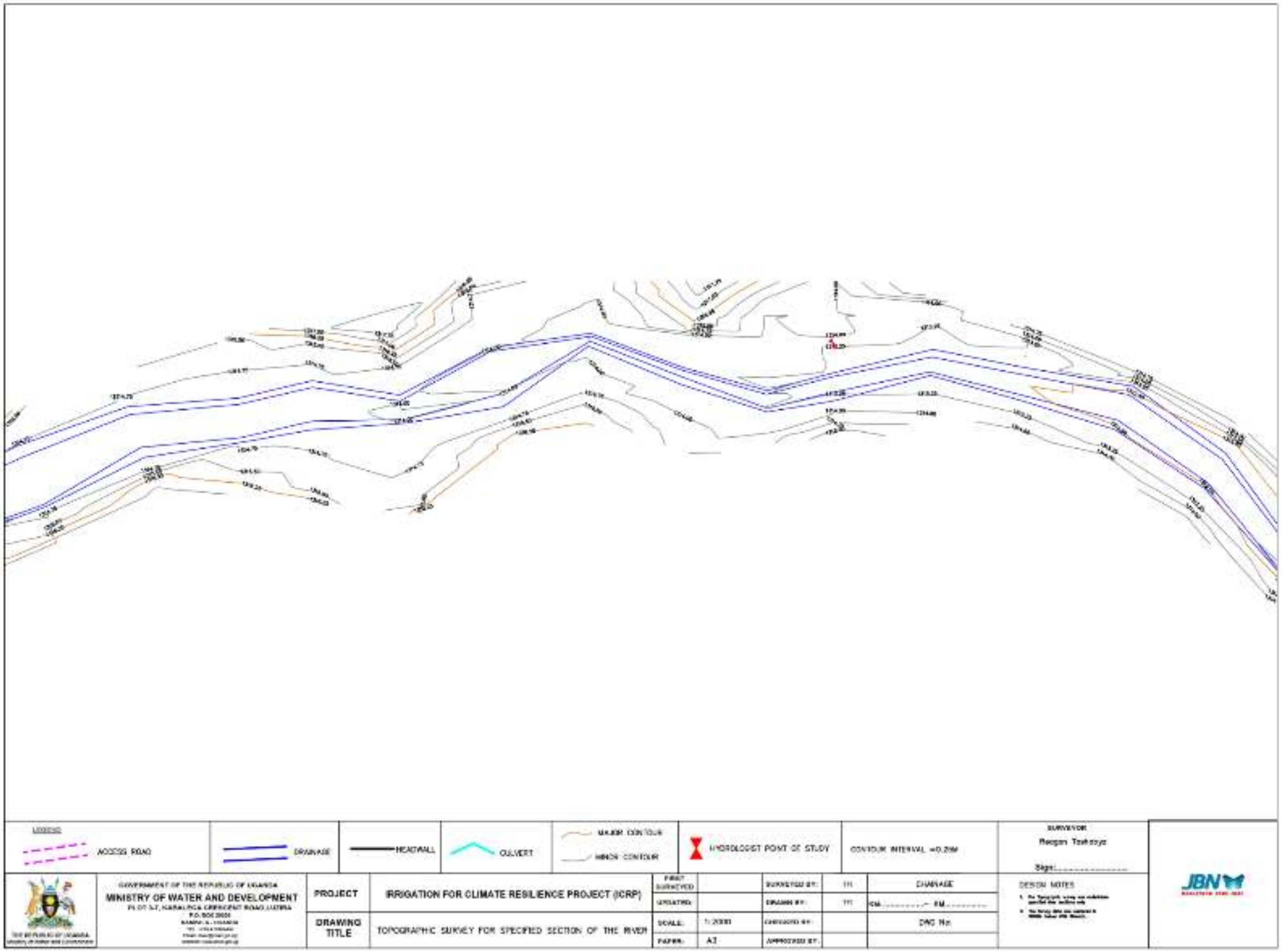
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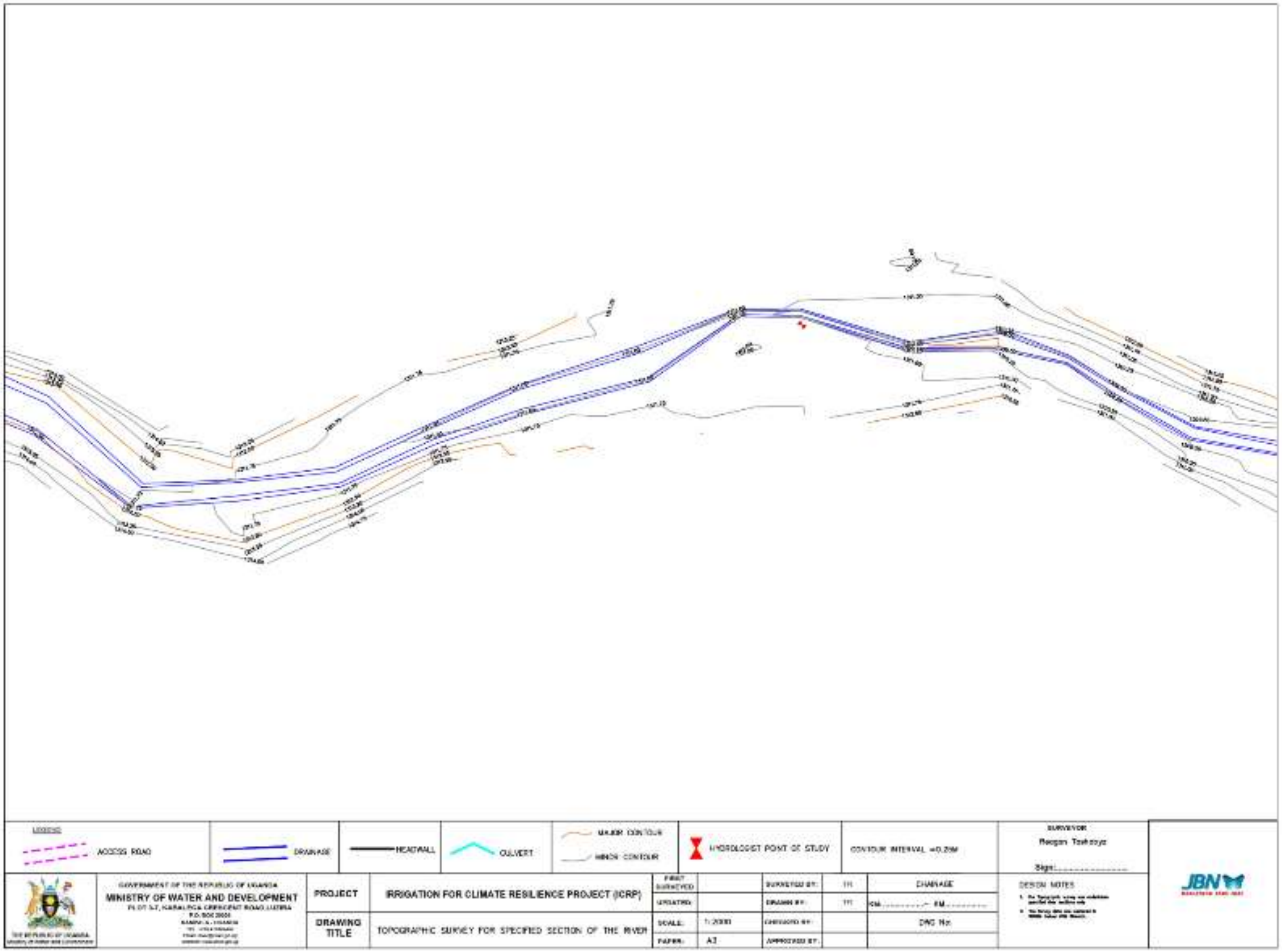
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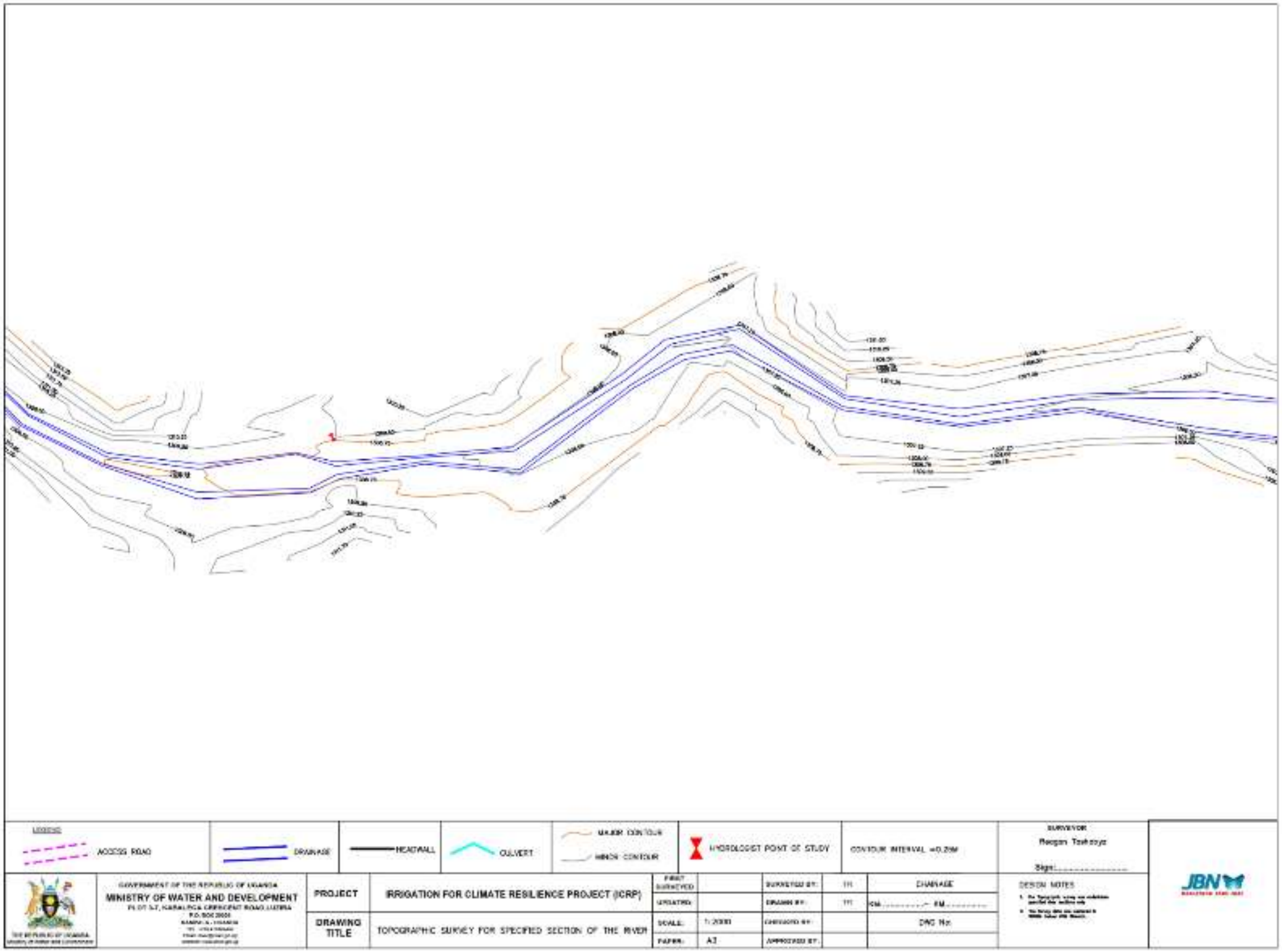
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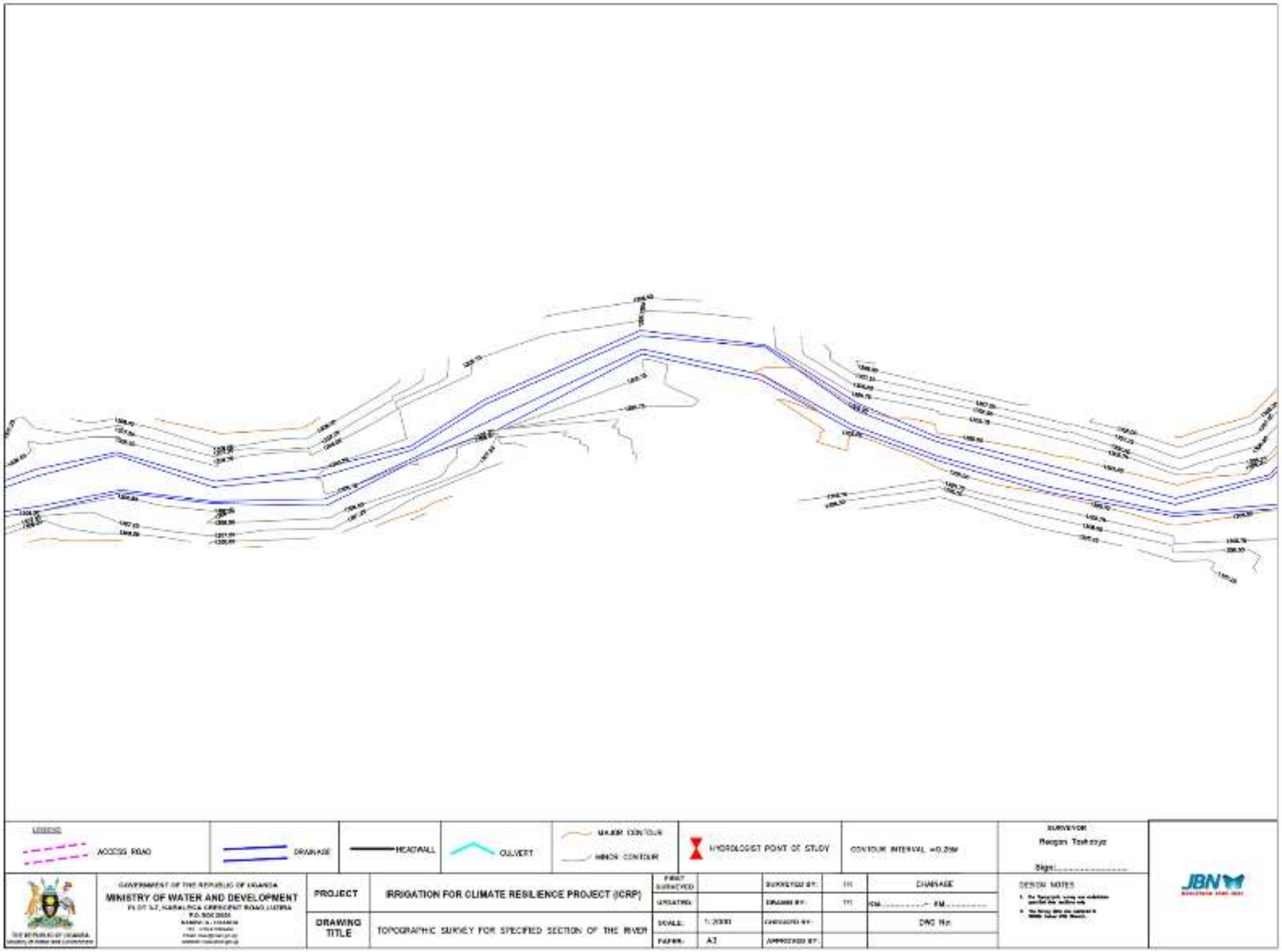
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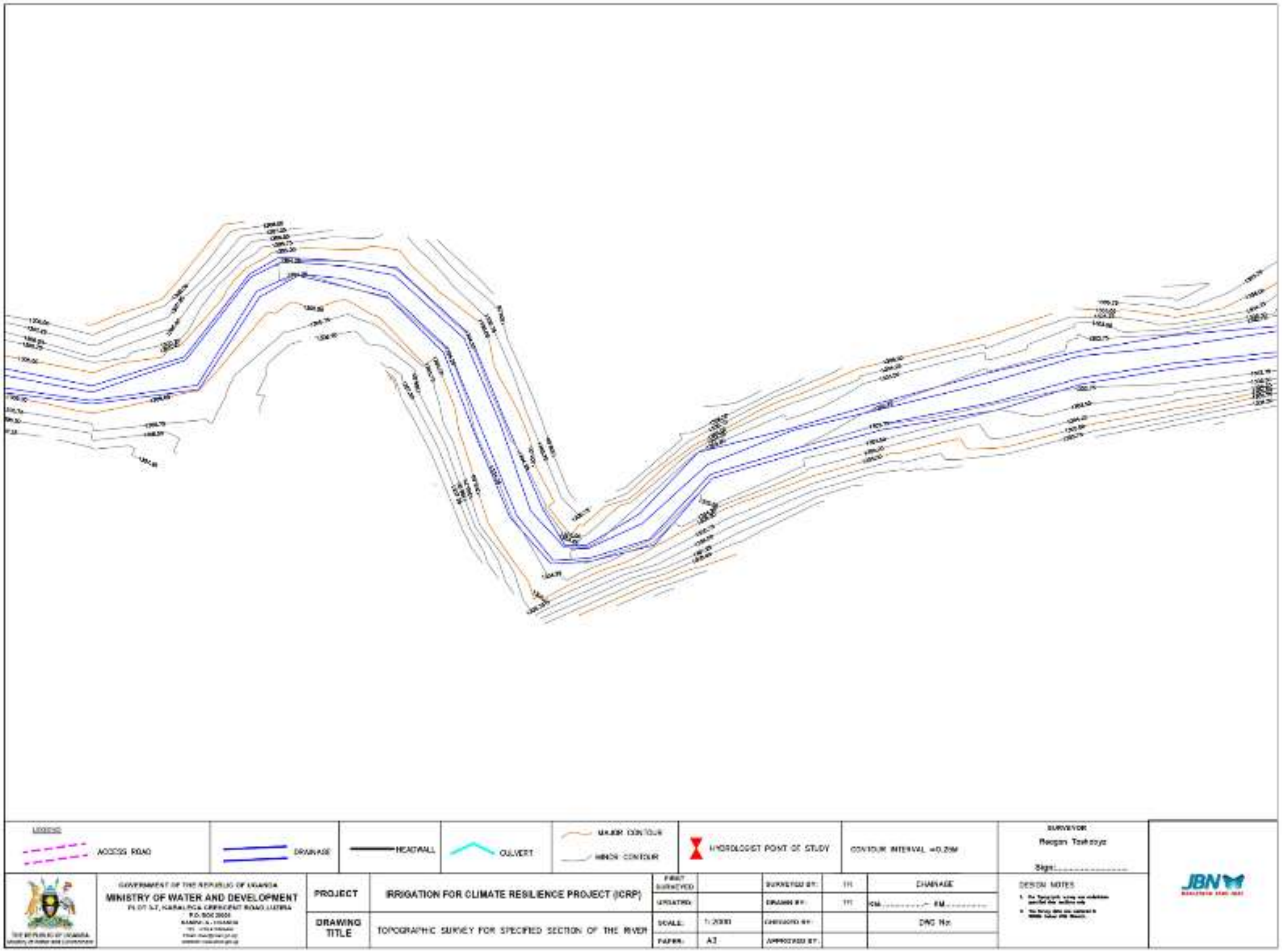

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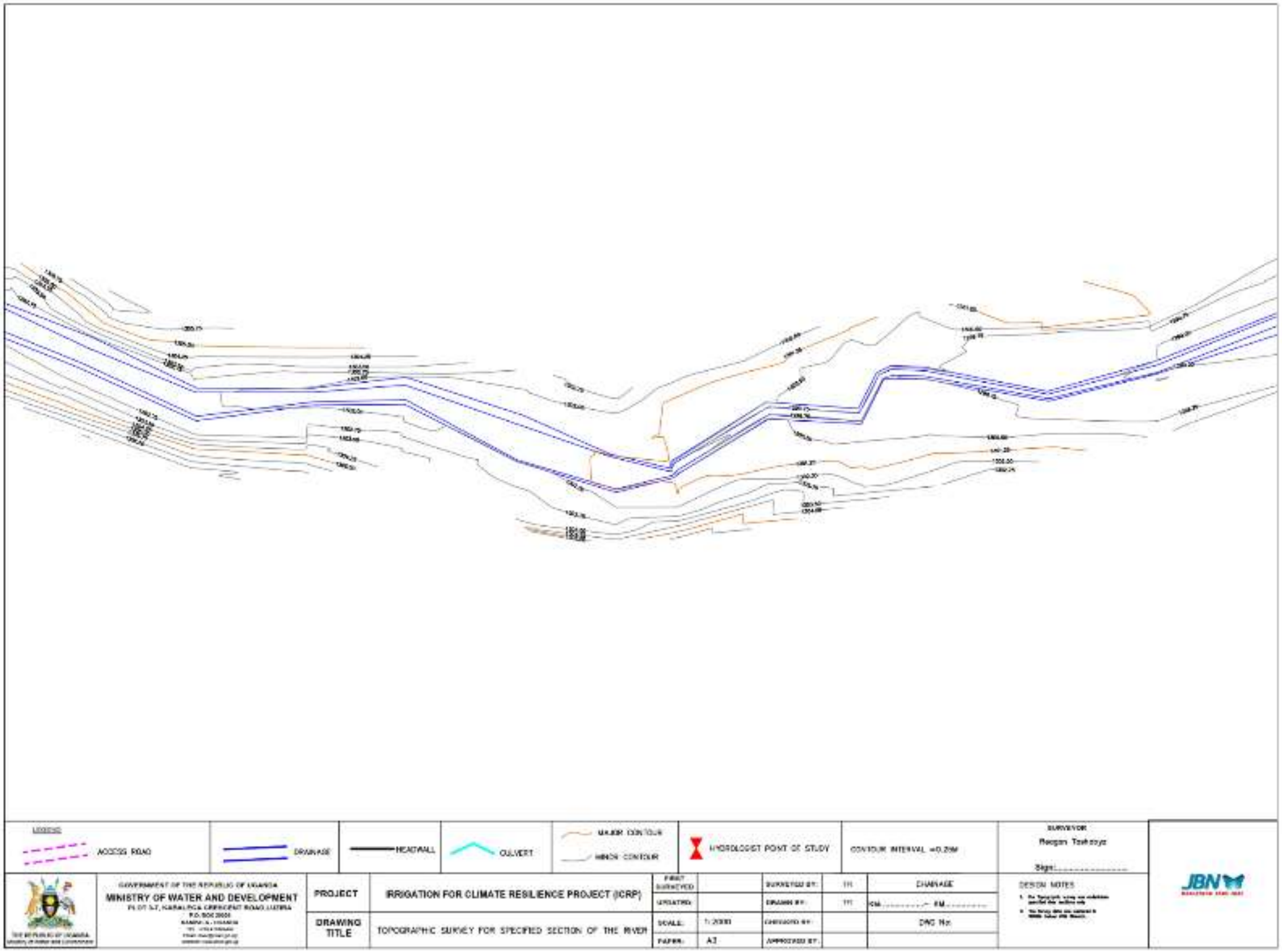
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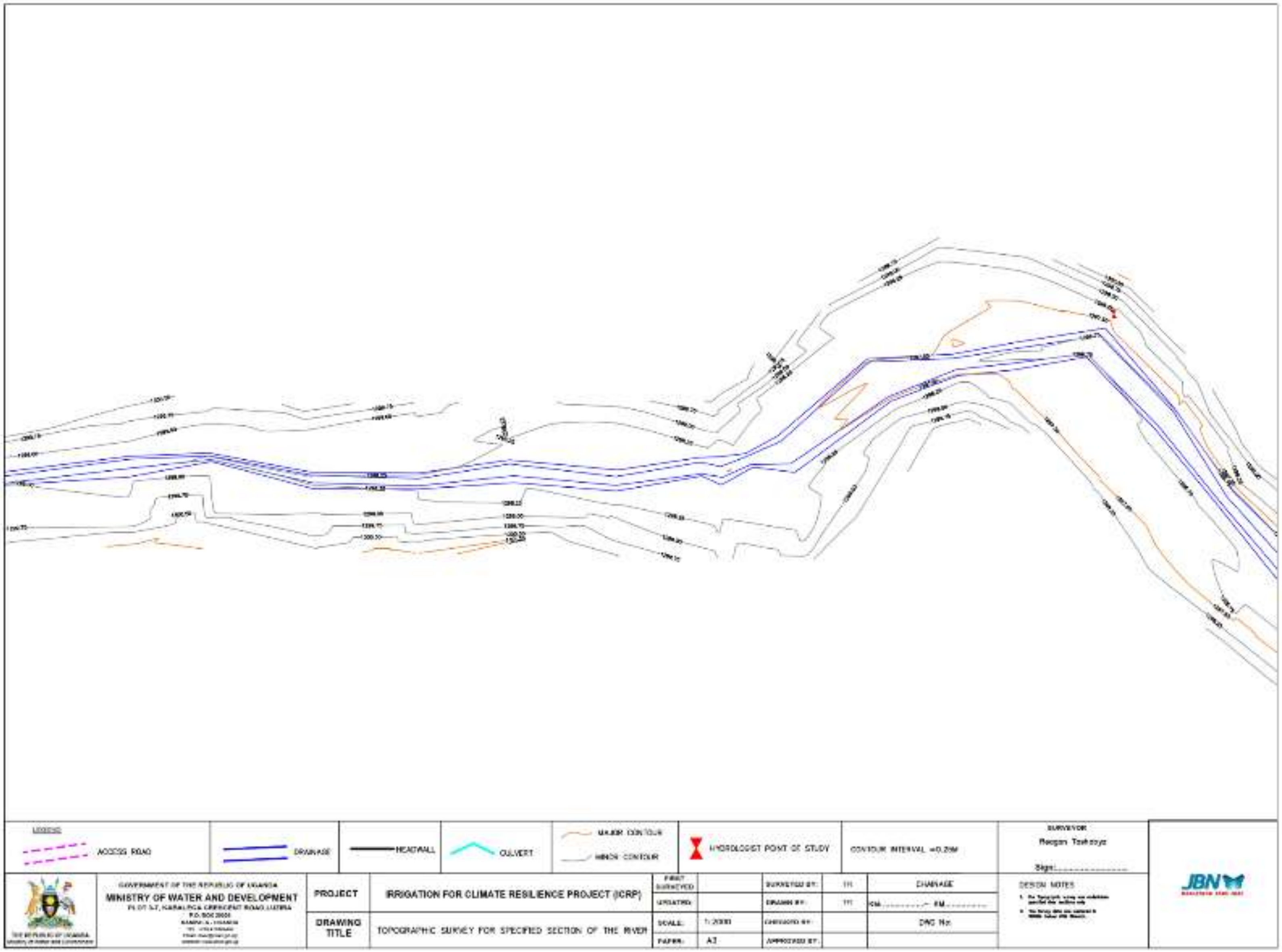
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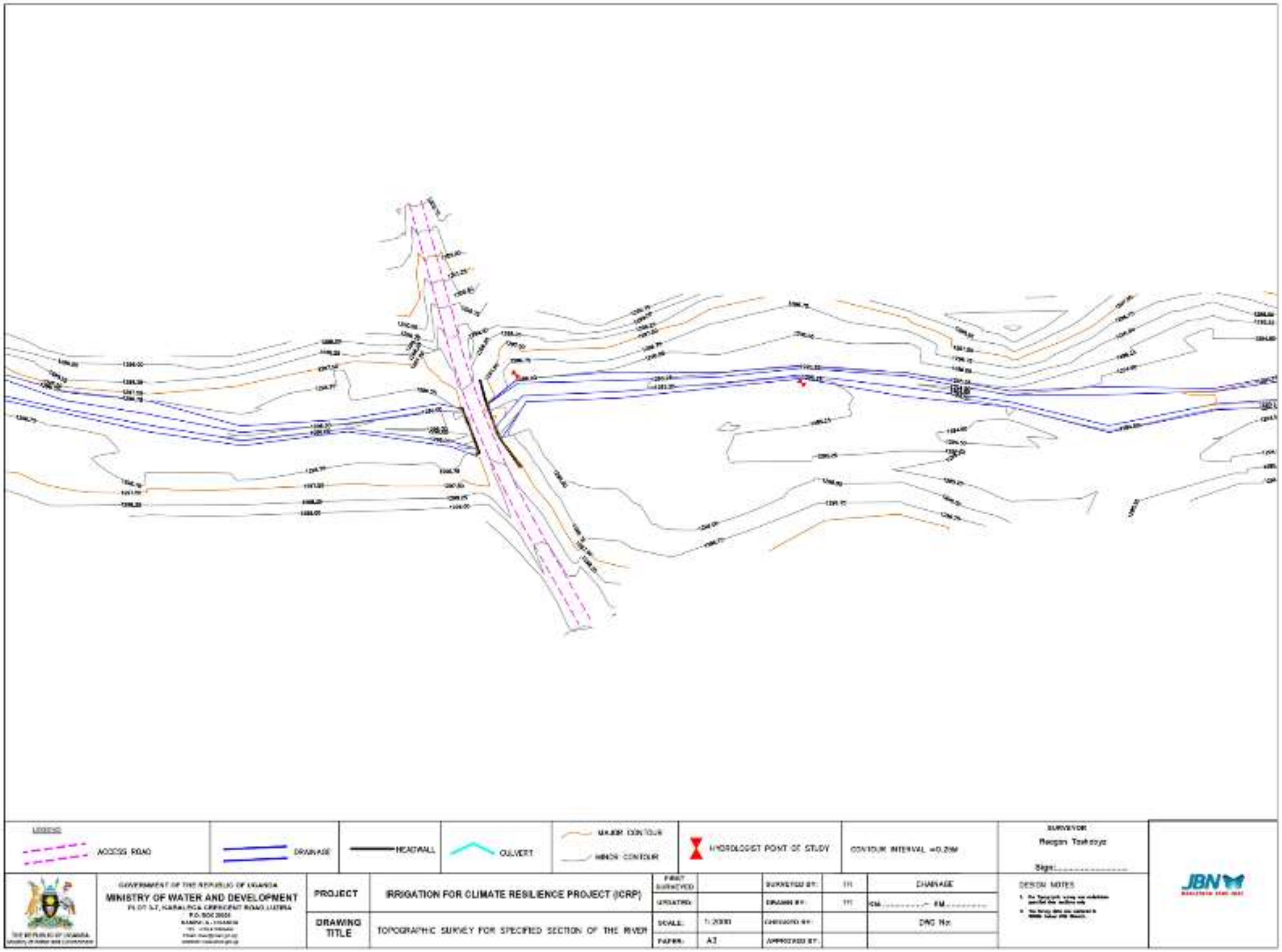
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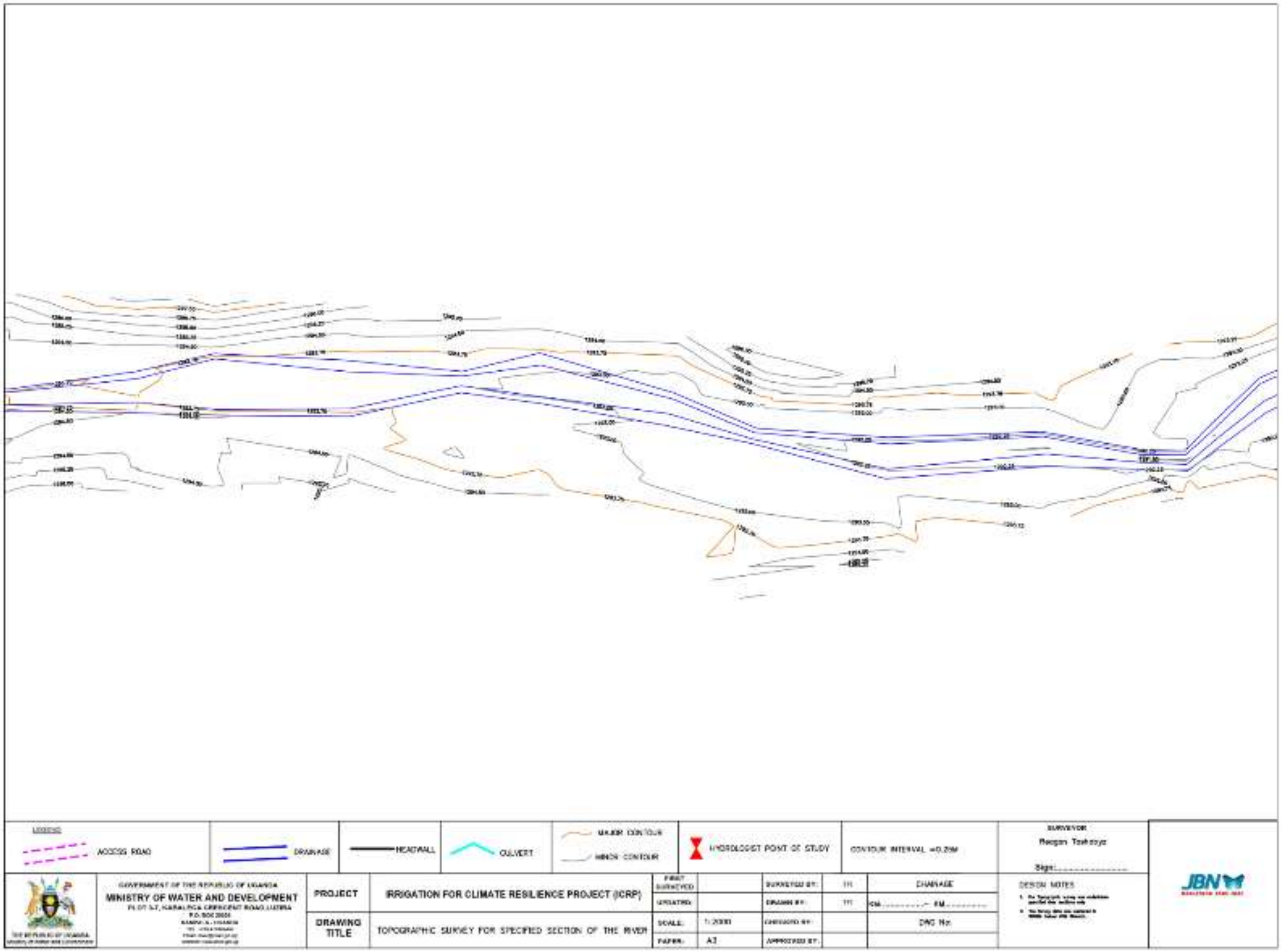
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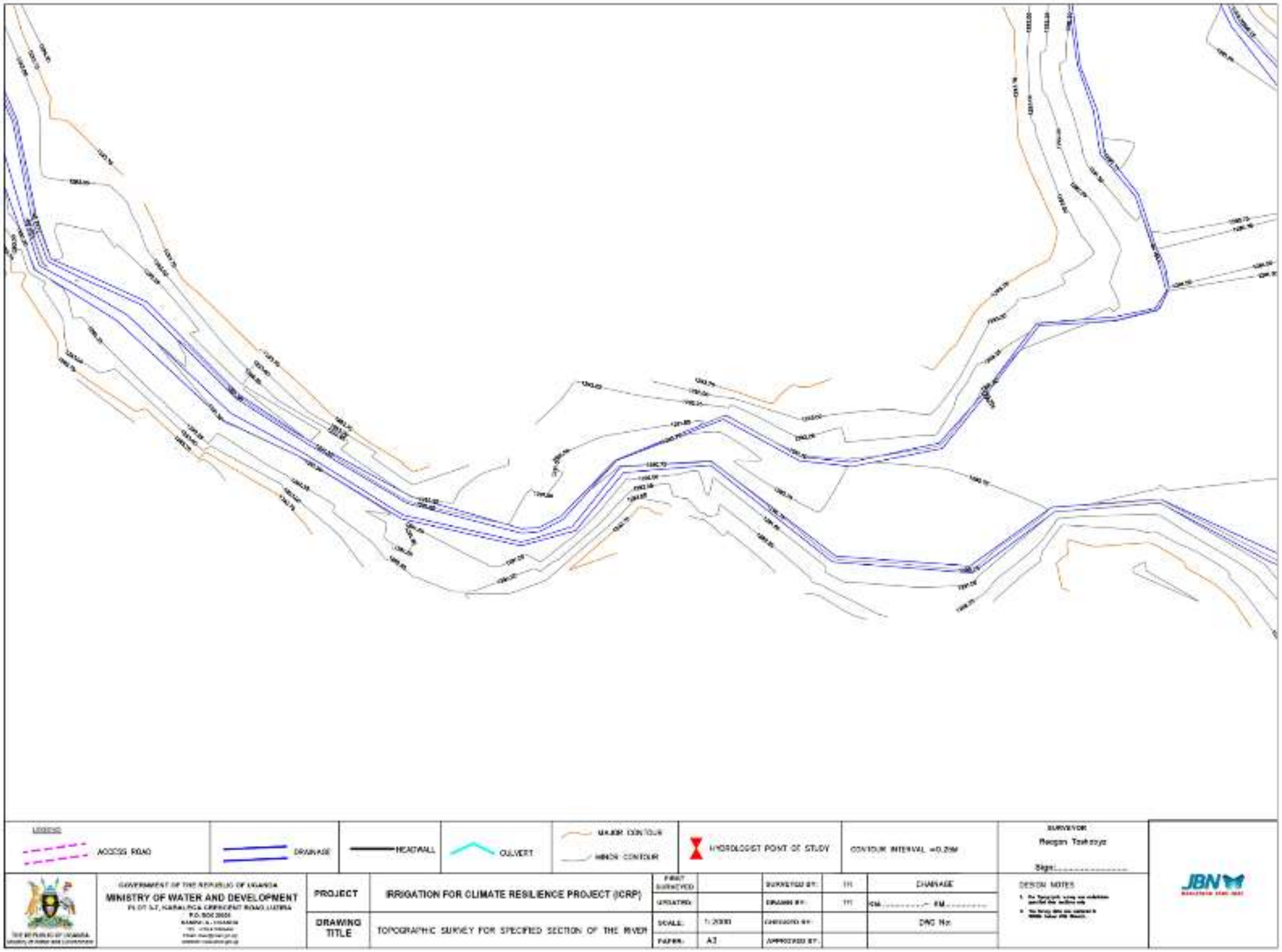
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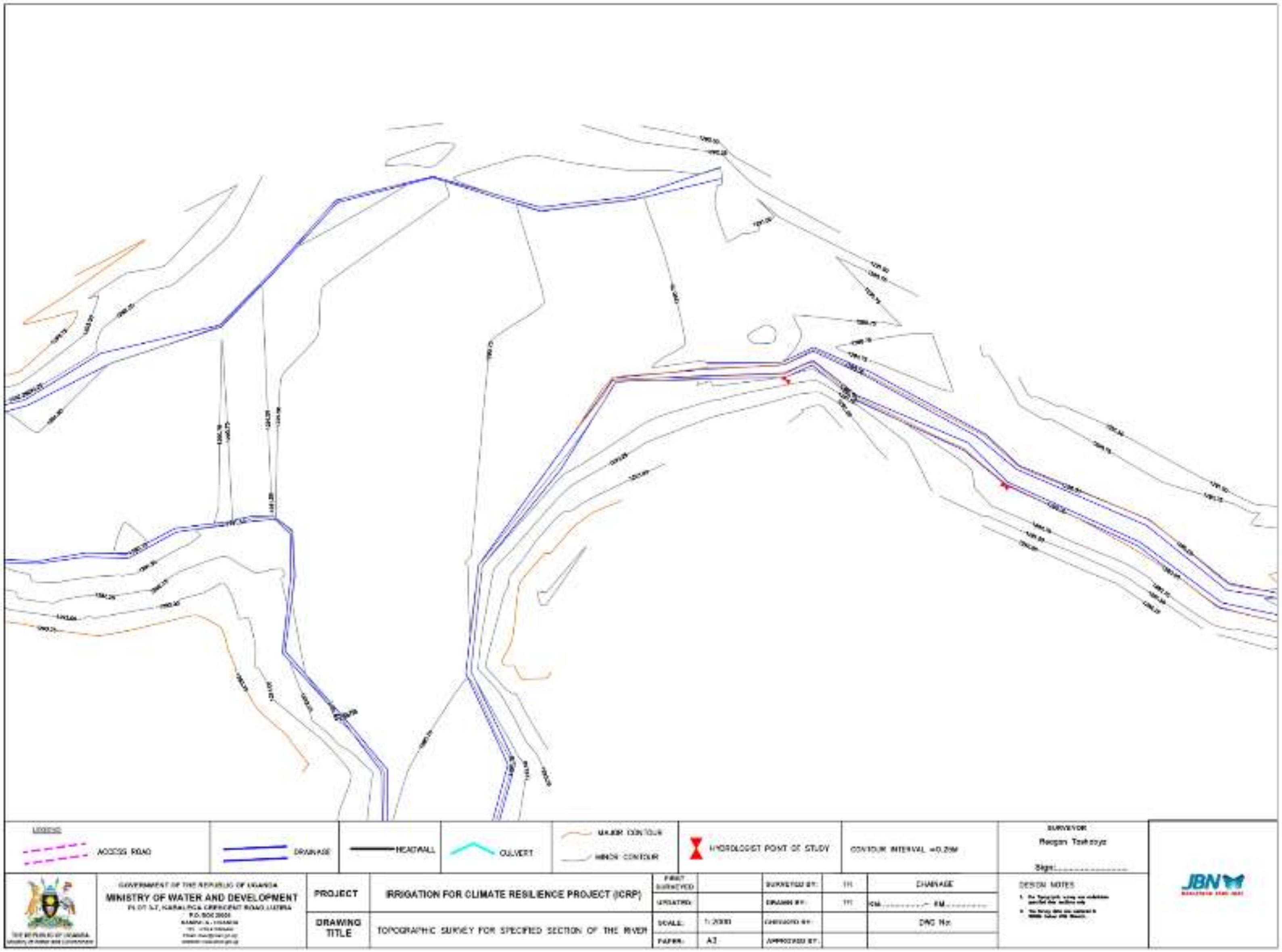
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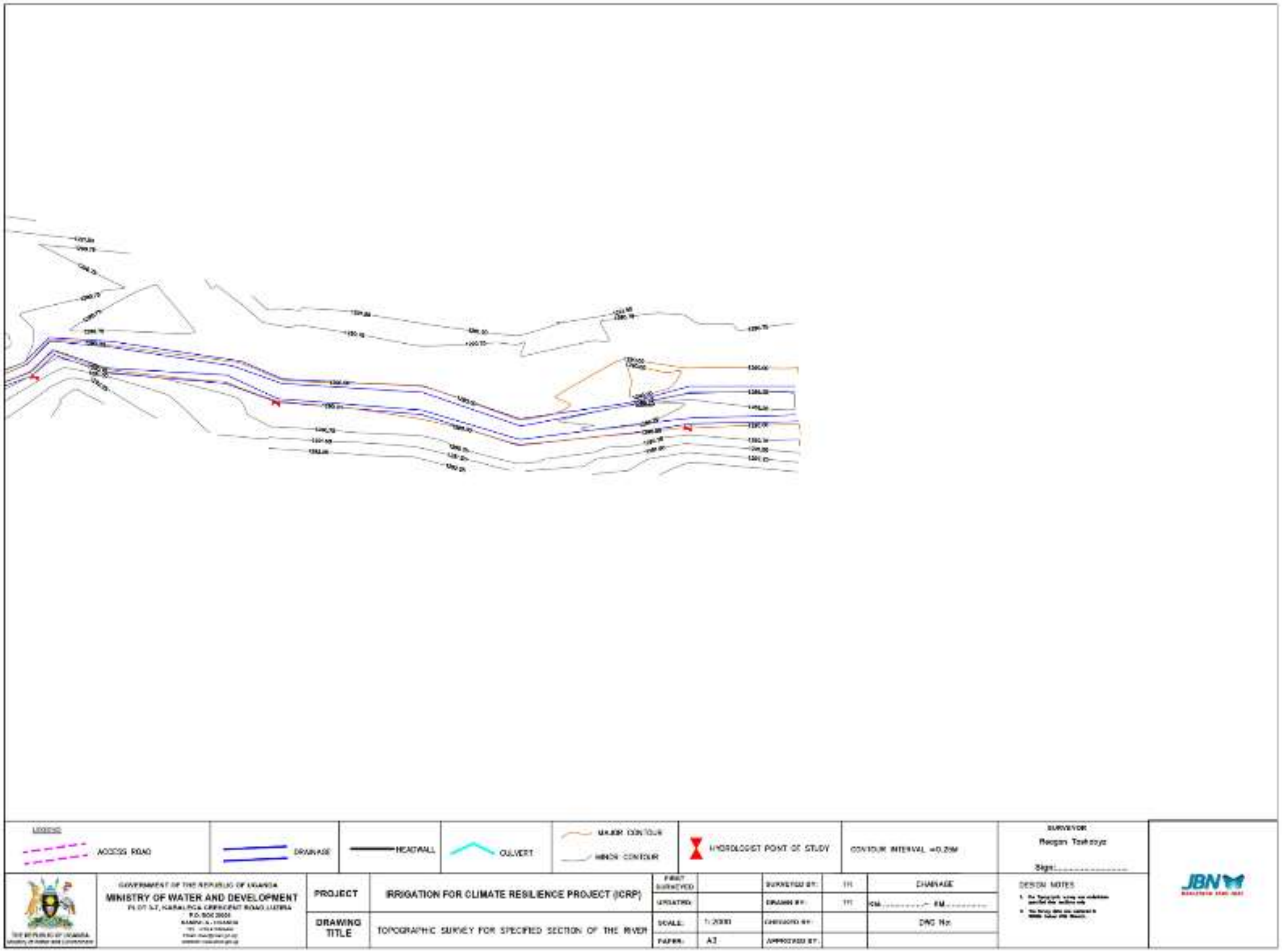
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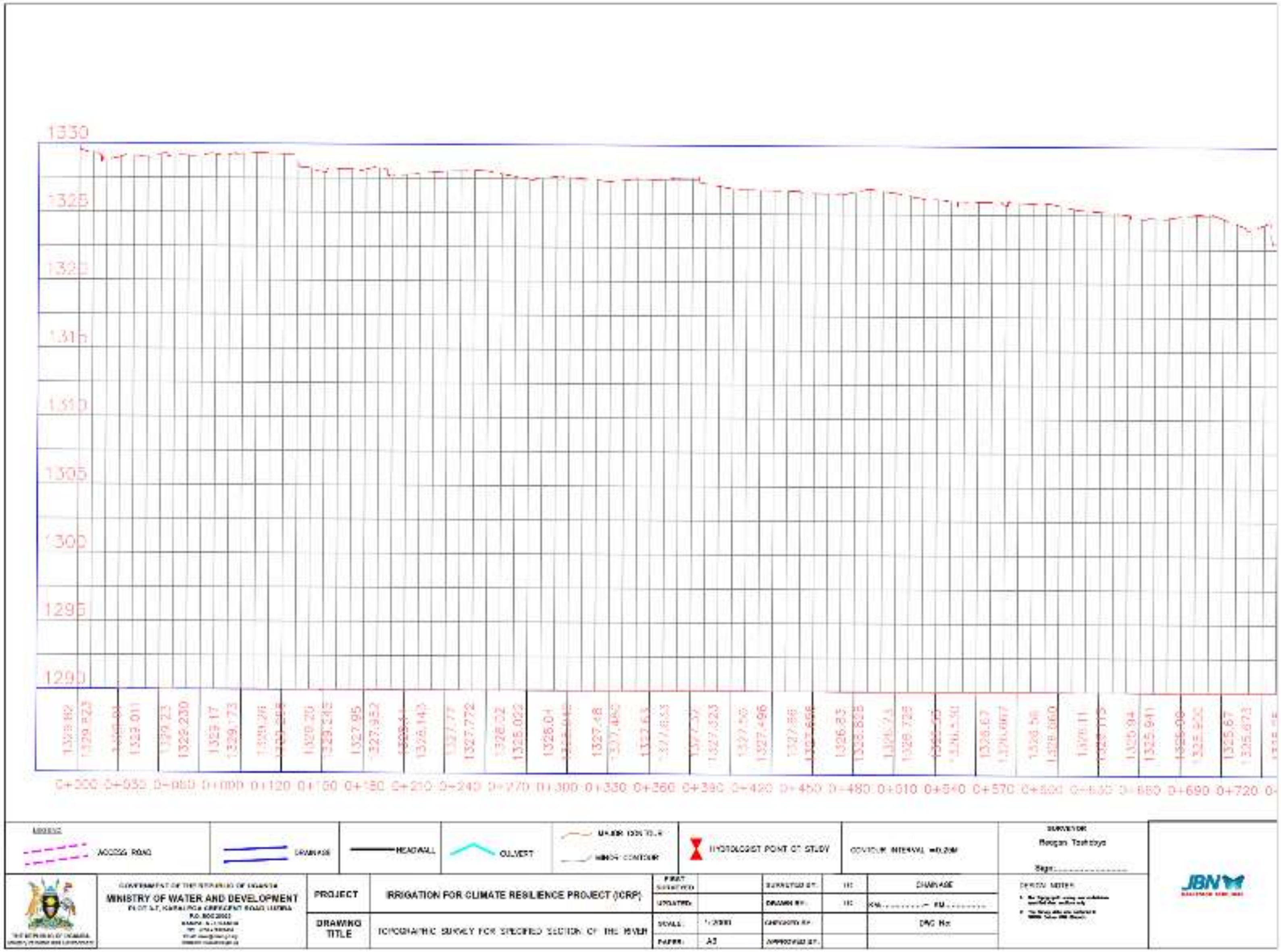
Topographic Surveys

February 2021

Section Profiles of River Mishumba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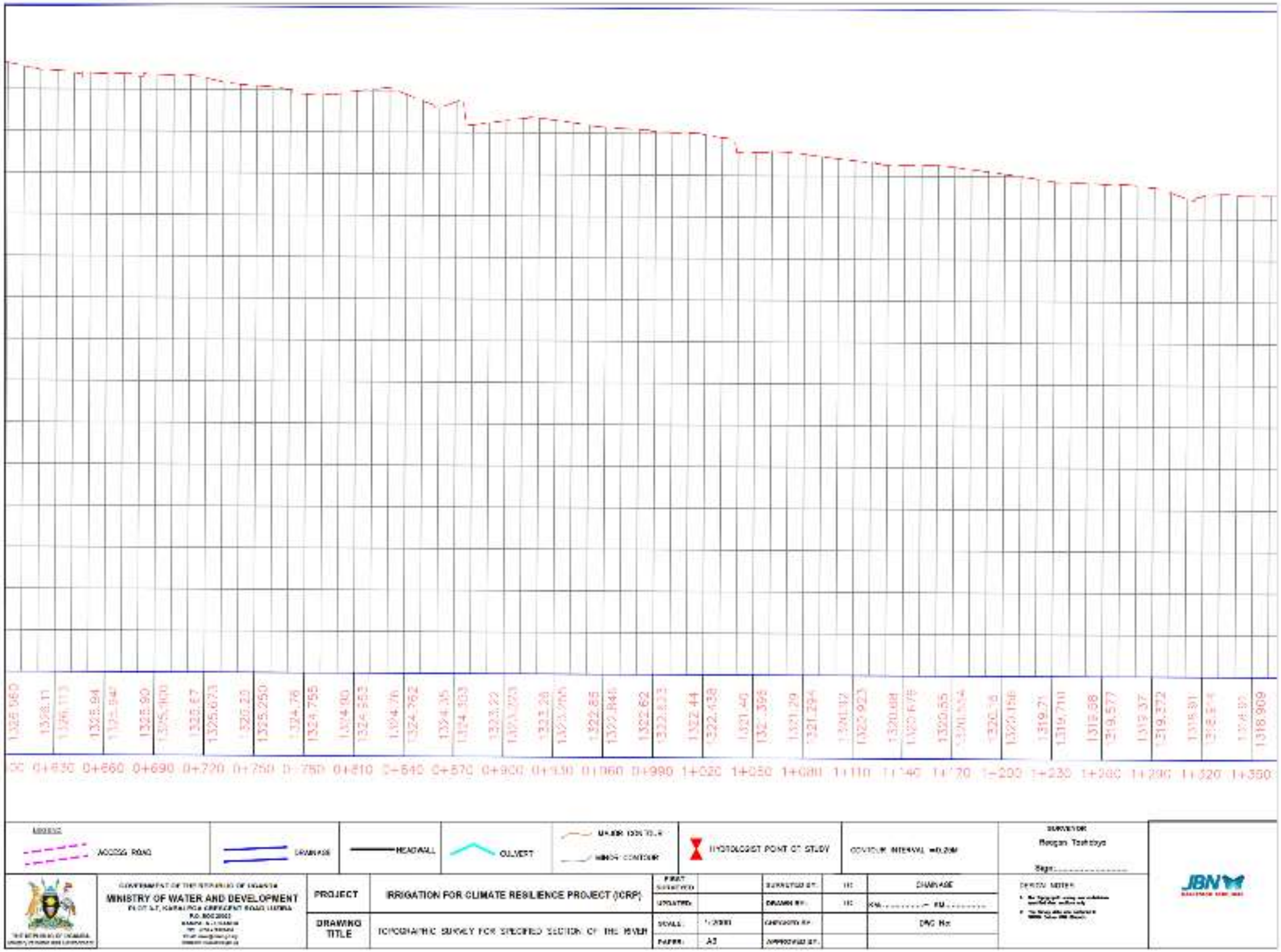
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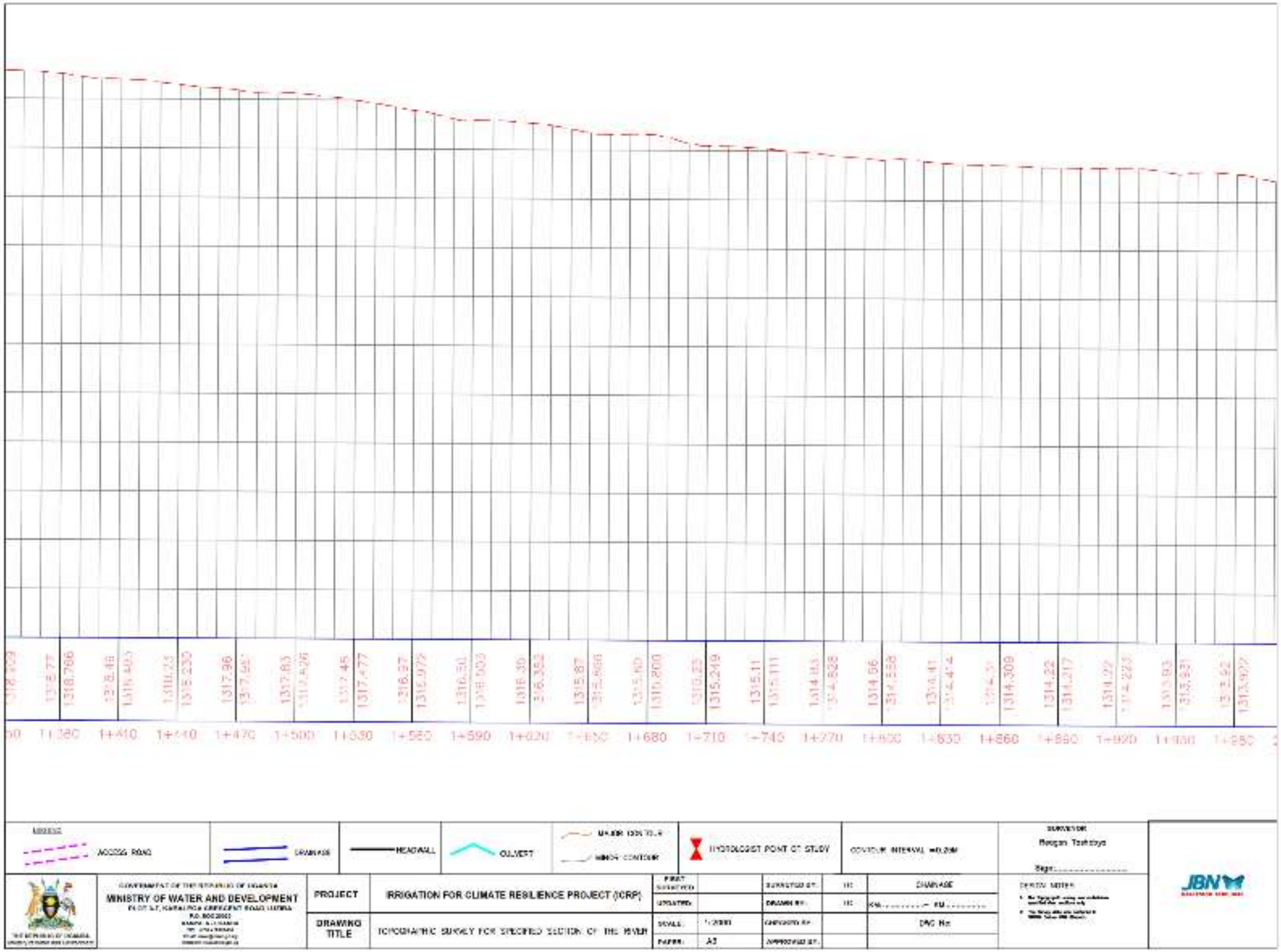

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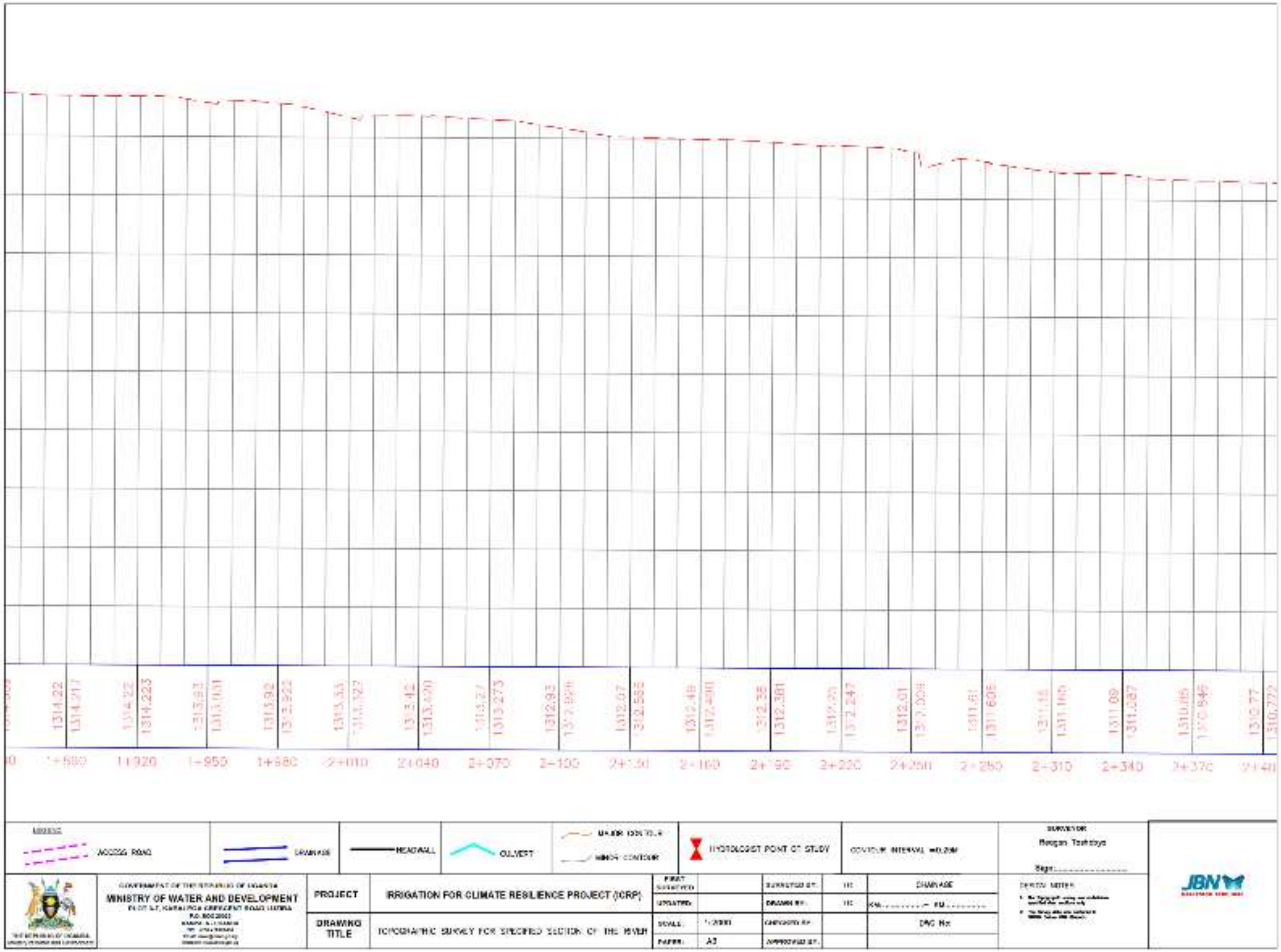

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2+160
2+220
2+250
2+280
2+310
2+340
2+370
ACCESS ROAD
DRAINAGE
HEADWALL
CULVERT
MAJOR CONTOUR
MINOR CONTOUR
HYDROLOGIST POINT OF STUDY
CONTOUR INTERVAL =0.20M
SURVEYOR
MINISTRY OF WATER AND DEVELOPMENT
PROJECT
IRRIGATION FOR CLIMATE RESILIENCE PROJECT (ICRP)
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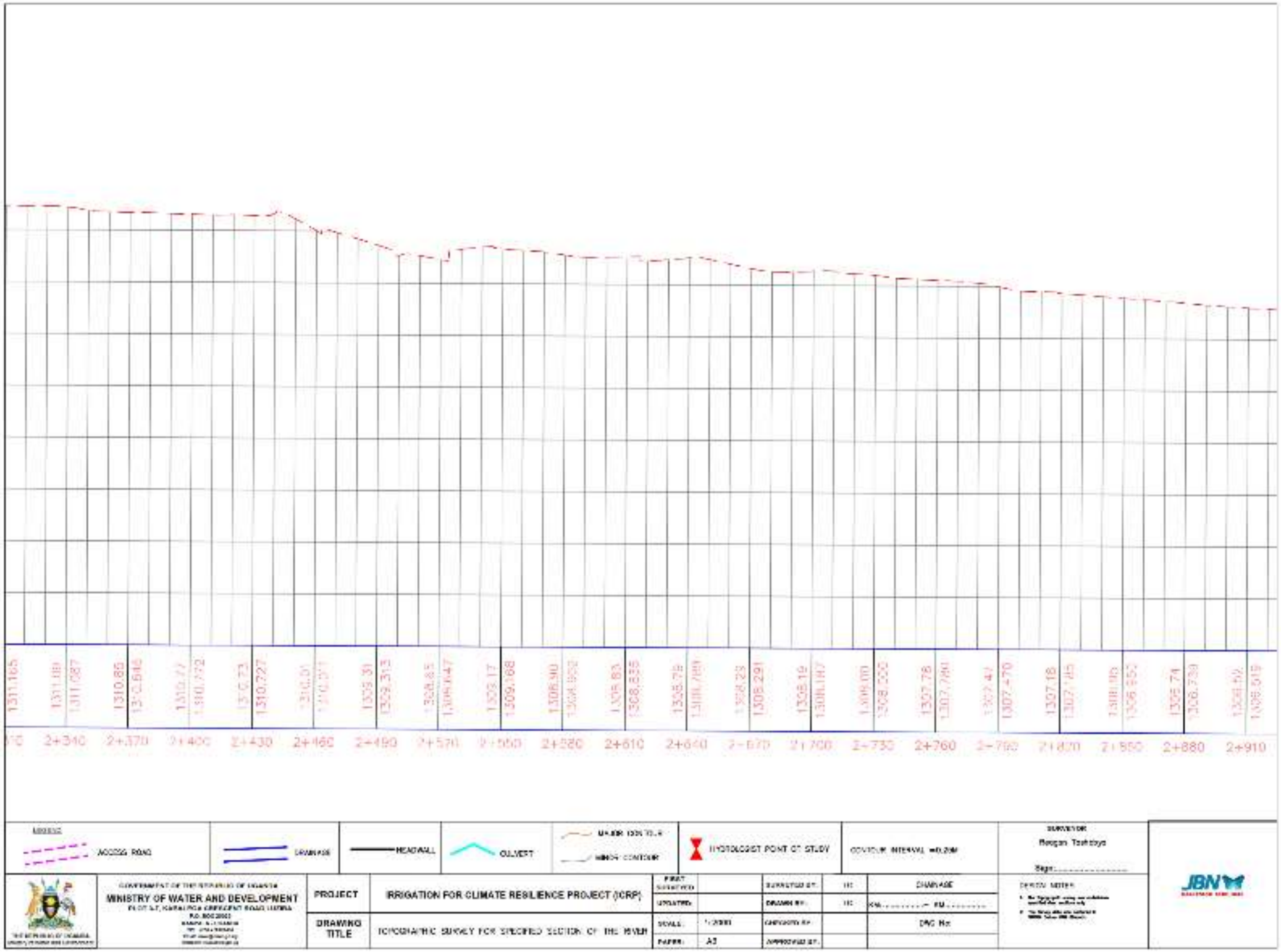
SCALE
PAPER
A3
CHAINAGE
DWG No
JBN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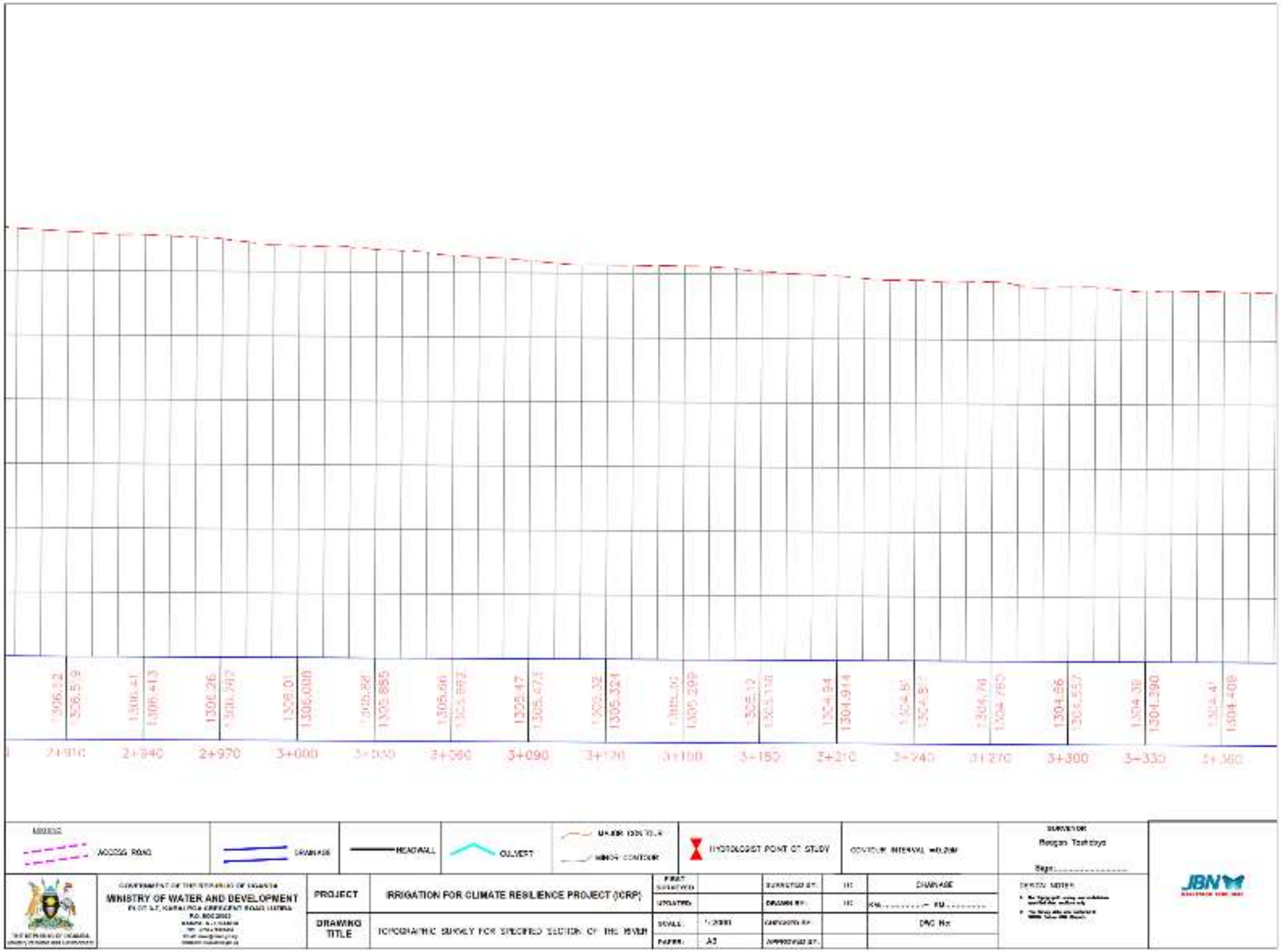
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2+940
2+970
3+000
3+090
3+300
ACCESS ROAD
DRAINAGE
HEADWALL
CULVERT
HYDROLOGIST POINT OF STUDY
MINISTRY OF WATER AND DEVELOPMENT
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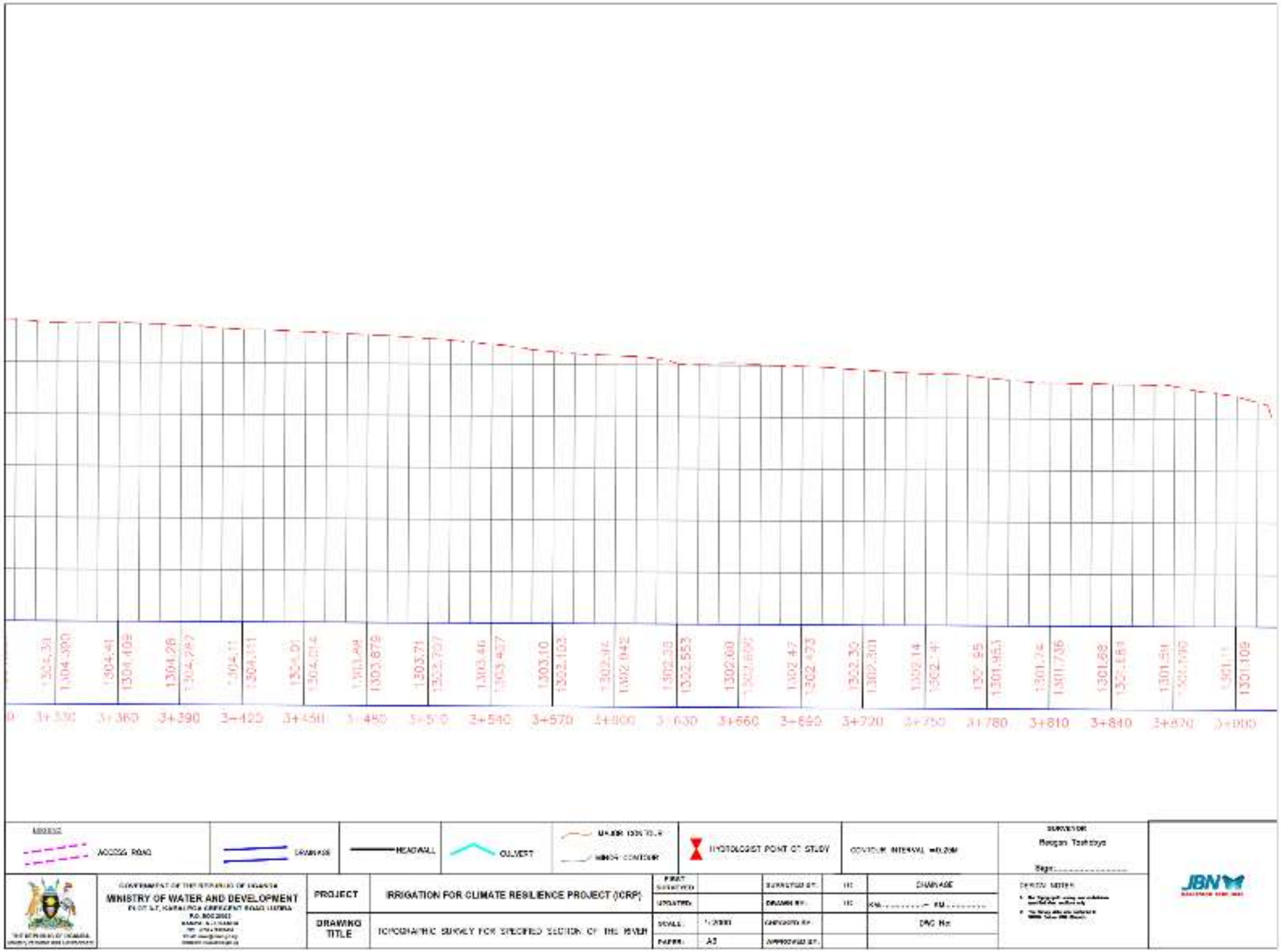

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3+570
3+660
3+720
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3+810
3+840
ACCESS ROAD
HEADWALL
CULVERT
HYDROLOGIST POINT OF STUDY
CONTOUR INTERVAL =0.20M
MINISTRY OF WATER AND DEVELOPMENT
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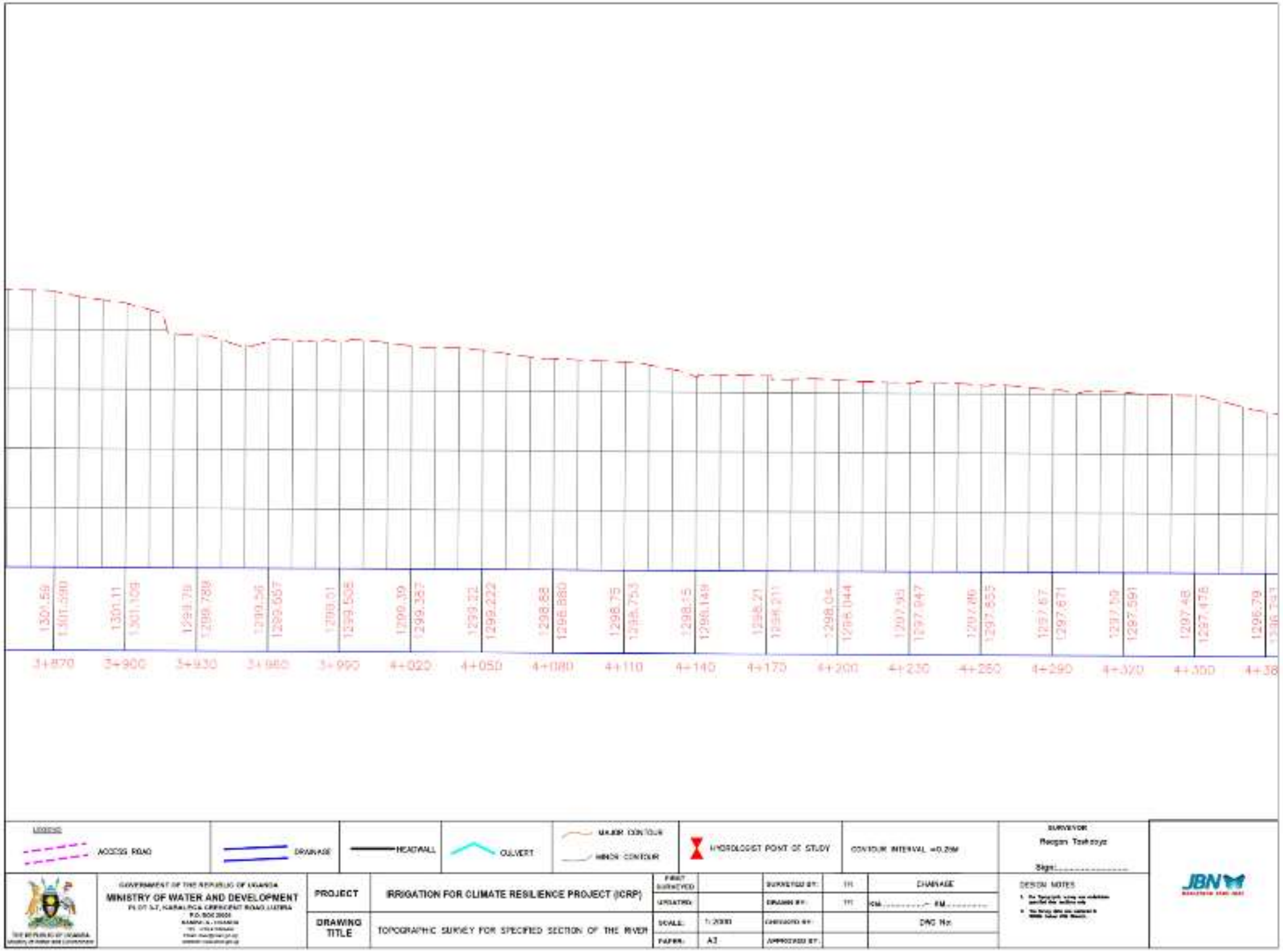
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4+080
4+110
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4+230
4+260
4+290
4+320
4+350
ACCESS ROAD
DRAINAGE
HEADWALL
CULVERT
MAJOR CONTOUR
MINOR CONTOUR
HYDROLOGIST POINT OF STUDY
CONTOUR INTERVAL =0.2M
MINISTRY OF WATER AND DEVELOPMENT
PROJECT
IRRIGATION FOR CLIMATE RESILIENCE PROJECT (ICRP)
DRAWING TITLE
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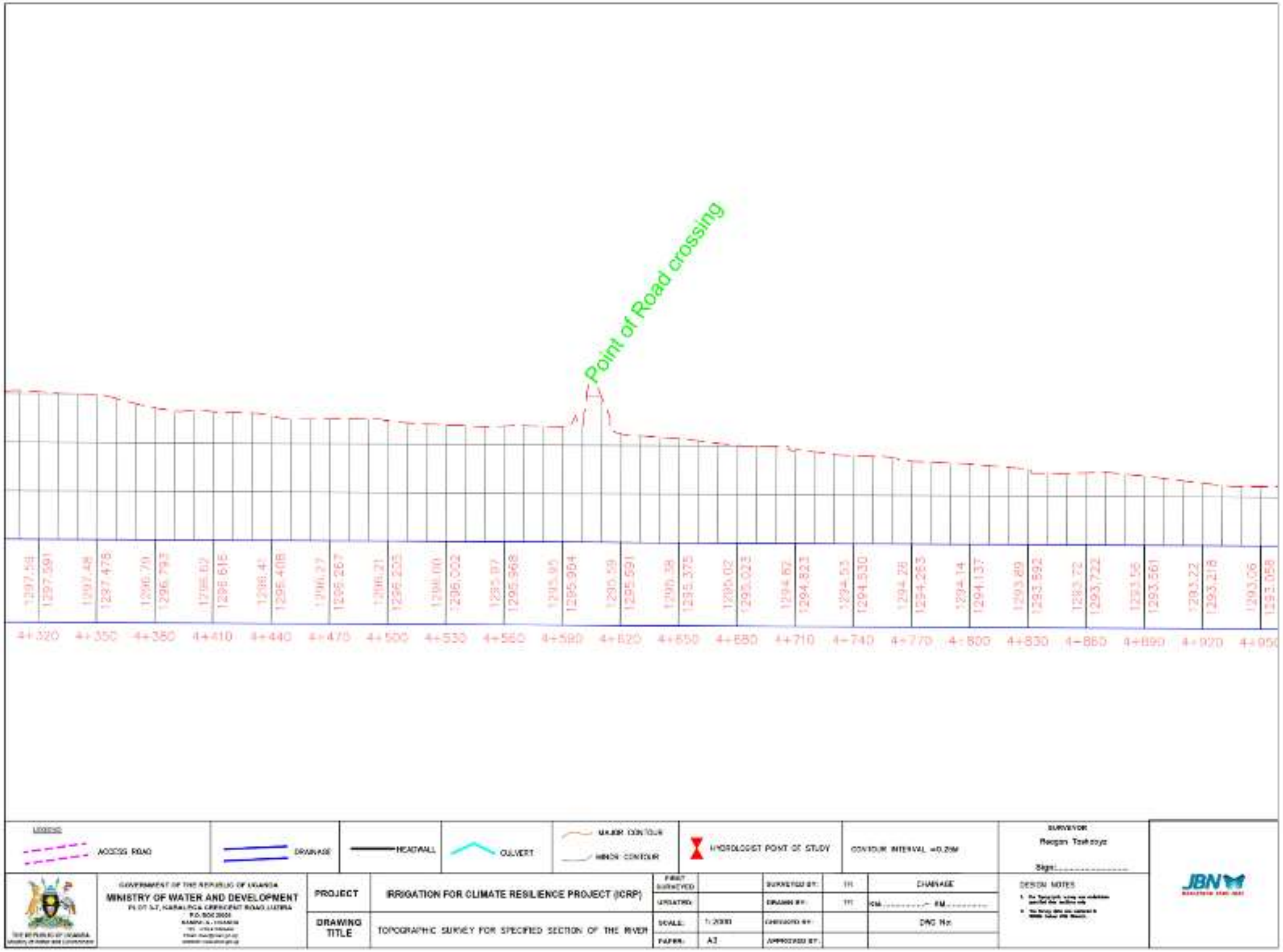
SCALE:
1:2000
PAPER:
A3
CHAINAGE
DWG No.
DESIGN NOTES
JBN


Point of Road crossing
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4+350
4+380
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4+680
4+710
4+740
4+770
4+830
4+890
ACCESS ROAD
DRAINAGE
HEADWALL
CULVERT
MAJOR CONTOUR
MINOR CONTOUR
HYDROLOGIST POINT OF STUDY
CONTOUR INTERVAL =0.2M
SURVEYOR
MINISTRY OF WATER AND DEVELOPMENT
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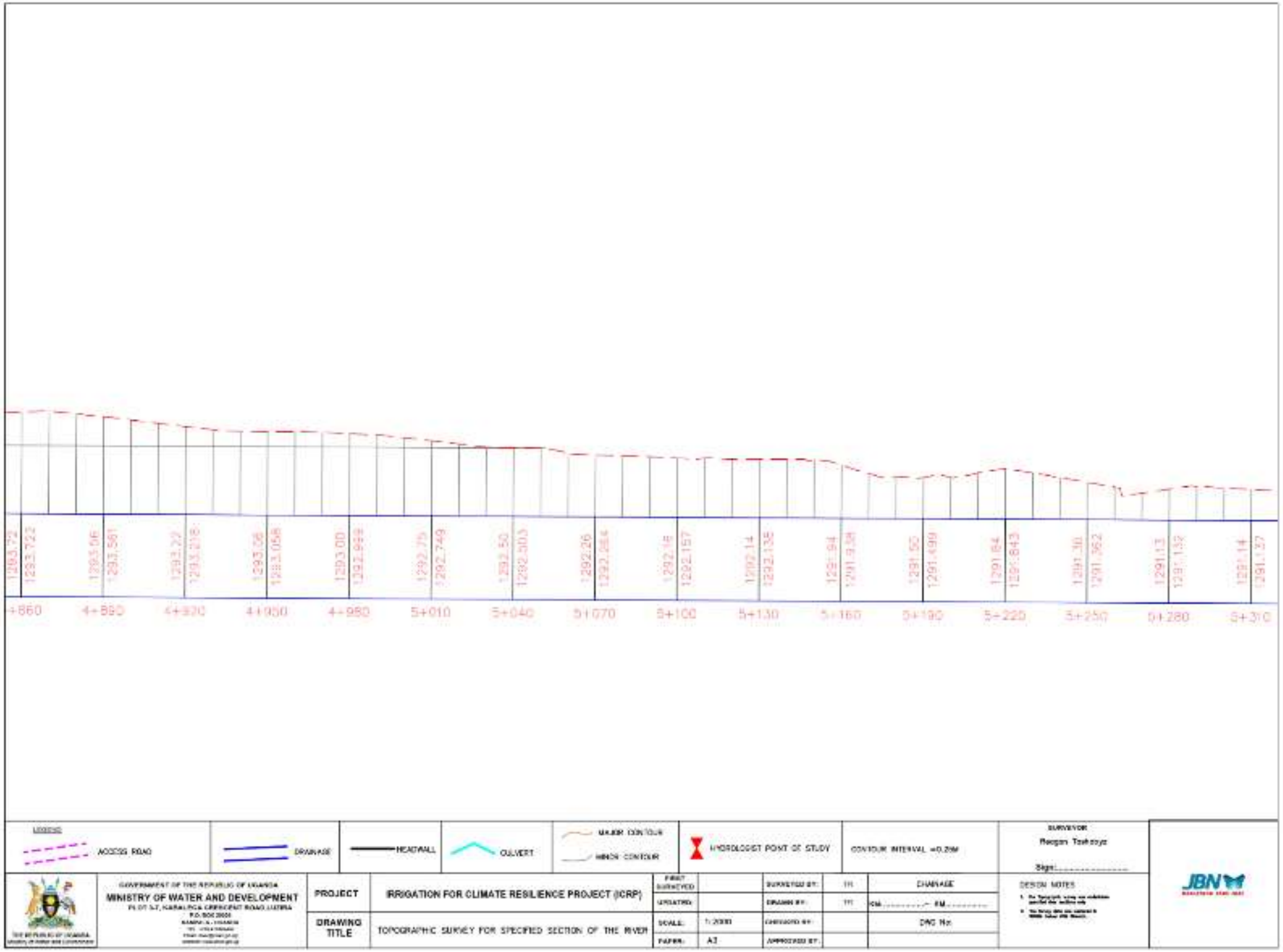
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4+890
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5+250
5+280
5+310
ACCESS ROAD
DRAINAGE
HEADWALL
CULVERT
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MINOR CONTOUR
HYDROLOGIST POINT OF STUDY
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1:2000
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A3
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DESIGN NOTES
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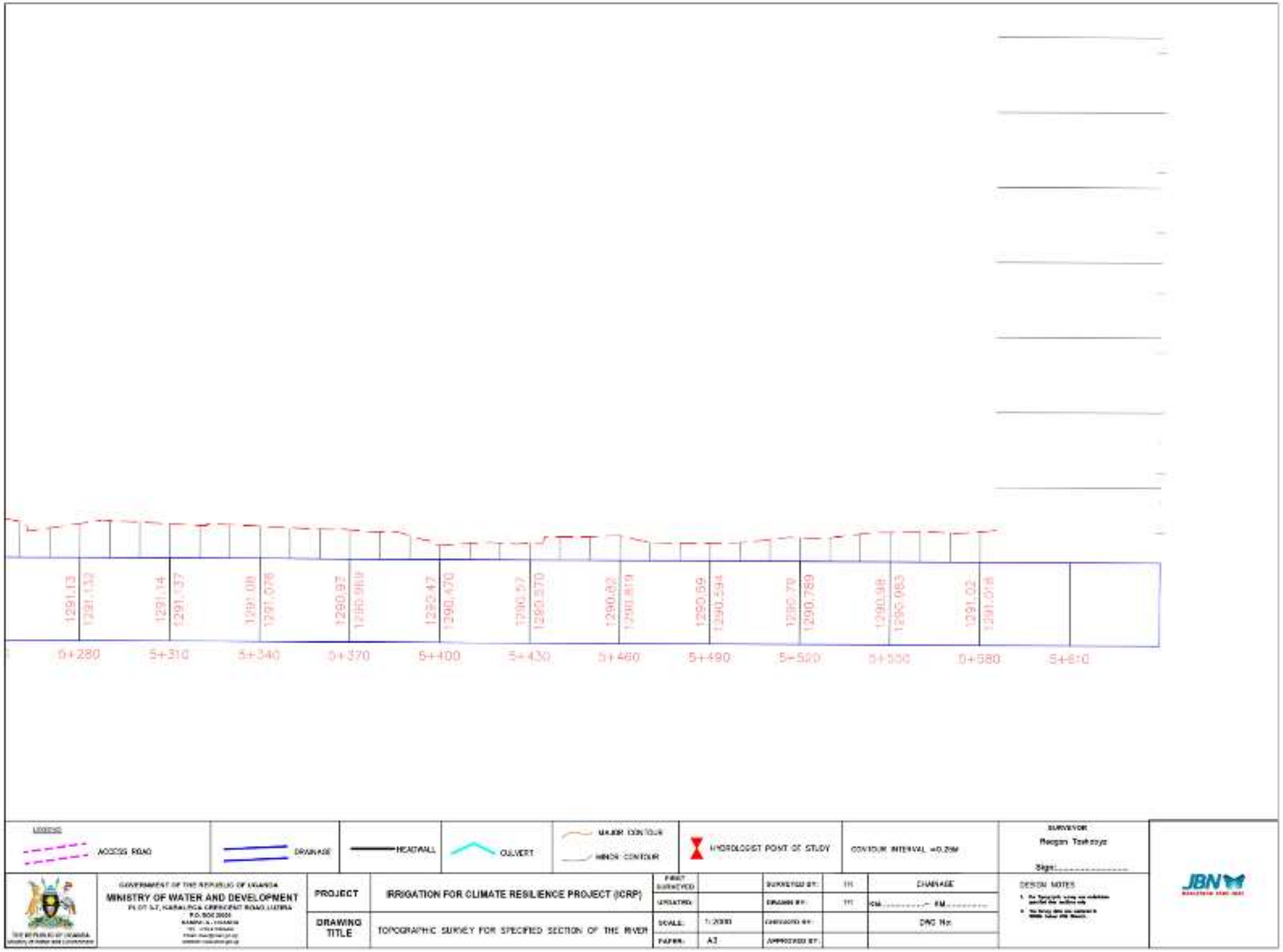
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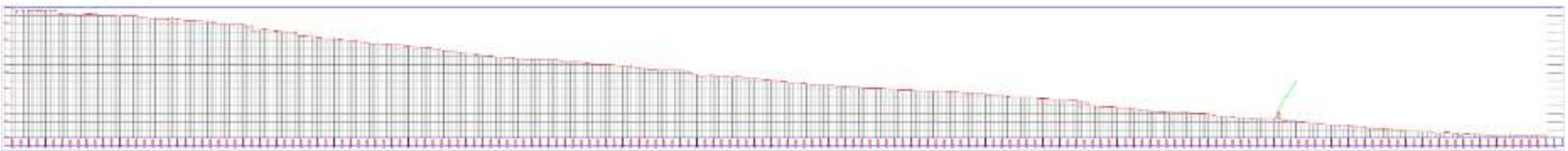
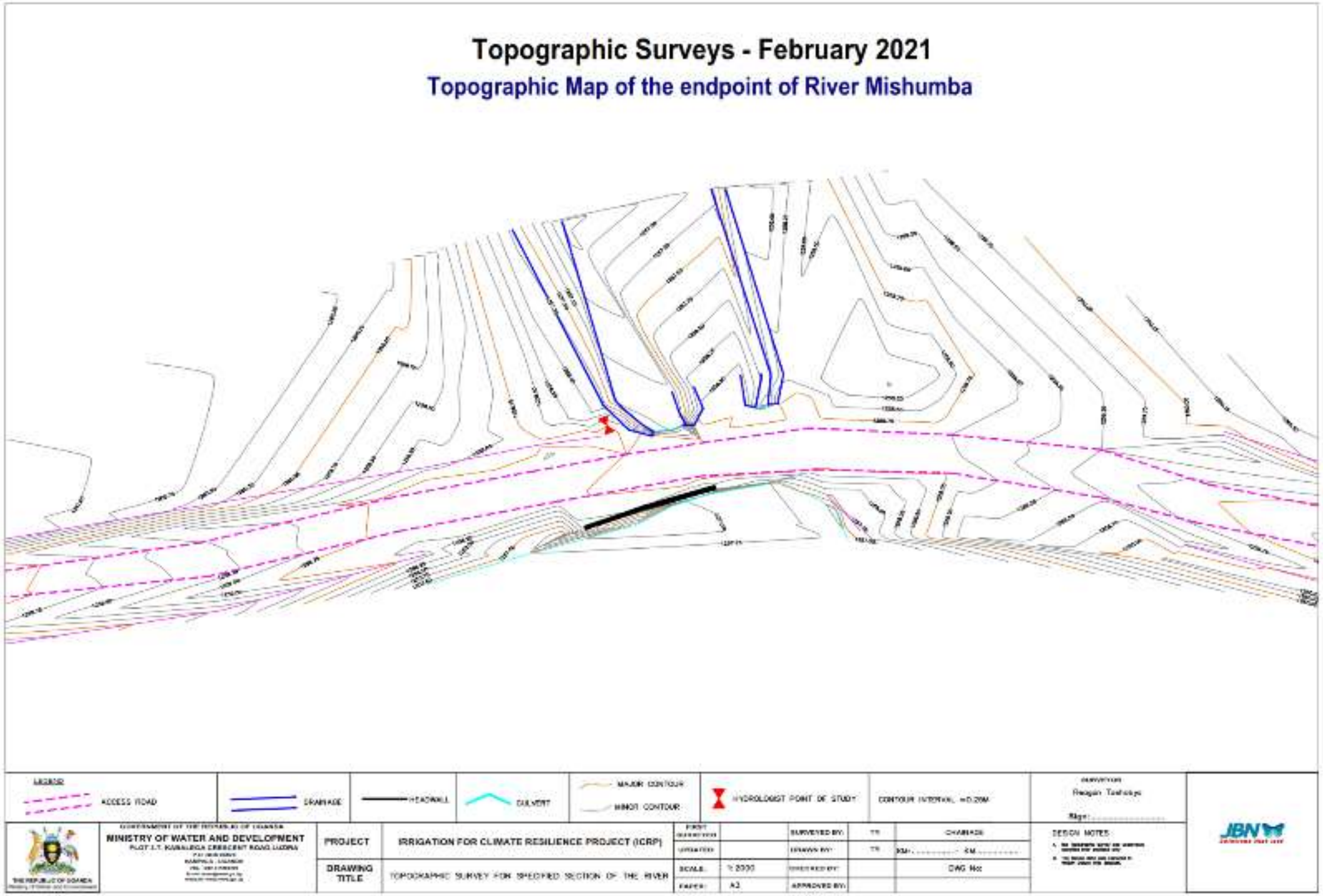
1290.79
1290.789
1290.98
1290.983
1291.02
1291.018
5+280
5+310
5+340
5+370
5+400
5+430
5+460
5+490
5+520
5+550
5+580
5+610
ACCESS ROAD
DRAINAGE
HEADWALL
CULVERT
MAJOR CONTOUR
MINOR CONTOUR
HYDROLOGIST POINT OF STUDY
CONTOUR INTERVAL =0.2M
SURVEYOR
MINISTRY OF WATER AND DEVELOPMENT
PROJECT
IRRIGATION FOR CLIMATE RESILIENCE PROJECT (ICRP)
DRAWING TITLE
TOPOGRAPHIC SURVEY FOR SPECIFIED SECTION OF THE RIVER
SCALE:
1:2000
PAPER:
A3
CHAINAGE
DWG No.
DESIGN NOTES
JBN

Topographic Surveys - February 2021

Full River Mishumba Profile




Topographic Surveys - February 2021
Topographic Map of the endpoint of River Mishumba
LEGEND
ACCESS ROAD
DRAINAGE
HEADWALL
CULVERT
MAJOR CONTOUR
MINOR CONTOUR
HYDROLOGIST POINT OF STUDY
CONTOUR INTERVAL =0.25M
SURVEYOR
Reagan Tashobya
Sign:
THE REPUBLIC OF UGANDA
MINISTRY OF WATER AND DEVELOPMENT
PROJECT
IRRIGATION FOR CLIMATE RESILIENCE PROJECT (ICRP)
DRAWING TITLE
TOPOGRAPHIC SURVEY FOR SPECIFIED SECTION OF THE RIVER
SURVEYED BY:
DRAWN BY:
SCALE: 1:2000
CHECKED BY:
PAPER: A3
APPROVED BY:
CHAINAGE
KM+ KM
DWG No:
DESIGN NOTES

Annex 12: Checklists/logs for different kinds of inspections for operation and maintenance of the dam and its associated structures.

Annex B: Dam Safety Inspection Form

Name of dam: ____

Location: ____

River name: ____________

Nearest downstream city, town, or village name: ________________________

Construction start date: ________ Completion date (actual or planned): _________

Name of owner: ____

Address of owner: ____

Email: ____

Telephone number: ____________________

Name of chief engineer: ___________________________________

Name(s) of main contractor(s): ____

Name of owner's engineer (if designer and construction supervisor are different, please list both names): ____

Name of contract engineer: ____

Section 1: Available Information

List all plans and reports that are available on the dam and that have been studied for the dam safety inspection. Please enclose copies of plans with typical details. If no such plans exist, sketches can be used.

A copy of a map of suitable size showing the location of the dam and reservoir area must also be attached. Photographs taken during the inspection should also be enclosed and referred to in the report.

____

____

____

____

____

____

Section 2: Description of the Dam

Dam type: ________________ Dam height: _____________________

Dam crest length: _____________ Storage capacity (gross, live, or dead): ________

(In addition to the main dam, the information of the saddle dams, such as dam type, height, and crest length, should be provided.)

Major repair and rehabilitation works done after completion, if any: ______________________________

____

Main dam safety issues previously observed, if any: ____

____

Section 3: Geology of Dam Site

General details (rock types, quality, weathering, joint openings and filling, shear zones, faults, and so on):

Please attach a copy of the geological map—plan view and cross-section.

____

____

____

Geological conditions and actual or potential problems, such as sliding resistance, settlement, seepage, and erodibility.

Left flank: ____

____

____

Right flank: ____

____

____

River section: ____

____

____

Spillway channel: ____

____

____

Are the slopes around the reservoir rim stable? ____

____

Section 4: Description of Main and Saddles Dams Material

____

____

____

____

____

____

Section 5: Evaluation of the Downstream Consequence Potential

Estimate of the number of people at risk/potential loss of life: ______________________________

____

Estimate of potential economic loss, including major infrastructure and potential environmental and social impacts: ____

Consequence potential level: ____

Section 6: Flood Estimates

Catchment area (square kilometers): ____

Mean annual precipitation (millimeters): ____

Methods used for flood estimates: ____

____

____

Flood estimates

Return period and inflow for diversion facilities design criteria during construction (1:50 and so on and discharge volume in cubic meters per second): ______________

____

1:100 (cubic meters per second):__________________________________

1:200 (cubic meters per second):__________________________________

1:1,000 (cubic meters per second):________________________________

1:5,000 (cubic meters per second):________________________________

1:10,000 (cubic meters per second):_______________________________

Probable maximum flood (cubic meters per second): ____________________

Inflow design flood (cubic meters per second): ______________________________

Safety check flood (cubic meters per second): ______________________________

Any explanation for determining the inflow design flood and safety check flood and any historical large flood events:

____

____

Section 7: Evaluation of Capacity of Service and Auxiliary Spillways

Spillway type: ______________________________

Spillway length: ______________ Critical spillway width: ______________

Spillway gates type and number, if any: ______________

Nonoverspill crest level: ________ Full supply level or spillway sill level (meters): ________

Maximum flood water level (surcharge water level under inflow design flood and safety check flood): __

____

Spillway design capacity during inflow design flood (cubic meters per second): ______________

Will the incoming flood be significantly reduced by flood attenuation? ______________

Available freeboard during inflow design flood (meters): ______________

Attach graphs for inflow and outflow hydrographs and reservoir water level corresponding to "design flood" and "check flood" as well as the rating curve for spillway discharge capacity vs. reservoir water level.

Any safety concerns related to the spillway capacity and gates operational reliability, if any: ________

____

Any safety concerns related to the actual freeboard as a result of crest settlements, reservoir silting, and so on:

____

Section 8: Dam Inspection

Date: ______________ Reservoir water level: ______________

Names of inspection team leader and members: ______________________________

____

____

Note: For dams under construction, the inspection report should indicate the quality of the construction works and any safety issues related to detailed design and construction methods or procedure.

Crest of Embankment Structure

Crest width (meters): ______________________________

Is the crest still level or has settlement occurred? ______________________________

Are there signs of erosion? ______________________________

Describe: ______________________________

Are there signs of crack?______________________________

Describe (use separate page, if necessary): ______________________________

____

Is maintenance necessary on the crest? ______________________________

Are there signs of animal holes (ants, rats, moles, and so on) or vegetation? ______________

Describe: ______________________________

Upstream Face of Embankment Structure

Slope (vertical: horizontal): ______________________________

Slope protection measures, if any: ______________________________

____

Are there signs of erosion? ______________ Describe: ______________________________

____

Are there signs of cracks? ______________ Describe: ______________________________

____

Are there signs of settlement? ______________ Describe: ______________________________

____

Downstream Face of Embankment Structure

Slope (vertical: horizontal): ______________________________

Slope protection measures, if any: ______________________________

____

Are there signs of erosion? ______________ Describe: ______________________________

____

Are there signs of cracks? ______________ Describe: ______________________________

____

Are there signs of settlement? ____________ Describe: ______________________________

____

Are there signs of bulging or sliding? ____

Are there wet patches? _______________ Describe: _________________________________

____

Are there signs of seepage or leaks? ___________ Describe: __________________________

____

Amount of leakage? ____

Is the leaking water clear or turbid? ____

Are there signs of animal holes (ants, rats, moles, and so on)? ________ Describe: ______________

Vegetation on Embankment Structures

Are there any trees or shrubs on the structures? _________________________________

____

If so, describe type, size, number, and position: _________________________________

____

Drainage System in Embankment Structures

Has a toe drain or internal drainage systems been provided? __________________________

Describe: ____

____

Amount of leakage (cubic meters/s)? ____

Is the water from the drains clear or turbid? ______________________________________

Concrete Structures

Any cracks? ________________ Describe position, size, and length (on separate page, if necessary): __

____

____

Is there leakage through the cracks? _______________ Describe (flow rate): ______________

____

____

Is there leakage at the joints? ___________________ Describe: _______________________

____

Is there settlement? ______________________ Describe: ____________________________________

____

Is there relative movement? _________________ Describe: ____________________________________

____

Describe condition of concrete: ____

____

Upstream slope (horizontal: vertical): ____

Downstream slope (horizontal: vertical): ____

Describe pressure relief holes: ____

____

Downstream Toe and Flanks of Dam Structures

Describe wet patches (position, size): ____

____

Seepage and leaks (position, flow rate): ____

____

Are there trees within 5 meters of the downstream toe of the dam structures? ______________________

____

Describe: ____

____

Flood Outlets, Return Channels, and Training Walls

Condition of structures in spillway channel (sills, retaining walls, and so on): ______________________

____

____

____

Is the stability of the dam threatened by the spillway channel? ___________________________________

Is there loose material in the spillway channel? ____

Describe: ____

Is there any erosion in the spillway channel? ____

Describe: ____

Is there any erosion in the river? ____

Describe: ____

Are the spillway length and freeboard still as shown on the drawings? ____________________________

Stilling Basins and Apron

When was the stilling basin last emptied and inspected for scouring? ____________________________

Observations and evaluation: ____

____

Outlet Works

Number of outlet conduits and pipes: ________ Diameter: ________________________________

Type: _____________ Maximum discharge capacity (cubic meters/s):____________________________

Condition of outlet works foundation: ____

Is the control upstream or downstream, and what are their types? ________________________

Is there provision for an upstream emergency gate or valve, and what are their types? _____________

____

Are the gates or valves used regularly? ____

Are the gates or valves in working condition? ____

Are there leaks alongside the outlet conduit or pipe? ____________________________________

Is there any erosion downstream of the outlet works? ____________________________________

Rust protection? ____

Sediment deposits and any removal facilities or functions?

____

Emergency drawdown rate (the number of days lowering from the full level to the half level and to the bottom):

____

Other observations:

____

Attach the rating curve of outlet works.

Section 9: Overall Safety Evaluation of the Dam and Associated Structures

____

____

Section 10: Evaluation of Construction and Quality Control (for Dams under Construction)

Quality of contractor's quality control plan and actual compliance: ____________________________

____

Owner's engineer's construction supervision and quality assurance plan and quality of control or progress reports:

____

____

First reservoir impoundment plan and actual filling:

____

____

Section 11: Evaluation of the Quality of Operation and Maintenance

Names and titles of operation staff:____

Have there been any major floods and damages since the beginning of operation or during construction works? ____

Are the Operation and Maintenance Plan and Emergency Preparedness Plan, or similar plans, available? Are they used and up to date?

____

____

What routine inspection reports, monitoring records, or maintenance records were available for evaluation? ____ ______________________________

____

Are relevant stakeholders aware and ready to implement the emergency action plan and any warning system installed?

____

____

Section 12: Other Findings

____

____

Section 13: List of Appendixes

Item	Y	N	Comments
Site plan			
Geological maps/model			
Selected design/completion drawings			
Spillway discharge curve/table/formula			

Reservoir elevation-area-capacity curves/tables			
Inflow/outflow hydrographs			
Instrumentation Plan			
Operation and Maintenance Plan			
Reservoir operation plan, including flood periods			
Accidents/damage reports, if applicable			
Any relevant photos			

Section 14: Recommendations of Previous Dam Safety Inspection, if Any

Date of previous evaluation: ___________________________________

Name of inspector: ____

List of previous recommendations and status of implementation:

No.	Recommendation	Status

Section 15: Recommendations of This Dam Safety Inspection, Assessment, and Examination

Recommendations for remedial works, safety improvement measures, and maintenance needs, regular routine inspections, monitoring, further investigations, rehabilitation should be included.

No.	Recommendation

The recommendation should be repeated in the main inspection report.

Signature (by the expert or team leader and all members of the inspection team): ___________________

Date: __________________