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SLR

Burundi – DRC - Rwanda
Ruzizi III Hydroelectric Power Project

Environmental & Social Impact Assessment
Vol. III: Annexes

Prepared for

REL
Ruzizi III Energy Limited

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A. ESIA Team

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B. Complementary Data for the Hydrological Baseline

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B.1 CRU TS data review

A key component in the hydrological modelling and associated derivation of Ruzizi III inflows (Tractebel, 2020) is the use of University of East Anglia's Climate Research Unit (CRU) time-series data.

The CRU time-series data is derived for 0.5 °grid cells and is based on data from local hydro-meteorological stations. The CRU TS Google Earth Interface provides a useful framework for assessing data quality uncertainty associated with the use of CRU TS 4.05 datasets.

Figure B-1 shows the CRU TS grid cells associated with the Lake Kivu catchment and Ruzizi River catchment upstream of the Burundi border. It can be seen that the Lake Kivu catchment is largely covered by three grid cells (1.75S, 29.25E; 2.25S, 29.25E; 2.25S, 28.75E) and that the Ruzizi River catchment upstream of Burundi is covered by two additional grid cells (2.75S, 28.75E; 2.75S, 29.25E).

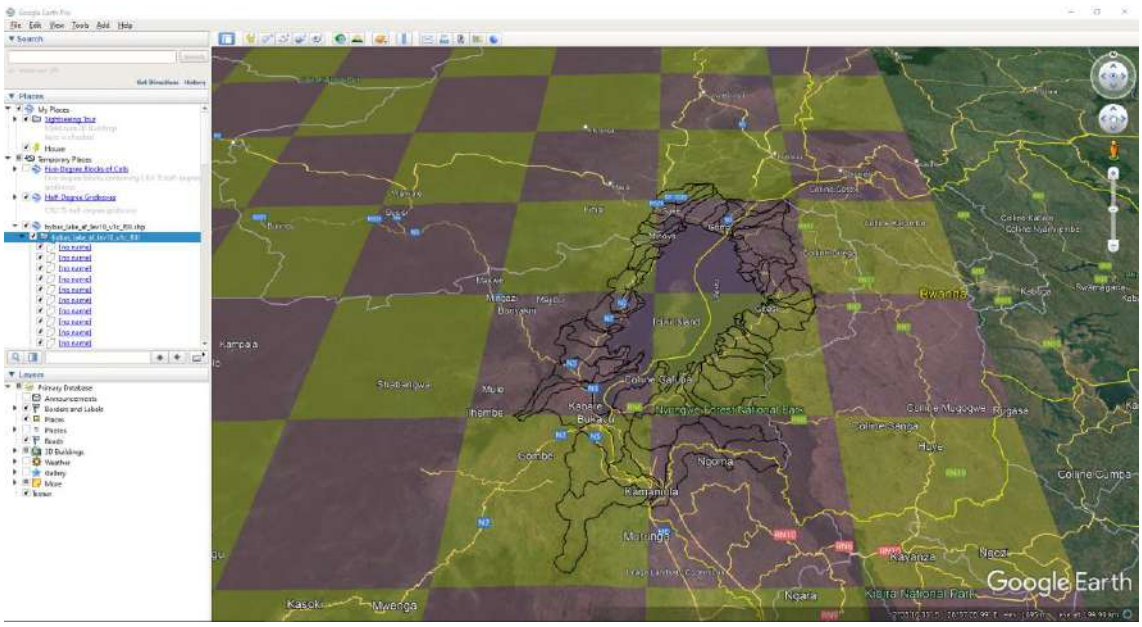

Figure B-1 Lake Kivu catchment CRU TS 0.5 ° grid cells

Figure B-2 summarises the temperature, diurnal temperature range, precipitation, and vapour pressure data associated with the three Lake Kivu grid cells, Figure B-3 summarises the same data for the two Ruzizi river grid cells.

Of particular note for all grid cells is that the number of contributing individual stations for all parameters is significantly lower for the period post-2000 and as such greater uncertainty can be associated with the time-series data for this later period.

Figure B-4 shows the contributing precipitation stations for each grid cell, illustrating both the wide spatial extent of the contributing station network and also that for all grid cells, the only current station is at Kigali (and although not shown, further analysis of the Kigali data shows extensive periods of missing data post-2000).

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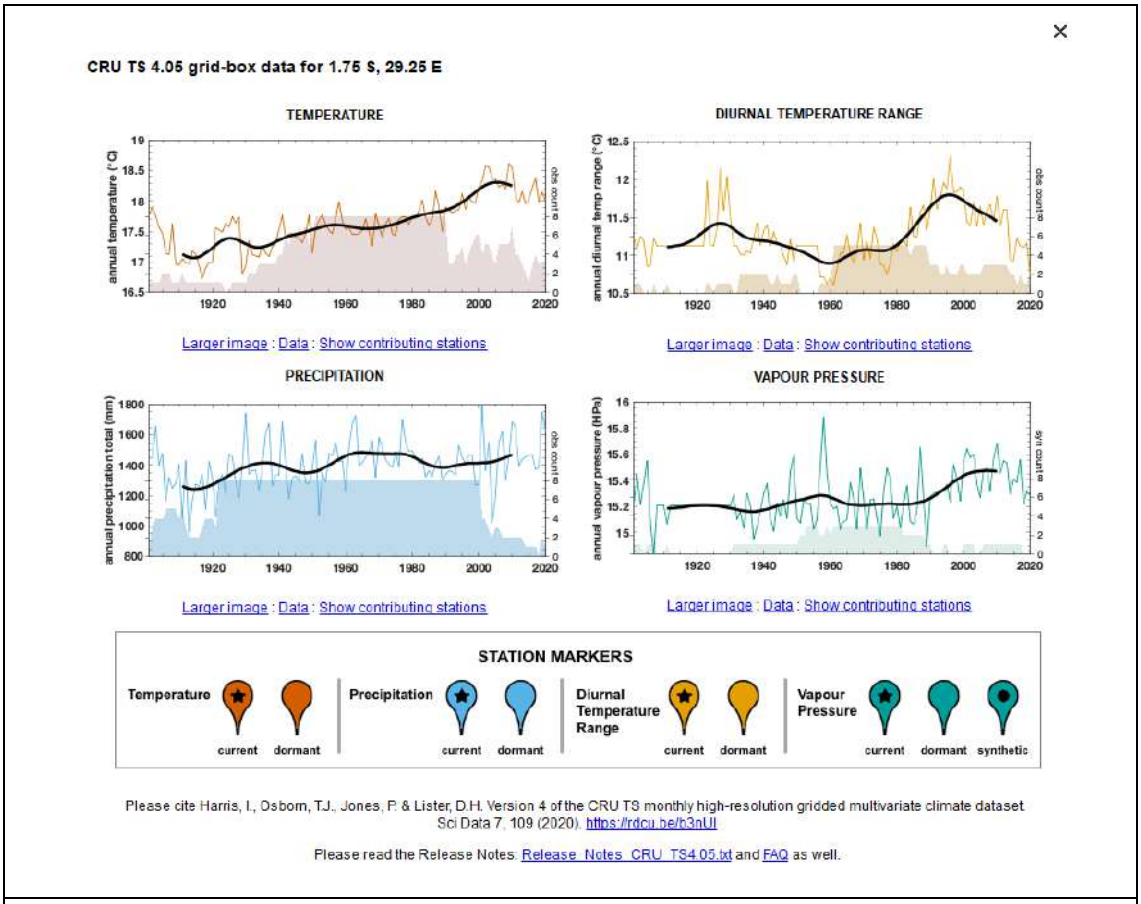

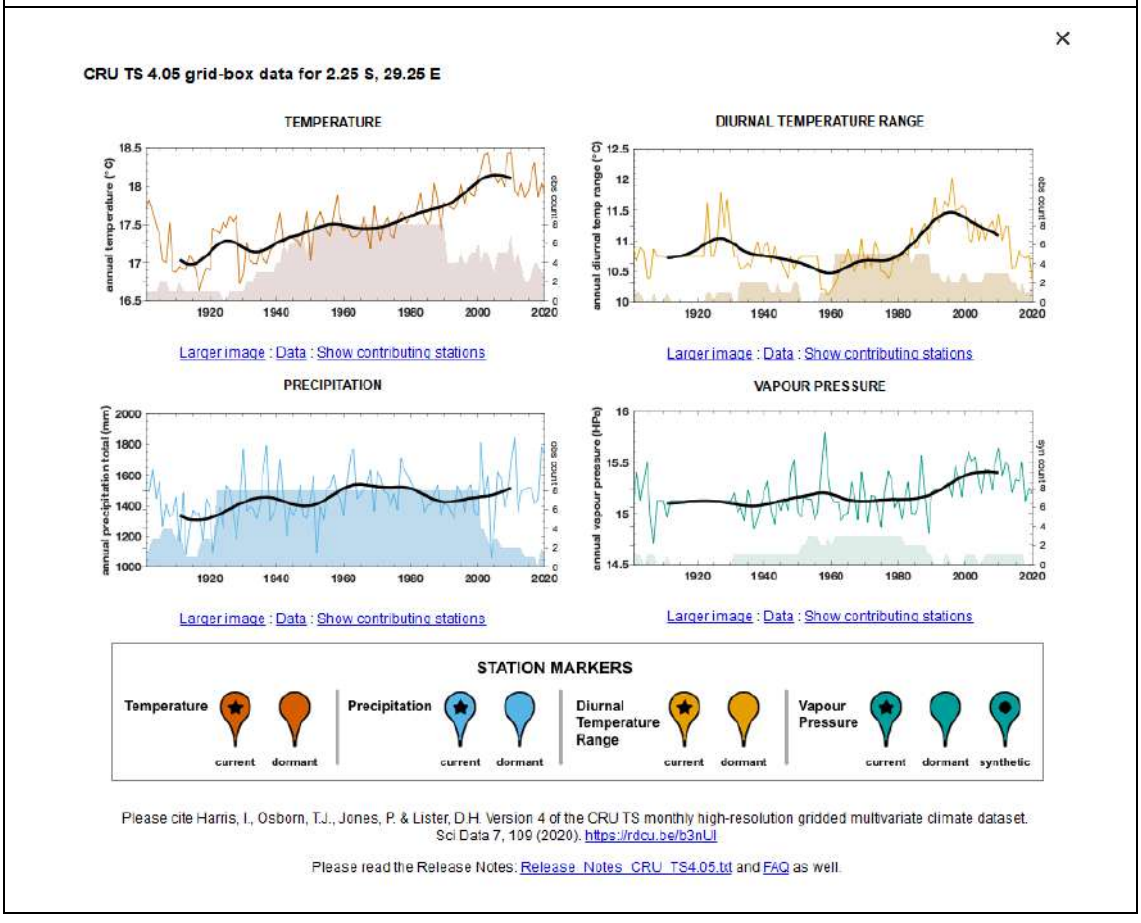

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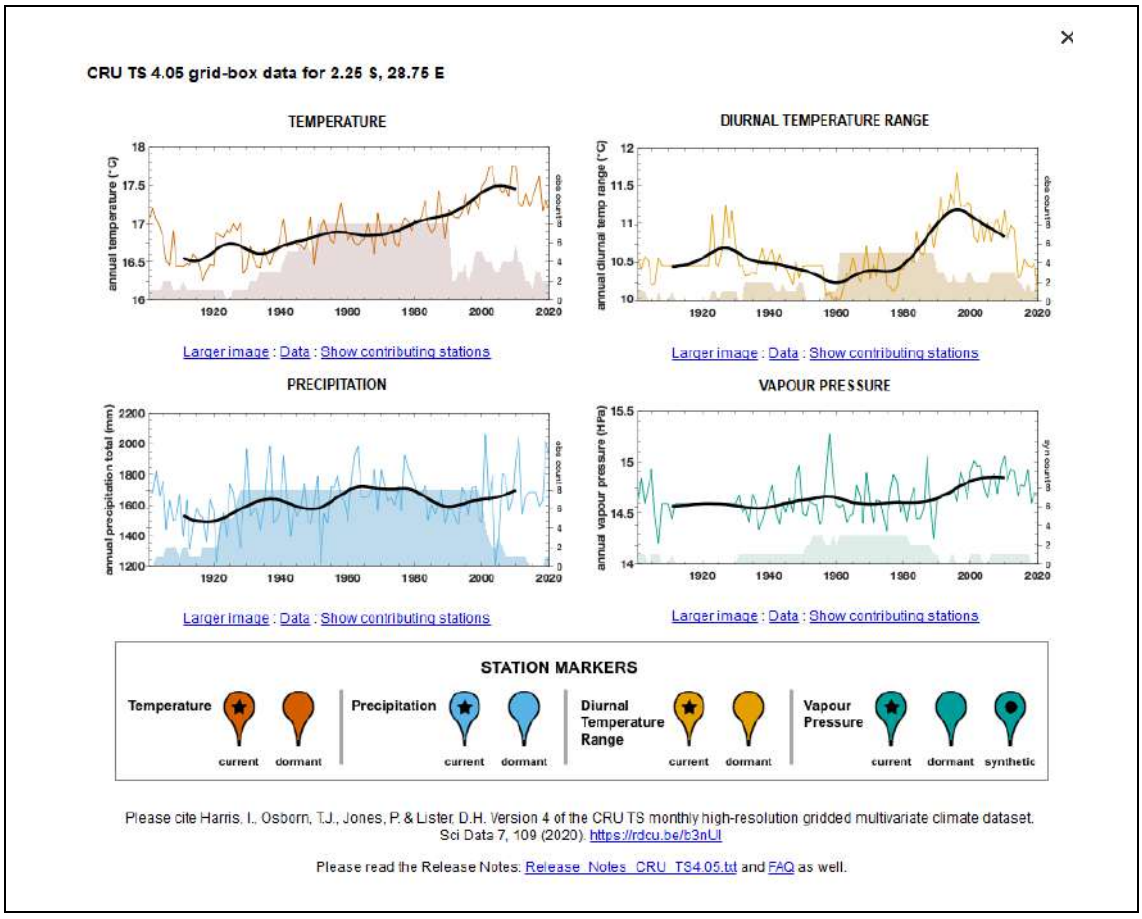

Figure B-2 Lake Kivu catchment CRU TS 4.05 data summaries by grid cell

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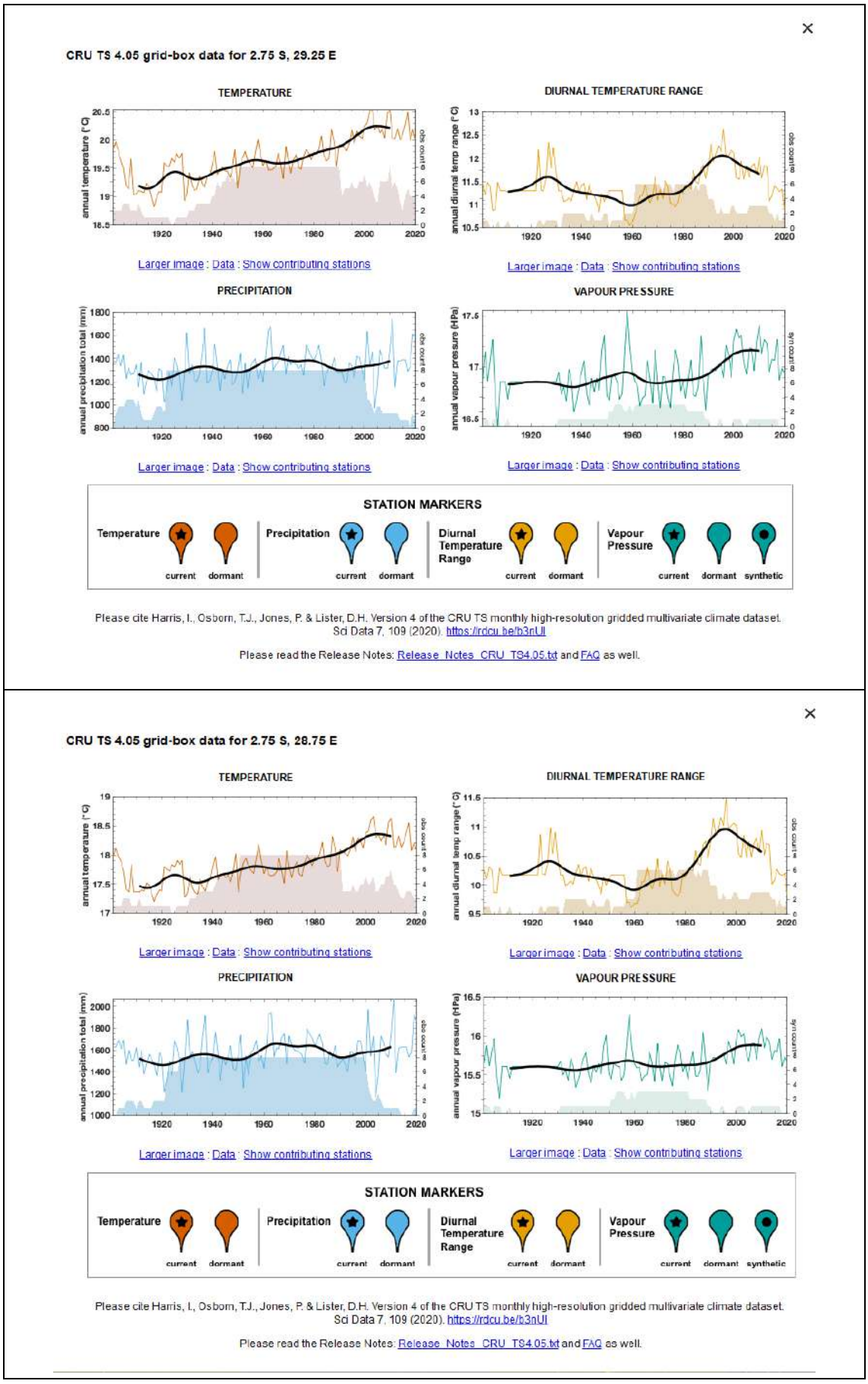

Figure B-3 Ruzizi catchment CRU TS 4.05 data summaries by grid cell

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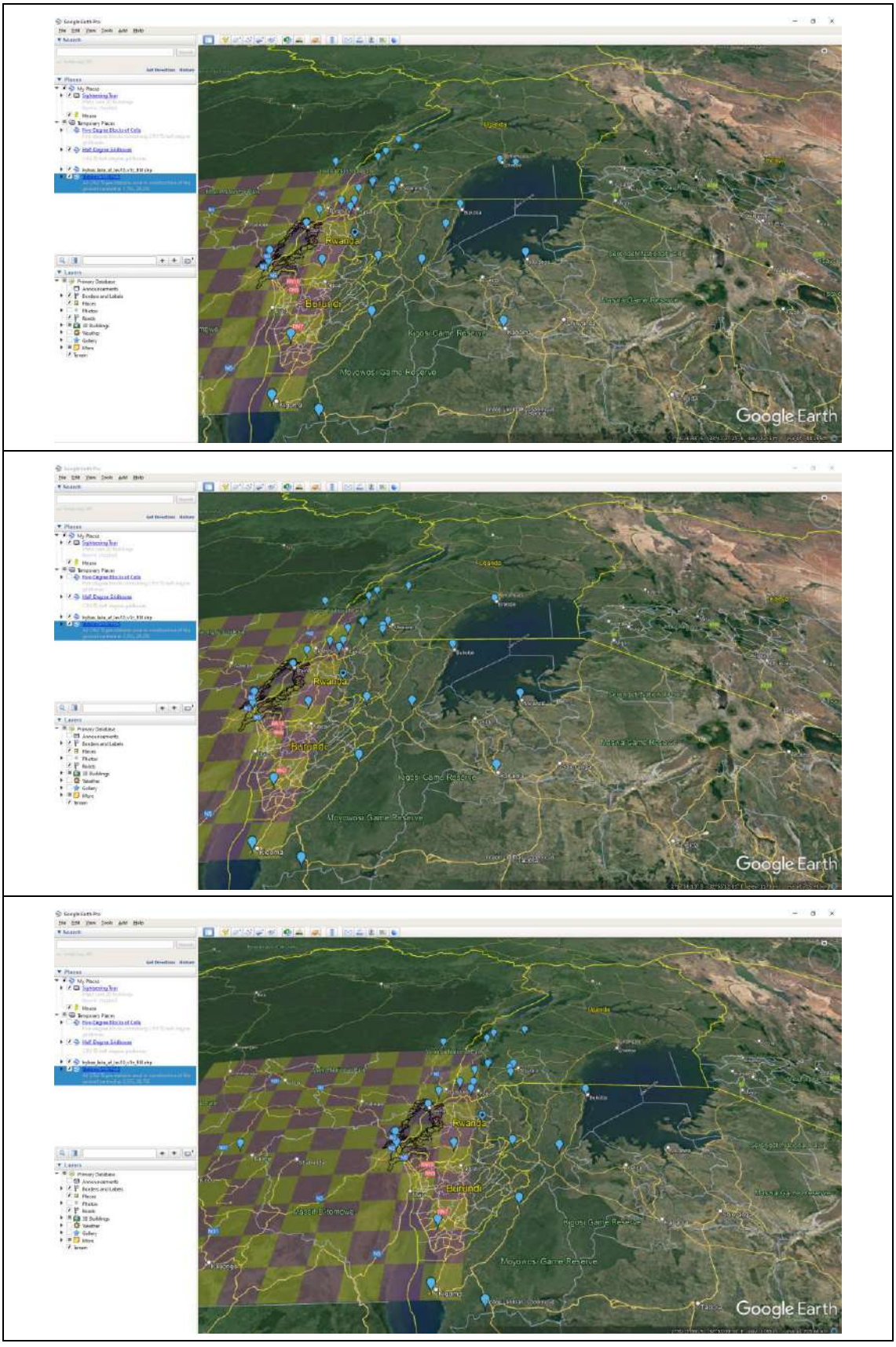

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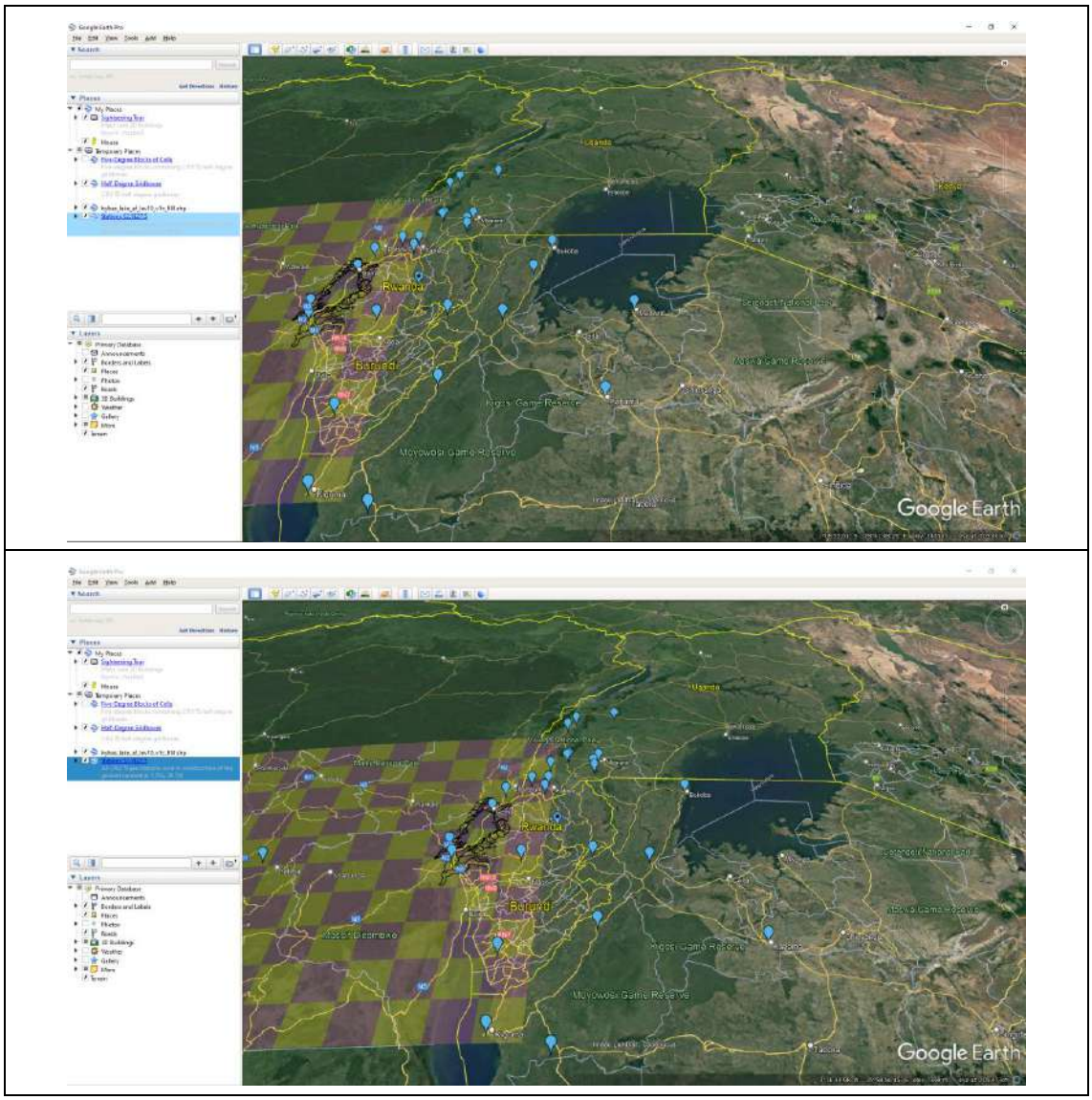

Figure B-4 CRU TS 4.05 contributing precipitation stations for Lake Kivu and Ruzizi river catchments

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C. Complementary Data - Terrestrial Biodiversity Baseline

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C.1 Terrestrial Baseline Approach and Methodology

C.1.1 Approach

Baseline conditions were based on a review of available information, plus data collected during a field survey in January 2022, which included vegetation and flora, birds and mammals. The information was used to classify and delineate terrestrial ecosystems to update remote sensing derived land cover and habitat type mapping, and to assess the quality and biodiversity importance of the terrestrial ecosystems within the potential Area of Influence. The assessment considered the presence or potential occurrence of threatened and protected species and ecosystems, areas of high biodiversity importance, corridors and other relevant features. Species data contained in earlier reports for the region were checked and IUCN Red List status updated.

A supplementary survey focussed on verification of key plant species and avifauna was conducted over five days in May 2024 (see Section C.1.3.4).

C.1.2 Data review

C.1.2.1 Key Data Sources

Primary sources of ecological data for the Project Area of the Ruzizi III HPP comprise the draft ESIA (Sofreco 2021) and various documents as summarised in Table C-1.

Table C-1 Primary Data for Terrestrial Ecosystems

Taxon	Available Data
Terrestrial Ecosystems	Biodiversity of the Albertine Rift (Plumptre et al. 2003) Terrestrial Ecoregions of Africa (Burgess et al. 2004)
Vegetation Types	Potential Natural Vegetation of East Africa project (Lillesø et al., 2011) (https://vegetationmap4africa.org) Botanical Specialist Study in Sofreco (2011)
Flora of Conservation Concern	IUCN Online Assessments (https://www.iucnredlist.org/) Various volumes of the Flore d'Afrique centrale (Meise Botanic Garden, Belgium)
Birds	Birds in Rwanda – an atlas and handbook (Vande weghe & Vande weghe, 2011) Rwanda chapter of the Important Bird Areas of Africa (Kanyamibwa, 2001)
Mammals	Mammal chapter of Biodiversity of the Albertine Rift (Plumptre et al. 2003) Field guide to the Mammals of Africa (Kingdon, 2015) Distribution maps in IUCN Online Assessments
Herpetofauna	Field guide to the reptiles of East Africa. (Spawls, 2002). Field guide to the amphibians of Africa (Channing & Rödel, 2019) Distribution maps in IUCN Online Assessments

A Vegetation and Flora

Available data on vegetation and flora of the actual project area were limited to information contained in the specialist botanical study undertaken by Sofreco (2021). No other site-specific data could be located. Regional descriptions of vegetation in south-western Rwanda were based on the classification used in the Map of Potential Natural Vegetation in Eastern Africa (https://vegetationmap4africa.org) and descriptions of vegetation communities in Kindt *et al.* (2011a, 2011b, 2011c).

B Birds and Mammals

Limited data relevant to the project area were collected during the specialist faunal assessment for Sofreco (2011), but not in sufficient quantity to adequately describe the faunal assemblages that are present and potentially affected by the project. However, accurate distribution data for south-western Rwanda were accessed from Vande weghe & Vande weghe (2011), which

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provided a comprehensive list of avifauna species that are known to occur in the general vicinity of the project area. A list of potentially occurring mammals was compiled using the distribution maps in the IUCN red-list assessments and the mammal chapter of Plumptre *et al.* (2003). Species-level distribution and ecological information contained in the IUCN assessments was used to predict the likelihood of occurrence of Species of Conservation Concern in the project area.

C Herpetofauna

A literature review was conducted to collate all available herpetofaunal information for the region and predict the species likely to occur within the project area of influence. Since no synthesised body of work capturing the reptile diversity for the project area exists, the literature review relied heavily on the species information (distribution, ecology, etc.) contained in the online IUCN Red-List assessments (IUCN, 2022). This information was cross-checked with species-specific scientific articles, particularly those capturing a list of species observed from a scientific expedition in close proximity to the project area of influence, and information captured by the scientifically recognised online facility Reptile Database (www.reptile-database.org). In addition, the distribution maps in Spawls *et al.* (2018) were used to predict which reptile species are likely to occur in south-western Rwanda. For amphibians, the updated distribution maps and ecological information in Channing & Rödel (2019) provided the basis for a list of potentially occurring species, which was supplemented by data contained in the IUCN online Red-List species assessments (IUCN, 2022) and the scientifically recognised online facility AmphibiaWeb (https://amphibiaweb.org).

Initially, a species list was generated for all herpetofauna species likely to occur within 100 km of the project area of influence. For each species, a likelihood of occurring in the project area of influence (ranging from Low to High) was then assigned based on interrogation of the known geographic distribution and habitat preferences. Species with a Medium or greater likelihood of occurrence where then evaluated further to determine which specific habitats present within the project area of influence would be suitable. If no suitable habitats within the project area of influence was available for a species with an initially evaluated Medium or greater likelihood of occurrence, it was removed from the final list of predicted species.

The extinction risk for each species was obtained from the most recent global IUCN assessment (IUCN, 2022). A list of endemic herpetofauna to the Albertine Rift Montane Forests Ecoregion was obtained from Ayebare *et al.* (2018) followed by additional information provided by the IUCN (2022) and contained in subsequent articles describing new species (e.g. *Kinyongia rugegensis*).

C.1.3 Field Surveys

To supplement the available terrestrial ecology data collected previously in the Ruzizi River for Sofreco 2011, a five-day field survey was undertaken by Warren McCleland and Elie Sinayitutse from 19-24 January 2022. Activities included:

- Timed Meander Searches / Walked Transects for Vegetation and Flora.
- Rapid characterisation of habitat type with GPS points for map validation.
- Walked transects for bird counts in representative habitats, using the MacKinnon list method and 10-species lists as recommended by Herzog *et al.* (2002).
- Walked transects for mammal observations.

These are described in more detail below. No fieldwork study was performed for herpetofauna.

A supplementary targeted bird and flora survey were undertaken in May 2024 and is discussed in Section C.1.3.4

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C.1.3.1 Area of Influence for Terrestrial Ecology

The area of influence (AoI) used to define the location of sampling areas (see Figure C-1) covered the following:

- The reservoir area for Ruzizi III (i.e. 3 km upstream of the proposed Ruzizi III dam site) and the riverbanks down to the confluence of the Ruzizi and Ruhwa River at the Burundi/Rwanda border (approximately 15 km from the dam site). This is considered the core area of influence of the project within which direct impacts on terrestrial habitat will be most pronounced. However, it is possible that impacts of hydropeaking may extend further downstream into Burundi, which may warrant additional studies, but this was not confirmed at the time of the ecology survey.
- The area earmarked for the powerhouse, offices, camps and other site facilities.
- The corridors of the access road and powerline on the right bank in the Democratic Republic of Congo (DRC).
- Two potential quarry sites on the plateau above the left bank above the reservoir.

Note: Physical land-take polygons for infrastructure provided by REL are sufficient to cater for anticipated noise and air quality impacts on biodiversity as these polygons are the outer boundary within which infrastructure is expected to be constructed. Impacts of noise and air quality on fauna/flora are likely to be minimal especially given the degree of habitat modification and scarcity of fauna.

The scope of work did not cover sampling further downstream in Burundi. At the time of sampling the Burundi border was closed and could not be accessed from Rwanda.

C.1.3.2 Sampling Sites

Potential terrestrial sampling areas were identified prior to the survey using a combination of Lidar imagery provided by REL and Google Earth™ imagery, as well as considerations such as ease of access, safety and the presence of potential natural or near-natural habitats. Kmz tiles of Google Earth™ imagery were pre-loaded onto a Huawei P40 Pro smartphone using LocusMap Pro software, as well as additional kmz layers of all project infrastructure and target sampling areas. This enabled navigation to each of the sample sites during fieldwork and ensured that transects adequately covered project infrastructure.

A total of 18.76 km was walked in the project area, along which 75 points were sampled for flora. Twenty-eight of the sample sites were in the reservoir and dam wall area, ten along the downstream reaches of the Ruzizi River, ten along the transmission line route, 14 along the access road and 13 in the two proposed quarry sites (Table C-2; and Figure C-2).. The transect external to the PAOI was the access route to habitats within the reservoir, but it also represented habitats within the PAOI.

Table C-2 Terrestrial Survey Transects

Site No.	Name	Description	Length	Elevation	Latitude	Longitude	Survey Date
			(m)	(masl)	dd.ddddd	dd.ddddd	
Ruzizi River							
RZ-1	Ruzizi Reservoir	Trail down into reservoir	4,563	1,273	-2.679783	28.9415346	20/01/2022
RZ-2	Ruzizi Reservoir	Trail along left bank of Ruzizi River	5,561	1,136	-2.6806387	28.9353054	20/01/2022
RZ-3	Ruzizi River	Batching Plant and warehouse	1,402	988	-2.7002129	28.9692012	21/01/2022
RZ-4	Ruzizi River	Powerhouse	465	1,001	-2.6983388	28.969467	21/01/2022
RZ-5	Ruzizi River	Upstream of Ruzizi - Rubyiro confluence	663	940	-2.7213263	29.0225671	21/01/2022
Transmission Lines							
RZ-6	Unnamed	Central section of line in hills below Kamanyola -Bukavu Road	483	1,009	-2.702266	28.992011	22/01/2022

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Site No.	Name	Description	Length	Elevation	Latitude	Longitude	Survey Date
			(m)	(masl)	dd.ddddd	dd.ddddd	
RZ-7	Unnamed	Central section of line in hills below Kamanyola -Bukavu Road	410	1,023	-2.7061456	28.9947884	22/01/2022
Access Road							
RZ-8	Main access road	Section road between Kamanyola road and powerhouse	3,526	970	-2.7012802	28.9929411	22/01/2022
Quarries							
RZ-9	Western Quarry	Transect through cultivation and quarry site	843	1,560	-2.672973	28.9230143	23/01/2022
RZ-10	Eastern Quarry	Transect through plantations and quarry site	845	1,173	-2.6715742	28.9409088	23/01/2022

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Figure C-1 Map showing the Terrestrial Ecology Area of Influence

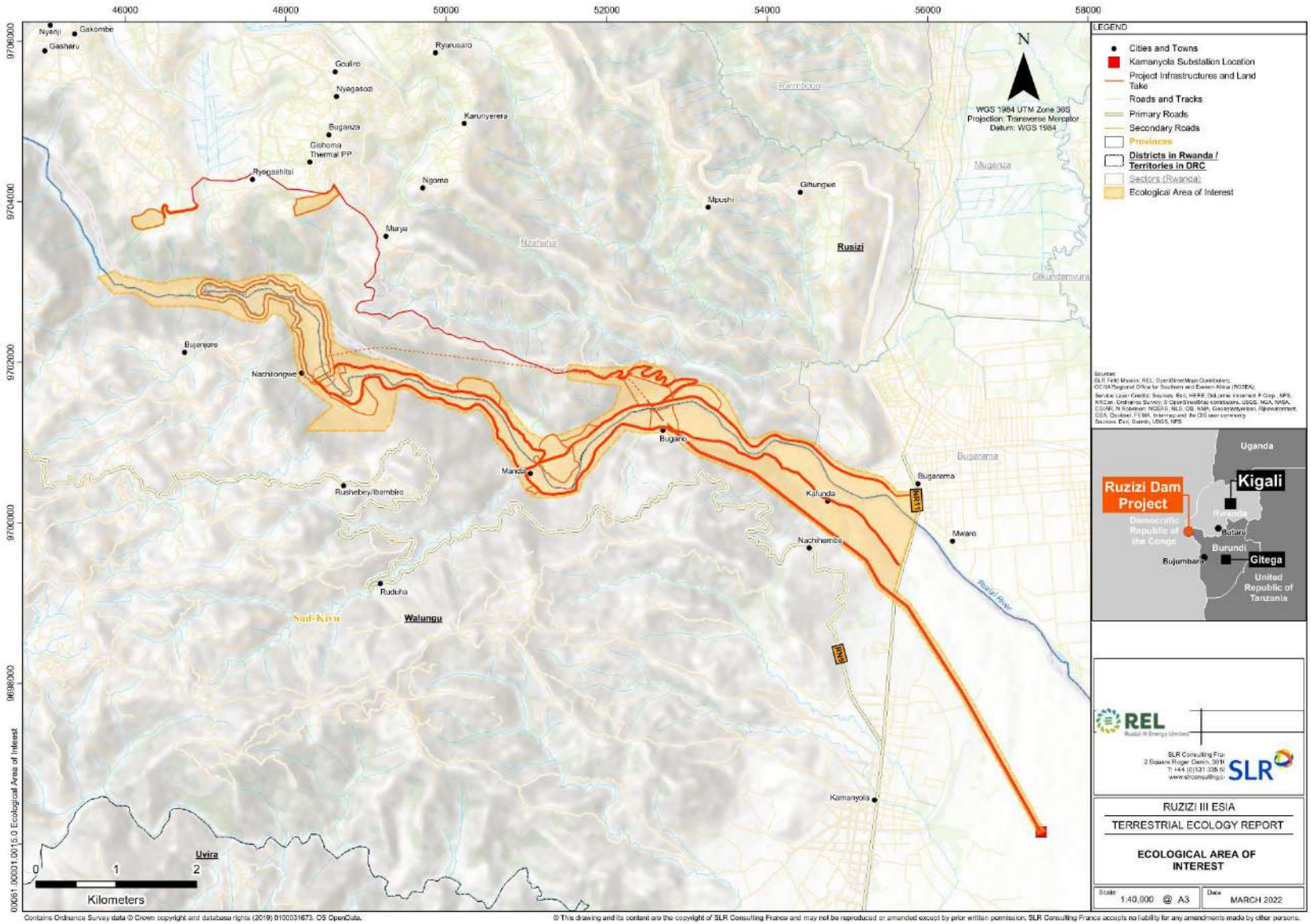

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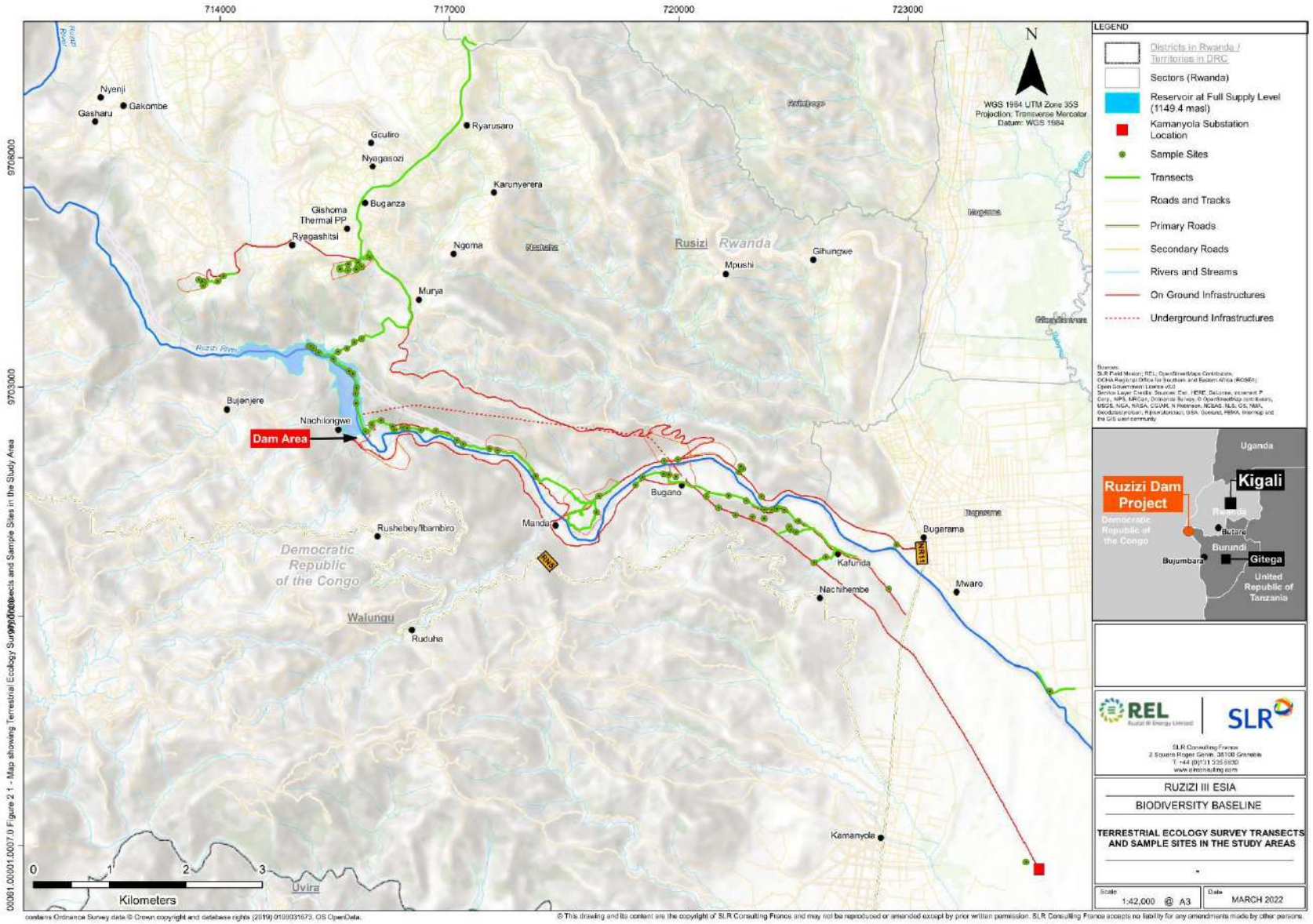
Figure C-2 SLR 2022 Terrestrial Ecology Survey Transects and Georeference Points in the Project Area



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C.1.3.3 Data Collection / Survey Methodology

The following section details the methods used. Photographs and GPS coordinates were taken at all sites visited. A photo of each site is presented in Annex 2.

A Vegetation and Flora

The Timed-Meander Search (TMS) method was used to survey flora at each sample site. This is a semi-quantitative survey technique that uses species accumulation curves to determine when plant communities have been adequately sampled and allows the observer to focus attention on micro-habitats that are likely to have plant Species of Conservation Concern (SCC) (Goff *et al*., 1982). The TMS method has been shown to be one of the most effective and time efficient methods for detecting rare species and documenting α-diversity (Huebner, 2007). Inventories of all visible flowering plants were made in each of the TMS transects, as well as estimating relative cover-abundance according to Braun-Blanquet cover scales (Kent & Coker, 1992). Plants that could not be identified immediately were photographed in situ and identified at a later stage.

The following reference works and websites provided important assistance in the identification of specimens and photographs:

- Flora of Tropical East Africa - a series of monographs of most families of East African plants.
- Global Biodiversity Information Facility (https://www.gbif.org) - digitised images of plant specimens from all the world's major online herbaria.
- African Plants Photo Database (http://www.africanplants.senckenberg.de/) – a comprehensive database of photos of plants from throughout Africa, with over 9,500 species covered.
- An illustrated field guide to the Plants of Nyungwe National Park (Fischer & Killmann, 2008).

B Birds

Two survey techniques were used for avifauna during fieldwork:

- Meandering transects were walked in faunal habitats at the same sites where botanical TMSs were being conducted. Birds were searched for by walking slowly through vegetation and recording all species seen or heard. Birds were viewed using Bushnell Legend 10x42 binoculars and vocalisations were recorded on a Huawei P40 Pro smartphone. The amount of time spent in each habitat was determined by species accumulation curves, with heterogenous habitats requiring more time than more homogenous habitats. Birds were recorded using the MacKinnon list method as recommended by O'Dea *et al.* (2004). This is a rapid assessment technique in which species are recorded in chronological sequence on consecutive lists of equal length. A species accumulation curve is then generated by plotting cumulative species totals against number of lists. The 10-species list method was used, which Herzog *et al.* (2002) considered to be the best compromise between stable richness estimation curves and robust sample size.
- Stationary counts were conducted at various viewpoints along the Ruzizi River and at sites along the transmission line route, with the primary aim of detecting raptors (birds of prey) and locating nest sites. Where possible, survey sites were visited during the late morning, when raptors (birds of prey) were most active and most visible, using thermals to achieve height for foraging flights. A minimum duration of 30 minutes was spent at each site, using binoculars to scan all visible cliff faces for raptor nests or perching raptors.

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C Mammals

Mammals were surveyed using two methods:

- Incidental observations of both direct evidence (sightings, vocalisations) and indirect evidence (spoor, dung) while surveying avifauna, and
- Discussions with local farmers and fishermen with reference to print outs of animal photos provided information regarding presence and movements of mammals such as hippo, monkeys and baboons.

C.1.3.4 Supplementary Survey in 2024

A supplementary survey was undertaken during over five days from 13-17 May 2024, which is at the interface between the long-wet season and the long-dry season. The aim of the supplementary survey was to fulfil the recommendation following the 2022 survey to conduct a pre-construction survey to confirm target plant species in hillslope grassland habitats and birds at risk from the transmission line. Tasks were as follows:

- Search remaining portions of Hillslope Grassland habitats for flora Species of Conservation Concern (SCC), and specifically targeting: *Emilia subscaposa* (Asteraceae), *Chlorophytum hirsutum* (Anthericaceae), *Blepharis burundiensis* (Acanthaceae) and *Bulbostylis longiradiata* (Cyperaceae). .

- Record presence of High-Risk Avifauna Species at most risk to collision with and/or electrocution from the transmission line, primarily migratory, large-bodied, or raptor species. The method for recording species was congruent with the method described in Section C.1.3.3B above.

- Ecosystem Services – Collect observed and/or anecdotal evidence of the ecosystem services associated with the habitats within the PAOI.

The location and extent of the sampling methods used in the supplementary are illustrated in 3. The supplementary flora and bird survey covered 15 km of the transmission line and 18 km of the Ruzizi River area in the area earmarked for project construction infrastructure.

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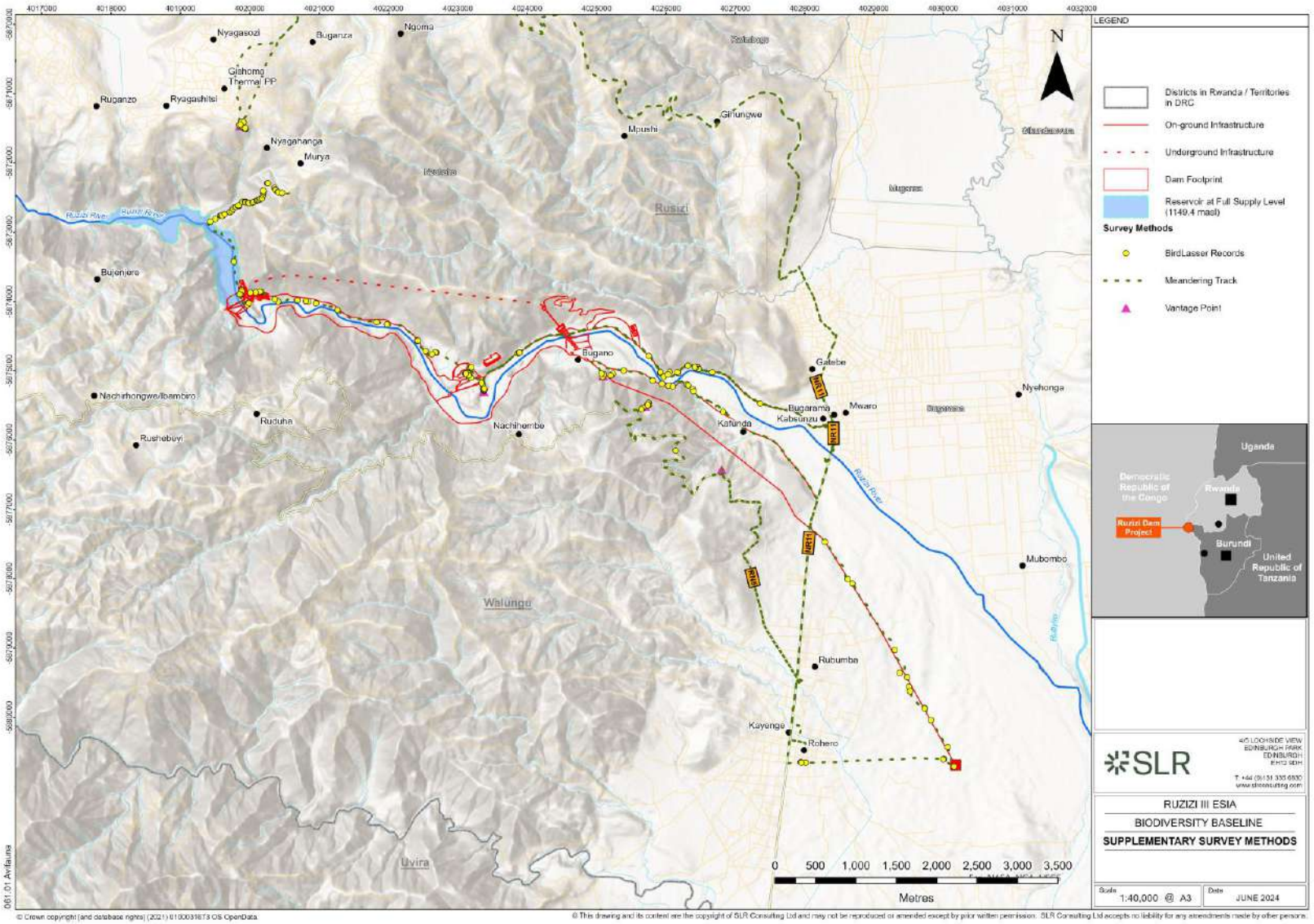
Figure C-3 SLR 2024 location and extent of sampling methods used in the supplementary survey



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C.1.3.5 Assumptions and Limitations

The assumptions and limitations applicable to the field activities and findings of this report are detailed in Table C-3.

Table C-3 Assumptions and Limitations

1. General	
Available Data	Very few ecological studies have been conducted in south-western Rwanda or in adjacent parts of the DRC and Burundi. Most of the research in this region has been conducted in Nyungwe National Park, which is located at much higher altitudes than the project area and supports habitats not represented in the project area. Very little ecological information is available for the only formal conservation area along the Ruzizi River, namely Rusizi National Park in Burundi. The only data relevant to the project area is the specialist flora and fauna surveys conducted for the Ruzizi III HPP ESIA (Sofreco 2021) which were performed in 2011. Individual species records for the vicinity of the project area were downloaded from the Global Biodiversity Information Facility (GBIF) in order to create a list of potentially occurring species of flora and fauna; this list was filtered to exclude species that do not occur at altitudes or in habitats not represented in the project area, either using relevant literature (e.g. Vande weghe & Vande weghe, 2011) or personal experience of the biodiversity specialists in East Africa.
Seasonality	This report was based largely on the outcomes of two terrestrial field surveys. The initial survey in January 2022 was undertaken in the short "dry season" between the "short rains" and "long rains" that make up the wet season. It is possible that plants that flower at other times of the year were under-represented. However, the timing coincided with the period during which most migratory bird species are present and these should have been adequately sampled. The second "supplementary survey" (see Section C.1.3.4) was undertaken at the interface between the long-wet season and the long-dry season and was targeted to confirm specific flora species and migratory birds. However, while seasonality was suitable for flowering plants, the timing was at the end of the migratory bird season for this region, when many migrants may have already left. This probably accounted for the few migrant birds observed.
Survey duration	The January 2022 and May 2024 survey were both undertaken over 5 days. These surveys are considered sufficient to understand baseline conditions due to the level of habitat degradation in the landscape which have been substantially modified by anthropogenic activities. While a longer survey duration may have revealed a higher species diversity, it is considered unlikely that additional biodiversity data would influence the results of the assessment. Data from previous surveys within the region were also considered.
Access to Reservoir Area & Survey Coverage	Access to the Inundation Zone was limited to only a few tracks to the river from Rwandan side which involved a steep descent of 500 m by foot from the nearest road access at Murya village. These tracks provided access to the middle and lower reaches of the inundation zone. However, analysis of satellite imagery did not indicate any upstream areas in the upper reservoir with different or unique habitats, so this is not seen as a major limitation.
2. Flora and Fauna	
Flora	A proportion of the plants located during the January 2022 fieldwork did not have diagnostic features (i.e. lacking flowers or fruit) and could only be identified to genus level. Each of these taxa has been screened against the list of potentially occurring Species of Conservation Concern (SCC) to confirm that they do not represent any of these species, so this is not considered to be a major limitation. No specimens were collected for herbarium identification, but diagnostic features were carefully photographed for identification purposes. With respect to surveying the Hillslope Grassland vegetation for flora SCC during the May 2024 supplementary survey, many of these areas were inaccessible due to the very steep terrain, especially along the transmission line route. In addition, certain slopes have experienced landslides and therefore, could not be traversed. Adjacent accessible portions of Hillslope Grassland were checked and are considered representative of the vegetation in the actual footprint.

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Mammals	No trapping of small mammals took place as such sampling methods require traps to be checked on a daily basis, which would have severely restricted the team's daily movements and would have made it impossible to complete fieldwork. This is unlikely to be a significant limitation as no threatened small mammals are likely to be present given the extensive habitat modification in the project area. No passive or active sampling of bat species were undertaken as well. However, to overcome this the PAOI was searched for caves and potential roosting sites.
Reptiles and Amphibians	No field survey for reptiles and amphibians was undertaken in 2022 or for previous ESIAs. The vegetation community descriptions provided by the botanical specialist were utilised as a basis for describing herpetofaunal habitats. A precautionary approach was applied that assumed a species could be present in cases where insufficient understanding of habitats or description of species habitat requirements were available. The true assemblage of species within the project area of influence is therefore almost certainly comprised of fewer species than predicted, especially when taking into consideration the extent of habitat modification and human presence as well as lack of significant wetland systems. Therefore, the approach followed is unlikely to be a significant limitation for the terrestrial baseline study.

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C.1.4 Field Survey Data

C.1.4.1 Field Reference Points

Table C-4 SLR 2022 Location of Field Reference Points and Vegetation Community

FRP	Date	Time	South	East	Elevation	Description	Current Classification
FRP 1	20.01.2022	9:39:38 AM	2.6797830	28.9415346	1273	Cultivated lands (maize, avocado, banana)	Not classified
FRP 2	20.01.2022	9:52:30 AM	2.6801593	28.9406788	1252	Scarp thicket on cliff edge	Not classified
FRP 3	20.01.2022	10:02:33 AM	2.6808921	28.9398042	1223	Small plantation (Grevillea robusta) with shade coffee understory	Not classified
FRP 4	20.01.2022	10:20:39 AM	2.6813193	28.9387490	1190	Small plantation (Euphorbia tirucallii, avocado)	Grassland / Dense Veg 1
FRP 5	20.01.2022	10:37:19 AM	2.6813955	28.9364298	1135	Banana plantation with maize understory	Dense Veg 1 / Sparse Veg
FRP 6	20.01.2022	10:45:24 AM	2.6808728	28.9359047	1139	Grevillea plantation with banana, avocado, papaya	Dense Veg 1
FRP 7	20.01.2022	11:05:00 AM	2.6806387	28.9353054	1136	Low riparian thicket	Grassland
FRP 8	20.01.2022	11:32:45 AM	2.6806661	28.9355745	1134	Banana plantation	Sparse Veg
FRP 9	20.01.2022	12:03:13 PM	2.6821963	28.9382232	1133	Scarp thicket on steep slope	Open Ground
FRP 10	20.01.2022	12:18:35 PM	2.6835709	28.9400354	1130	Cultivated lands (cassava, avocado, banana) with scattered small thickets	Dense Veg 1 / Grassland
FRP 11	20.01.2022	12:22:22 PM	2.6838875	28.9405088	1120	Banana plantation (tall, dense)	Dense Veg 1 / Sparse Veg
FRP 12	20.01.2022	12:36:02 PM	2.6855624	28.9409469	1126	Grevillea plantation with maize and cassava below	Grassland / Dense Veg 1
FRP 13	20.01.2022	12:40:11 PM	2.6862509	28.9408356	1111	Riparian thicket	Dense Veg 1
FRP 14	20.01.2022	12:48:51 PM	2.6874090	28.9409166	1105	Grevillea plantation	Sparse Veg
FRP 15	20.01.2022	1:03:33 PM	2.6907337	28.9420080	1100	Hillslope savannah / grassland	Sparse Veg / Dense Veg 1
FRP 16	20.01.2022	1:39:07 PM	2.6899763	28.9427256	1138	Hillslope savannah / grassland	Grassland / Sparse Veg
FRP 17	20.01.2022	1:48:30 PM	2.6894289	28.9438336	1135	Hillslope thicket (Lantana, Senegalia)	Dense Veg 2 / Sparse Veg
FRP 18	20.01.2022	1:59:07 PM	2.6901535	28.9451907	1104	Large avocado plantation	Sparse Veg / Dense Veg 1
FRP 19	20.01.2022	2:02:51 PM	2.6905497	28.9453510	1095	Large avocado plantation	Dense Veg 1
FRP 20	20.01.2022	2:10:01 PM	2.6902562	28.9463364	1091	Riparian thicket along seasonal stream	Dense Veg 1 / Sparse Veg
FRP 21	20.01.2022	2:16:08 PM	2.6903576	28.9469171	1089	Hillslope savannah / grassland	Sparse Veg / Dense Veg 1
FRP 22	20.01.2022	2:31:15 PM	2.6905267	28.9485543	1078	Banana plantation (tall, dense)	Dense Veg
FRP 23	20.01.2022	2:38:16 PM	2.6906748	28.9502881	1076	Hillslope thicket on steep slope close to river	Dense Veg
FRP 24	20.01.2022	3:30:13 PM	2.6917420	28.9527411	1061	Cultivated lands (maize) with scattered Grevillea and avocado	Exposed Rock / Sparse Veg
FRP 25	20.01.2022	3:35:42 PM	2.6922292	28.9534857	1059	Hillslope thicket with much Lantana	Water / Sparse Veg
FRP 26	20.01.2022	3:55:03 PM	2.6927297	28.9565857	1050	Cultivated lands (cassava) on steep slopes	Grassland / Dense Veg
FRP 27	20.01.2022	4:00:00 PM	2.6929614	28.9575385	1024	Plantation (avocado)	Dense Veg

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FRP	Date	Time	South	East	Elevation	Description	Current Classification
FRP 28	20.01.2022	4:27:03 PM	2.6959679	28.9620108	1024	Hillslope thicket	Exposed Rock
FRP 29	21.01.2022	10:52:29 AM	2.7002129	28.9692012	988	Riparian wetland with Phragmites and Cyperus	Dense Veg 1
FRP 30	21.01.2022	11:10:16 AM	2.6983388	28.9694670	1001	Mosaic of Hillslope thicket and cultivation (bananas)	Grassland / Sparse Veg
FRP 31	21.01.2022	11:48:24 AM	2.6941583	28.9771347	987	Cultivated lands (maize) with scattered Grevillea and avocado	Grassland / Dense Veg 1
FRP 32	21.01.2022	12:23:38 PM	2.6939673	28.9787367	981	Cultivated lands (maize) and plantations (banana); slopes above are mosaic of Hillslope savannah / grassland and cultivation	Open Ground / Grassland
FRP 33	21.01.2022	12:43:30 PM	2.6954377	28.9859412	972	Cultivation (maize, citrus)	Dense Veg 1 / Sparse Veg
FRP 34	21.01.2022	12:48:21 PM	2.6950639	28.9863805	975	Hillslope savannah / grassland on very steep slopes	Open Ground
FRP 35	21.01.2022	12:49:14 PM	2.6947755	28.9861644	975	Hillslope savannah / grassland on very steep slopes	Sparse Veg / Grassland
FRP 36	21.01.2022	12:52:20 PM	2.6983456	28.9886065	967	Cultivated lands (maize)	Dense Veg 2
FRP 37	21.01.2022	1:04:57 PM	2.7040034	29.0045067	956	Cultivated lands (maize)	Open Area
FRP 38	21.01.2022	2:56:53 PM	2.7213263	29.0225671	940	Cultivated lands (sorghum, maize) with thin strip and riparian wetland (Phragmites)	Sparse Veg
FRP 39	22.01.2022	8:09:42 AM	2.7092540	29.0035937	958	Cultivated lands (maize)	Grassland
FRP 40	22.01.2022	8:29:07 AM	2.7012802	28.9929411	970	Cultivated lands (maize) and plantations (banana); slopes above are mosaic of Hillslope savannah / grassland and cultivation	Sparse Veg / Dense Veg
FRP 41	22.01.2022	8:32:33 AM	2.7018994	28.9918473	966	Hillslope savannah / grassland on steep slopes	Open Area
FRP 42	22.01.2022	8:36:08 AM	2.6999328	28.9912758	964	Hillslope thicket	Grassland / Sparse Veg
FRP 43	22.01.2022	8:43:17 AM	2.6997982	28.9904359	962	Hillslope savannah / grassland on very steep slopes	Dense Veg 1 / Sparse Veg
FRP 44	22.01.2022	8:45:11 AM	2.6999043	28.9898149	962	Riparian thicket (Tithonia)	Sparse Veg
FRP 45	22.01.2022	8:48:23 AM	2.7009530	28.9889349	963	Hillslope savannah / grassland on steep slopes above cultivation	Grassland / Dense Veg
FRP 46	22.01.2022	8:51:11 AM	2.6998965	28.9889539	960	Hillslope thicket	Dense Veg 1 / Sparse Veg
FRP 47	22.01.2022	8:51:51 AM	2.7007741	28.9875634	960	Hillslope savannah / grassland on steep slopes	Grassland
FRP 48	22.01.2022	9:07:30 AM	2.6988693	28.9868052	970	Cultivated lands (maize); hillslope thicket adjacent to lands and grassland on ridge above	Grassland / Sparse Veg
FRP 49	22.01.2022	9:07:56 AM	2.7005502	28.9855738	970	Mosaic of Hillslope savannah / grassland and old cultivation	Grassland
FRP 50	22.01.2022	9:13:55 AM	2.6996711	28.9835387	987	Hillslope savannah / grassland on steep slopes	Grassland
FRP 51	22.01.2022	9:14:32 AM	2.6982513	28.9847376	987	Cultivated lands (maize)	Sparse Veg
FRP 52	22.01.2022	9:49:02 AM	2.6957910	28.9777185	997	Cultivated lands (maize) with adjacent thicket dominated by Lantana	Grassland / Open Area
FRP 53	22.01.2022	9:52:33 AM	2.6960043	28.9785094	1006	Cultivated lands (maize)	Grassland
FRP 54	22.01.2022	10:12:29 AM	2.6956899	28.9770966	993	Degraded riparian scrub	Sparse Veg / Grassland
FRP 55	22.01.2022	10:18:22 AM	2.6960778	28.9746182	981	Hillslope thicket; grassland higher up on very steep slope	Sparse Veg / Open Ground
FRP 56	22.01.2022	10:22:36 AM	2.6970062	28.9737848	982	Cultivated lands (sorghum, avocado, banana); small grassy hill to west of site	Open Ground / Sparse Veg
FRP 57	22.01.2022	10:59:34 AM	2.6983677	28.9820975	1022	Hillslope savannah / grassland on steep slopes above cultivation	Grassland

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FRP	Date	Time	South	East	Elevation	Description	Current Classification
FRP 58	22.01.2022	11:34:19 AM	2.7025531	28.9926765	980	Eucalyptus plantation with Lantana understory	Dense Veg
FRP 59	22.01.2022	11:54:19 AM	2.7022660	28.9920110	1009	Hillslope savannah / grassland on steep slopes with some erosion	Grassland
FRP 60	22.01.2022	12:43:01 PM	2.7054857	28.9961794	986	Hillslope savannah / grassland on steep slopes with some erosion	Open Area
FRP 61	22.01.2022	12:55:09 PM	2.7061456	28.9947884	1023	Hillslope savannah / grassland on steep slopes with some erosion	Grassland / Open Area
FRP 62	22.01.2022	1:32:15 PM	2.7415181	29.0197798	928	Rocky terrace surrounded by cultivated lands (maize)	Open Area
FRP 63	23.01.2022	8:19:37 AM	2.6723775	28.9252309	1571	Cultivated lands (maize, sunflowers)	Not classified
FRP 64	23.01.2022	8:22:36 AM	2.6729786	28.9246058	1561	Eucalyptus plantation	Not classified
FRP 65	23.01.2022	8:36:14 AM	2.6729730	28.9230143	1526	Scarp forest	Not classified
FRP 66	23.01.2022	8:51:59 AM	2.6729808	28.9227610	1521	Banana plantation	Not classified
FRP 67	23.01.2022	9:04:36 AM	2.6727906	28.9223653	1515	Mosaic of plantations (banana, avocado) and small Scarp forest patches	Not classified
FRP 68	23.01.2022	9:21:29 AM	2.6735213	28.9228394	1513	Cultivated lands (maize, sweet potato)	Not classified
FRP 69	23.01.2022	10:09:28 AM	2.6707274	28.9410862	1656	Heavily grazed grassland within Eucalyptus plantation	Not classified
FRP 70	23.01.2022	10:14:12 AM	2.6715742	28.9409088	1645	Eucalyptus plantation	Not classified
FRP 71	23.01.2022	10:17:43 AM	2.6712370	28.9415513	1627	Eucalyptus plantation	Not classified
FRP 72	23.01.2022	10:21:01 AM	2.6716718	28.9398996	1627	Banana and coffee plantation	Not classified
FRP 73	23.01.2022	10:23:39 AM	2.6715300	28.9389502	1619	Cultivated lands (maize)	Not classified
FRP 74	23.01.2022	10:31:07 AM	2.6709593	28.9399386	1643	Eucalyptus plantation	Not classified
FRP 75	23.01.2022	10:36:33 AM	2.6701544	28.9424843	1647	Eucalyptus plantation	Not classified

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FRP 1	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.679783	
	GPS E	28.941535	
	Elevation	1273 masl	
	Vegetation structure	Cultivated lands (maize, avocado, banana)	
FRP 2	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.680159	
	GPS E	28.940679	
	Elevation	1252 masl	
	Vegetation structure	Scarp thicket on cliff edge	
FRP 3	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.680892	
	GPS E	28.939804	
	Elevation	1223 masl	
	Vegetation structure	Small plantation (Grevillea robusta) with shade coffee understory	
FRP 4	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.681319	
	GPS E	28.938749	
	Elevation	1190 masl	
	Vegetation structure	Small plantation (Euphorbia tirucallii, avocado)	
FRP 5	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.681396	
	GPS E	28.936430	
	Elevation	1135 masl	
	Vegetation structure	Banana plantation with maize understory	
FRP 6	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.680873	
	GPS E	28.935905	
	Elevation	1139 masl	
	Vegetation structure	Grevillea plantation with banana, avocado, papaya	

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FRP 7	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.680639	
	GPS E	28.935305	
	Elevation	1139 masl	
	Vegetation structure	Low riparian thicket	
FRP 8	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.680666	
	GPS E	28.935575	
	Elevation	1134 masl	
	Vegetation structure	Banana plantation	
FRP 9	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.682196	
	GPS E	28.938223	
	Elevation	1133 masl	
	Vegetation structure	Scarp thicket on steep slope	
FRP 10	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.683571	
	GPS E	28.940035	
	Elevation	1130 masl	
	Vegetation structure	Cultivated lands (cassava, avocado, banana) with scattered small thickets	
FRP 11	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.683888	
	GPS E	28.940509	
	Elevation	1120 masl	
	Vegetation structure	Banana plantation (tall, dense)	
FRP 12	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.685562	
	GPS E	28.940947	
	Elevation	1126 masl	
	Vegetation structure	Grevillea plantation with maize and cassava below	

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FRP 13	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.686251	
	GPS E	28.940836	
	Elevation	1111 masl	
	Vegetation structure	Riparian thicket	
FRP 14	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.687409	
	GPS E	28.940917	
	Elevation	1105 masl	
	Vegetation structure	Grevillea plantation	
FRP 15	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.690734	
	GPS E	28.942008	
	Elevation	1100 masl	
	Vegetation structure	Hillslope savannah / grassland	
FRP 16	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.689976	
	GPS E	28.942726	
	Elevation	1138 masl	
	Vegetation structure	Hillslope savannah / grassland	
FRP 17	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.689429	
	GPS E	28.943834	
	Elevation	1135 masl	
	Vegetation structure	Hillslope thicket (Lantana, Senegalia)	
FRP 18	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.690154	
	GPS E	28.945191	
	Elevation	1104 masl	
	Vegetation structure	Large avocado plantation	

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FRP 19	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.690550	
	GPS E	28.945351	
	Elevation	1095 masl	
	Vegetation structure	Large avocado plantation	
FRP 20	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.690256	
	GPS E	28.946336	
	Elevation	1091 masl	
	Vegetation structure	Riparian thicket along seasonal stream	
FRP 21	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.690358	
	GPS E	28.946917	
	Elevation	1089 masl	
	Vegetation structure	Hillslope savannah / grassland	
FRP 22	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.690527	
	GPS E	28.948554	
	Elevation	1078 masl	
	Vegetation structure	Banana plantation (tall, dense)	
FRP 23	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.690675	
	GPS E	28.950288	
	Elevation	1076 masl	
	Vegetation structure	Hillslope thicket on steep slope close to river	
FRP 24	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.691742	
	GPS E	28.952741	
	Elevation	1061 masl	
	Vegetation structure	Cultivated lands (maize) with scattered Grevillea and avocado	

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FRP 25	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.692229	
	GPS E	28.953486	
	Elevation	1059 masl	
	Vegetation structure	Hillslope thicket with much Lantana	
FRP 26	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.692730	
	GPS E	28.956586	
	Elevation	1050 masl	
	Vegetation structure	Cultivated lands (cassava) on steep slopes	
FRP 27	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.692961	
	GPS E	28.957539	
	Elevation	1024 masl	
	Vegetation structure	Plantation (avocado)	
FRP 28	Date	20.01.2022	
	Location	Reservoir	
	GPS S	2.695968	
	GPS E	28.962011	
	Elevation	1024 masl	
	Vegetation structure	Hillslope thicket	
FRP 29	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.700213	
	GPS E	28.969201	
	Elevation	988 masl	
	Vegetation structure	Riparian wetland with Phragmites and Cyperus	
FRP 30	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.698339	
	GPS E	28.969467	
	Elevation	1001 masl	
	Vegetation structure	Mosaic of Hillslope thicket and cultivation (bananas)	

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FRP 31	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.694158	
	GPS E	28.977135	
	Elevation	987 masl	
	Vegetation structure	Cultivated lands (maize) with scattered Grevillea and avocado	
FRP 32	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.693967	
	GPS E	28.978737	
	Elevation	981 masl	
	Vegetation structure	Cultivated lands (maize) and plantations (banana); slopes above are mosaic of Hillslope savannah / grassland and cultivation	
FRP 33	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.695438	
	GPS E	28.985941	
	Elevation	972 masl	
	Vegetation structure	Cultivation (maize, citrus)	
FRP 34	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.695064	
	GPS E	28.986381	
	Elevation	975 masl	
	Vegetation structure	Hillslope savannah / grassland on very steep slopes	
FRP 35	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.694776	
	GPS E	28.986164	
	Elevation	975masl	
	Vegetation structure	Hillslope savannah / grassland on very steep slopes	
FRP 36	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.698346	
	GPS E	28.988607	
	Elevation	967 masl	
	Vegetation structure	Cultivated lands (maize)	

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FRP 37	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.704003	
	GPS E	29.004507	
	Elevation	956 masl	
	Vegetation structure	Cultivated lands (maize)	
FRP 38	Date	21.01.2022	
	Location	Reservoir	
	GPS S	2.721326	
	GPS E	29.022567	
	Elevation	940 masl	
	Vegetation structure	Cultivated lands (sorghum, maize) with thin strip and riparian wetland (Phragmites)	
FRP 39	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.709254	
	GPS E	29.003594	
	Elevation	958 masl	
	Vegetation structure	Cultivated lands (maize)	
FRP 40	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.701280	
	GPS E	28.992941	
	Elevation	970 masl	
	Vegetation structure	Cultivated lands (maize) and plantations (banana); slopes above are mosaic of Hillslope savannah / grassland and cultivation	
FRP 41	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.701899	
	GPS E	28.991847	
	Elevation	966 masl	
	Vegetation structure	Hillslope savannah / grassland on steep slopes	
FRP 42	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.699933	
	GPS E	28.991276	
	Elevation	964 masl	
	Vegetation structure	Hillslope thicket	

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FRP 43	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.699798	
	GPS E	28.990436	
	Elevation	962 masl	
	Vegetation structure	Hillslope savannah / grassland on very steep slopes	
FRP 44	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.699904	
	GPS E	28.989815	
	Elevation	962 masl	
	Vegetation structure	Riparian thicket (Tithonia)	
FRP 45	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.700953	
	GPS E	28.988935	
	Elevation	963 masl	
	Vegetation structure	Hillslope savannah / grassland on steep slopes above cultivation	
FRP 46	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.699897	
	GPS E	28.988954	
	Elevation	960 masl	
	Vegetation structure	Hillslope thicket	
FRP 47	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.700774	
	GPS E	28.987563	
	Elevation	960 masl	
	Vegetation structure	Hillslope savannah / grassland on steep slopes	
FRP 48	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.698869	
	GPS E	28.986805	
	Elevation	970 masl	
	Vegetation structure	Cultivated lands (maize); hillslope thicket adjacent to lands and grassland on ridge above	

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FRP 49	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.700550	
	GPS E	28.985574	
	Elevation	970 masl	
	Vegetation structure	Mosaic of Hillslope savannah / grassland and old cultivation	
FRP 50	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.699671	
	GPS E	28.983539	
	Elevation	987 masl	
	Vegetation structure	Hillslope savannah / grassland on steep slopes	
FRP 51	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.698251	
	GPS E	28.984738	
	Elevation	987 masl	
	Vegetation structure	Cultivated lands (maize)	
FRP 52	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.695791	
	GPS E	28.977719	
	Elevation	997 masl	
	Vegetation structure	Cultivated lands (maize) with adjacent thicket dominated by Lantana	
FRP 53	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.696004	
	GPS E	28.978509	
	Elevation	1006 masl	
	Vegetation structure	Cultivated lands (maize)	
FRP 54	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.695690	
	GPS E	28.977097	
	Elevation	993 masl	
	Vegetation structure	Degraded riparian scrub	

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FRP 55	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.696078	
	GPS E	28.974618	
	Elevation	981 masl	
	Vegetation structure	Hillslope thicket; grassland higher up on very steep slope	
FRP 56	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.697006	
	GPS E	28.973785	
	Elevation	982 masl	
	Vegetation structure	Cultivated lands (sorghum, avocado, banana); small grassy hill to west of site	
FRP 57	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.698368	
	GPS E	28.982098	
	Elevation	1022 masl	
	Vegetation structure	Hillslope savannah / grassland on steep slopes above cultivation	
FRP 58	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.702553	
	GPS E	28.992677	
	Elevation	980 masl	
	Vegetation structure	Eucalyptus plantation with Lantana understory	
FRP 59	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.702266	
	GPS E	28.992011	
	Elevation	1009 masl	
	Vegetation structure	Hillslope savannah / grassland on steep slopes with some erosion	
FRP 60	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.705486	
	GPS E	28.996179	
	Elevation	986 masl	
	Vegetation structure	Hillslope savannah / grassland on steep slopes with some erosion	

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FRP 61	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.706146	
	GPS E	28.994788	
	Elevation	1023 masl	
	Vegetation structure	Hillslope savannah / grassland on steep slopes with some erosion	
FRP 62	Date	22.01.2022	
	Location	Reservoir	
	GPS S	2.741518	
	GPS E	29.019780	
	Elevation	928 masl	
	Vegetation structure	Rocky terrace surrounded by cultivated lands (maize)	
FRP 63	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.672378	
	GPS E	28.925231	
	Elevation	1571 masl	
	Vegetation structure	Cultivated lands (maize, sunflowers)	
FRP 64	Date	23.02.2022	
	Location	Reservoir	
	GPS S	2.672979	
	GPS E	28.924606	
	Elevation	1571 masl	
	Vegetation structure	Eucalyptus plantation	
FRP 65	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.672973	
	GPS E	28.923014	
	Elevation	1526 masl	
	Vegetation structure	Scarp forest	
FRP 66	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.672981	
	GPS E	28.922761	
	Elevation	1521 masl	
	Vegetation structure	Banana plantation	

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FRP 67	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.672791	
	GPS E	28.922365	
	Elevation	1515 masl	
	Vegetation structure	Mosaic of plantations (banana, avocado) and small Scarp forest patches	
FRP 68	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.673521	
	GPS E	28.922839	
	Elevation	1513 masl	
	Vegetation structure	Cultivated lands (maize, sweet potato)	
FRP 69	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.670727	
	GPS E	28.941086	
	Elevation	1656 masl	
	Vegetation structure	Heavily grazed grassland within Eucalyptus plantation	
FRP 70	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.671574	
	GPS E	28.940909	
	Elevation	1645 masl	
	Vegetation structure	Eucalyptus plantation	
FRP 71	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.671237	
	GPS E	28.941551	
	Elevation	1627 masl	
	Vegetation structure	Eucalyptus plantation	
FRP 72	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.671672	
	GPS E	28.939900	
	Elevation	1627 masl	
	Vegetation structure	Banana and coffee plantation	

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FRP 73	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.671530	
	GPS E	28.938950	
	Elevation	1619 masl	
	Vegetation structure	Cultivated lands (maize)	
FRP 74	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.670959	
	GPS E	28.939939	
	Elevation	1643 masl	
	Vegetation structure	Eucalyptus plantation	
FRP 75	Date	23.01.2022	
	Location	Reservoir	
	GPS S	2.670154	
	GPS E	28.942484	
	Elevation	1647 masl	
	Vegetation structure	Eucalyptus plantation	

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C.1.4.2 Flora Species Data

Table C-5 SLR 2022 Plant Species List by Vegetation Community

Species	Alien	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savanna	Cultivation / Secondary Shrubland
CLASS LYCOPODIOPSIDA						
Family Selaginellaceae						
Selaginella species (photos)		u			u	
CLASS POLYPODIOPSIDA						
Family Adiantaceae						
Adiantum capillus-veneris				u		
Adiantum incisum		u		fc	fc	
Family Aspleniaceae						
Asplenium species (photos)				u		
Family Nephrolepidaceae						
Nephrolepis species				fc		
Family Polypodiaceae						
Platycerium elephantotis				u		
Family Pteridaceae						
Actiniopteris semiflabellata				u	u	
Aleuritopteris farinosa				u	u	
Cheilanthes viridis				r		
Haplopteris guineensis		r				
CLASS MAGNOLIOPSIDA						
Family Acanthaceae						
Asystasia gangetica		fc	fc	fc		u
Hypoestes species (sterile)				u		
Justicia diclipteroides					u	
Justicia flava		fc		fc		
Nelsonia canescens						
Family Amaranthaceae						
Celosia trigyna				u		u
Gomphrena celosioides	x					u
Family Anacardiaceae						
Lannea discolor					u	
Lannea cf. antiscorbutica				u	fc	
Mangifera indica	x	fc				c
Ozoroa insignis					fc	
Searsia longipes				c	u	
Searsia pyroides					u	
Family Annonaceae						
Annona senegalensis				fc	fc	u
Family Apocynaceae						
Cascabela thevetia	x					fc
Catharanthus roseus	x			u		fc
Landolphia species		u				
Tabernaemontana cf. stapfiana (distant)		u				
Family Araliaceae						
Cussonia arborea				u	fc	
Family Aristolochiaceae						
Aristolochia species (photos)				r		
Family Asteraceae						
Acanthospermum hispidum	x					fc
Ageratum conyzoides	x	fc	fc	u		fc
Bidens pilosa	x	fc	u	fc		c
Bothriocline cf. longipes					fc	
Crassocephalum crepidioides					u	
Dicoma anomala					u	
Emilia coccinea					u	
Erigeron sumatrensis	x			fc		

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Species	Alien	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savanna	Cultivation / Secondary Shrubland
Galinsoga parviflora	x					fc
Gymnanthemum amygdalinum		fc		fc	fc	
Gymnanthemum myrianthum			u	u		u
Helianthus annus	x					u
Laggera crispata						u
Linzia gerberiformis					u	
Lipotriche scandens			fc			
Microglossa densiflora					u	
Parthenium hysterophorus	x	fc	fc			c
Pluchea ovalis			fc			
Senecio species (sterile)					fc	
Solanecio angulatus				u		
Tagetes minuta	x		u			u
Tithonia diversifolia	x	fc	u			c
Tridax procumbens	x					c
Family Balanitaceae						
Balanites aegyptiaca					r	
Family Balsaminaceae						
Impatiens cf. burtonii				r		
Family Bignoniaceae						
Jacaranda mimosiifolia	x					u
Markhamia lutea		u			u	c
Markhamia obtusifolia				u		
Family Cannabaceae						
Trema orientalis		fc		fc		fc
Family Capparaceae						
Capparis tomentosa				u		
Family Caricaceae						
Carica papaya	x					fc
Family Celastraceae						
Gymnosporia senegalensis				u	fc	
Family Combretaceae						
Combretum adenogonium					u	
Combretum molle				u	fc	
Family Euphorbiaceae						
Acalypha cf. bipartita		c		fc		
Acalypha brachiata				u		u
Acalypha ornata		c		fc		
Acalypha psilostachya				u		
Euphorbia heterophylla	x					fc
Euphorbia hirta	x					fc
Euphorbia ingens				u		
Euphorbia tirucallii				u		u
Ricinis communis	x		u			
Synadenium species		r				
Family Fabaceae						
Albizia grandibracteata		u		u		
Albizia gummifera		fc			u	
Baphia cf. multiflora (sterile)		fc				
Berlinia species (sterile; cf. orientalis)		r				
Canavalia rosea			u			
Chamaecrista absus	?					u
Chamaecrista mimosoides					u	u
Crotalaria hyssopifolia					r	
Crotalaria spinosa						r
Desmodium tortuosum	x	fc		fc		c
Desmodium species (simple leaves)				u	u	

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Species	Alien	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savanna	Cultivation / Secondary Shrubland
Eriosema psoraleoides						u
Erythrina abyssinica					u	
Indigofera species (sterile)						u
Mimosa pigra	x	u	fc			
Mucuna species (sterile)		u				
Pseudarthria hookeri					u	
Rhynchosia cf. minima (sterile)					u	
Senegalia brevispica				u		
Senegalia polyacantha		fc	u			
Senna hirsuta	x				u	fc
Senna septemtrionalis	x					fc
Senna spectabilis	x	u				fc
Tylosema fassoglense				fc	u	
Vachellia hockii					c	
Vigna luteola			u			
Family Hypericaceae						
Harungana madagascariensis				u		
Family Lamiaceae						
Aeollanthus suaveolens					u	
Clerodendrum formicarum				u		
Clerodendrum johnstonii				u		
Hyptis suaveolens						r
Leonotis nepetifolia					fc	
Ocimum obovatum					fc	
Plectranthus species (sterile)				u		
Tinnea apiculata					u	
Family Lauraceae						
Persea americana	x	fc				c
Family Loganiaceae						
Strychnos innocua					fc	
Family Malvaceae						
Abutilon mauritianum		u		u		
Grewia forbesii		fc		c		
Hibiscus cf. calyphyllus (sterile)		u				
Hibiscus cf. cannabinus (sterile)			u			u
Sida acuta		u				c
Sterculia quinqueloba				fc	fc	
Sterculia tragacantha		d		c		
Triumfetta rhomboidea		fc	u	u		fc
Urena lobata			u	u		fc
Family Meliaceae						
Carapa procera		r				
Ekebergia capensis		r				
Lepidotrichilia volkensii		u		u		
Family Melianthaceae						
Bersama abyssinica		u				
Family Menispermaceae						
Cissampelos mucronata		u	u			
Family Moraceae						
Ficus asperifolia		u		u		
Ficus cyathistipula		u				
Ficus glumosa				u		
Ficus ingens				fc	fc	
Ficus lutea		u		r		
Ficus oreodryadum		fc		fc		
Ficus sycomorus		fc	fc	fc		u
Ficus thonningii		fc		fc		
Ficus vallis-choudae		c		fc		
Milicia excelsa				r		

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Species	Alien	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savanna	Cultivation / Secondary Shrubland
Family Myrtaceae						
Eucalyptus species (photos)	x				fc	c
Psidium guajava	x		u			u
Family Nyctaginaceae						
Boerhavia erecta	x					u
Commicarpus plumbagineus				fc		
Mirabilis jalapa	x					u
Family Ochnaceae						
Ochna species (sterile; cf. holstii)		r		r		
Family Oxalidaceae						
Biophytum helenae						
Family Pedaliaceae						
Sesamum angustifolium						u
Family Phyllanthaceae						
Antidesma venosum		u		fc	u	
Bridelia micrantha		fc		fc	u	
Flueggea virosa		fc		fc		
Phyllanthus cf. maderaspatensis					u	u
Phyllanthus species (sterile)		u				
Family Piperaceae						
Peperomium cf. leptostachya		fc		fc	fc	
Family Proteaceae						
Grevillea robusta	x	u				c
Family Rhamnaceae						
Helinis integrifolius				u		
Ziziphus mucronata				fc	u	
Family Rubiaceae						
Coffea arabica	x					fc
Hymenodictyon floribundum		u		u		
Pavetta species (photos)				u		
Pentas zanzibarica					r	
Psychotria species (photos)				u		
Richardia brasilensis	x					u
Spermacoce species 1 (photos)						fc
Spermacoce cf. chaetocephala (photos)						u
Family Rutaceae						
Citrus x aurantium	x					fc
Family Sapindaceae						
Allophylus africanus				u		
Allophylus chaunostachys				fc		
Blighia unijugata		u				
Cardiospermum grandiflorum		fc		fc		
Pancovia species		r				
Paullinia pinnata		u		u		
Family Solanaceae						
Manihot esculenta	x					c
Solanum aethiopicum	x					u
Solanum anguivi						u
Solanum betaceum	x					fc
Solanum chrysotrichum		u	u			fc
Solanum incanum						u
Solanum lycopersicum	x					fc
Solanum nigrum	x		u			
Family Ulmaceae						
Celtis africana		u		u		
Celtis gomphophylla		r				
Family Urticaceae						
Laportea cf. aestuans (photos)				fc		

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Species	Alien	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savanna	Cultivation / Secondary Shrubland
Urera trinervis		u		fc		
Family Verbenaceae						
Hoslundia opposita		c		c	u	fc
Lantana camara	x	fc		c	u	c
Lantana ukambensis					fc	
Lippia javanica					fc	
Family Vitaceae						
Cissus cf. petiolata				fc		
Cyphostemma species 1 (photos)				fc		
Rhocissus tridentata		u				
CLASS LILIOPSIDA						
Family Amaryllidaceae						
Scadoxus multiflorus		r		u		
Family Anthericaceae						
Chlorophytum species 1 (photos)		r				
Family Araceae						
Colocasia esculenta	x					fc
Family Arecaceae						
Phoenix reclinata		fc				
Raphia farinifera						u
Family Asparagaceae						
Asparagus africanus		fc		fc		
Family Asphodelaceae						
Aloe cf. lateritia (sterile)					u	
Aloe species 1 (sterile, narrow leaves)		u		u		
Family Cannaceae						
Canna indica	x		u			u
Family Commelinaceae						
Commelina benghalensis						u
Commelina species (sterile)					u	
Family Cyperaceae						
Bulbostylis species					fc	
Cyperus cyperoides			fc			
Cyperus cf. dives			fc			
Cyperus cf. dubius			u			
Cyperus species 1			fc			
Family Dioscoreaceae						
Dioscorea cf. bulbifera				fc		
Dioscorea dumetorum				u		
Family Dracaenaceae						
Dracaena cf. laxissima (photos)				u		
Family Musaceae						
Musa acuminata	x	fc				c
Family Orchidaceae						
Bonatea steudneri				r		
Cyrtorchis praetermissa		u				
Eulophia guineensis				u		
Habenaria cf. *adolphi* (photo)					r	
Family Poaceae						
Bambusa vulgaris	x	u	fc	u		u
Cymbopogon species (photos)					d	
Cynodon dactylon			u			u
Digitaria cf. sanguinalis						u
Eleusine indica	?					fc
Eragrostis ciliaris						fc
Hyparrhenia cf. filipendula					u	
Hyparrhenia species			fc			
Leersia hexandra			u			u

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Species	Alien	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savanna	Cultivation / Secondary Shrubland
Melinis repens						fc
Oplismenus species		fc		fc		
Panicum maximum					u	fc
Phragmites mauritianus			d			
Setaria cf. lindenbergiana		fc		fc		
Setaria sphacelata					fc	fc
Setaria cf. verticillata		u				
Sorghum species (cultivated)	x					fc
Sporobolus africanus			fc		u	fc
Sporobolus species (cf. *pectinatus*)					fc	
Sporobolus cf. pyramidalis					fc	
Zea mays	x					d

Notes: fc = fairly common; u = uncommon; r= rare; c= common; d= dominant

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Table C-6 SLR 2022 Priority Plant Species – Likelihood of Occurrence

Scientific Name	IUCN Status	Habitat	Likelihood	Rationale
Emilia subscaposa	EN	Prefers swamps, but has also been reported from sandy fallows, cassava fields, and dry grassland, at 775–1030 m altitude	Low*	While much suitable present downstream of the project, this poorly known species has not been collected in 1971 and only known from 6 specimens from the southern reaches of the Rusizi. It was not found during targeted searches in Feb 2022 or May 2024
Senecio rugegensis	EN	Occurs in montane forest clearings and swamp edges at 1850-2450 m.	Very Low	No suitable habitat present
Vernonia scaettae	EN	Occurs on rocky slopes in montane forest and secondary habitats at 1580-3300 m.	Very Low	No suitable habitat present
Chlorophytum hirsutum	EN	Grows in open forest, Loudetia grassland, forest margins among boulders, gallery forest, ravine with Euphorbia; at 675-1200 m altitude.	Low*	Some suitable present in the project area. It was not found during targeted searches in Feb 2022 or May 2024.
Emilia pammicrocephala	EN	Grows in open habitats such as upland wooded grassland, rocky slopes, edges of streams and springs (1350 to 2 350 masl)	Very Low	Project area is below the altitude limits for this species
Carpha angustissima	EN	Occurs in montane bogs between 2400 and 3300 masl	Very Low	Project area is below the altitude limits for this species
Aeschynomene bullockii	EN	Occurs in grassland or Brachystegia woodland on stony soil at 780-1600 masl.	Very Low	No suitable habitat or known nearby records
Beilschmiedia michelsonii	EN	A species of montane forest at 1000-2200 masl.	Very Low	No suitable habitat present
Warneckea bequaertii	EN	Occurs in mid-altitudinal and submontane rainforest where it can be very common.	Very Low	Project area is below the altitude limits for this species
Sterculia tragacanthoides	EN	Occurs in evergreen forest and gallery forest, at 800–1400 masl	Low	Limited suitable habitat
Bulbophyllum vulcanicum	EN	Epiphyte growing on trees in montane rainforest.	Very Low	No suitable habitat present
Eggelingia ligulifolia	EN	Epiphyte growing on trees in montane rainforest.	Very Low	No suitable habitat present
Polystachya pachychila	EN	Epiphyte growing on trees in montane rainforest.	Very Low	No suitable habitat present
Pteris kivuensis	EN	Occurs in wet mountain forests, at 1900-2400 maltitude.	Very Low	No suitable habitat present
Englerophytum rwandense	EN	Occurs in montane forests between 1900 and 2400 masl	Very Low	Project area is below the altitude limits for this species
Strophanthus bequaertii	EN	A liane growing in montane forest.	Very Low	No suitable habitat present
Emilia chiovendeana	EN	Occurs in montane grassland and shrubland at 2200–3300 masl.	Very Low	Project area is well below the altitude limits for this species
Erythrina orophila	EN	Occurs on hill slopes and in ravines in highland forest and afromontane grassland	Very Low	No suitable habitat present

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Scientific Name	IUCN Status	Habitat	Likelihood	Rationale
Polystachya undulata	EN	Grows on trees in submontane forest, at 1500-1700 m altitude.	Very Low	No suitable habitat present
Brachystephanus roseus	EN	Occurs in montane and submontane forest	Very Low	No suitable habitat present
Tarenna rwandensis	EN	Occurs in various moist forest types, generally above 1000 masl	Low	Limited suitable habitat
Psychotria palustris	EN	Occurs in montane forest understory at 1780-2550 masl.	Very Low	No suitable habitat present
Chlorophytum burundiense	EN	Occurs in grassland, wet grassland, tea plantations, ericaceous scrubland or in temporary pools, at 2000-2700 m altitude.	Very Low	No suitable habitat present
Tarenna kivuensis	EN	Restricted to dense montane forest at 2050–2300 m elevation	Very Low	No suitable habitat present
Casearia michelsonii	EN	Occurs on mountain slopes in humid montane forest up to the bamboo zone.	Very Low	No suitable habitat present
Blepharis burundiensis	EN	Grows in savanna palm groves, ranging between 800 and 850 m altitude.	Low	Occurs at altitudes lower than project area; no suitable habitat
Polystachya winigeri	EN	An epiphyte in montane forest	Very Low	No suitable habitat present
Asplenium burundense	EN	Occurs in the upper zone of montane moist forest and secondary forest, at 2100-2600 m altitude	Very Low	No suitable habitat present
Leptoderris burundiensis	EN	Occurs in a wide variety of habitats, including montane forests, gallery forests and savanna, at 1700-2400 m altitude.	Very Low	Project area is well below the altitude limits for this species
Justicia violaceotincta	EN	Occurs in mid-altitude and montane rain forest, between 1 200 and 2 000 m elevation.	Very Low	No suitable habitat present
Bulbostylis longiradiata	EN	Grows in grassland and open woodland at 800-1250 m asl.	Low*	Some suitable present in the project area. It was not found during targeted searches in Feb 2022 or May 2024.
Psychotria parvistipulata	EN	Montane forest scrub.	Very Low	No suitable habitat present
Milicia excelsa	NT	Occurs in a variety of forest types	Confirmed	A single tree observed at the edge of Hillslope Thicket at the base of a slope downstream of the powerhouse
Entandrophragma angolense	NT	Prefers moist semi-deciduous forest, but also occurs in evergreen forest. Occurs in lowland and mid-altitude rainforest, but sometimes also in gallery forest and thickets.	Moderate	Some suitable habitat present although highly fragmented
Mitragyna stipulosa	NT	Occurs in swamps, marshy localities and gallery forest in the dry forest and savanna zone,	Moderate	While much evergreen forest has been destroyed, the species can often persist in riparian habitat
Brachystephanus coeruleus	NT	Occurs in the undergrowth of forest particularly along rivers and streams.	Moderate	While much evergreen forest has been destroyed, the species can often persist in riparian habitat
Rytigynia beniensis	NT	Shrub growing on forest edges, thickets, woodland, grassland, rocky areas, or eroded land at 910-2750 masl.	Moderate	Some suitable present in the project area
Rytigynia kiwuensis	NT	Shrub growing in forest at 940-2480 masl.	Moderate	Some suitable present in the project area

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Scientific Name	IUCN Status	Habitat	Likelihood	Rationale
Trifolium purseglovei	NT	Small herb growing in grassland, open marshy places at 1460-2750 masl.	Very Low	Project area is below the altitude limits for this species
Balthasaria schliebenii	NT	Occurs in montane forest at 1400-2450 masl.	Very Low	Project area is below the altitude limits for this species
Vernonia melanocoma	NT	An annual herb of roadsides in wooded grassland and grassland.	Moderate	Some suitable present in the project area
Hypericum humbertii	NT	Grows in wet montane forest and marshes at 1750-2600 masl.	Very Low	Project area is well below the altitude limits for this species
Peddiea rapaneoides	NT	Occurs in montane forest, swamp forest, gallery forest and Cyperus wetlands up to 3000 masl.	Very Low	No suitable habitat present
Lasianthus seseensis	NT	Occurs in various moist forest types, generally above 1000 masl	Low	Limited suitable habitat
Sclerochiton bequaertii	NT	Occurs in mid-altitude to montane forest, from 1000 to 2300 masl.	Low	Limited suitable habitat
Lovoa swynnertonii	NT	Found in lowland to mid-elevation forest.	Low	Limited suitable habitat
Vernonia kirungae	NT	Grows on forest margins and secondary scrub at 1860–2500 masl.	Very Low	Project area is well below the altitude limits for this species
Impatiens bequaertii	NT	Montane rainforest near streams, bamboo forest, also on roadside and in clearings.	Very Low	No suitable habitat present
Monanthotaxis orophila	NT	Grows in upland forest, at 1900-2520 m altitude.	Very Low	No suitable habitat present
Xyris valida	NT	Occurs in swamps and peat bog with Xyris and Sphagnum, humid meadows, and in floating mats on lake sides; at 1125–3400 m altitude.	Low	Limited suitable habitat
Habenaria macrostele	NT	Grows in montane grassland at 1400-2592 masl.	Very Low	No suitable habitat present
Stapfiella claoxyloides	NT	Grows in montane forest, forest margin, secondary forest, marsh edge, stream banks; at 1200-2350 masl.	Very Low	Project area is below the altitude limits for this species
Isoglossa vulcanicola	NT	Occurs in montane Forest, on roadsides and in degraded areas.	Very Low	No suitable habitat present
Thunbergia mildbraediana	NT	Grows in montane rainforest, often in clearings, bamboo forest.	Very Low	No suitable habitat present
Leptonychia melanocarpa	NT	Occurs in dense humid semi-deciduous rainforest, montane rainforest, gallery forest, between 850 to 1950 m elevation.	Low	Limited suitable habitat
Entandrophragma cylindricum	VU	Occurs in semi-deciduous forests, frequently in relatively dry habitats, including fallow old lands, although does not tolerate burning.	Low	Limited suitable habitat
Khaya anthotheca	VU	Widespread in areas of evergreen forest.	Moderate	While much evergreen forest has been destroyed, the species can often persist in riparian habitat
Polystachya hastata	VU	An epiphyte growing on montane rainforest trees.	Very Low	No suitable habitat present
Polystachya stauroglossa	VU	An epiphyte growing in mid-altitude forest; unlikely to be able to tolerate degraded forest	Low	Limited suitable habitat
Pterygota bequaertii	VU	Lowland rainforest and gallery forest	Low	Limited suitable habitat
Leplaea mayombensis	VU	Occurs in mid-altitude rainforest	Low	Limited suitable habitat

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Scientific Name	IUCN Status	Habitat	Likelihood	Rationale
Oxyanthus troupinii	VU	Small tree of primary montane forest	Very Low	No suitable habitat present
Globimetula kivuensis	VU	Occurs as an epphyte on trees at forest edges, 1350-2250 masl	Very Low	Project area is below the altitude limits for this species
Polystachya laurentii	VU	Epiphyte growing on trees in various forest types at 590-1350 masl	Low	Limited suitable habitat
Rhipidoglossum bilobatum	VU	Epiphyte growing on trees in forest and thickets at 1 280-2255 masl.	Low	Limited suitable habitat
Isolona lebrunii	VU	Occurs in moist montane forests	Very Low	No suitable habitat present
Vittaria reekmansii	VU	Epiphyte growing in forest between 1650-2400 masl	Very Low	Project area is below the altitude limits for this species
Ixora burundiensis	VU	Grows in montane rainforest, forest ridges and dry woodland, at 1950–2350 masl	Very Low	Project area is below the altitude limits for this species
Psychotria lebrunii	VU	Occurs in mountain forests, gallery forests, rainforest and marshland, between 1650 and 2700 masl	Very Low	Project area is below the altitude limits for this species
Helichrysum helvolum	VU	Grows in montane forest clearings and edges at 1500-2790 masl.	Very Low	Project area is below the altitude limits for this species
Swertia adolfi-friderici	VU	Grows in swamps in montane rainforest and subalpine swamps.	Very Low	No suitable habitat present
Polystachya leucorhoda	VU	Epiphyte of montane rainforest and bamboo forest	Very Low	No suitable habitat present
Buchnera keilii	VU	Grows in grassland, light woodland at 1300-2000 masl.	Moderate	Some suitable present in the project area
Cassipourea ndando	VU	Occurs in dense montane forest at 1670-2500 masl.	Very Low	No suitable habitat present
Cynorkis rungweensis	VU	Occurs in montane grassland and heathland at 2000-2800 masl.	Very Low	Project area is well below the altitude limits for this species
Polystachya woosnamii	VU	Grows on trees in montane forest, at 1900-3000 m altitude.	Very Low	No suitable habitat present
Sericanthe leonardii	VU	Grows in montane forest shrub.	Very Low	No suitable habitat present
Crotalaria adenocarpoides	VU	Occurs in grassland at 1500-2350 masl	Very Low	No suitable habitat present
Ochna hackarsii	VU	Occurs in riparian forest at 750-1470 masl.	Moderate	Some suitable present in the project area
Zanthoxylum mildbraedii	VU	Occurs in mid-altitude to montane forest, from 750-2100 masl.	Low	Limited suitable habitat
Embelia libeniana	VU	Occurs in upland forests and occasionally marshes, between 2000 and 2450 masl	Very Low	No suitable habitat present
Otiophora lebruniana	VU	Found in mid- to high-altidue grassland an ericaceous scrub, between 1400 and 2600 m altitude.	Very Low	No suitable habitat present
Pavetta urundensis	VU	Found in montane forest at 1850-2600 masl	Very Low	No suitable habitat present
Bothriocline nyungwensis	VU	Grows in forest and swamps at 1400-2460 masl	Very Low	Project area is well below the altitude limits for this species
Helichrysum ellipticifolium	VU	Found growing in swamps, montane grassland, Hagenia forest and heath at 2000-3570 masl.	Very Low	No suitable habitat present

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Scientific Name	IUCN Status	Habitat	Likelihood	Rationale
Pauridiantha bequaertii	VU	Occurs in lowland to mid-altitude forests at 700-1350 m elevation.	Moderate	Some suitable present in the project area
Rytigynia ruwenzoriensis	VU	Occurs in the understorey of evergreen forest, at 1400–2400 m altitude.	Very Low	No suitable habitat present
Prunus africana	VU	Occurs primarily in moist montane forest above 1800 masl	Very Low	No suitable habitat present
Ocotea michelsonii	VU	Grows in mid-altidue to montane forest at 1100-2500 masl.	Low	Limited suitable habitat
Polystachya gracilenta	VU	Occurs in montane forest, bamboo forest, heathland, and rocky open places at 1950-2550 masl.	Very Low	No suitable habitat present
Oenanthe mildbraedii	VU	Grows in swamps, edges of streams in open Hagenia forest, wet depressions in grassland; 1600-2400 m altitude.	Very Low	No suitable habitat present
Mimulopsis excellens	VU	Grows in wet montane forest	Very Low	No suitable habitat present
Harungana montana	VU	Occurs in montane forest at 2000-2300 m altitude.	Very Low	No suitable habitat present
Agelanthus myrsinifolius	VU	Grows in montane or swamp forests and heath zone; at 1900-3300 m altitude	Very Low	No suitable habitat present
Sabicea bequaertii	VU	Found in evergreen forest understorey at 1950-2450 m elevation.	Very Low	Project area is well below the altitude limits for this species
Tridactyle virgula	VU	An epiphyte in montane forest	Very Low	No suitable habitat present
Lebrunia bushaie	VU	A large dominant tree in tropical lowland and montane rain forest.	Low	Limited suitable habitat
Cincinnobotrys speciosa	VU	Found in various forest types between ±1200 and ±2350 m altitude	Very Low	No suitable habitat present
Justicia amanda	VU	Grows in the open at the edge of swamps and in heath above 1100 masl	Low	Limited suitable habitat
Alvesia clerodendroides	VU	Occurs in seasonally open bush on sandy soil, in fire-maintained grassland with patches of woodland, on heathland between rocks, between 1430 and 2300 m altitude.	Low	Limited suitable habitat
Polygala engleri	VU	Occurs in montane forest, often in marshes or on riverbanks, at 650-2700 masl.	Very Low	No suitable habitat present
Tricalysia kivuensis	VU	Grows in mid-altitude and montane forest at 1450-2115 masl.	Very Low	No suitable habitat present
Impatiens erecticornis	VU	Montane rainforest along streams.	Very Low	No suitable habitat present
Impatiens mildbraedii	VU	Grows in open swamps and streams in montane forest.	Very Low	No suitable habitat present
Brachystephanus glaberrimus	VU	Occurs in montane forest undergrowth and swamps.	Very Low	No suitable habitat present

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C.1.4.3 Bird Species Data

Table C-7 SLR 2022 Bird Species List by Habitat Type

Common Name	Scientific Name[1]	Rwanda Status[2]	Hillslope Grassland / Savanna	Hillside Thicket	Riparian Wetland	Riparian Thicket	Open Water	Cultivation	Towns /Villages
ORDER GALLIFORMES Family Phasianidae									
Red-necked Spurfowl	*Pternistis afer harterti*	Common breeding resident		x				x	
Scaly Francolin	*Pternistis squamatus schuetti*	Fairly common breeding resident		x				x	
ORDER ANSERIFORMES Family Anatidae									
White-faced Whistling Duck	*Dendrocygna viduata*	Very common partial migrant although not recorded from the Ruzizi (Vande Weghe, 2011)					x		
ORDER PELECANIFORMES Family Ardeidae									
Black-headed Heron	*Ardea melanocephala*	Common breeding resident			x		x		
Western Great Egret	*Casmerodius albus melanorhynchus*	Common visitor, breeding irregularly					x		
Striated Heron	*Butorides striata atricapilla*	Common breeding resident			x		x		
Family Scopidae Hamerkop	*Scopus umbretta*	Common breeding resident			x		x		
ORDER SULIFORMES Family Phalacrocoracidae									
White-breasted Cormorant	*Phalacrocorax lucidus*	Common breeding resident and partial migrant					x		
Reed Cormorant	*Microcarbo africanus*	Common breeding resident			x		x		
ORDER ACCIPITRIFORMES Family Accipitridae									
African Harrier-Hawk	*Polyboroides typus*	Fairly common breeding resident	x	x				x	
Long-crested Eagle	*Ictinaetus occipitalis*	Common breeding resident		x				x	
Yellow-billed Kite	*Milvus aegyptius parasitus*	Very common breeding resident and intra-African passage migrant	x					x	x
Augur Buzzard	*Buteo augur*	Common breeding resident	x					x	
Common Buzzard	*Buteo buteo vulpinus*	Very common Palearctic passage migrant	x					x	
Western Marsh Harrier	*Circus aeruginosus*	Fairly common Palearctic passage migrant and wintering bird			x			x	
Wahlberg's Eagle	*Hieraaetus wahlbergi*	Common breeding migrant (Aug-Apr)						x	
ORDER GRUIFORMES Family Rallidae									
Red-knobbed Coot	*Fulica cristata*	Common breeding resident in north-western Rwanda, but unknown from the Ruzizi system					x		
ORDER CHARADRIIFORMES Family Scolopacidae									

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Common Name	Scientific Name[1]	Rwanda Status[2]	Hillslope Grassland / Savanna	Hillside Thicket	Riparian Wetland	Riparian Thicket	Open Water	Cultivation	Towns /Villages
Common Sandpiper	*Actitis hypoleucos*	Common Palearctic passage migrant and wintering bird			x		x		
ORDER COLUMBIFORMES									
Family Columbidae									
Speckled Pigeon	*Columba guinea*	Common breeding resident							x
Red-eyed Dove	*Streptopelia semitorquata*	Very common breeding resident		x		x		x	x
Ring-necked Dove	*Streptopelia capicola tropica*	Very common breeding resident	x	x					
Laughing Dove	*Spilopelia senegalensis*	Very common breeding resident	x					x	x
Blue-spotted Wood Dove	*Turtur afer*	Common breeding resident	x	x		x		x	
African Green Pigeon	*Treron calvus gibberifrons*	Common breeding resident		x					
ORDER MUSOPHAGIFORMES									
Family Musophagidae									
Ross's Turaco	*Musophaga rossae*	Common breeding resident		x		x		x	
ORDER CUCULIFORMES									
Family Cuculidae									
Blue-headed Coucal	*Centropus monachus fischeri*	Common breeding resident		x	x			x	
White-browed Coucal	*Centropus superciliosus loandae*	Common breeding resident				x		x	
Levaillant's Cuckoo	*Clamator levaillantii*	Common breeding intra-African migrant		x				x	
Diederik Cuckoo	*Chrysococcyx caprius*	Common breeding intra-African migrant		x	x				
Klaas's Cuckoo	*Chrysococcyx klaas*	Common breeding resident and partial migrant	x	x				x	
Black Cuckoo	*Cuculus clamosus gabonensis*	Fairly common breeding intra-African migrant		x				x	
Red-chested Cuckoo	*Cuculus solitarius*	Common breeding intra-African migrant		x				x	
ORDER STRIGIFORMES									
Family Tytonidae									
Western Barn Owl	*Tyto alba affinis*	Common breeding resident							x
Family Strigidae									
Pearl-spotted Owlet	*Glaucidium perlatum*	Common breeding resident						x	x
ORDER APODIFORMES									
Family Apodidae									
African Palm Swift	*Cypsiurus parvus myochrous*	Common breeding resident					x	x	x
African Black Swift	*Apus barbatus roehli*	Uncommon breeding resident	x						
Little Swift	*Apus affinis*	Very common breeding resident	x				x	x	x
Scarce Swift	*Schoutedenapus myoptilus*	Very common resident in western Rwanda	x						
White-rumped Swift	*Apus caffer*	Common breeding resident	x					x	
ORDER COLIIFORMES									
Family Coliidae									
Speckled Mousebird	*Colius striatus kivuensis*	Very common breeding resident	x	x		x		x	x
ORDER CORACIIFORMES									

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Common Name	Scientific Name[1]	Rwanda Status[2]	Hillslope Grassland / Savanna	Hillside Thicket	Riparian Wetland	Riparian Thicket	Open Water	Cultivation	Towns /Villages
Family Meropidae									
Little Bee-eater	*Merops pusillus meridionalis*	Common breeding resident	x		x			x	
Cinnamon-chested Bee-eater	*Merops oreobates*	Common breeding resident	x	x					
European Bee-eater	*Merops apiaster*	Very common Palearctic migrant	x				x	x	
ORDER PICIFORMES									
Family Indicatoridae									
Lesser Honeyguide	*Indicator minor*	Fairly common breeding resident		x				x	
ORDER FALCONIFORMES									
Family Falconidae									
Common Kestrel	*Falco tinnunculus rufescens*	Common breeding resident	x						
Lanner Falcon	*Falco biarmicus*	Fairly common breeding resident	x					x	
Lesser Kestrel	*Falco naumanni*	Fairly common passage migrant (Dec, Apr)	x						
ORDER PASSERIFORMES									
Family Platysteiridae									
Brown-throated Wattle-eye	*Platysteira cyanea nyansae*	Fairly common breeding resident		x		x		x	
Family Malaconotidae									
Brown-crowned Tchagra	*Tchagra australis emini*	Common breeding resident	x	x				x	
Black-crowned Tchagra	*Tchagra senegalus armena*	Common breeding resident		x		x		x	
Northern Puffback	*Dryoscopus gambensis erwini*	Common breeding resident		x					
Tropical Boubou	*Laniarius major*	Common breeding resident		x	x	x		x	
Family Laniidae									
Mackinnon's Shrike	*Lanius mackinnoni*	Common breeding resident		x				x	
Common Fiscal	*Lanius collaris humeralis*	Common breeding resident	x					x	x
Family Monarchidae									
African Paradise Flycatcher	*Terpsiphone viridis kivuensis*	Common breeding resident and partial migrant		x		x		x	
Family Corvidae									
Pied Crow	*Corvus albus*	Very common breeding resident						x	x
White-necked Raven	*Corvus albicollis*	Common breeding resident	x					x	x
Family Pycnonotidae									
Dark-capped Bulbul	*Pycnonotus tricolor*	Very common breeding resident	x	x		x		x	x
Yellow-throated Leaflove	*Atimastillas flavicollis pallidigula*	Fairly common breeding resident		x		x			
Family Hirundinidae									
Black Saw-wing	*Psalidoprocne pristoptera ruwenzori*	Very common breeding resident	x	x				x	
Angola Swallow	*Hirundo angolensis*	Common breeding resident	x					x	x
Wire-tailed Swallow	*Hirundo smithii*	Fairly common breeding resident					x		x
Rock Martin	*Ptyonoprogne fuligula rufigula*	Fairly common breeding resident	x				x	x	x
Red-rumped Swallow	*Cecropis daurica emini*	Common breeding resident	x		x		x	x	x
Family Macrosphenidae									
Moustached Grass Warbler	*Melocichla mentalis*	Common breeding resident	x					x	
Family Phylloscopidae									

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Common Name	Scientific Name[1]	Rwanda Status[2]	Hillslope Grassland / Savanna	Hillside Thicket	Riparian Wetland	Riparian Thicket	Open Water	Cultivation	Towns /Villages
Willow Warbler	*Phylloscopus trochilus*	Very common Palearctic passage migrant and wintering bird		x				x	
Family Acrocephalidae									
Eastern Olivaceous Warbler	*Iduna pallida*	Uncommon Palearctic migrant, not recorded in the western part of the country		x					
Dark-capped Yellow Warbler	*Iduna natalensis massaica*	Uncommon breeding resident			x			x	
Eurasian Reed Warbler	*Notiocichla scirpacea*	Very common Palearctic passage migrant and wintering bird		x	x			x	
Greater Swamp Warbler	*Acrocephalus rufescens foxi*	Common breeding resident			x				
Great Reed Warbler	*Acrocephalus arundinaceus*	Fairly common Palearctic passage migrant and wintering bird						x	
Family Cisticolidae									
Red-faced Cisticola	*Cisticola erythrops sylvia*	Common breeding resident	x		x	x		x	
Chubb's Cisticola	*Cisticola chubbi*	Common breeding resident	x					x	
Tawny-flanked Prinia	*Prinia subflava graueri*	Common breeding resident	x		x			x	
White-chinned Prinia	*Schistolais leucopogon reichenowi*	Fairly common breeding resident		x					
Grey-capped Warbler	*Eminia lepida*	Common breeding resident		x				x	
Grey-backed Camaroptera	*Camaroptera brevicaudata aschani*	Very common breeding resident		x		x		x	
Family Zosteropidae									
Green White-eye	*Zosterops stuhlmanni*	Very common breeding resident		x		x		x	
Family Leiothrichidae									
Black-lored Babbler	*Turdoides sharpei*	Common breeding resident		x				x	
Arrow-marked Babbler	*Turdoides jardinei emini*	Common breeding resident		x		x		x	
Family Sturnidae									
Slender-billed Starling	*Onychognathus tenuirostris theresae*	Uncommon breeding resident	x			x			
Family Turdidae									
African Thrush	*Turdus pelios graueri*	Common breeding resident		x		x		x	x
Family Muscicapidae									
White-eyed Slaty Flycatcher	*Melaenornis fischeri toruensis*	Common breeding resident		x				x	
Ashy Flycatcher	*Fraseria caerulescens*	Fairly common breeding resident				x			
Spotted Flycatcher	*Muscicapa striata*	Common Palearctic passage migrant and wintering bird						x	
White-browed Robin-Chat	*Cossypha heuglini*	Very common breeding resident		x		x			x
Familiar Chat	*Oenanthe familiaris modesta*	Fairly common breeding resident	x						
Family Nectariniidae									
Green-headed Sunbird	*Cyanomitra verticalis cephaelis*	Common breeding resident		x				x	
Scarlet-chested Sunbird	*Chalcomitra senegalensis lamperti*	Common breeding resident	x	x		x		x	x
Bronzy Sunbird	*Nectarinia kilimensis*	Common breeding resident	x	x				x	
Olive-bellied Sunbird	*Cinnyris chloropygius orphogaster*	Common breeding resident		x					

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Common Name	Scientific Name[1]	Rwanda Status[2]	Hillslope Grassland / Savanna	Hillside Thicket	Riparian Wetland	Riparian Thicket	Open Water	Cultivation	Towns /Villages
Marico Sunbird	*Cinnyris mariquensis suahelicus*	Very common breeding resident	x	x					
Red-chested Sunbird	*Cinnyris erythrocercus*	Common breeding resident, although not recorded in western Rwanda			x				
Variable Sunbird	*Cinnyris venustus igneiventris*	Common breeding resident	x	x				x	x
Copper Sunbird	*Cinnyris cupreus*	Common breeding resident	x	x		x		x	
Family Ploceidae									
Baglafecht Weaver	*Ploceus baglafecht stuhlmanni*	Very common breeding resident		x	x	x		x	x
Spectacled Weaver	*Ploceus ocularis crocatus*	Common breeding resident		x				x	
Holub's Golden Weaver	*Ploceus xanthops*	Common breeding resident	x	x	x			x	
Village Weaver	*Ploceus cucullatus*	Very common breeding resident			x	x		x	x
Black-winged Red Bishop	*Euplectes hordeaceus*	Very uncommon breeding resident, but abundant near Bugarama						x	x
Southern Red Bishop	*Euplectes orix nigrifrons*	Common breeding resident			x			x	x
Yellow Bishop	*Euplectes capensis crassirostris*	Common breeding resident	x	x				x	
Red-collared Widowbird	*Euplectes ardens tropicus*	Very common breeding resident	x					x	
Fan-tailed Widowbird	*Euplectes axillaris*	Very common breeding resident						x	
Slender-billed Weaver	*Ploceus pelzelni*	Fairly common breeding resident		x				x	
Black-necked Weaver	*Ploceus nigricollis*	Locally common breeding resident		x				x	
Family Estrildidae									
Black-and-white Mannikin	*Spermestes bicolor poensis*	Common breeding resident		x		x		x	
Bronze Mannikin	*Spermestes cucullatus scutatus*	Very common breeding resident	x	x	x			x	x
Red-billed Firefinch	*Lagonosticta senegala ruberrima*	Common breeding resident		x		x		x	
Common Waxbill	*Estrilda astrild peasei*	Common breeding resident	x		x			x	
Red-throated Twinspot	*Hypargos niveoguttatus*	Very uncommon breeding resident		x				x	
Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	Common breeding resident		x				x	
Yellow-bellied Waxbill	*Coccopygia quartinia*	Common breeding resident		x				x	
Family Viduidae									
Village Indigobird	*Vidua chalybeata centralis*	Common breeding resident						x	
Pin-tailed Whydah	*Vidua macroura*	Common breeding resident	x					x	x
Family Passeridae									
House Sparrow	*Passer domesticus indicus*	Common breeding resident							x
Northern Grey-headed Sparrow	*Passer griseus*	Very common breeding resident	x					x	x
Family Motacillidae									
Cape Wagtail	*Motacilla capensis wellsi*	Common breeding resident			x		x		
Mountain Wagtail	*Motacilla clara torrentium*	Uncommon breeding resident				x	x		
African Pied Wagtail	*Motacilla aguimp vidua*	Common breeding resident			x		x		x
Family Fringillidae									
Brimstone Canary	*Crithagra sulphurata shelleyi*	Common breeding resident	x	x				x	x
Western Citril	*Dendrospiza frontalis*	Very common breeding resident	x	x		x		x	x
Yellow-fronted Canary	*Ochrospiza mozambica barbatus*	Common breeding resident	x		x			x	x
Streaky Seedeater	*Crithagra striolata*	Common breeding resident		x				x	
Family Emberizidae									

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Common Name	Scientific Name[1]	Rwanda Status[2]	Hillslope Grassland / Savanna	Hillside Thicket	Riparian Wetland	Riparian Thicket	Open Water	Cultivation	Towns /Villages
Golden-breasted Bunting	*Emberiza flaviventris*	Common breeding resident	x					x	
Cinnamon-breasted Bunting	*Emberiza tahapisi*	Common breeding resident	x						

[1] Taxonomy follows Birds of the World Online (https://birdsoftheworld.org)

[2] Country status follows Vande Weghe & Vande Weghe 2011

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Table C-8 SLR 2022 Bird Species List by Transect

Bird Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Pied Crow	x																												x	x			x							x						
Northern Grey-headed Sparrow	x					x																			x		x				x														x
Tropical Boubou	x							x								x		x		x							x	x				x		x			x		x			x			x
House Sparrow	x					x																																							
Pearl-spotted Owlet	x																																												
Bronze Mannikin	x				x	x			x					x		x			x	x						x					x			x			x						x	
Wire-tailed Swallow	x					x																																							
Baglafecht Weaver	x		x		x									x			x						x				x													x			x	
African Pied Wagtail	x				x																				x						x									x				x
White-browed Robin-Chat	x						x			x	x		x				x									x		x		x						x				x	x	x	x		
Speckled Mousebird		x						x				x							x							x	x		x	x				x				x				x		
Yellow-billed Kite		x																																										
Brimstone Canary		x				x									x								x															x						
Rock Kestrel		x																																	x									
Northern Fiscal		x					x	x															x	x		x	x								x	x			x					x
Red-rumped Swallow		x					x						x												x									x									
Black Saw-wing		x		x									x									x			x																		
Angolan Swallow		x																																										
Pin-tailed Whydah		x										x		x		x						x					x					x												
Dark-capped Bulbul		x		x			x	x				x				x	x				x	x		x			x		x		x	x	x						x		x			x
Black-billed Weaver			x																																									
African Paradise-Flycatcher			x						x							x			x			x														x				x				
Northern Double-collared Sunbird			x																																									
Grey-backed Camaroptera			x		x		x			x						x		x			x																		x		x	x		
Gray-capped Warbler			x																																				x					
African Yellow-Warbler			x																																									
Long-crested Eagle			x																																									

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Bird Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
African Yellow White-eye			x																																										
Golden-breasted Bunting			x			x												x																											
Bronzy Sunbird				x	x																																				x	x	x	
Cape Wagtail				x																																								
Variable Sunbird				x														x														x								x				
Yellow-fronted Canary				x				x							x			x								x		x				x							x				x
White-eyed Slaty Flycatcher				x																																							
Cape Wagtail				x																						x																	
Mackinnon's Shrike				x							x																																
Chubb's Cisticola				x																																					x			
Black-and-white Mannikin					x										x	x					x																						
Ashy Flycatcher					x					x																																		
Red-billed Firefinch					x									x																														
Village Weaver					x										x							x						x	x	x	x					x	x						
Green-headed Sunbird					x									x								x																					
Mountain Wagtail						x																			x																		
Red-chested Cuckoo						x									x			x																							x		x	
Speckled Pigeon						x																																					
Red-eyed Dove						x	x				x	x							x				x			x		x		x				x			x					x	
Rock Martin							x				x											x																					
Western Citril							x		x										x																	x						x	
African Palm Swift							x													x									x						x								
Copper Sunbird							x					x		x			x							x	x				x														
Little Swift								x																	x								x										
Reed Cormorant								x		x												x		x	x		x	x	x	x			x			x						
Scaly Francolin								x											x																								
Blue-spotted Wood Dove								x	x								x			x			x									x		x						x	x			x
Red-necked Spurfowl								x							x			x																							x			
Tawny-flanked Prinia									x					x					x				x								x												
Brown-throated Wattle-eye									x							x				x			x			x	x														x		

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Bird Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Yellow Bishop									x														x											x											
Scarlet-chested Sunbird									x			x		x			x	x		x	x																		x		x			x
Lesser Honeyguide									x																																			
Brown-crowned Tchagra									x														x																				x	
Red-faced Cisticola										x				x		x			x							x							x	x	x			x			x			
Yellow-throated Leaflove										x																x																		
Eastern Olivaceous Warbler										x																																		
African Thrush										x			x		x			x				x		x							x								x	x			x	
Levaillant's Cuckoo										x																																		
Common Sandpiper										x														x							x								x					
Slender-billed Starling											x																																	
Augur Buzzard											x																																	
Olive-bellied Sunbird											x																																	
White-chinned Prinia											x																																	
Striated Heron											x											x		x	x																		
White-browed Coucal											x		x				x																		x								
Holub's Golden Weaver												x	x																					x									
Little Bee-eater												x								x			x								x												
Northern Puffback												x								x	x																			x				
Spectacled Weaver												x			x																				x							x	
Diederik Cuckoo													x								x										x												
Ross's Turaco													x				x							x															x	x		x		
Familiar Chat													x																															
Laughing Dove													x			x			x		x										x								x				
Common Waxbill														x							x																		x				
Klaas's Cuckoo															x												x										x						
Cinnamon-breasted Bunting															x		x																										
Marico Sunbird																	x																										

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Bird Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Red-chested Sunbird																		x																											
Ring-necked Dove																			x																			x							
Grey-capped Warbler																				x																									
Blue-headed Coucal																				x																		x							
Black-winged Red Bishop																					x						x			x	x	x			x								
Spotted Flycatcher																					x																							
Red-collared Widowbird																								x																				
Hamerkop																									x																			
White-necked Raven																												x																x
White-faced Whistling Duck																												x										x						
Great Egret																												x									x	x						
Arrow-marked Babbler																													x								x							
Common Buzzard																													x				x										x		
Greater Swamp Warbler																													x						x	x	x							
European Bee-eater																													x			x												
Black-headed Heron																														x						x								
Southern Red Bishop																															x		x		x		x							
African Harrier-Hawk																																x				x								
Black-crowned Tchagra																																x								x	x			
Eurasian Reed Warbler																																	x											
African Black Swift																																	x											
Western Marsh Harrier																																				x								
Great Reed Warbler																																					x							
Moustached Grass Warbler																																						x						
Red-knobbed Coot																																							x					

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Bird Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Willow Warbler																																										x				
Black-lored Babbler																																											x			
African Green Pigeon																																										x			
Village Indigobird																																											x		
White-rumped Swift																																											x		
White-breasted Cormorant																																													x

Table C-9 Summary of bird data for the 2024 supplementary survey per sampling point

Common Name	Scientific Name	Date	Time	Latitude (dd)	Longitude (dd)	Altitude	Seen/Heard
Black-headed Heron	*Ardea melanocephala*	2024/05/17	11:39:20	-2.742	29.004	946	Seen
Pied Crow	*Corvus albus*	2024/05/17	10:17:31	-2.71735	29.006645	949	Seen
Speckled Mousebird	*Colius striatus*	2024/05/17	10:04:35	-2.721508	29.009181	933	Seen
Long-crested Eagle	*Lophaetus occipitalis*	2024/05/17	09:57:01	-2.721997	29.00969	934	Seen
Ring-necked Dove	*Streptopelia capicola*	2024/05/17	09:47:07	-2.721997	29.00969	934	Seen
White-browed Robin-Chat	*Cossypha heuglini*	2024/05/17	09:46:55	-2.721997	29.00969	934	Seen
Yellow Bishop	*Euplectes capensis*	2024/05/17	09:20:45	-2.729434	29.014418	924	Seen
Northern Fiscal	*Lanius humeralis*	2024/05/17	09:14:19	-2.732	29.015	923	Seen
Bronze Mannikin	*Lonchura cucullata*	2024/05/17	09:11:32	-2.7325	29.015817	927	Seen
Wahlberg's Eagle	*Hieraaetus wahlbergi*	2024/05/17	09:03:53	-2.733545	29.016	924	Seen
Ring-necked Dove	*Streptopelia capicola*	2024/05/17	08:57:32	-2.734054	29.016133	926	Seen
Black-crowned Tchagra	*Tchagra senegalus*	2024/05/17	08:51:06	-2.735899	29.01775	923	Seen
Red-faced Cisticola	*Cisticola erythrops*	2024/05/17	08:50:35	-2.735945	29.017758	920	Heard
Pied Crow	*Corvus albus*	2024/05/17	08:46:24	-2.737265	29.018472	930	Seen
Tawny-flanked Prinia	*Prinia subflava*	2024/05/17	08:38:40	-2.74028	29.020318	926	Seen
Pin-tailed Whydah	*Vidua macroura*	2024/05/17	08:32:37	-2.742455	29.021037	923	Seen
White-browed Coucal	*Centropus superciliosus*	2024/05/17	08:15:57	-2.741626	29.019909	927	Heard
Pied Crow	*Corvus albus*	2024/05/17	08:15:34	-2.741654	29.019839	924	Seen
House Sparrow	*Passer domesticus*	2024/05/17	08:02:31	-2.742043	29.004545	945	Seen
Black-headed Heron	*Ardea melanocephala*	2024/05/17	08:02:18	-2.742056	29.004044	946	Seen
Speckled Mousebird	*Colius striatus*	2024/05/17	12:07:05	-2.701852	28.987007	1170	Seen

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Common Name	Scientific Name	Date	Time	Latitude (dd)	Longitude (dd)	Altitude	Seen/Heard
Common Kestrel	*Falco tinnunculus*	2024/05/17	12:01:11	-2.701852	28.987007	1170	Seen
Baglafecht Weaver	*Ploceus baglafecht*	2024/05/17	11:46:19	-2.702063	28.98703	1181	Seen
White-necked Raven	*Corvus albicollis*	2024/05/17	11:42:42	-2.702082	28.986908	1180	Seen
Cinnamon-chested Bee-eater	*Merops oreobates*	2024/05/17	11:38:13	-2.702392	28.986345	1195	Seen
Red-collared Widowbird	*Euplectes ardens*	2024/05/17	11:37:26	-2.70257	28.986212	1198	Seen
Cinnamon-breasted Bunting	*Emberiza tahapisi*	2024/05/17	11:18:01	-2.707178	28.990017	1144	Seen
Black-crowned Tchagra	*Tchagra senegalus*	2024/05/16	14:57:16	-2.702802	28.995282	957	Heard
Pied Crow	*Corvus albus*	2024/05/16	14:53:13	-2.702802	28.995282	957	Seen
African Thrush	*Turdus pelios*	2024/05/16	14:51:58	-2.702802	28.995282	957	Seen
African Black Swift	*Apus barbatus*	2024/05/16	13:52:22	-2.698587	28.983035	996	Seen
Lesser Kestrel	*Falco naumanni*	2024/05/16	13:40:11	-2.698772	28.982788	1027	Seen
Tropical Boubou	*Laniarius major*	2024/05/16	13:18:03	-2.698913	28.981873	1064	Heard
Red-collared Widowbird	*Euplectes ardens*	2024/05/16	12:20:31	-2.698643	28.98203	1045	Seen
Yellow-fronted Canary	*Crithagra mozambica*	2024/05/16	12:00:55	-2.698568	28.981757	1041	Seen
Blue-spotted Wood Dove	*Turtur afer*	2024/05/16	11:26:52	-2.69823	28.984244	990	Heard
Yellow Bishop	*Euplectes capensis*	2024/05/16	11:14:47	-2.699334	28.98745	959	Seen
Red-rumped Swallow	*Cecropis daurica*	2024/05/16	11:10:53	-2.699686	28.98849	967	Seen
African Palm Swift	*Cypsiurus parvus*	2024/05/16	11:09:05	-2.699911	28.98921	960	Seen
Northern Fiscal	*Lanius humeralis*	2024/05/16	11:07:44	-2.699975	28.989716	970	Seen
Tropical Boubou	*Laniarius major*	2024/05/16	10:57:40	-2.69978	28.991268	961	Seen
Red-faced Cisticola	*Cisticola erythrops*	2024/05/16	10:57:08	-2.699759	28.991288	959	Heard
Black-crowned Tchagra	*Tchagra senegalus*	2024/05/16	10:53:21	-2.699857	28.991414	956	Heard
Speckled Mousebird	*Colius striatus*	2024/05/16	10:52:06	-2.700307	28.991916	943	Seen
African Pied Wagtail	*Motacilla aguimp*	2024/05/16	10:51:47	-2.700524	28.992005	943	Seen
Black-lored Babbler	*Turdoides sharpei*	2024/05/15	16:45:30	-2.698518	28.990307	954	Seen
Common Kestrel	*Falco tinnunculus*	2024/05/15	16:24:36	-2.6989	28.98867	950	Seen
African Black Swift	*Apus barbatus*	2024/05/15	16:15:33	-2.698468	28.988288	956	Seen
Barn Swallow	*Hirundo rustica*	2024/05/15	16:13:40	-2.698468	28.988288	956	Seen
African Thrush	*Turdus pelios*	2024/05/15	16:10:02	-2.698367	28.98832	961	Seen
Red-rumped Swallow	*Cecropis daurica*	2024/05/15	15:42:36	-2.69837	28.989357	963	Seen
Bronzy Sunbird	*Nectarinia kilimensis*	2024/05/15	15:34:18	-2.698645	28.989165	958	Seen

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Common Name	Scientific Name	Date	Time	Latitude (dd)	Longitude (dd)	Altitude	Seen/Heard
Northern Fiscal	*Lanius humeralis*	2024/05/15	15:24:09	-2.701887	28.99942	949	Seen
White-browed Robin-Chat	*Cossypha heuglini*	2024/05/15	13:44:16	-2.670452	28.941702	1639	Seen
Dark-capped Bulbul	*Pycnonotus tricolor*	2024/05/15	13:39:18	-2.670495	28.941913	1636	Seen
Tropical Boubou	*Laniarius major*	2024/05/15	13:31:15	-2.670807	28.94142	1628	Seen
Scarlet-chested Sunbird	*Chalcomitra senegalensis*	2024/05/15	13:19:30	-2.671055	28.941805	1609	Seen
Yellow-billed Kite	*Milvus aegyptius*	2024/05/15	13:18:21	-2.671055	28.941805	1609	Seen
Red-necked Spurfowl	*Pternistis afer*	2024/05/15	13:17:50	-2.671055	28.941805	1609	Heard
Brown-crowned Tchagra	*Tchagra australis*	2024/05/15	12:58:23	-2.671273	28.94217	1604	Seen
Chubb's Cisticola	*Cisticola chubbi*	2024/05/15	12:57:30	-2.671273	28.94217	1604	Seen
Red-billed Firefinch	*Lagonosticta senegala*	2024/05/15	12:50:27	-2.671273	28.94217	1604	Seen
Speckled Mousebird	*Colius striatus*	2024/05/15	12:45:49	-2.671255	28.942072	1607	Seen
Little Bee-eater	*Merops pusillus*	2024/05/15	12:44:00	-2.671255	28.942072	1607	Seen
Tropical Boubou	*Laniarius major*	2024/05/15	12:43:06	-2.671255	28.942072	1607	Heard
Cinnamon-chested Bee-eater	*Merops oreobates*	2024/05/15	12:42:37	-2.671255	28.942072	1607	Seen
Dark-capped Bulbul	*Pycnonotus tricolor*	2024/05/15	12:41:44	-2.671255	28.942072	1607	Seen
Blue-spotted Wood Dove	*Turtur afer*	2024/05/15	12:37:56	-2.671165	28.942068	1609	Heard
White-necked Raven	*Corvus albicollis*	2024/05/15	12:35:50	-2.671165	28.942068	1609	Seen
Lanner Falcon	*Falco biarmicus*	2024/05/15	12:26:44	-2.670783	28.941568	1637	Seen
Northern Puffback	*Dryoscopus gambensis*	2024/05/15	11:08:57	-2.699	28.967	1029	Heard
White-browed Robin-Chat	*Cossypha heuglini*	2024/05/15	10:45:15	-2.697875	28.967267	1048	Seen
Red-throated Twinspot	*Hypargos niveoguttatus*	2024/05/15	10:11:19	-2.698448	28.966932	1029	Seen
Speckled Mousebird	*Colius striatus*	2024/05/15	10:06:16	-2.698448	28.966932	1029	Seen
Klaas's Cuckoo	*Chrysococcyx klaas*	2024/05/15	10:00:24	-2.698547	28.96696	1029	Heard
African Firefinch	*Lagonosticta rubricata*	2024/05/15	10:00:06	-2.698547	28.96696	1029	Seen
Green-throated Sunbird	*Chalcomitra rubescens*	2024/05/15	09:55:06	-2.698648	28.967003	1022	Seen
Tropical Boubou	*Laniarius major*	2024/05/15	09:48:43	-2.698845	28.967055	1026	Seen
Black-crowned Tchagra	*Tchagra senegalus*	2024/05/15	09:48:12	-2.698845	28.967055	1026	Heard
Yellow-fronted Canary	*Crithagra mozambica*	2024/05/15	09:45:50	-2.699059	28.967245	1013	Seen
Blue-spotted Wood Dove	*Turtur afer*	2024/05/15	09:14:38	-2.700285	28.968633	1016	Seen
Yellow-fronted Canary	*Crithagra mozambica*	2024/05/15	09:02:12	-2.70054	28.968708	1016	Seen
Hamerkop	*Scopus umbretta*	2024/05/15	08:31:40	-2.700475	28.968672	1016	Seen

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Common Name	Scientific Name	Date	Time	Latitude (dd)	Longitude (dd)	Altitude	Seen/Heard
Ross's Turaco	*Tauraco rossae*	2024/05/15	08:28:25	-2.700382	28.968672	1015	Seen
Red-collared Widowbird	*Euplectes ardens*	2024/05/15	08:25:30	-2.700382	28.968672	1015	Seen
Cinnamon-breasted Bunting	*Emberiza tahapisi*	2024/05/15	08:20:49	-2.700382	28.968672	1015	Seen
Red-rumped Swallow	*Cecropis daurica*	2024/05/15	08:13:44	-2.700365	28.96876	1016	Seen
Red-faced Cisticola	*Cisticola erythrops*	2024/05/15	08:09:06	-2.700277	28.968723	1013	Seen
Little Bee-eater	*Merops pusillus*	2024/05/15	08:08:26	-2.700277	28.968723	1013	Seen
Grey-backed Camaroptera	*Camaroptera brevicaudata*	2024/05/15	07:56:08	-2.69976	28.96852	1000	Heard
Pin-tailed Whydah	*Vidua macroura*	2024/05/15	07:53:59	-2.699635	28.968418	1003	Seen
Brown-throated Wattle-eye	*Platysteira cyanea*	2024/05/15	07:39:22	-2.696302	28.972453	980	Seen
Copper Sunbird	*Cinnyris cupreus*	2024/05/15	07:38:22	-2.696275	28.972578	980	Seen
Village Weaver	*Ploceus cucullatus*	2024/05/15	07:33:29	-2.69623	28.97264	978	Seen
Dark-capped Bulbul	*Pycnonotus tricolor*	2024/05/15	07:33:15	-2.69623	28.97264	978	Seen
Southern Red Bishop	*Euplectes orix*	2024/05/15	07:22:02	-2.696592	28.987015	971	Seen
Red-eyed Dove	*Streptopelia semitorquata*	2024/05/15	07:21:44	-2.696592	28.987015	971	Seen
Grey-capped Warbler	*Eminia lepida*	2024/05/15	07:17:35	-2.698406	28.990194	948	Seen
Tropical Boubou	*Laniarius major*	2024/05/15	07:02:45	-2.697797	28.992472	986	Seen
Brimstone Canary	*Crithagra sulphurata*	2024/05/15	07:02:20	-2.697797	28.992472	986	Seen
Scarlet-chested Sunbird	*Chalcomitra senegalensis*	2024/05/15	07:00:51	-2.697797	28.992472	986	Seen
Red-faced Cisticola	*Cisticola erythrops*	2024/05/15	06:59:14	-2.697847	28.992453	990	Heard
Cinnamon-breasted Bunting	*Emberiza tahapisi*	2024/05/15	06:53:08	-2.698023	28.992575	976	Seen
Dark-capped Bulbul	*Pycnonotus tricolor*	2024/05/15	06:46:14	-2.697912	28.992217	976	Seen
Southern Red Bishop	*Euplectes orix*	2024/05/15	06:37:50	-2.697822	28.992123	972	Seen
Village Weaver	*Ploceus cucullatus*	2024/05/14	16:05:32	-2.698405	28.994068	956	Seen
Grey-capped Warbler	*Eminia lepida*	2024/05/14	15:59:49	-2.697658	28.991368	963	Seen
Yellow Bishop	*Euplectes capensis*	2024/05/14	15:34:51	-2.698784	28.966992	1036	Seen
Fan-tailed Widowbird	*Euplectes axillaris*	2024/05/14	15:23:33	-2.698563	28.966598	1033	Seen
Village Indigobird	*Vidua chalybeata*	2024/05/14	15:22:26	-2.698585	28.966626	1037	Seen
Pin-tailed Whydah	*Vidua macroura*	2024/05/14	15:19:21	-2.698595	28.966633	1038	Seen
Red-necked Spurfowl	*Pternistis afer*	2024/05/14	15:18:57	-2.698602	28.966638	1037	Heard
Klaas's Cuckoo	*Chrysococcyx klaas*	2024/05/14	15:16:44	-2.698592	28.966645	1040	Heard
Red-faced Cisticola	*Cisticola erythrops*	2024/05/14	15:16:13	-2.698592	28.966676	1047	Heard

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Common Name	Scientific Name	Date	Time	Latitude (dd)	Longitude (dd)	Altitude	Seen/Heard
Red-eyed Dove	*Streptopelia semitorquata*	2024/05/14	15:04:14	-2.69626	28.9634	1056	Seen
Blue-spotted Wood Dove	*Turtur afer*	2024/05/14	15:04:03	-2.696251	28.963354	1056	Seen
Blue-spotted Wood Dove	*Turtur afer*	2024/05/14	15:03:49	-2.696209	28.963261	1050	Seen
Lesser Striped Swallow	*Cecropis abyssinica*	2024/05/14	15:02:47	-2.696406	28.962907	1047	Seen
Blue-headed Coucal	*Centropus monachus*	2024/05/14	14:55:50	-2.696074	28.962188	996	Seen
Greater Swamp Warbler	*Acrocephalus rufescens foxi*	2024/05/14	14:36:47	-2.694954	28.961302	1011	Seen
African Thrush	*Turdus pelios*	2024/05/14	14:36:26	-2.694884	28.961282	1015	Seen
Yellow-throated Leaflove	*Atimastillas flavicollis*	2024/05/14	14:36:09	-2.694902	28.961305	1013	Seen
Copper Sunbird	*Cinnyris cupreus*	2024/05/14	14:23:46	-2.693083	28.957883	1016	Seen
Village Weaver	*Ploceus cucullatus*	2024/05/14	14:18:19	-2.692837	28.956742	1032	Seen
African Pied Wagtail	*Motacilla aguimp*	2024/05/14	13:55:02	-2.691477	28.952388	1071	Seen
Green-backed Camaroptera	*Camaroptera brachyura*	2024/05/14	13:37:12	-2.690744	28.949975	1062	Heard
Tropical Boubou	*Laniarius major*	2024/05/14	13:37:00	-2.690756	28.949994	1061	Seen
Slender-billed Weaver	*Ploceus pelzelni*	2024/05/14	13:34:35	-2.690528	28.94915	1062	Heard
White-browed Robin-Chat	*Cossypha heuglini*	2024/05/14	13:33:13	-2.690512	28.948871	1070	Seen
African Pied Wagtail	*Motacilla aguimp*	2024/05/14	13:33:03	-2.690504	28.948876	1069	Seen
Scarlet-chested Sunbird	*Chalcomitra senegalensis*	2024/05/14	13:28:34	-2.690415	28.947938	1088	Seen
White-necked Raven	*Corvus albicollis*	2024/05/14	13:15:05	-2.690558	28.9458	1115	Seen
Bronzy Sunbird	*Nectarinia kilimensis*	2024/05/14	13:08:04	-2.690298	28.945417	1114	Seen
Dark-capped Bulbul	*Pycnonotus tricolor*	2024/05/14	13:00:02	-2.689466	28.943856	1116	Seen
Brown-throated Wattle-eye	*Platysteira cyanea*	2024/05/14	12:56:17	-2.689447	28.943767	1122	Seen
Speckled Mousebird	*Colius striatus*	2024/05/14	12:52:28	-2.689526	28.94327	1128	Seen
Red-eyed Dove	*Streptopelia semitorquata*	2024/05/14	12:52:19	-2.689532	28.943265	1127	Seen
Mackinnon's Shrike	*Lanius mackinnoni*	2024/05/14	12:44:36	-2.689543	28.942697	1124	Seen
Hamerkop	*Scopus umbretta*	2024/05/14	12:39:09	-2.690775	28.942448	1118	Seen
Ross's Turaco	*Tauraco rossae*	2024/05/14	12:34:49	-2.690925	28.942365	1119	Seen
Hamerkop	*Scopus umbretta*	2024/05/14	12:28:30	-2.690727	28.942517	1109	Seen
Brown-crowned Tchagra	*Tchagra australis*	2024/05/14	11:42:28	-2.689285	28.941725	1127	Seen
Thick-billed Seedeater	*Crithagra burtoni*	2024/05/14	11:41:45	-2.689285	28.941725	1127	Seen
Thick-billed Seedeater	*Crithagra burtoni*	2024/05/14	11:41:02	-2.689285	28.941725	1127	Seen
African Black Swift	*Apus barbatus*	2024/05/14	11:24:10	-2.68941	28.941733	1127	Seen

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Common Name	Scientific Name	Date	Time	Latitude (dd)	Longitude (dd)	Altitude	Seen/Heard
Black Saw-wing	*Psalidoprocne pristoptera*	2024/05/14	11:19:05	-2.689758	28.941615	1113	Seen
Dark-capped Bulbul	*Pycnonotus tricolor*	2024/05/14	11:16:26	-2.689732	28.941502	1104	Seen
Bronze Mannikin	*Lonchura cucullata*	2024/05/14	10:51:00	-2.686082	28.940845	1107	Seen
Black-necked Weaver	*Ploceus nigricollis*	2024/05/14	10:16:44	-2.681642	28.938218	1144	Seen
Yellow-bellied Waxbill	*Coccopygia quartinia*	2024/05/14	10:05:56	-2.681353	28.938772	1178	Seen
Speckled Mousebird	*Colius striatus*	2024/05/14	09:59:54	-2.680951	28.939373	1197	Seen
Yellow Bishop	*Euplectes capensis*	2024/05/14	09:59:35	-2.68091	28.939415	1197	Seen
Blue-spotted Wood Dove	*Turtur afer*	2024/05/14	09:57:39	-2.680987	28.939549	1205	Heard
Dark-capped Bulbul	*Pycnonotus tricolor*	2024/05/14	09:53:53	-2.680818	28.939825	1214	Seen
Grey-capped Warbler	*Eminia lepida*	2024/05/14	09:53:32	-2.680818	28.939825	1214	Seen
Slender-billed Weaver	*Ploceus pelzelni*	2024/05/14	09:50:38	-2.680576	28.940414	1226	Seen
Green White-eye	*Zosterops stuhlmanni*	2024/05/14	09:47:49	-2.680463	28.940593	1235	Seen
White-tailed Blue Flycatcher	*Elminia albicauda*	2024/05/14	09:41:36	-2.680243	28.940735	1242	Seen
Scarce Swift	*Schoutedenapus myoptilus*	2024/05/14	09:37:14	-2.680067	28.940878	1248	Seen
Augur Buzzard	*Buteo augur*	2024/05/14	09:33:39	-2.680067	28.940878	1248	Seen
Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	2024/05/14	09:30:58	-2.680003	28.941077	1247	Seen
Western Citril	*Crithagra frontalis*	2024/05/14	09:26:32	-2.679858	28.941328	1257	Seen
Copper Sunbird	*Cinnyris cupreus*	2024/05/14	09:23:56	-2.679866	28.941451	1255	Seen
Spectacled Weaver	*Ploceus ocularis*	2024/05/14	09:21:41	-2.679867	28.941322	1262	Seen
Black-necked Weaver	*Ploceus nigricollis*	2024/05/14	09:21:32	-2.679876	28.941327	1262	Seen
Blue-headed Coucal	*Centropus monachus*	2024/05/14	09:15:49	-2.679816	28.941347	1274	Seen
Rock Martin	*Ptyonoprogne fuligula*	2024/05/14	09:11:23	-2.679417	28.941816	1302	Seen
Streaky Seedeater	*Crithagra striolata*	2024/05/14	09:08:43	-2.679417	28.942095	1315	Seen
Klaas's Cuckoo	*Chrysococcyx klaas*	2024/05/14	09:08:00	-2.679456	28.942144	1315	Seen
Green-backed Camaroptera	*Camaroptera brachyura*	2024/05/14	09:06:11	-2.679486	28.94243	1333	Seen
Emerald-spotted Wood Dove	*Turtur chalcospilos*	2024/05/14	09:05:52	-2.679547	28.94248	1338	Seen
White-browed Robin-Chat	*Cossypha heuglini*	2024/05/14	09:02:05	-2.679503	28.942929	1351	Seen
Green-backed Camaroptera	*Camaroptera brachyura*	2024/05/14	09:01:34	-2.679434	28.943059	1362	Heard
Cinnamon-chested Bee-eater	*Merops oreobates*	2024/05/14	08:55:05	-2.6793	28.943355	1373	Seen
Green White-eye	*Zosterops stuhlmanni*	2024/05/14	08:52:58	-2.679236	28.943432	1376	Seen
Red-eyed Dove	*Streptopelia semitorquata*	2024/05/14	08:51:36	-2.679227	28.94356	1387	Seen

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Common Name	Scientific Name	Date	Time	Latitude (dd)	Longitude (dd)	Altitude	Seen/Heard
African Paradise Flycatcher	*Terpsiphone viridis*	2024/05/14	08:50:10	-2.679168	28.943698	1394	Seen
Tropical Boubou	*Laniarius major*	2024/05/14	08:44:28	-2.679056	28.943806	1409	Seen
Baglafecht Weaver	*Ploceus baglafecht*	2024/05/14	08:43:18	-2.679012	28.943967	1431	Seen
Brown-throated Wattle-eye	*Platysteira cyanea*	2024/05/14	08:37:15	-2.678674	28.944066	1451	Heard
Baglafecht Weaver	*Ploceus baglafecht*	2024/05/14	08:35:11	-2.678438	28.944098	1465	Seen
Tawny-flanked Prinia	*Prinia subflava*	2024/05/14	08:33:58	-2.678295	28.944142	1468	Seen
Yellow-fronted Canary	*Crithagra mozambica*	2024/05/14	08:33:17	-2.678178	28.94411	1457	Seen
Speckled Mousebird	*Colius striatus*	2024/05/14	08:33:07	-2.678175	28.944118	1457	Seen
White-browed Robin-Chat	*Cossypha heuglini*	2024/05/14	08:29:18	-2.677322	28.944564	1484	Seen
Tropical Boubou	*Laniarius major*	2024/05/14	08:28:12	-2.677322	28.944618	1492	Heard
Brown-crowned Tchagra	*Tchagra australis*	2024/05/14	08:25:20	-2.677862	28.945336	1503	Seen
Bronze Mannikin	*Lonchura cucullata*	2024/05/14	08:25:05	-2.678036	28.94545	1505	Seen
Dark-capped Bulbul	*Pycnonotus tricolor*	2024/05/14	08:24:54	-2.678081	28.945475	1504	Seen
Brimstone Canary	*Crithagra sulphurata*	2024/05/14	08:24:16	-2.678316	28.945726	1505	Seen
Variable Sunbird	*Cinnyris venustus*	2024/05/14	08:23:56	-2.67833	28.945768	1503	Seen
White-browed Robin-Chat	*Cossypha heuglini*	2024/05/14	08:23:04	-2.678403	28.946195	1525	Seen

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Table C-10 Priority Bird Species by Habitat Type and Likelihood

Common Name	Scientific Name	IUCN Status	Habitat	Likelihood	Rationale[1]
Hooded Vulture	*Necrosyrtes monachus*	CR	Occurs in open grassland, forest edge, wooded savanna and desert, often associated with human settlements north of the Equator	Low	Absent from western Rwanda; habitats mostly degraded; high human density
White-backed Vulture	*Gyps africanus*	CR	Occurs in open wooded savanna, particularly areas of *Acacia*	Low	Absent from western Rwanda; habitats mostly degraded; high human density
Rüppell's Vulture	*Gyps rueppelli*	CR	Prefers open landscapes such as open Acacia woodland, grassland and montane regions	Low	Absent from western Rwanda; habitats mostly degraded; high human density
Congo Bay-owl	*Phodilus prigoginei*	EN	Occurs in a mosaic of grassland and either montane or bamboo forest, above 1 800 masl	Very Low	No suitable habitat present
Lappet-faced Vulture	*Torgos tracheliotos*	EN	Found in dry savanna, arid plains, deserts and open mountain slopes, up to 3 500 masl	Low	Absent from western Rwanda; habitats mostly degraded; high human density
Secretarybird	*Sagittarius serpentarius*	EN	Prefers open landscapes, ranging from open plains and grasslands, to lightly wooded savanna, but is also found in agricultural areas and semi-desert	Low	Absent from western Rwanda; habitats mostly degraded; high human density
Steppe Eagle	*Aquila nipalensis*	EN	Occurs in open habitats such as grasslands, lightrly wooded savannah and semi-desert shrublands during passage and when overwintering.	Low	Absent from western Rwanda; habitats mostly degraded; high human density
Madagascar Pond-heron	*Ardeola idae*	EN	Prefers freshwater wetlands, particularly shallow waterbodies fringed with vegetation and adjacent trees	Low	Absent from south-western Rwanda; limited suitable habitat present
Grey Parrot	*Psittacus erithacus*	EN	Occurs in dense forest, including forest edges and clearings; also in gallery forest, mangroves, wooded savannah and cultivated areas close to forest	Very Low	No suitable habitat present; high human density
Grey Crowned Crane	*Balearica regulorum*	EN	Occurs in shallow wetlands such as marshes, pans and dams with tall emergent vegetation, as well as riverbanks, shallowly flooded plains and temporary pools, sometimes foraging in adjacent grasslands, open savannas and croplands	Low	No suitable habitat present on the Ruzizi floodplain; only known from high altitude wetlands near Ryagashitsi, about 4 km nw of reservoir
Shelley's Crimsonwing	*Cryptospiza shelleyi*	EN	Prefers the understorey of closed-canopy moist forest, often in valleys near water; also in low secondary growth at forest edges, forest clearings and glades; above 1 900 masl	Very Low	No suitable habitat present
Red-collared Mountain-babbler	*Kupeornis rufocinctus*	EN	Confined to montane forest and bamboo at altitudes of 1 500-3 200 masl.	Very Low	No suitable habitat present
Bateleur	*Terathopius ecaudatus*	EN	Frequents open country, including grasslands, savanna and semi-desert, often foraging over secondary vegetation near towns	Moderate	Suitable foraging habitat present; unlikely to breed in the project area
Martial Eagle	*Polemaetus bellicosus*	EN	Occurs in open woodland, wooded savanna, grassland and open thornbush; avoids densely populated areas	Low	Absent from western Rwanda; habitats mostly degraded; high human density
Lesser Flamingo	*Phoeniconaias minor*	NT	Occurs on large undisturbed alkaline and saline lakes and salt pans, occasionally occurring at other shallow open-water wetlands when on passage	Low	Absent from southern Rwanda; limited suitable habitat present
Black-winged Pratincole	*Glareola nordmanni*	NT	Occurs in open landscapes such as grasslands or large salt pans in its overwintering grounds in southern Africa	Low	Rarely overwinters in Rwanda

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Common Name	Scientific Name	IUCN Status	Habitat	Likelihood	Rationale[1]
Eurasian Curlew	*Numenius arquata*	NT	Mostly coastal habitats during the austral winter, rarely occurring inland at lakes and rivers	Low	Rarely overwinters in Rwanda
Pallid Harrier	*Circus macrourus*	NT	Occurs in open landscapes such as grasslands or lightly wooded savannah in its overwintering grounds in southern Africa	Low	At edge of its known distribution; habitats mostly degraded; high human density
Black-tailed Godwit	*Limosa limosa*	NT	Occurs in freshwater habitats during the austral winter, such as swampy lake shores, pools, flooded grassland and irrigated rice fields.	Low	Rarely overwinters in Rwanda
Great Snipe	*Gallinago media*	NT	Occurs in marshlands and short grass or sedges on lake edges or in flooded fields.	Moderate	Limited suitable habitat present
Papyrus Gonolek	*Laniarius mufumbiri*	NT	Occurs in papyrus swamps and adjacent thicket vegetation	Low	Absent from western Rwanda; limited suitable habitat present
Crowned Eagle	*Stephanoaetus coronatus*	NT	Occurs in forests and dense woodland, avoding open habitats except where forest fragments are present; also occurs in plantations and secondary growth	Low	No suitable habitat present; high human density
Lagden's Bush-shrike	*Malaconotus lagdeni*	NT	Inhabits montane forest up to 2 500 masl	Very Low	No suitable habitat present
Mountain Buzzard	*Buteo oreophilus*	NT	Occurs in montane forest, exotic plantations and adjoining grassland between 2 000 m and 3 500 masl	Low	Mostly degraded habitat present; high human density
Oberländer's Ground-thrush	*Geokichla oberlaenderi*	NT	Occurs in lowland and transitional riparian forest at altitudes of 700-2 000 masl; avoids secondary or degraded forest	Very Low	No suitable habitat present
Albertine Owlet	*Glaucidium albertinum*	VU	Found in very open montane and transitional forest, with many clearings and a dense understorey	Very Low	No suitable habitat present
Red-footed Falcon	*Falco vespertinus*	VU	Occurs in open landscapes such as grasslands or lightly wooded savannah in its overwintering grounds in southern Africa	Low	Absent from western Rwanda
Shoebill	*Balaeniceps rex*	VU	Breeds and forages in seasonally flooded marshes that are dominated by a mixture of papyrus, reeds, cattails and grasses	Very Low	Absent from western Rwanda; no suitable habitat present
Southern Ground-hornbill	*Bucorvus leadbeateri*	VU	Frequents woodland and savanna, as well as grassland adjoining patches of forest; avoids areas of high human density but does well in sparsely inhabited agricultural landscapes	Low	Absent from western Rwanda; habitats mostly degraded; high human density
Grauer's Swamp-warbler	*Bradypterus graueri*	VU	Occurs in montane marshes, usually dominated by grass or sedge	Very Low	No suitable habitat present
Papyrus Yellow Warbler	*Calamonastides gracilirostris*	VU	Found mainly in papyrus-swamps but occasionally in other marshy habitats, especially reeds	Very Low	Absent from western Rwanda; no suitable habitat present
Tawny Eagle	*Aquila rapax*	VU	Occurs in dry open habitats across a wide elevation range, including both woodland and wooded savannah.	Low	At edge of its known distribution; habitats mostly degraded; high human density
Rockefeller's Sunbird	*Cinnyris rockefelleri*	VU	Prefers thickets along streams in bamboo forest, as well as montane forest and afro-alpine moorland.	Very Low	No suitable habitat present
Chapin's Flycatcher	*Fraseria lendu*	VU	Occurs in dense montane forest between 1 470 and 1 820 masl	Very Low	No suitable habitat present
Blue Swallow	*Hirundo atrocaerulea*	VU	Prefered wintering habitat is open grassland, often with bushes and trees and marshy areas	Very Low	Only one record from central Rwanda; habitats mostly degraded; high human density

[1] Comments regarding avifaunal distribution are from vanden Weghe & Vanden Weghe (2011)

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C.1.4.4 Mammal Species

Table C-11 Mammal Species List by Habitat Type and Likelihood

Common Name	Scientific Name	IUCN Status	Habitat	Likelihood	Rationale
African Forest Elephant	*Loxodonta cyclotis*	CR	Occurs in a variety of forest habitats including lowland humid forest, swamp forests, lower reaches of Afromontane forests, dry forests and forest-savanna mosaics.	Very Low	No suitable habitat present and high disturbance levels
Chimpanzee	*Pan troglodytes*	EN	Occurs in primary and secondary moist lowland forest, swamp forest, submontane and montane forest, dry forest, forest galleries in savanna woodland, and farmland	Low	Limited suitable habitat present, habitat degradation is severe and human density is high
Foa's Red Colobus	*Piliocolobus foai*	EN	Occurs in primary montane and submontane forest from 800 to 2 270 masl.	Very Low	No suitable habitat present and high disturbance levels
Ulindi River Red Colobus	*Piliocolobus lulindicus*	EN	Poorly known; recorded from primary lowland forest and along rivers	Very Low	No suitable habitat present; high human density
White-bellied Pangolin	*Phataginus tricuspis*	EN	Occurs in moist tropical lowland forests and secondary growth, but also occurs in dense woodlands, especially along water courses; associated with abandoned oil palm plantations in some areas	Low	Limited suitable habitat present, habitat degradation is severe and human density is high
Giant Ground Pangolin	*Smutsia gigantea*	EN	Occurs in primary and secondary rainforest forest formations, gallery forests, swamp forests, forest-savannah mosaic habitats and wooded savannah	Very Low	No suitable habitat present; high human density
Leopard	*Panthera pardus*	VU	Occupies a very wide range of habitat types	Low	Limited suitable habitat present, habitat degradation is severe and human density is high
Temminck's Pangolin	*Smutsia temminckii*	VU	Occurs in savannas and woodlands in low-lying regions, as well as floodplain grassland, rocky slopes and sandveld; avoids true forest and heavily populated areas	Very Low	No suitable habitat present and high disturbance levels
Grey-cheeked Mangabey	*Lophocebus albigena*	VU	Found in both primary and secondary forest, although it prefers undisturbed forest	Very Low	No suitable habitat present and high disturbance levels
L'Hoest's Monkey	*Allochrocebus lhoesti*	VU	Occurs in primary lowland, submontane and montane forests, avoiding degraded habitats and densely populated areas	Very Low	No suitable habitat present and high disturbance levels
African Golden Cat	*Caracal aurata*	VU	Occurs in primary moist equatorial forest, although on the edge of its range it enters savanna regions along riverine forest.	Very Low	No suitable habitat present and high disturbance levels
Ruwenzori Shrew	*Ruwenzorisorex suncoides*	VU	Associated with damp and dense mossy vegetation in montane primary tropical moist forest.	Very Low	No suitable habitat present
Delany's Swamp Mouse	*Delanymys brooksi*	VU	Confined to high altitude marshes within bamboo and montane forest.	Very Low	No suitable habitat present
Lemara Shrew	*Crocidura lanosa*	VU	Prefers primary montane forest, Cyperus swamps, and bamboo forests; has been recorded from secondary montane forest and in disturbed areas above 1 850 masl	Very Low	No suitable habitat present

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Common Name	Scientific Name	IUCN Status	Habitat	Likelihood	Rationale
Angolan Colobus	*Colobus angolensis*	VU	Occurs in evergreen and semi-deciduous forest, including gallery forests, swamp forest, montane forest and seasonally flooded forests; avoids degraded habitats and densely settled areas.	Confirmed	Confirmed presence by local villagers. Predominantly exploratory troops typically arriving into the area mainly during crop harvesting.
Owl-faced Monkey	*Cercopithecus hamlyni*	VU	Occurs in lowland to mid-montane tropical moist forest and montane bamboo forest; avoids degraded forest and densely settled areas	Very Low	No suitable habitat present; high human density
Medium-tailed Brush-furred Rat	*Lophuromys medicaudatus*	VU	Inhabits montane forests and swamps, avoiding modified habitats.	Very Low	No suitable habitat present
Kemp's Thicket Rat	*Thamnomys kempi*	VU	Occurs in thickets in open areas of montane secondary forests (and occasionally in primary forests).	Very Low	Project area well below the altitudinal limit for this species
Yellow-backed Duiker	*Cephalophus silvicultor*	NT	Occurs in moist lowland and montane forests (primary and secondary), forest-savanna mosaics, gallery forests, thickets; also in plantations and farmbush	Low	Even though some suitable habitat present, habitat degradation is severe and human density is high
Spotted-necked Otter	*Hydrictis maculicollis*	NT	Prefers freshwater habitats where water is unsilted, unpolluted, and rich in small to medium sized fishes, including lakes and other shallow water habitats	Moderate	Some suitable habitat although possibly too silted for this species
Congo Clawless Otter	*Aonyx congicus*	NT	Occurs in tropical rainforests and lowland swamps of the Congo River basin	Moderate	Some suitable habitat although habitats are degraded and human density is high
Bay Duiker	*Cephalophus dorsalis*	NT	Frequents primary and relatively unmodified lowland to mid-altitude forests; prefers primary forest, but has been recorded in secondary forest and farmbush	Low	Limited suitable habitat present, habitat degradation is severe and human density is high
African Buffalo	*Syncerus caffer*	NT	Occurs in a wide range of woodland, savannah and forest habitats	Low	Limited suitable habitat present, habitat degradation is severe and human density is high
Rahm's Brush-furred Rat	*Lophuromys rahmi*	NT	Inhabits dense primary montane forest; has been recorded in secondary forest and sparse bamboo stands covered with grass.	Very Low	No suitable habitat present
Moon Forest Shrew	*Sylvisorex lunaris*	NT	Occurs in primary and secondary montane tropical moist forest and swamps above 1700 masl	Very Low	No suitable habitat present
African Straw-coloured Fruit-bat	*Eidolon helvum*	NT	Occurs in a very wide range of habitats; can also inhabit wooded areas in large urban areas, often rossting in cities and towns	High	Suitable habitat present; can persist in degraded habitats and densely settled areas
Large-eared Free-tailed Bat	*Otomops martiensseni*	NT	Occurs in a very wide range of habitats; can also tolerate urban or agricultural areas	Moderate	Some suitable habitat present; can tolerate urban and agricultural habitats

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C.1.4.5 Herpetofauna Species

Table C-12 Amphibian Species List by Habitat Type and Likelihood

Scientific Name	IUCN Red Data	Endemic	Likelihood of occurrence	Assemblages				
				Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savannah	Cultivation /Shrubland
Family: Arthroleptidae								
Arthroleptis adolfifriederici	LC		H				x	
Arthroleptis lameerei	LC		M-H				x	x
Arthroleptis pyrrhoscelis	LC	X	H			x		x
Arthroleptis schubotzi	LC		H			x	x	x
Cardioglossa cyaneospila	NT	X	M				x	
Cardioglossa escalerae	LC		M-H	x			x	
Leptopelis bocagii	LC		M			x		x
Leptopelis calcaratus	LC		M-H				x	
Leptopelis christyi	LC		H			x	x	x
Leptopelis fiziensis	DD	X	M	x			x	x
Leptopelis kivuensis	LC		H				x	
Leptopelis millsoni	LC		M	x		x	x	
Leptopelis modestus	LC		M	x			x	
Family: Bufonidae								
Sclerophrys channingi	LC		H				x	
Sclerophrys funerea	LC		H				x	
Sclerophrys pusilla	LC		H	x	x	x	x	x
Sclerophrys regularis	LC		M	x	x	x	x	x
Family: Dicroglossidae								
Hoplobatrachus occipitalis	LC		H	x	x	x	x	x
Family: Hemisotidae								
Hemisus olivaceus	LC		M				x	
Family: Hyperoliidae								
Acanthixalus spinosus	LC		M-H				x	
Afrixalus laevis	LC		H				x	
Afrixalus leucostictus	LC		M-H				x	
Afrixalus orophilus	LC	X	H		x			x
Afrixalus osorioi	LC		M			x	x	
Afrixalus quadrivittatus	LC		H		x		x	x
Hyperolius castaneus	LC	X	M-H				x	x
Hyperolius cinnamomeoventris	LC		M-H	x	x	x	x	x
Hyperolius diaphanus	DD	X	M				x	
Hyperolius discodactylus	LC	X	H	x			x	
Hyperolius frontalis	LC	X	M-H	x			x	
Hyperolius glandicolor	LC		H	x	x	x	x	x
Hyperolius hutsebauti	LC		H		x		x	
Hyperolius kivuensis	LC		H		x	x	x	x
Hyperolius lateralis	LC		H	x	x	x	x	
Hyperolius marginatus	LC		H	x	x	x		x
Hyperolius ocellatus	LC		H			x	x	

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Scientific Name	IUCN Red Data	Endemic	Likelihood of occurrence	Assemblages				
				Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savannah	Cultivation /Shrubland
Hyperolius rwandae	LC		H		x	x		
Hyperolius tuberculatus	LC		H			x	x	
Hyperolius viridiflavus	LC		H	x	x	x	x	x
Kassina mertensi	LC		M-H	x		x	x	
Kassina senegalensis	LC		H		x	x	x	x
Phlyctimantis verrucosus	LC		M			x	x	
Family: Microhylidae								
Phrynomantis bifasciatus	LC		M		x	x	x	x
Family: Phrynobatrachidae								
Phrynobatrachus auritus	LC		M	x			x	
Phrynobatrachus bequaerti	LC	X	M-H		x		x	x
Phrynobatrachus dendrobates	LC		H				x	
Phrynobatrachus graueri	LC		M-H				x	
Phrynobatrachus natalensis	LC		H	x	x	x	x	x
Phrynobatrachus perpalmatus	LC		H		x	x	x	x
Phrynobatrachus versicolor	LC	X	H				x	
Family: Pipidae								
Xenopus epitropicalis	LC		M				x	
Xenopus pygmaeus	LC		H		x	x	x	
Xenopus vestitus	LC	X	M		x	x		x
Xenopus victorianus	LC		H	x	x	x		
Xenopus wittei	LC	X	H	x	x	x		
Family: Ptychadenidae								
Ptychadena chrysogaster	LC		H	x			x	
Ptychadena grandisonae	LC		H		x	x		x
Ptychadena nilotica	LC		H	x	x	x		x
Ptychadena porosissima	LC		M		x	x	x	x
Ptychadena uzungwensis	LC		H		x			
Amietia desaegeri	LC	X	H	x			x	
Amietia nutti	LC		H	x	x	x	x	x
Amietia ruwenzorica	LC		H	x			x	
Family: Ranidae								
Amnirana albolabris	LC		H	x		x	x	
Amnirana galamensis	LC		M-H	x	x	x		x
Family: Rhacophoridae								
Chiromantis rufescens	LC		M				x	x

LC = Least Concern

DD = Data Deficient

VU = Vulnerable

NT = Near Threatened

EN = Endangered

M = Medium

M-H = Medium-High

H = High

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Scientific Name	IUCN Red Data	Endemic	Likelihood of occurrence	Assemblages				
				Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savannah	Cultivation /Shrubland

Endemic = restricted to the Albertine Rift Montane Forests Ecoregion

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Table C-13 Reptile Species List by Habitat Type and Likelihood

Scientific Name	IUCN Red Data	Endemic	Likelihood of occurrence	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savannah	Cultivation / Shrubland
Family: Atractaspididae								
Atractaspis irregularis	LC		H		x	x	x	x
Polemon christyi	LC		H				x	
Polemon fulvicollis	LC		M				x	
Polemon gabonensis	LC		H				x	
Polemon graueri	LC		H				x	
Family: Chamaeleonidae								
Chamaeleo dilepis	LC		Confirmed	x	x		x	x
Chamaeleo laevigatus	LC		M	x			x	x
Kinyongia rugegensis	-	**X**	M				x	
Rhampholeon boulengeri	LC		H				x	
Trioceros ellioti	LC		H	x		x	x	x
Trioceros johnstoni	LC	**X**	H				x	
Trioceros rudis	LC	**X**	H		x	x	x	x
Trioceros schoutedeni	**DD**	**X**	M-H			?	x	?
Family: Colubridae								
Crotaphopeltis hotamboeia	LC		H	x	x	x	x	x
Dasypeltis atra	LC		H	x		x	x	x
Dasypeltis scabra	LC		H	x		x	x	x
Dipsadoboa unicolor	LC		H	x			x	
Dipsadoboa viridis	LC		M				x	
Dipsadoboa weileri	LC		M				x	
Dispholidus typus	LC		H	x			x	x
Philothamnus angolensis	LC		H	x	x	x	x	x
Philothamnus carinatus	LC		H	x			x	x
Philothamnus heterolepidotus	LC		H	x	x	x	x	x
Philothamnus ruandae	LC	**X**	H	x	x	x	x	x
Philothanus semivariegatus	-		H	x		x	x	x
Rhamnophis aethiopissa	LC		M				x	
Thelotornis kirtlandii	LC		H	x			x	
Thrasops jacksonii	LC		H	x			x	
Family: Crocodylidae								
Crocodylus niloticus	LC		H	x	x			
Family: Elapidae								
Dendroaspis jamesoni	LC		H	x			x	x
Elapsoidea loveridgei	LC		H				x	x
Naja annulata	LC		M	x				
Naja melanoleuca	LC		H	x			x	
Naja nigricollis	LC		H	x			x	x
Naja subfulva	LC		H	x			x	x
Pseudohaje goldii	LC		M				x	
Family: Gekkonidae								
Chondrodactylus laevigatus	LC		M				x	x
Cnemaspis quattuorseriata	**NT**	**X**	M-H				x	
Hemidactylus mabouia	LC		M			x	x	x

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Scientific Name	IUCN Red Data	Endemic	Likelihood of occurrence	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savannah	Cultivation / Shrubland
Lygodactylus gutturalis	LC		H	x			x	
Family: Gerrhosauridae								
Gerrhosaurus nigrolineatus	LC		Confirmed					x
Family: Grayiidae								
Grayia tholloni	LC		H	x				
Family: Lacertidae								
Adolfus africanus	LC		H	x			x	
Adolfus jacksoni	LC		Confirmed				x	
Congolacerta vaueresselli	LC		H				x	
Family: Lamprophiidae								
Boaedon fuliginosus	LC		H			x	x	x
Boaedon olivaceus	LC		H	x			x	
Gonionotophis brussauxi	LC		H	x			x	
Hormonotus modestus	LC		M				x	
Limaformosa chanleri	LC		H				x	x
Lycodonomorphus bicolor	LC	**X**	M	x				
Lycophidion capense	LC		H				x	x
Lycophidion jacksoni	-		M				x	x
Mehelya poensis	LC		H				x	
Mehelya stenophthalmus	-		H				x	
Family: Leptotyphlopidae								
Leptotyphlops emini	LC		H					x
Leptotyphlops latirostris	**NT**	**X**	M					x
Family: Natricidae								
Natriciteres olivacea	LC		H	x	x		x	x
Family: Pelomedusidae								
Pelomedusa neumanni	LC		H	x	x			
Pelusios rhodesianus	LC		H	x				
Pelusios sinuatus	LC		H	x				
Pelusios subniger	LC		M-H	x	x			
Pelusios williamsi	LC		M	x				
Family: Psammophiidae								
Psammophis lineatus	LC		M-H		x			x
Psammophis mossambicus	LC		H					x
Psammophylax tritaeniatus	LC		H		x			x
Psammophylax variabilis	LC		M		x			x
Family: Pseudaspididae								
Pseudaspis cana	LC		H					x
Family: Pseudoxyrhophiidae								
Buhoma depressiceps	LC		H				x	
Duberria lutrix	LC		H		x	x	x	x
Family: Pythonidae								
Python natalensis	LC		H	x	x		x	x
Python sebae	**NT**		H	x	x		x	x
Family: Scincidae								
Leptosiaphos graueri	**EN**	**X**	M		x	x		
Mochlus hinkeli	LC		H				x	

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Scientific Name	IUCN Red Data	Endemic	Likelihood of occurrence	Riparian Thicket	Riparian Wetland	Hillslope Thicket / Forest	Hillslope Grassland / Savannah	Cultivation / Shrubland
Trachylepis maculilabris	LC		H	x	x	x	x	
Trachylepis megalura	LC		Confirmed					x
Trachylepis striata	LC		H	x		x	x	x
Trachylepis varia	LC		H	x		x	x	x
Family: Testudinidae								
Kinixys spekii	**VU**		M					x
Family: Typhlopidae								
Afrotyphlops angolensis	LC		H				x	x
Letheobia graueri	LC		M			x	x	x
Family: Varanidae								
Varanus niloticus	LC		H	x	x	x		
Family: Viperidae								
Atheris nitschei	LC	**X**	H	x			x	x
Bitis arietans	LC		Confirmed	x		x	x	x
Bitis gabonica	**VU**		H	x		x	x	
Bitis nasicornis	**VU**		M			x	x	
Causus lichtensteinii	LC		H				x	
Causus resimus	LC		H	x			x	x
Causus rhombeatus	LC		M	x	x	x	x	x

LC = Least Concern

DD = Data Deficient

VU = Vulnerable

NT = Near Threatened

EN = Endangered

M = Medium

M-H = Medium-High

H = High

Endemic = restricted to the Albertine Rift Montane Forests Ecoregion

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D. Complementary Data - Aquatic Biodiversity Baseline

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D.1 Aquatic Baseline Approach and Methodology

D.1.1 Approach

The approach to this report was to focus on the key aquatic ecosystem drivers and responses that could be directly or indirectly impacted by the proposed Project. The key ecological drivers that were considered were water quantity and quality. The key ecological responses considered were aquatic flora, benthic diatoms, aquatic macroinvertebrates and fish. The report also considered the distribution of fish species in selected tributaries beyond the Project Area of Influence (AoI) because of the potential impact on two species of *Chiloglanis* fish that are classified by the IUCN at *Threatened.*

D.1.2 Data Review

D.1.2.1 Key Data Sources

Key data sources for this report comprised the following:

- Baseline study for the basin of Lake Kivu and the Ruzizi River (Sher Consult 2020)
- Draft ESIA for proposed Ruzizi III HPP (Sofreco 2021a)
- Ruzizi III Fish Survey (Sofreco 2021b)
- Ruzizi III Limnological Survey (Mulungula 2020)
- Rwanda Dragonfly Biotic Index (Uyizeye *et al.* 2021)
- Checklist of fishes of Rwanda (de Vos *et al.* 2001)
- IUCN Red list of threatened species (www.iucnredlist.org)
- Global Biodiversity Information Facility (www.gbif.org)
- Global information system on fishes (www.fishbase.org)
- African Dragonflies and Damselflies Online (http://addo.adu.org.za/)
- Published data on key species (various sources)

D.1.2.2 The literature review was supported by informal consultation with Jos Snoeks and Emmanuel Evreven at the Royal Museum for Central Africa on the *Chiloglanis* and *Labeobarbus* fish species. Fish species identifications were supported and verified by fish taxonomist Denis Tweddle, at the Southern African Institute for Aquatic Biodiversity (SAIAB). Available Data

A Water Quantity

Monthly inflows into Ruzizi III, simulated for the period 1901 to 2018 (118 years), were obtained from the feasibility study for the proposed Ruzizi III HPP (Tractebel 2021).

B Water Quality

Water quality in the upper reaches of the Ruzizi River matches that of Lake Kivu. The water quality is characterised by high pH and salinity, attributed to thermal springs and the volcanic regions of South Kivu (Sher Consult 2020). The pH is ~9; electrical conductivity is ~100 mS/m; the concentrations of phosphate are elevated, while that of nitrate and nitrite are very low (Sher Consult 2020). Salt concentrations in the Ruzizi River decline with distance downstream because of the dilution effect of tributaries (Sher Consult 2020). By contrast, turbidity increases with distance downstream because of tributary contributions (Sher Consult 2020). A study of water quality of the Ruzizi River and its major tributaries highlighted the following (SMEC 2018, cited by Sher Consult 2020):

- Elevated turbidity, generally ranging between 300 and 1,000 Nephelometric Turbidity Units (NTU)
- Elevated concentrations of phosphate, chloride and ammonium

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- Elevated concentrations of iron and manganese
- Elevated abundance of bacteria (total coliforms and *E. coli*).

C Aquatic Flora and Benthic Diatoms

There were no known existing data available on aquatic flora or benthic diatoms in the Ruzizi River.

D Macroinvertebrates

Available data on aquatic macroinvertebrates within the Project AoI appears to be limited to a single survey undertaken as part of the initial ESIA for Ruzizi III, conducted 10-13 February 2020 (Mulungula 2020). The survey recorded a low diversity of macroinvertebrates, dominated numerically by non-biting midges (Chironomidae). The report highlighted the presence of intermediate host snails of urinary and rectal human bilharzia (Mulungula 2020). The survey recorded 12 macroinvertebrate taxa in the impoundments upstream of Ruzizi I and II, and ten macroinvertebrate taxa in the Ruzizi River downstream of Ruzizi I and II, as follows:

Impoundments

- Oligochaeta
- Hirudinea*: Aliolimnatis* sp. and *Mesobdella sp.**
- Potamonautidae: *Potamonautes* sp.
- Coenagrionidae: *Pseudagrion sp.*
- Naucoridae: *Laccoccoris sp.* and *Naucoris sp.*
- Hydraenidae
- Chironomidae
- Bithynidae: *Gabiella sp.*
- Bulininae: *Bulinus truncatus*
- Planorbinae: *Biomphalaria pfeifferi*
- Lymnaeidae: *Lymnaea sp.*
- Thiaridae: *Melanoides sp.*

Ruzizi River

- Oligochaeta
- Caenidae: *Afrocaenis sp.*
- Coenagrionidae: *Pseudagrion sp.*
- Libellulidae: *Trithemis* sp. and *Macrodiplax** sp.
- Hydropsychidae: *Hydropsyche sp.*
- Elmidae
- Chironomidae
- Bulininae: *Bulinus truncatus*
- Planorbinae: *Biomphalaria pfeifferi*
- Thiaridae: *Melanoides sp.*

[* These identifications are unlikely because the genus *Mesobdella* is terrestrial; and genus *Macrodiplax* does not occur in central Africa].

There have been other reports of macroinvertebrates in the area, but none in the Project AoI, and none in habitats that are comparable to the Ruzizi River, so these are of limited value for the purposes of this report. These other reports include:

- Lake Kivu and its tributaries (Pilsbry and Bequaert 1927, de Moulin 1956, Gouteux 1978, Meyer 2011).
- Ruzizi River Floodplain (Kiss 1960, Gillet 1961, Elsen and Fain 1981, Gryseels 1985, Shabani 2015, Ruffin *et al.* 2018).
- Nyungwe National Park (Ngirinshuti *et al.* 2019, Kipping *et al.* 2001).

E Historic Fish Presence

Based on a review of museum specimen holdings, Banyankimbona, Emmanuel *et al.* (2012) identified 45 fish species as occurring in the Ruzizi River Basin, the greatest number being represented by Cyprinidae (16 species), followed by Cichlidae (7) and Clariidae (4) (Table D-1). The paper cites the following eight species as being shared with Lake Kivu *Enteromius apleurogramma, Enteromius pellegrini, Labeobarbus altianalis, Raiamas moori, Amphilius uranoscopus, Clarias garieipinus, Clarias liocephalus* and *Oreochromis niloticus*.

A review of the IUCN distributional database suggests that there are 59 species of fish in the Ruzizi River (IUCN 2021), the greatest proportion being represented by Cyprinidae (20 species), Cichlidae (12 species) and Clariidae (4).

The discrepancies in the estimates of the number of species in the river are likely to vary depending on the whether these estimates include species from Lakes Kivu or Tanganyika,

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with the possibility of lake fish being present in any of the estimates – particularly in closer proximity to the inlet and outlet. In general, however the Ruzizi River fish fauna is dominated by Cypriniformes (minnows, large barbs and labeos), rheophilic Siluriformes (Amphiliid and Mochokid catfish) and the Characiformes (Alestidae). Cichlids, while present in the river, will exploit the reservoirs, the river margins and floodplains where these provide sufficient lentic habitat.

F Fish Survey 2021 (SOFRECO 2021b)

Fish surveys were conducted by the SOFRECO environmental team at three sites in 2010 – Ruzizi I reservoir, Ruzizi II reservoir and the Ruzizi River near Kamanyola. A second survey was conducted in 2011 at seven sites – upstream and downstream of Ruzizi II, at the proposed Ruzizi III dam site and on the Ruzizi River near Kamanyola and Nyanguezi, as well as one site on the Munzinzi River (SOFRECO 2021b). A total of 14 and 17 species were caught in 2010 and 2011, respectively. Of these, 14 species were reported to part of the Lake Kivu fish community and three belonged to the Lake Tanganyika community (Table 2-1). Both surveys confirmed a greater proportion and different complement of Haplochromine fish species than reported either by the IUCN (2021) or Banyankimbona, Emmanuel, *et al*. (2012). Most of these are Lake Kivu endemics. The SOFRECO survey sites included the Ruzizi I and II HPP reservoirs, where lentic conditions likely favour the persistence of non-rheophilic species which would have dispersed there from the lake.

SOFRECO (Annex 5, Table HB9) provided an inventory of fishes provided by the Mbisa-Congo Project (Table 2-1). Here, a total of 50 species were reported for the Ruzizi River basin and photographs of additional species are provided in Annex 5, HB10 (Table 2-1). The discrepancy in numbers from the IUCN and Banyankimbona, Emmanuel *et al*. (2012) inventories is once again attributable to the larger number of Lake Kivu endemics, of which 11 were identified in the SOFRECO surveys, reflecting the location of sampling sites in the Ruzizi I and II reservoirs. The combined inventory provided in Table D-1 suggests there may be as many as 80 species of fish present in 17 families in the Ruzizi River. The dominance of Lake Kivu species also suggests the way these reservoirs might be affecting fish populations in the upper Ruzizi in terms of altering habitat in favour of lentic species and blocking upstream spawning and dispersal migrations by the river-adapted rheophilic species.

G 2015-2022 Fish Data from CRBEC and CRSNE

Additional fish survey data for the Lower and Middle Ruzizi (collected between 2015 and 2022) was obtained from national fish experts at Centre of Research in Biodiversity, Ecology, Evolution and Conservation (CRBEC) and the Research Centre in Natural Sciences and Environment (CRSNE) in Burundi. The results are not yet published and only key findings from information provided confidentially have been integrated into the report where appropriate.

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Table D-1. Fish Species Reported in The Ruzizi River

This table was compiled from consultancies (SOFREC 2010, SOFRECO 2011, SOFRECO 2021 (Annex 5) SOFRECO (Annex 5, Table HB9) and SLR 2022), IUCN species distribution maps and Banyankimbona, Emmanuel, *et al*. (2012) checklist of the freshwater fishes of Burundi. The table indicates which records are from species inventories and which from field studies. RR = Range Restricted, Ke = Lake Kivu endemic, * = Introduced species. Note: the Banayankim et al 2012 fish inventory for Ruzizi applies to the basin and its tributaries, and not restricted to species occurring in the Ruzizi mainstem only

				INVENTORIES FOR RUZIZI BASIN					FIELD STUDIES			
Order	Family	Scientific Name	Common Name	Status	Range	Banayankimbona *et al*. (2012)	IUCN (2021)	SOFRECO (2021) Annex 5	SOFRECO (2010)	SOFRECO (2011)	SOFRECO (2021) Photos	SLR (2022)
CERATODONTIFORMES	**Protopteridae**	*Protopterus aethiopicus*	Marbled lungfish	LC		+		+				
CHARACIFORMES	**Alestidae**	*Alestes macrophthalmus*	Torpedo Robber	LC		+	+	+				
		Brycinus imberi	Spot-tail	LC		+	+	+				
		Micralestes stormsi		LC		+	+	+				
CICHLIFORMES	**Cichlidae**	*Astatoreochromis straeleni*	Bluelip haplo	LC	RR	+	+	+				
		Astatoreochromis vanderhorsti		LC	RR		+					
		Astatotilapia stappersii		LC	RR	+	+	+				
		Aulonocranus dewindti		LC			+					
		Coptodon rendalli	Redbreast tilapia	LC			+					
		Ctenochromis horei	Hore's haplo	LC	RR	+	+	+	+	+		+
		Gnathochromis pfefferi		LC	RR		+					
		Haplochromis adolphifrederici	Frederich's Kivu haplo	NE	Ke						+	
		Haplochromis astatodon	Regan's Kivu haplo	NE	Ke				+	+		+
		Haplochromis burtoni	Burton's haplo	LC	RR	+	+	+	+	+		+
		Haplochromis graueri	Grauer's Kivu haplo	LC	Ke		+	+	+	+		+
		Haplochromis insidae	Snoek's Kivo haplo	LC	Ke						+	
		Haplochromis kamiranzovu	Kamiranzovu haplo	LC	Ke				+	+	+	
		Haplochromis microchrysomelas	Orangetail Kivu haplo	LC	Ke						+	
		Haplochromis olivaceus	Olive Kivu haplo	LC	Ke						+	
		Haplochromis paucidens	Trimorphic Kivu haplo	LC	Ke				+	+	+	
		Haplochromis rubescens	Red Kivu haplo	LC	Ke						+	
		Haplochromis scheffersi	Scheffers' Kivu haplo	LC	Ke				+	+		
		Haplochromis vittatus	Striped Kivu haplo	LC	Ke						+	
		*Oreochromis leucostictus**	Blue spotted tilapia	LC		+	+	+				
		*Oreochromis macrochir **	Longfin tilapia	VU		+		+				
		Oreochromis mweruensis	Mweru tilapia	LC				+				
		*Oreochromis niloticus**	Nile tilapia	LC			+	+	+	+	+	+
		Oreochromis tanganicae	Tanganyika tilapia	LC	RR	+						
		Tylochromis polylepis		LC			+					
CLUPEIFORMES	**Clupeidae**	*Limnothrissa miodon **	Lake Tanganyika sardine	LC				+	+	+	+	
CYPRINIFORMES	**Cyprinidae**	*Acapoeta tanganicae*	Mbaraga	LC	RR	+	+	+				
		Chelaethiops congicus		LC			+					
		Clypeobarbus congicus	Congo barb	LC		+	+	+				
		Enteromius apleurogramma	East African red-finned barb	LC		+	+	+	+	+		+
		Enteromius kerstenii	Redspot barb	LC			+					+
		Enteromius lineomaculatus	Line-spotted barb	LC		+	+	+				
		Enteromius lufukiensis		NT	RR	+	+	+				

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Order	Family	Scientific Name	Common Name	INVENTORIES FOR RUZIZI BASIN					FIELD STUDIES			
				Status	Range	Banayankimbona *et al.* (2012)	IUCN (2021)	SOFRECO (2021) Annex 5	SOFRECO (2010)	SOFRECO (2011)	SOFRECO (2021) Photos	SLR (2022)
		Enteromius neumayeri	Neumayer's barb	LC		+	+	+				
		Enteromius oligogrammus		LC		+	+	+				
		Enteromius pellegrini	Pellegrin's barb	LC		+	+	+		+		+
		Enteromius taeniopleura		LC	RR	+	+	+				+
		Enteromius urostigma		LC			+					
		Labeo cylindricus	Redeye labeo	LC		+	+	+	+	+		+
		Labeobarbus altianalis	Ripon barbel	LC		+	+	+	+	+	+	+
		Labeobarbus caudovittatus		LC		+	+	+				
		Labeobarbus leleupanus	Leleup's carp	VU	RR	+	+	+				
		Labeobarbus somereni	Someren's barb	LC		+	+	+				
		Labeobarbus tropidolepis		LC	RR	+	+					
	Danionidae	*Raiamas moorii*	Lake Rukwa minnow	LC	RR	+	+	+	+	+	+	+
		Raiamas salmolucius		LC			+					
CYPRINODONTIFORMES	**Poeciliidae**	*Lacustricola pumilus*	Tanganyika lampeye	LC		+	+	+				
		Lamprichthys tanganicanus	Tanganyika killifish	LC	RR			+			+	+
		*Poecilia reticulata**	Guppy	LC				+				+
OSTEOGLOSSIFORMES	**Mormyridae**	*Cyphomyrus discorhynchus*	Zambesi parrotfish	LC		+		+				
		Mormyrus longirostris	Eastern bottlenose mormyrid	LC		+		+				
		Petrocephalus catostoma	Churchill	LC			+					
		Pollimyrus nigricans	Dark stonebasher	LC		+	+	+				
PERCIFORMES	**Anabantidae**	*Ctenopoma muriei*	Ocellated labyrinth fish	LC		+	+	+				
	Latidae	*Lates mariae*	Bigeye lates	VU			+					
SILURIFORMES	**Amphiliidae**	*Amphilius kivuensis*		NE		+		+				+
		Amphilius platychir	Mountain barbel	LC		+		+				
		Amphilius ruziziensis		NE	RR			+				
		Amphilius uranoscopus	Stargazer mountain catlet	LC		+	+					
		Zaireichthys brevis		LC				+				
	Bagridae	*Bagrus docmak*	Sudan catfish	LC		+	+	+				+
	Clariidae	*Clarias alluaudi*	Alluaud's catfish	LC		+	+					
		Clarias gariepinus	Sharptooth catfish	LC		+	+	+		+	+	+
		Clarias liocephalus	Smoothhead catfish	LC		+	+	+		+	+	+
		Clarias theodorae	Snake catfish	LC				+				
		Clarias werneri	Werner's catfish	LC		+	+	+				
	Claroteidae	*Auchenoglanis occidentalis*	Bubu	LC			+					
		Chrysichthys brachynema	Kibonde	LC					+	+		
		Chrysichthys sianenna	Kanimba	LC	RR		+					
	Malapteruridae	*Malapterurus electricus*	Electric catfish	LC			+					
	Mochokidae	*Chiloglanis asymetricaudalis*	Longtail suckermouth	EN	RR	+	+	+				+Rubyiro
		Chiloglanis lukugae		LC			+	+				
		Chiloglanis ruziziensis	Ruzizi suckermouth	CR	RR	+	+	+				
		Synodontis melanostictus		NE		+						
SYNBRANCHIFORMES	**Mastacembelidae**	*Mastacembelus frenatus*	Longtail spiny eel	LC		+	+	+				
			Totals			**45**	**52**	**50**	**14**	**17**	**15**	**20**

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D.1.3 Study Area and Project Area of Influence (AoI)

The Study Area for the aquatic survey comprised the following:

- Ruzizi River between the existing Ruzizi II and the confluence with the Ruhwa Rivers, a distance of ~27 km; and
- Left bank tributaries of the Ruzizi River between Ruzizi II and the confluence of the Ruhwa River, including the Rubyiro and Ruhwa Rivers in Rwanda. These tributaries were included because of the potential need to determine the wider distribution of threatened fish species that could be impacted by the proposed Project.

Note: The Study Area for this report was restricted to aquatic ecosystems within Rwanda. A detailed explanation about this limitation and the implications for the Project are detailed under "Assumptions and Limitations" (Section D.1.5.4).

The Project AoI on aquatic ecosystems within the Study Area comprised the following:

- Middle Ruzizi River between the existing Ruzizi II and the confluence with the Ruhwa Rivers, a distance of ~27 km. This area comprised the core AoI with respect to potential direct and indirect impacts of the proposed Project on aquatic ecosystems. It includes:
  - The 12.5 km upstream reach between the Ruzizi III dam and the existing Ruzizi II dam which will be blocked to fish migration from downstream (including the 3 km reservoir inundation zone).
  - The 6 km dewatered reach between the main dam and powerhouse that will receive a minimum flow of approximately 10 m^3/s (10% of mean average rainfall);
  - The 14 km downstream reach between the powerhouse and Ruhwa River confluence on the border of Burundi, most directly affected by sub-daily fluctuation
- Middle to Lower Ruzizi River comprising the entire downstream reach of 130 km to Lake Tanganika (including the Rusizi National Park and Ramsar site) within which fish migrate and where some hydrological effects of hydropeaking may be noticeable.

  Note: the critical habitat assessment has screened species within the entire Ruzizi Basin and conducted more detailed assessment of screened in species for Ecologically Appropriate Areas of Analysis (EAAAs) based on hydrobasins that intersect with the Ruzizi River (see Section 9).

D.1.4 Aquatic Sampling Sites

Potential aquatic sampling sites were identified prior to the field survey using Google Earth™ imagery and Lidar imagery provided by REL. The selection of potential sampling sites was based on the proposed infrastructure layout; access; safety; suitability of instream habitats; and distribution records of threatened *Chiloglanis* fish species. In addition, the river downstream of the existing Ruzizi II was selected as a case study to provide direct evidence of downstream ecological impacts of peak power generation on the Ruzizi River. Several potential sampling sites could not be sampled because they were inaccessible, unsafe to survey due to strong currents, or lacked suitable instream habitats. During the first field survey, in January 2022, a total of 12 sites in the Ruzizi River was visited, and a further nine sites in tributaries were sampled for fish only (Table D-2 and Figure D-1). During the second field survey, in February 2022, two sites in the Ruzizi River (Sites R09a and R12) were sampled for fish, focussing on *Chiloglanis* spp. only, and one site (Site R12), was sampled for macroinvertebrates.

It should be noted that there were a higher number of upstream sites (above the dam) as these have been monitored for upstream HPPs and therefore is able to provide relatively

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long-term data for the system and it also provides information of species that migrate upstream.

Sampling sites were coded as follows:

- Ruzizi River (R) Sampling sites in the Ruzizi River were numbered serially, starting at R01, immediately downstream of Ruzizi II (~11 km upstream of the proposed HPP). The lowest site sampled (R14a) was near the border between Rwanda and Burundi (~15 km downstream of the proposed HPP). Aerial images of aquatic sampling sites in the Ruzizi River are included in Annex 2. Photographs of sampling sites are included in Annex 3; and
- Tributaries. Tributaries sampled comprised the following:
  - Rubyiro River and upper tributaries, starting with Rb1, near the boundary of the Nyungwe National Park (Rb1), as well as the type locality of the *Chiloglanis ruziziensis* (Rb2);
  - Ruhwa River, sampled at one location only (Rh2); and
  - Other Tributaries, including one site within the proposed Full Supply Level (T1), that was sampled for macroinvertebrates only.

Table D-2 Aquatic Sampling Sites

Code	Location	Sub-catchment	Hydrogeomorphic Zone	Elevation	Latitude	Longitude	Date
				(masl)	dd.ddddd	dd.ddddd	
Ruzizi River							
R01	Ruzizi II - Case Study	Ruzizi	Transitional	1,397	-2.627040	28.904150	2022/01/24
R04a	Ruzizi III - Reservoir	Ruzizi	Transitional	1,147	-2.680790	28.935358	2022/01/20
R04	Ruzizi III - Reservoir Midway	Ruzizi	Transitional	1,146	-2.680989	28.935825	2022/01/20
R05	Ruzizi III - Wall	Ruzizi	Transitional	1,114	-2.689976	28.941517	2022/01/20
R08	Ruzizi III – D/S Batching Plant	Ruzizi	Transitional	1,003	-2.701370	28.969530	2022/01/23
R09a	Ruzizi III – U/S Penstock	Ruzizi	Transitional	1,003	-2.696580	28.972250	2022/01/21 2022/02/27
R09	Ruzizi III – U/S Penstock	Ruzizi	Transitional	985	-2.694706	28.976259	2022/01/21
R10	Ruzizi III – D/S Village	Ruzizi	Transitional	954	-2.695560	28.985700	2022/01/21
R12	Ruzizi III – D/S	Ruzizi	Upper Foothill	953	-2.703978	29.003612	2022/01/21 2022/02/27
R13	Ruzizi III – D/S	Ruzizi	Upper Foothill	951	-2.709700	29.010210	2022/01/22
R13b	Ruzizi III – D/S	Ruzizi	Upper Foothill	940	-2.722220	29.023610	2022/01/22
R14a	Ruzizi III – D/S	Ruzizi	Upper Foothill	934	-2.730178	29.030092	2022/01/22
Tributaries of Ruzizi River							
Rb1	Rubyiro R.	Rubyiro	Transitional	1,488	-2.528601	29.074212	2022/01/19
Rb2a	Ntondwe R.	Rubyiro	Transitional	1,316	-2.531390	29.042220	2022/01/19
Rb2	Ntondwe R.	Rubyiro	Transitional	1,145	-2.564910	29.035110	2022/01/23
Rb2b	Rubyiro R.	Rubyiro	Mountain Stream	1,134	-2.568320	29.039080	2022/01/23
Rb3	Rubyiro R.	Rubyiro	Lower Foothill	951	-2.706570	29.031030	2022/01/23
Rb4	Rubyiro R.	Rubyiro	Upper Foothill	950	-2.720557	29.033144	2022/01/22
Rh2	Ruhwa R.	Ruhwa	Lower Foothill	931	-2.726457	29.041560	2022/01/23

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Code	Location	Sub-catchment	Hydrogeomorphic Zone	Elevation	Latitude	Longitude	Date
T1	Ruzizi reservoir	Ruzizi	Mountain Headwater	1,188	-2.680628	28.938912	2022/01/20
T2	Katabavuga R. (in Kambogo village)	Rubyiro	Mountain Stream	1,044	-2.637032	29.013830	2022/01/23
T3	Njambwe R. (near Mashesha village)	Rubyiro	Mountain Stream	1,107	-2.599938	29.012166	2022/01/23

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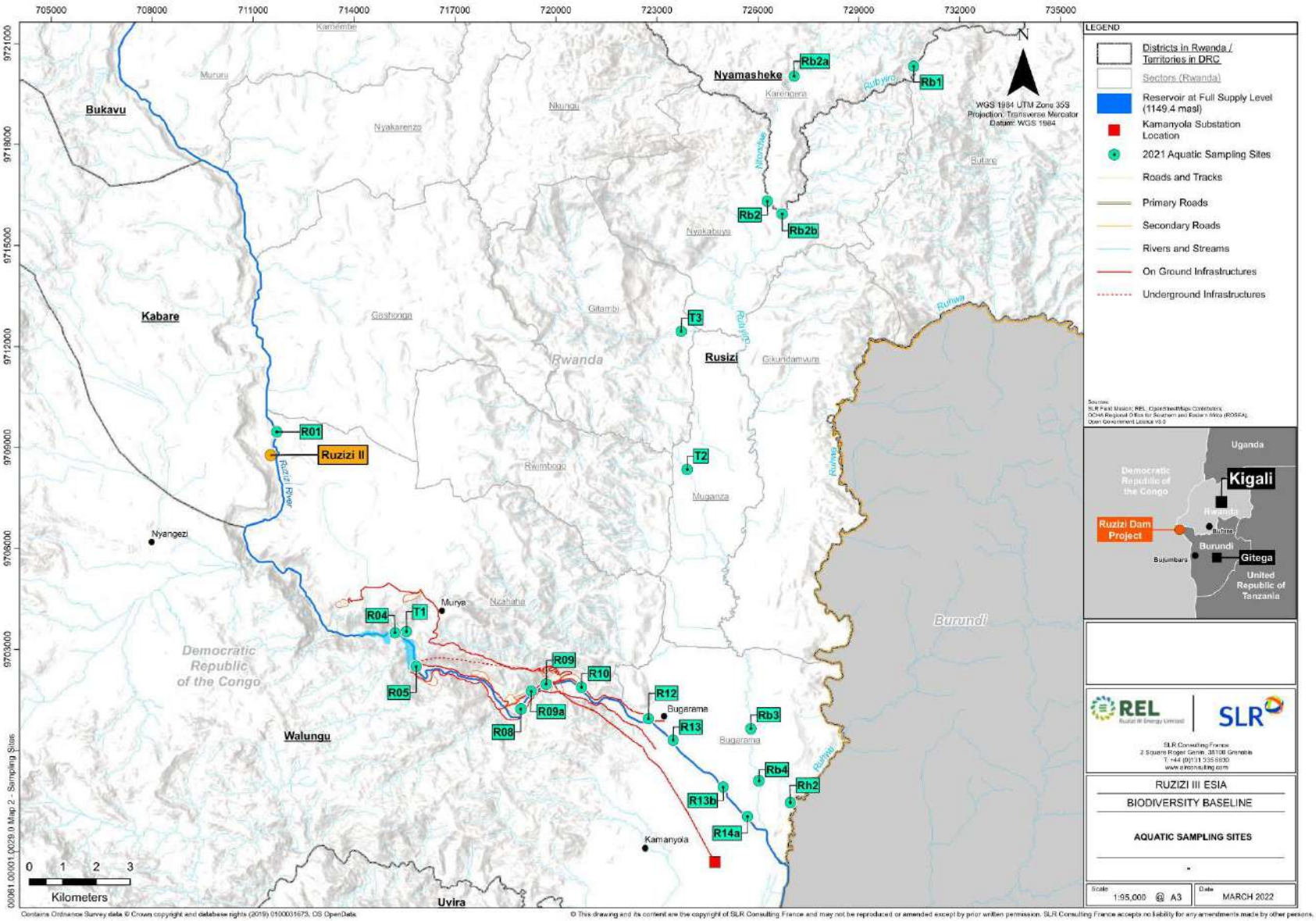

Figure D-1 SLR 2022 Aquatic Sampling Sites

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D.1.5 Field Surveys

Two field surveys were conducted for this report as follows:

Survey 1	Main Field Survey
Dates:	19-23 January 2022
Duration:	5 days
Season:	Wet
Water Levels:	Water levels in the Ruzizi River were high for most of this survey (during peak power generation at upstream hydropower projects), except on the afternoon of Sunday 22 January 2022.
Data Collected:	Field water quality; Aquatic flora; Benthic diatoms; Aquatic macroinvertebrates; and Fish

Survey 2	Supplementary Low Flow Field Survey
Dates:	27 February 2022
Duration:	~2 hours
Season:	Wet
Water Levels:	Prior arrangements were made with Ruzizi I and II HPPs for water levels in the Ruzizi River to be dropped for a few hours to allow the river to be sampled (i.e. non-peaking power generation at upstream HPPs).
Data Collected:	Fish were sampled at Sites R09a and R12. The fish survey focussed on determining the presence of threatened *Chiloglanis* species. Additional data on aquatic macroinvertebrates were collected at Site R12.

Itineraries for the two field surveys are included in Annex 1.

D.1.5.1 Aquatic Ecosystem Types

Aquatic ecosystem types within the Project AoI were classified according to the hierarchical system described by Ollis *et al.* (2013). This system was developed for inland aquatic ecosystems in South Africa but can be applied to aquatic ecosystems throughout the Afrotropical region. The system comprises a six-tiered system that incorporates hydrogeomorphic attributes such as gradient, inflows and outflows, and structural attributes such as substrate composition, depth and current speed.

D.1.5.2 Mapping of Aquatic Biotopes

Aquatic biotopes within the Project AoI were classified visually from Google Earth images and Lidar images, where available, and delineated using ArcMap. Five depth-flow categories were recognised as follows:

- Deep – Very Fast (cascades)
- Deep – Fast (rapids)
- Deep – Slow (pools)
- Shallow – Fast (riffles)
- Shallow – Slow (runs)

Where: Deep = >0.5 m
Shallow = <0.5 m
Very Fast = Super Critical
Fast = >0.3 m/s
Slow = <0.3 m/s

Aquaculture ponds were classified separately as a "Fish Ponds". Tributaries within the Direct AoI, such as T1, as well as irrigation diversion channels, were too narrow to map and therefore excluded from the delineation. The classification was ground-truthed during the field survey in January 2022.

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D.1.5.3 Field Data Collected

A summary of data collected at each sampling site is shown in Table D-3.

Table D-3 Summary of Data Collected at Each Site

Code	Photos	Instream Habitats					Riparian Habitats	
		Field WQ	Diatoms	Kick net	Crab Trap	Fish	Sweep Net	Malaise Trap
Ruzizi River								
R01	X	-	X	X	-	F+S	X	-
R04a #	X	-	X	-	-	E	-	-
R04 #	-	X	-	X	-	E	X	-
R05 #	X	-	-	-	-	E	-	-
R08	-	-	-	X	-	E	X	-
R09a	-	-	-	-	X	T	-	-
R09	X	X	X	X	-	E	-	-
R10	X	-	-	X	-	F+E	-	-
R12	X	X	-	X	-	F+E	X	X*
R13	X	X	-	-	-	F+E	X	-
R13b	X	-	-	-	-	F	X	-
R14a	X	X	-	-	-	F	-	-
Tributaries								
Rb1	X	-	-	-	-	E	-	-
Rb2a	X	-	-	-	-	E	-	-
Rb2	-	-	-	-	-	E	-	-
Rb2b	-	-	-	-	-	E	-	-
Rb3	X	-	-	-	-	E	-	-
Rb4	-	X	-	-	-	-	-	-
Rh2	X	X	-	-	-	E	-	-
T1 #	-	-	-	X	-	-	X	-
T2	-	-	-	-	-	E	-	-
T3	-	-	-	-	-	E	-	-

Fishing Methods: E=Electro-fishing; F=Community Fishers; S=Seine net; T=Throw-net

* = Malaise trap was set in the grounds of the Guesthouse near R12.

#= within the potential Area of Inundation

A Field Water Quality

Field measurements were made of the following parameters:

- pH, using an Extech EC400
- Conductivity (mS/m), using an Extech EC400
- Turbidity, using an Extech TB400

B Water Level

Water level was observed at a rated cross-section at S2.696590, E28.962200, ~2.8 km downstream of the proposed HPP.

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C Benthic Diatoms

Benthic diatoms provide a simple and accurate measure of overall biological water quality in the short-term (days). Diatoms are ecologically important because of their role as primary producers, which form the base of the aquatic food chain. Furthermore, diatoms usually account for the highest number of species among the primary producers in aquatic ecosystems.

Benthic diatoms were collected at three sites in the Ruzizi River. Diatoms were collected by brushing stone substrates and marginal vegetation as described by Taylor *et al.* (2007a). Preparation of diatom slides followed the Hot HCl and $KMnO_4$ method as described by Taylor *et al.* (2007a).

A Nikon Eclipse E100 microscope with phase contrast optics (1000x) was used to identify diatom valves on slides. The aim of the data analysis was to count 400 diatom valves to produce semi-quantitative data from which ecological conclusions can be drawn (Taylor *et al.* 2007a). This range is supported by Prygiel *et al.* (2002), Schoeman (1973) and Battarbee (1986) as satisfactory approach for the calculation of relative abundance of diatom species. Nomenclature followed Krammer and Lange-Bertalot (1986-91).

Diatom index values were calculated in the database programme OMNIDIA (Lecointe *et al.*, 1993). Various indices housed within the OMNIDIA programme were used to characterise biological water quality. To assign biological water quality Ecological Categories and associated water quality classes, the average index scores of two general pollution indices were used:

- Specific Pollution Sensitivity Index (SPI) (Coste in CEMAGREF, 1982): The SPI has the broadest species base and highest taxonomic resolution of all the indices and evaluates organic and inorganic pollution based on the sensitivity of each taxon, while considering the response of the whole diatom community (Almeida 2001). This index is used to indicate general water quality; and
- Biological Diatom Index (BDI) Lenoir and Coste (1996): The BDI index is primarily a practical index, as it treats morphologically related taxa as one group and composes so-called associated taxa eliminating species that are difficult to identify.

Present Ecological State (PES) Categories and associated water quality classes were based on the average index scores of the SPI (Table D-4).

Table D-4 Diatom Present Ecological State Classification

Ecological Category	Desription	Index Score (SPI)
A	High Quality	18 - 20
A/B		17 - 18
B	Good Quality	15 - 17
B/C		14 - 15
C	Moderate Quality	12 - 14
C/D		10 - 12
D	Poor Quality	8 - 10
D/E		6 - 8
E	Bad Quality	5 - 6
E/F		4 - 5
F		< 4

Other indices used in the interpretation of diatom results comprised:

- Trophic Diatom Index (TDI) (Kelly and Whitton, 1995). This index provides the percentage pollution tolerant diatom valves (PTVs) in a sample and was developed for monitoring sewage outfall (orthophosphate-phosphorus concentrations), and not general stream quality. The presence of more than 20% PTVs shows significant organic impact.
- Valve Deformities. The presence of valve[1] deformities is an indication of possible metal toxicity that may be present within the aquatic system. The general threshold for valve

[1] Siliceous part of the diatom cell wall, containing most of the morphological features used to describe diatoms.

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deformities is considered potentially hazardous if the valve deformities make up >2% of the total count (Taylor, pers. comm.)

D Aquatic Macroinvertebrates

Aquatic macroinvertebrate are useful biological indicators of river health in the medium-term (weeks). Macroinvertebrates are ecologically important because they provide food for fish, and some (crabs) are harvested for subsistence use. Furthermore, some species are medically important because of their role in disease, particularly malaria and bilharzia. Aquatic macroinvertebrates were collected using various methods appropriate to the available instream habitats (Table D-5). Analysis of macroinvertebrate data at each site was not possible because of the low diversity and abundance associated with high flows. Pooling the data provided an alternative approach for analysis. The pooled data were analysed broadly according to the South African Scoring System version 5 (SASS5) (Dickens and Graham 2002). The SASS5 method is a rapid method of assessing river health based in the composition of aquatic macroinvertebrate taxa that are identified in the field mostly to family level. Each SASS5 taxon has been allocated a sensitivity score that ranges from 1 to 15 for tolerant and sensitive taxa respectively. The sensitivity scores are added for all taxa recorded at a site to determine the Total SAS5 Score. The Total Score is then divided by the number of taxa to derive an Average Score per Taxon (ASPT). The Total Score and ASPT are used to interpret the data. The abundance of aquatic macroinvertebrates in instream habitats at each site was classified visually into five categories as follows:

- 1 = 1
- A = 2 to 9 (present)
- B = 10 to 99 (common)
- C = 100 to 1,000 (abundant)
- D = >1,000 (very abundant)
-

Table D-5 Methods Used to Sample Aquatic Macroinvertebrates

Method	Description
Instream Habitats	
Kick net	Bed substrates and marginal vegetation were sampled using a standard 30x30cm SASS5 kick net with a mesh size of 1 mm. The substrates comprised mostly large boulders, embedded cobbles, and bedrock in-current.
Plankton Net	Drifting macroinvertebrates in the water column were sampled using a plankton net with a mesh size of 120 µm. The aim of this was to collect drifting stages of aquatic insects that could be missed because of the difficulty of sampling in high current speeds.
Crab Trap	A funnel trap made from wire chicken mesh and baited with raw beef was left at R09a for three days. The aim of the trap was to collect and identify crab species.
Riparian Habitats	
Sweep Net	Aerial netting of riparian vegetation was undertaken using a standard butterfly net. The aim here was to collect adult stages of aquatic insects to supplement information obtained from sampling instream habitats. This was important for the Ruzizi River because the main channel was impossible to sample for most of the time because of high current speeds and depth. Aerial netting focussed on Odonata (dragonflies and damselflies) because adult stages can be identified to species and because the conservation status of most species of Odonata has been assessed.
Malaise Trap	Adult insects were sampled using a black Malaise trap baited with artificial ox-breath (octenol). The trap was set for 5 days in the garden of a Guest House in Bugarama, ~200 m from the river near Site R12. The net was inspected twice daily. The aim of the trap was to collect adult stages of aquatic insects to supplement information obtained from instream habitats that could be missed from aerial sweep netting during the day.

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E Fish Sampling

Fish are useful biological indicators of river health in the long-term (months) and provide a longer temporal scale for monitoring ecological change than diatoms and macroinvertebrates. The fish survey presented in this report was intended to provide supplementary data to support the 2021 surveys by SOFRECO (2021b) and was not intended as a comprehensive survey. All fishing was undertaken from the bank of the river. No boat-based sampling was attempted because of the high velocity of the river. Sampling methods used are detailed in Table D-6 with examples shown in Figure D-2.

Table D-6 Methods Used to Sample Fish

Method	Description
Electrofishing	A SAMUS 725MP portable electrofisher with a maximum output power of 650 Watts and an output voltage of between 650 and 1000V was used to capture fish in shallow side channels, bays and inlets to a depth of ~1 m. Pulse frequency was set at 80-90Hz. The pulse duration (L) was increased to achieve an output power of 150 Watts. Electrofishing was conducted at each site along the margins of the active channel and side channels. Electrofishing effort varied between 8 and 45 minutes and was limited by the availability of suitable shallow-water habitat. The current was applied intermittently to avoid chasing fish occurring in the flight zone.
Seine-Net	A 10 m seine-net with a mesh size of 10 mm was used at selected sites. Sampling involved two people sweeping the net for a recorded number of sweeps.
Throw-Net	A throw-net with a mesh size of 4 cm was used at selected sites.
Fisher Catches	Local fishers were interviewed on an ad hoc basis where fishers were encountered on site. Some catches were bought from fishers so that their catches could be identified, photographed, counted and measured.

Information recorded at each site comprised the following:

- Sampling gear and sampling effort
- Species composition
- Total Length (mm) of each specimen
- Abundance of each species
- Catch per unit Effort of each species (where feasible)

Fish species were identified and photographed in the field. Specimens of *Chiloglanis* species were preserved in 95% ethanol and left with REL on departure of the team for export to the South African Institute for Aquatic Biodiversity (SAIAB) for further morphological identification.

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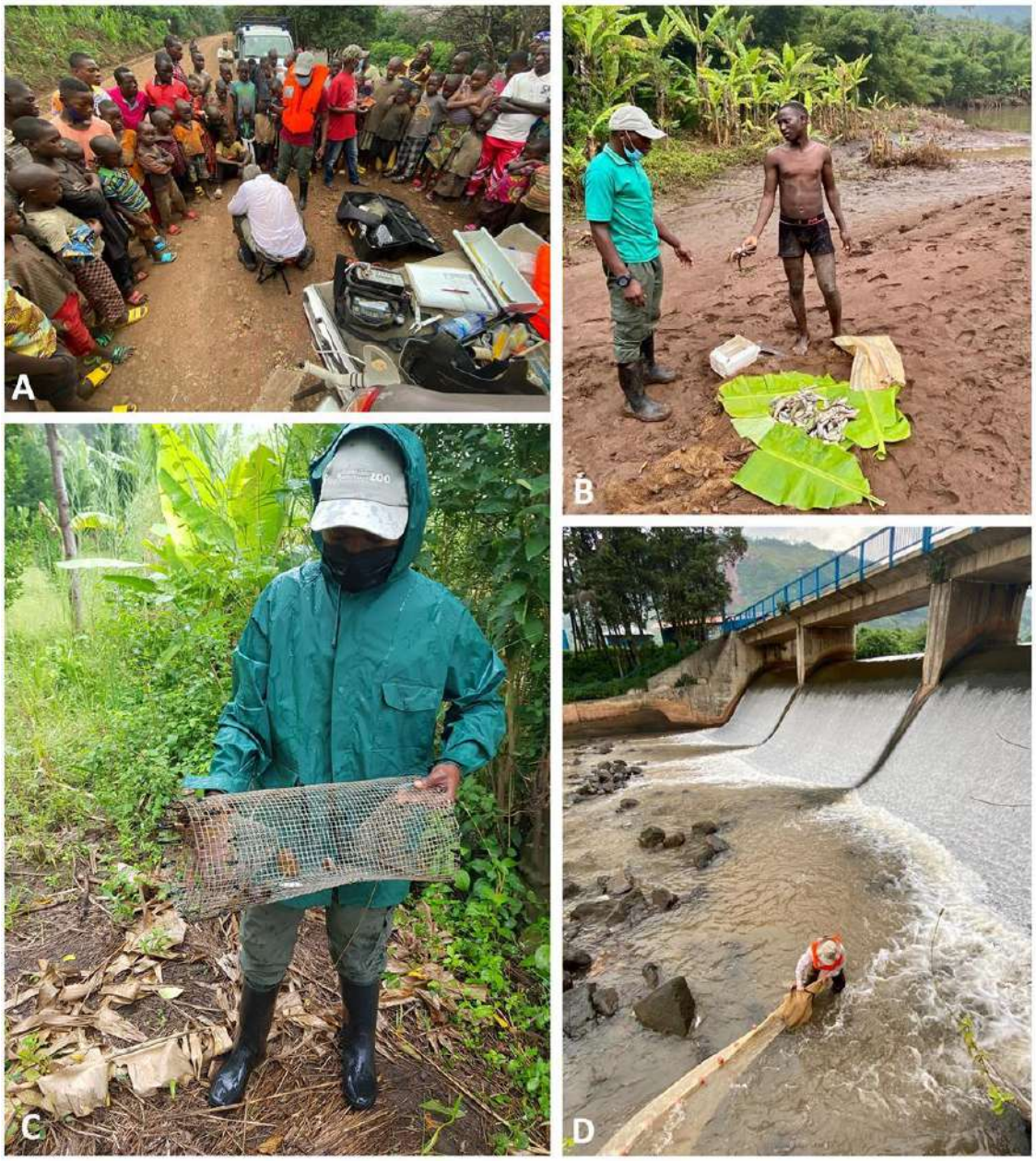

Figure D-2 Photographs of Aquatic Survey Activities (January 2022)

[A) Field identification at Rb2b; B) Bartering with Local Fisher at R01; C) Funnel trap for crabs set at R09a; D) seine netting at R01.]

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D.1.5.4 Assumptions and Limitations

The assumptions and limitations of this report are detailed in Table D-7.

Table D-7 Assumptions and Limitations

Item	Aspect	Description
1. General		
1.1	AoI	Potential impacts of hydropeaking from the proposed Ruzizi III could extend as far as the Ruzizi River Floodplain, but sampling on the floodplain was excluded from the scope of this assessment because: 1) the border between Rwanda and Burundi was closed at the time of the aquatic field survey in January 2022, and had been for several years; 2) there were security concerns in eastern DRC; 3) the main downstream impacts are likely to occur close to the proposed development; and 4) hydraulic modelling of the likely attenuation of water level fluctuations with distance downstream of the proposed Ruzizi III had not yet been undertaken. An additional aquatic survey (or surveys) in the floodplain may be warranted, pending the findings of the hydraulic modelling.
1.2	Baseline Data	The available data on aquatic ecosystems was sufficient to assess potential impacts for the purposes of this ESIA, but not sufficient as a reference for long-term monitoring. The data collected on aquatic ecosystems during this and the previous aquatic surveys do not provide a reliable quantitative baseline against which future changes may be compared. Additional baseline data on aquatic ecosystems should therefore be collected prior to construction, and when water levels are low. These recommendations will be included in the project Environmental and Social Management and Monitoring Plan (ESMMP).
1.3	Seasonal Variation	Seasonal variation of ecological conditions in the Ruzizi River is expected to be small, so seasonal sampling was not deemed necessary. Seasonal fish surveys had also been done under separate contract through SOFRECO in 2021. Flows are relatively stable throughout the year because of attenuation caused by Lake Kivu, and because air temperatures remain largely stable throughout the year. Ecological differences between wet and dry seasons are therefore likely to be minimal, although sediment inputs from tributaries are likely to be elevated during the wet seasons, and these are likely to trigger upstream migration of fish.
1.4	Daily Variation	Daily variation of flows in the Ruzizi River within the Project AoI during the field survey in January 2022 were extreme because of the operation of Ruzizi II for peak power generation. Water levels were high for most of the five days of the field survey, and accessible substrates were devoid of aquatic macroinvertebrates, so quantitative sampling of macroinvertebrates was not possible. The macroinvertebrate survey therefore relied largely on aerial sweep netting and trapping of adult aquatic insects, and a few occasions when water levels dropped low enough to collect benthic samples. The most reliable data on macroinvertebrates was collected from Site R12 during the second survey, in February 2022.
1.5	Data Quality	The data collected was mostly qualitative because of the difficulty of sampling at high flow. Furthermore, data from different sites are not comparable as sampling intensity varied between sites because of differences in aquatic habitats and access.
2. Physico-chemical Drivers		
2.1	Water Quality	Water quality analysis for this report was limited to in-field analysis of pH, electrical conductivity and turbidity. Detailed water quality analysis was undertaken as part of the initial ESIA (Mulungula 2020). Measurable changes in water quality between 2020 and 2022 are unlikely, so the available water quality data were considered sufficient for the purposes of the ESIA.

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Item	Aspect	Description
3. Aquatic Flora & Fauna		
3.1	Diatoms	Diatom communities had high abundance of endemic and tropical species, and many could not be identified to species level. The confidence in the overall assessment was low to moderate because: • There was a high prevalence of tropical diatom species so the Biological Diatom Index (developed for genus level identification) could not be used as most of the species observed are not included in this index. • Using genus level identification would influence the Specific Pollution Index (SPI) score to some degree and not all species are included in the index. Between 96% and 100% of the species identified for this study are included in the SPI score and the confidence in the SPI score is therefore moderate, especially if the excluded species occurred as dominant and sub-dominant in the samples. • The ecology of endemic species occurring in tropical African areas is poorly understood and literature is limited. Therefore, accurate community composition analysis was limited. This is especially valid for dominant and sub-dominant species.
3.2	Flora	Riparian and marginal vegetation were excluded from the aquatic ecology report and are described in a separate specialist Terrestrial Ecology Report.
3.3	Mammals, Reptiles and Amphibians	Aquatic mammals, reptiles and amphibians were excluded from this report and will be described in a separate specialist Terrestrial Ecology Report.
4. Aquatic Macroinvertebrates		
4.1	Reference Conditions	The Present Ecological State (PES) of aquatic macroinvertebrates indicates the extent to which the composition and/or abundance of aquatic macroinvertebrates may have changed from natural (reference) conditions. There are no historical data on the composition or abundance of macroinvertebrates for the Ruzizi River, so reference conditions for macroinvertebrates are unknown. The river has unusually high concentrations of salt, and this could be sufficient to exclude sensitive taxa that could be expected in a river of this size, such as Oligoneuridae, Heptageniidae and Prosopistomatidae. The PES for macroinvertebrates in this report was therefore categorised broadly as “natural” or “modified”, as defined by the IFC (2021).
4.2	Spatial Coverage	Macroinvertebrate sampling was limited to the middle zone of the river near the proposed HPP. No sampling was undertaken upstream of the proposed reservoir Full Supply Level, other than immediately downstream of Ruzizi II (R01). Furthermore, no sampling was undertaken in the floodplain area in Burundi as it is understood that alteration of flows downstream of Ruzizi III HPP will not extend this far. These limitations are not considered critical for the purposes of assessing potential impacts of the proposed HPP and could be addressed in an aquatic biomonitoring programme that should form part of future project monitoring.
4.3	Data Quality	Aquatic macroinvertebrates in the Ruzizi River were difficult to sample because of high water levels, so sampling comprised a range of methods, all of which are likely to have underestimated the diversity of macroinvertebrates present. However, macroinvertebrate abundance and diversity appeared low and may reflect existing impacts from upstream hydropower peaking operations.
5. Fish		
5.1	Available Data	This study was conducted using the best available information on the occurrence and distribution of fishes in the Ruzizi River and supported by expert input from the SAIAB for fish identifications. There are some key

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Item	Aspect	Description
		uncertainties relating to fish population distribution and abundance, migration requirements and species identification each of which are highlighted below.
5.2	Sampling Frequency	This study was based on one field survey plus available data from previous surveys and is therefore limited in terms of seasonal changes in fish distribution and abundance and intra-annual changes in fish community structure and composition. Furthermore, high volume releases from Ruzizi II made sampling dangerous because of the water depth and high current speeds. An additional once-off survey was undertaken in March 2022 following a request to cease releases from Ruzizi II while the survey team was sampling which provided an opportunity to sample the river at low flow with a specific goal of searching for threatened and restricted range species. In order to compensate for the lack of sampling frequency, results from previous surveys within the sub-catchment were included.
5.3	Spatial Datasets	The spatial datasets on species distributions used for the purposes of this study were obtained from their EOO published by the IUCN (2021). These EOOs are determined based on known historical museum or published distributions, as well as by consulting experts. In all but instances of restricted-range species, sampling for fishes is impossible throughout their distribution ranges. Thus, many of the distributions are inferred based on expert knowledge and may therefore be inaccurate. This is particularly problematic where a species range may have contracted due to anthropogenic factors and may be misrepresented or excluded from the Critical Habitat Assessment.
5.4	Population Size and Extent of Occurrence (Critical Habitat Assessment)	While the known and predicted spatial distribution of priority fish species is available on IUCN databases, there is no information on the population size in specific locations within each species' EOO. Therefore, a key assumption used in the Critical Habitat Assessment was that a species' EOO is a proxy for its population size which therefore assumes that a species population is evenly distributed across its EOO. This is unlikely to be the case as certain fish species will concentrate in different habitats on a seasonal basis depending on their feeding and breeding/spawning requirements. However, the approach of using a species EOO as a proxy for population size was used by Sayer *et al.* 2018 to identify Key Biodiversity Areas (KBAs) in the Lake Victoria Basin and therefore provides a precedent for this approach. Nonetheless it is important to infer potential variation in population distribution where habitats are not preferential for a species or where there is significant threat in certain areas of a species distribution.
5.5	Migration	Knowledge of cyclically predictable migrations of African freshwater fishes is incomplete and evidence is often anecdotal – relying largely on visual observations of large aggregations of juvenile or adult fish. While there is strong evidence to suggest that a large proportion of African tropical and subtropical fish depend on migration, the distances and functions of such migrations (e.g. dispersal, spawning, recolonization), is less clear. In the absence of a clearer understanding of the importance of the movement of priority fish species in the Ruzizi River including *Labeobarbus altianalis, L. caudovittatus, L. leleupanus, L. somereni* and *L. tropidolepis* a precautionary approach will have to be adopted to assess project impacts. Evidence, for migration has therefore been obtained from the literature, from inferences regarding habitat requirements. Freshwater fish movement can be inferred from repeated seasonal surveys, from radio telemetry studies, or mark recapture experiments. However, all these methods require lengthy multi-year studies which are not within the scope of the current assessment.
5.6	Taxonomy	Much of the freshwater fish research in the region is focussed on Lake Kivu and Lake Tanganyika both because of the importance of commercial fish catches and for the diversity of the endemic haplochromine cichlids that occur in both lakes. Taxonomic guides or keys for fish species in the Ruzizi River are not available and many anatomical features that distinguish species – particularly among the haplochromine species – require preserved specimens to be dissected by specialist taxonomists. Some of the fish species' identities

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Item	Aspect	Description
		collected in this study are therefore types, or denoted "c.f." between the genus and species name, indicating that the specimen most strongly resembles the species indicated.

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D.2 Field Survey Itineraries

Survey 1

Date	Activity
16th January 2022	Arrive Kigali International Airport
17th January 2022	24hr quarantine in Kigali for COVID-19
18th January 2022	Drive to Bugarama, arrive 5pm Purchase meat from butchery for crab trap bait; Install crab trap in Ruzuziz River (R09a) Set Malaise Trap in garden at Lodge in Bugarama, near R12
19th January 2022	Inspect Malaise Trap Drive to Kamembe for second COVID-19 Test Sample fish in upper Rubyiro River (Rb01) and Ntondwe River (Rb02A)
20th January 2022	Inspect Malaise Trap Sample field water quality, diatoms, macroinvertebrates and fish in proposed Area of Inundation (R04) Sample macroinvertebrates in small tributary (T1)
21st January 2022	Inspect Malaise Trap Sample field water quality, diatoms, macroinvertebrates and fish upstream of proposed penstock (R09) Sample field water quality, macroinvertebrates and fish downstream of proposed village (R10 and R12) Retrieve crab trap
22nd January 2022	Inspect Malaise Trap Sample fish in Ruzizi River near border with Burundi (R13, 13b; R14a) Collect field water quality sample in Rubyiro River at Rb4
23rd January 2022	Inspect Malaise Trap Sample fish in lower Ruhwa River (Rh2); Ntondwe River (Rb2), Rubyiro River (Rb2b; Rb3) and tributaries (T2&T3)
24th January 2022	Inspect Malaise Trap Drive to Kamembe for COVID-19 Test Sample diatoms, macroinvertebrates and fish in dewatered zone downstream of Ruzizi II (R01) – Case Study
25th February 2022	Drive to Kigali
26th February 2022	Depart Kigali International Airport

Survey 2

Date	Activity
25th February 2022	Arrive Kigali International Airport
26th February 2022	Fly to Bugarama
27th February 2022	Meet team from Bukavo at border with DRC Attend REL Health and Safely Induction and Toolbox Meeting Sample fish during low flow at R09a and R12 between 14h00 and 14h45 Sample macroinvertebrates during low flow at R12 between 14h45 and 15h00
28th February 2022	Fly to Kigali (08h30), and Depart Kigali International Airport (10h30)

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D.3 Aerial Images

Transitional Zone

A) Site R01

[Image Source: Google Maps 17 Aug 2020].

B) Site R04a

[Image Source: REL May 2020].

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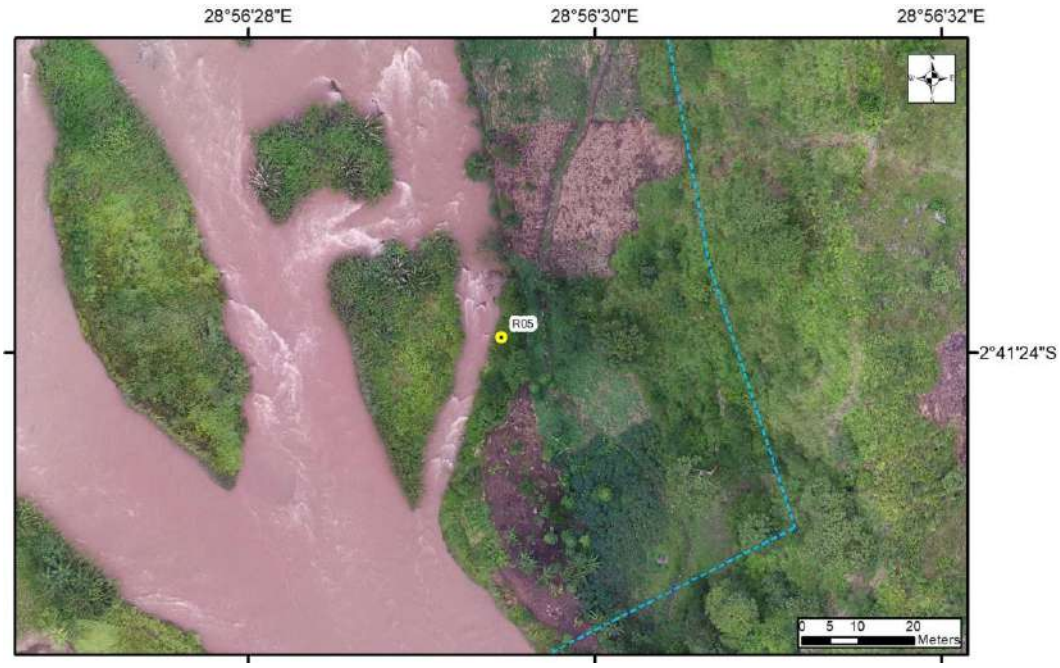

C) Site R05

[Source: REL May 2020]

D) Site R08

E) [Source: REL May 2020].

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F) Site R09
G) [Source: REL May 2020].

H) Site R10
I) [Source: REL May 2020].

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Upper Foothills

J) Site R12

[Image Source: Google Maps 29 June 2020].

K) Site R13b

[Image Source: Google Maps 18 September 2018].

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D.4 Site Photographs

Transitional Zone

A) Site R01 (Ruzizi II)

[Palmer, R. January 2022].

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B) Site R04a

[Palmer, R. January 2022].

C) Site R05

[Palmer, R. January 2022].

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D) Site R08

[Palmer, R. January 2022].

E) Site R09

[Palmer, R. January 2022].

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F) Site R10

[Palmer, R. January 2022].

Upper Foothills

G) Site R12

[Palmer, R. 27th February 2022].

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H) Site R13b

[Palmer, R. January 2022].

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l) Site R14

[Palmer, R. January 2022].

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D.5 Diatom Data

Species	Abbr.	R01	R04	R09
ACHNANTHIDIUM F.T. Kützing	ACHD	6		
Achnanthes inflata (Kützing) Grunow	AINF			1
AMPHORA C.G. Ehrenberg ex F.T. Kützing	AMPH	4		1
Amphora pediculus (Kützing) Grunow	APED	21		
CALONEIS Cleve	CALO	2		2
COCCONEIS C.G. Ehrenberg	COCO		1	
Cymbella tropica Krammer	CTRO	3		
CYMBELLA C.Agardh	CYMB			3
DENTICULA F.T. Kützing	DENT	2		
ENCYONOPSIS Krammer	ENCP	2		
Eolimna minima (Grunow) Lange-Bertalot	EOMI	2		
FRAGILARIA H.C. Lyngbye	FRAG	10	6	2
Fragilaria ungeriana Grunow	FUNG	3		
Gomphonema clavatum Ehrenberg	GCLA	1		
GEISSLERIA Lange-Bertalot & Metzeltin	GEIS	23		11
GOMPHONEMA C.G. Ehrenberg	GOMP	13	3	2
Gomphonema parvulum (Kützing)	GPAR	1		
Hantzschia amphioxys (Ehr.) Grunow	HAMP	1		
LUTICOLA D.G. Mann	LUTI	104	268	147
NAVICULA J.B.M. Bory de St. Vincent	NAVI	1		1
Nitzschia dissipata (Kützing) Grunow	NDIS	4		
Nitzschia frustulum (Kützing) Grunow	NIFR	2		15
Nitzschia inconspicua Grunow	NINC	10	1	4
NITZSCHIA A.H. Hassall	NITZ	155	105	186
Nitzschia palea (Kützing) W.Smith	NPAL	1		11
Nitzschia recta Hantzsch in Rabenhorst	NREC	6		1
Navicula schroeteri Meister	NSHR	9	1	
Navicula schroeteri var. *symmetrica* (Patrick) Lange-Bertalot	NSSY	4	13	11
Navicula tenelloides Hustedt	NTEN			1
Navicula trivialis Lange-Bertalot	NTRV	1		
NUPELA W. Vyverman & P. Compere	NUPE	3		
PINNULARIA C.G. Ehrenberg	PINU		1	
Rhoicosphenia curvata (Kützing) Grunow	RCUR	3		
RHOPALODIA O Müller	RHOP	1	1	1
Surirella brebissonii Krammer & Lange-Bertalot var.brebissonii	SBRE	1		
Sellaphora pupula (Kützing) Mereschkowksy	SPUP	1		
Total count		**400**	**400**	**400**

Key	
Low abundance	
Moderate abundance	
High abundance	

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D.6 Macroinvertebrate List

			Ruzizi River: Transitional						Upper Foothill						
Taxon (sensitivity)	Species (RDBI)	Status	R01	R04	R08	R9a	R9	R10	R12	R12#	R13	R13b	Rb3	T1	Trap
ANNELIDA															
Glossiphoniidae	-	-											X		
Glossiphoniidae	*Alboglossiphonia sp.*	-			A				1						
Hirudinidae	*Aliolimnatis sp.*	-			A			A	A						
Naididae	*Limnodrilus sp.*	-								A					
Salifidae	*Salifa perspicax*	-	A					A	A						
CRUSTACEA															
Potamonautidae	*Potamonautes lirrangensis*	LC				A				1	A				
Ostracoda	-	-								1					
PLECOPTERA															
Perlidae	*Neoperla spio* complex	LC	A							B	A				
EPHEMEROPTERA															
Baetidae	*Afroptiloides sp.*	-		A											
Baetidae	*Baetis harrisoni*	-	A	A			A	A	A	A					
Baetidae	*Baetis sp.*	-	A				A	A	A	A					
Baetidae	*Cloeoen sp.*	-								1					
Caenidae	*Afrocaenis sp.*	-	A						1	1					
Dicercomyzidae	*Dicercomyzon sp.*	-		1											
Tricorythidae	*Trichorythus sp.*	-	1												
ODONATA															
Calopterygidae	*Phaon irridipennis (2+0+0)*	LC										X			
Chlorocyphidae	*Platycypha caligata (2+2+0)*	LC	1	X					X	X					
Coenagrionidae	*Pseudagrion hamoni (1+0+0)*	LC		X											
Coenagrionidae	*Pseudagrion kersteni (1+0+0)*	LC												X	
Coenagrionidae	*Pseudagrion massaicum (1+0+0)*	LC							X						
Libellulidae	-	-	A					1		A					
Libellulidae	*Brachythemis leucosticta (0+1+0)*	LC							X						
Libellulidae	*Nesciothemis farinosa (1+1+0)*	LC		X	A				X	X					
Libellulidae	*Palpopleura lucia (0+0+0)*	LC	X						X	X					
Libellulidae	*Trithemis arteriosa (1+1+0)*	LC							X	X	X				
Libellulidae	*Zygonyx natalensis (3+0+0)*	LC						X			X				
Macromiidae	*Phyllomacromia contumax (3+3+0)*	LC	1												
HEMIPTERA															
Gerridae	*Limnogonus sp.*	-			A					1					
TRICHOPTERA															
Ecnomidae	*Ecnomus sp.*	-	1												
Hydropsychidae	*Hydropsyche sp.*	-	A						A	A					X
Hydroptilidae	-	-													X
COLEOPTERA															
Elmidae	*Potamodytes sp.*	-	A												
Elmidae	*Stenelmis sp.*	-	A							A					
Gyrinidae	-	-												X	
DIPTERA															
Ceratopogonidae	-	-													X
Chironomidae	-	-	A					B	A	A					
Culicidae	-	-								1					
Ephydridae	*Pelina sp.*	-			X										
Muscidae	-	-								1					
Sciomyzidae	*Sepodon sp.*	-			X										
Psychodidae	*Psychoda sp.*	-													X
Simuliidae	*Simulium adersi*	-	A												
Simuliidae	*Simulium hargreavesi*	-	A					A							X
Simuliidae	*Simulium perforatum*	-												X	
Simuliidae	*Simulium dentulosum*	-												X	
GASTROPODA															
Planorbidae	*Bulinus truncatus*	LC								1					
Planorbidae	*Biomphalaria pfeifferi*	LC	A		A			1							

Abundance Codes: 1 = 1; A = rare; B = common; X = present

= Survey 2 (27 Feb 2022)

[1 = 1; A = rare; B = common; x = present.]

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D.7 SASS5 Data

SASS Version 5 Score Sheet

Version date: 22-Nov-16

Date	2022-02-19 to 23	Project	Ruzizi III
Site Code	Pooled Data	Collector	Rob Palmer
		Flow	High
River	Ruzizi		

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1				
Hirudinea (Leeches)	3	A			A
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3	A			A
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12	A			A
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4				
Baetidae 2 sp	6	A			A
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6	A			A
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9	A			A
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10		A		A
Chlorocyphidae (Jewels)	10	A			A
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		A		A
Lestidae (Emerald Damselflies/Spreadwing	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6	A			A
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moth					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5		A		A
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M…veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies &					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8	1			1
Hydropsychidae 1 sp	4	1			A
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6	A			A
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8	A			A
Gyrinidae* (Whirligig beetles)	5	A	A		A
Haliplidae* (Crawling water beetles)	5				
Scirtidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blephariceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5		1		1
Chironomidae (Midges)	2	A	A		A
Culicidae* (Mosquitoes)	1				
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3	1			1
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1	1			1
Simuliidae (Blackflies)	5	A	A		A
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3		A		A
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalves)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					124
No. of Taxa					22
ASPT					5.6
Present Ecological State (A-F)					E
Other biota:					
Comments/Observations:					

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SASS Version 5 Score Sheet

Version date: 22-Nov-16

Date	27-Feb-2022	Project	Ruzizi III	Biotopes	(0-5)	Weight
Site Code	R12	Collector	Rob Palmer	Stones In Current (SIC)	4	20.0
		Flow	V Low	Stones Out Current (SOOC)	0	10.0
River	Ruzizi	Clarity (NTU)	-	Bedrock	3	5.0
Elevation (m)	953	Turbidity	Medium	Aquatic Veg	0	0.5
Grid	S2.703978 E29.003612	Colour	Light Brown	Marg Veg In Current (MVIC)	1	2.0
Accuracy	-	Algae (%)	40	Marg Veg Out Of Current	1	2.0
Gradient		Temp (°C)	-	Gravel	0	3.5
Zonation	D: Upper Foothills	pH	-	Sand	2	1.0
		Cond (mS/m)	-	Mud	1	0.5
		DO (mg/L)	-	Visual observation	Yes	
		Disturbance	-	BIOTOPE SUITABILITY	46%	D

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1			A	A
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3	1			1
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12	B			B
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4				
Baetidae 2 sp	6				
Baetidae > 2 sp	12	A			A
Caenidae (Squaregills/Cainfles)	6	A			A
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4				
Lestidae (Emerald Damselflies/Spreadwing	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6				
Libellulidae (Darters/Skimmers)	4	A			A
LEPIDOPTERA (Aquatic Caterpillars/Moth					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5		A		A
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies &					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4	A			A
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8	A			A
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Scirtidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blephariceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2	A			A
Culicidae* (Mosquitoes)	1				
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1	1			1
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalves)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					58
No. of Taxa					11
ASPT					5.3
Present Ecological State (A-F)					E

Other biota:
Adjacent fish pond: *Bulinus truncatus; Ostracoda; Culicidae*

Comments/Observations:
Water levels were dropped to allow sampling

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D.8 Fish Data

Cover (0-4)

Marginal Vegetation	2
Macrophytes	0
Undercut Banks & Roots	0
Woody Debris	1
Bed Substrate	3
	30%

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	1
Shallow-Fast	3
Deep-Fast	0
	44%

Site: R01
River: Ruzizi
Location: S2.627040 E28.904150
Date: 2022/01/24
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC	3	6			3									
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC	1	4				1								
Labeobarbus sp. A	-														
Raiamas moorii	LC	68	129			68									
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC	1	4				1								
Perciformes															
Haplochromis cf. graueri	LC					(16)	(46)	(8)							
Haplochromis cf astatodon	-					(3)	(5)								
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC		-		(25)	(33)	(22)	(13)	(1)						
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC		-					(5)	(6)	(5)					
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min): Seine Netting 4 Sweeps	15	
Total Catch	73	143
Catch per Unit Effort (/Hour)	292	572
Total Number of Species	8 (4+4)	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	4
Macrophytes	0
Undercut Banks & Roots	0
Woody Debris	1
Bed Substrate	2
	35%

Site: **R04a**
River: Ruzizi
Location: S2.680789 E28.935358
Date: 2022/01/20
Collector: Rob Palmer

Depth-Flow Classes (0-4)

Shallow-Slow	1
Deep-Slow	0
Shallow-Fast	4
Deep-Fast	0
	31%

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC	23	52		5	11	7								
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC	1	16					1							
Chiloglanis asymetricaudalis	EN														

Effort (min)	12	
Total Catch	24	68
Catch per Unit Effort (/Hour)	120	338
Total Number of Species	2	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	3
Macrophytes	0
Undercut Banks & Roots	0
Woody Debris	3
Bed Substrate	3
	45%

Site: **R04**
River: Ruzizi
Location: S2.680989 E28.935825
Date: 2022/01/20
Collector: Rob Palmer

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	0
Shallow-Fast	1
Deep-Fast	0
	25%

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC	1	1		1										
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC	23	54		5	10	8								
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	12	
Total Catch	24	54
Catch per Unit Effort (/Hour)	120	271
Total Number of Species	2	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	2
Macrophytes	0
Undercut Banks & Roots	0
Woody Debris	2
Bed Substrate	3
	35%

Depth-Flow Classes (0-4)

Shallow-Slow	0
Deep-Slow	0
Shallow-Fast	3
Deep-Fast	0
	19%

Site: **R05**
River: Ruzizi
Location: S2.689976 E28.941517
Date: 2022/01/20
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-	22	56		2	12	8								
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC	1	16					1							
Chiloglanis asymetricaudalis	EN														

Effort (min)	8	
Total Catch	23	72
Catch per Unit Effort (/Hour)	173	539
Total Number of Species	2	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	4
Macrophytes	0
Undercut Banks & Roots	0
Woody Debris	0
Bed Substrate	3
	35%

Depth-Flow Classes (0-4)

Shallow-Slow	4
Deep-Slow	0
Shallow-Fast	2
Deep-Fast	0
	38%

Site: **R08**
River: Ruzizi
Location: S2.701370 E28.969530
Date: 2022/01/23
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC	5	3		5										
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC	8	15			8									
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	10	
Total Catch	13	18
Catch per Unit Effort (/Hour)	78	107
Total Number of Species	2	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	0
Macrophytes	0
Undercut Banks & Roots	0
Woody Debris	0
Bed Substrate	0
	0%

Depth-Flow Classes (0-4)

Shallow-Slow	0
Deep-Slow	0
Shallow-Fast	0
Deep-Fast	0
	0%

Site: **R09a**
River: Ruzizi
Location: S2.696580 E28.972250
Date: 2022/02/27
Collector: Kisekelwa Tchalondawa

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC	X													
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC	XX													
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	-	
Total Catch	-	
Catch per Unit Effort (/Hour)	-	
Total Number of Species	2	

** = Alien or translocated species*

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Cover (0-4)

Marginal Vegetation	2
Macrophytes	0
Undercut Banks & Roots	1
Woody Debris	0
Bed Substrate	3
	30%

Depth-Flow Classes (0-4)

Shallow-Slow	1
Deep-Slow	0
Shallow-Fast	3
Deep-Fast	0
	25%

Site: **R09**
River: Ruzizi
Location: S2.694706 E28.976259
Date: 2022/01/21
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC	54	38	40	1	8	5								
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	10	
Total Catch	54	38
Catch per Unit Effort (/Hour)	324	228
Total Number of Species	1	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	3
Macrophytes	0
Undercut Banks & Roots	2
Woody Debris	0
Bed Substrate	3
	40%

Depth-Flow Classes (0-4)

Shallow-Slow	2
Deep-Slow	1
Shallow-Fast	3
Deep-Fast	0
	38%

Site: **R10**
River: Ruzizi
Location: S2.695560 E28.985700
Date: 2022/01/21
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC	1	2			1									
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC											(1)			
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-									(1)					
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC	1	0	1											
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC	29	54	4	9	7	9								
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC	1	113							1					
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	10	
Total Catch	32	169
Catch per Unit Effort (/Hour)	192	1 015
Total Number of Species	6 (4+2)	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	3
Macrophytes	0
Undercut Banks & Roots	1
Woody Debris	0
Bed Substrate	4
	40%

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	0
Shallow-Fast	3
Deep-Fast	0
	38%

Site: **R12**
River: Ruzizi
Location: S2.703978 E29.003612
Date: 2022/01/21
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC	2	4			2									
Enteromius cf taeniopleura	LC	1	2			1									
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC	5	14			3	2								
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC	1	1		1										
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC	1	2			1									
Ctenochromis horei	LC	72	281		21	20	22	9							
Oreochromis niloticus	LC	2	4			2									
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC									(1)					
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	25	
Total Catch	84	307
Catch per Unit Effort (/Hour)	202	736
Total Number of Species	8 (7+1)	

** = Alien or translocated species*

X = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	1
Macrophytes	0
Undercut Banks & Roots	0
Woody Debris	0
Bed Substrate	4
	25%

Site: **R12**
River: Ruzizi
Location: S2.703978 E29.003612
Date: 2022/02/27
Collector: Rob Palmer

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	1
Shallow-Fast	4
Deep-Fast	4
	75%

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC	X													
Labeobarbus cf altianalis	LC	(X)													
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC	X													
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC	X													
Ctenochromis horei	LC	XX													
Oreochromis niloticus	LC	(X)													
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC	X													
Chiloglanis asymetricaudalis	EN														

Effort (min)	45	
Total Catch	0	-
Catch per Unit Effort (/Hour)	0	-
Total Number of Species	7	

** = Alien or translocated species*

X = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	-
Macrophytes	-
Undercut Banks & Roots	-
Woody Debris	-
Bed Substrate	-
	0%

Depth-Flow Classes (0-4)

Shallow-Slow	-
Deep-Slow	-
Shallow-Fast	-
Deep-Fast	-
	0%

Site: **R14a**
River: Ruzizi
Location: S2.730178 E29.030092
Date: 2022/01/23
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC											(1)			
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC											(1)			
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	-	
Total Catch	-	-
Catch per Unit Effort (/Hour)	-	-
Total Number of Species	2	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	2
Macrophytes	0
Undercut Banks & Roots	1
Woody Debris	0
Bed Substrate	2
	25%

Depth-Flow Classes (0-4)

Shallow-Slow	1
Deep-Slow	0
Shallow-Fast	2
Deep-Fast	0
	19%

Site: **R13**
River: Ruzizi
Location: S2.709700 E29.010210
Date: 2022/01/22
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC	1	2			1									
Enteromius cf taeniopleura	LC	2	6			1	1								
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC	4	28				3	1							
Labeobarbus sp. A	-														
Raiamas moorii	LC							X							
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC	4	16				4								
Ctenochromis horei	LC	80	255	30	20	10	8	12							
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC									(1)			(1)		
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	25	
Total Catch	91	307
Catch per Unit Effort (/Hour)	218	736
Total Number of Species	5	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	-
Macrophytes	-
Undercut Banks & Roots	-
Woody Debris	-
Bed Substrate	-
	0%

Depth-Flow Classes (0-4)

Shallow-Slow	-
Deep-Slow	-
Shallow-Fast	-
Deep-Fast	-
	0%

Site: **R13b**
River: Ruzizi
Location: S2.722220 E29.023610
Date: 2022/01/22
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC													(1)	
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	-	
Total Catch	-	-
Catch per Unit Effort (/Hour)	-	-
Total Number of Species	1	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	0
Macrophytes	0
Undercut Banks & Roots	2
Woody Debris	0
Bed Substrate	4
	30%

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	2
Shallow-Fast	4
Deep-Fast	1
	63%

Site: **Rb1**
River: Rubyiro
Location: S2.528601 E29.074212
Date: 2022/01/19
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-	8	19			6	2								
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	15	
Total Catch	8	19
Catch per Unit Effort (/Hour)	32	78
Total Number of Species	1	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	0
Macrophytes	0
Undercut Banks & Roots	2
Woody Debris	0
Bed Substrate	4
	30%

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	2
Shallow-Fast	4
Deep-Fast	1
	63%

Site: **Rb2a**
River: Ntondwe
Location: S2.531390 E29.042220
Date: 2022/01/19
Collector: Rob Palmer

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN	6	11			6									

Effort (min)	10	
Total Catch	6	11
Catch per Unit Effort (/Hour)	36	68
Total Number of Species	1	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	0
Macrophytes	0
Undercut Banks & Roots	2
Woody Debris	0
Bed Substrate	4
	30%

Site: **Rb2b**
River: Rubyriro
Location: S2.568320 E29.039080
Date: 2022/01/23
Collector: Rob Palmer

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	1
Shallow-Fast	4
Deep-Fast	0
	50%

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN	9	19			8	1								

Effort (min)	10	
Total Catch	9	19
Catch per Unit Effort (/Hour)	54	115
Total Number of Species	1	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	1
Macrophytes	0
Undercut Banks & Roots	0
Woody Debris	0
Bed Substrate	3
	20%

Site: **Rb3**
River: Rubyiro
Location: S2.706570 E29.031030
Date: 2022/01/23
Collector: Rob Palmer

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	0
Shallow-Fast	2
Deep-Fast	0
	31%

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC														
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC	1	4				1								
Labeobarbus sp. A	-														
Raiamas moorii	LC														
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC	2	68					1	1						
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	10	
Total Catch	3	72
Catch per Unit Effort (/Hour)	18	432
Total Number of Species	2	

** = Alien or translocated species*

(n) = Collected by local community fishers

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Cover (0-4)

Marginal Vegetation	2
Macrophytes	0
Undercut Banks & Roots	1
Woody Debris	0
Bed Substrate	2
	25%

Site: **Rh2**
River: Ruhwa
Location: S2.726457 E29.041560
Date: 2022/01/23
Collector: Rob Palmer

Depth-Flow Classes (0-4)

Shallow-Slow	3
Deep-Slow	0
Shallow-Fast	1
Deep-Fast	0
	25%

Species	IUCN Status	Total (No)	Weight (g)	R1	3 - 5 (0.52 g)	5 - 7 (1.9 g)	7 - 10 (4.0 g)	10 - 15 (16 g)	15 - 20 (52 g)	20 - 25 (113 g)	25 - 30 (210 g)	30 - 35 (352 g)	35 - 40 (547 g)	40 - 45 (800 g)	45 - 50 (1130 g)
Cypriniformes															
Enteromius apleurogramma	LC														
Enteromius cf taeniopleura	LC	3	2		3										
Enteromius kerstenii	LC														
Enteromius cf pellegrini	LC														
Labeo cf cylindricus	LC														
Labeobarbus cf altianalis	LC														
Labeobarbus sp. A	-														
Raiamas moorii	LC	1	2			1									
Cyprinodontiformes															
Poecilia reticulata *	LC														
Lamprichthys tanganicanus *	LC														
Perciformes															
Haplochromis cf. graueri	LC														
Haplochromis cf astatodon	-														
Haplochromis sp nov	-														
Haplochromis burtoni	LC														
Ctenochromis horei	LC														
Oreochromis niloticus	LC														
Siluriformes															
Amphilius cf kivuensis	-														
Bagrus docmak	LC														
Clarias gariepinus	LC														
Clarias liocephalus	LC														
Chiloglanis asymetricaudalis	EN														

Effort (min)	10	
Total Catch	4	3
Catch per Unit Effort (/Hour)	24	21
Total Number of Species	2	

** = Alien or translocated species*

(n) = Collected by local community fishers

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E. Complementary Data - Social Baseline

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E.1 List of interviews for the Qualitative Social Survey

List of interviews during the Qualitative Social Survey in DRC:

#	Date	Occupation	Estimated Age	Country	Village	Subject of Interview	Interview Type	Total Number of Interviewees	Male Interviewees	Female Interviewees
1	19/01/2022	Head of the Village Village Committee Members	45-75	DRC	Kafunda	Socio-ecomic and cultural profile of village	Focus Group	5	3	2
2	19/01/2022	Villagers	40-50	DRC	Kafunda	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	5	0	5
3	19/01/2022	Villagers	20-60	DRC	Kafunda	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	6	0
4	19/01/2022	Vulnerable Villagers	55-65	DRC	Kafunda	Vulnerability	Focus Group	4	0	4
5	20/01/2022	Head of the Village Village Committee Members	100 38-58	DRC	Bugano	Socio-ecomic and cultural profile of village	Focus Group	6	6	0
6	20/01/2022	Villagers	20-50	DRC	Bugano	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	5	0	5
7	20/01/2022	Villagers	30-40	DRC	Bugano	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	6	0
8	20/01/2022	Farmers	40-60	DRC	Kafunda	Economic and physical displacement	Informal discussion	2	0	2
9	20/01/2022	Farmers	30-60	DRC	Bugano	Livelihoods, land tenure, vulnerability and gender dynamics	Informal discussion	2	0	2
10	20/01/2022	Farmers	20-50	DRC	Downstream Riverside	River use and ecosystem services	Informal discussion	4	2	2
11	20/01/2022	Fish farmers	20-30	DRC	Downstream Riverside	Fishfarming	Informal discussion	2	2	
12	20/01/2022	Vulnerable Villagers	60-90	DRC	Bugano	Vulnerability	Focus Group	5	1	4
13	21/01/2022	Main Nurse Nurse Receptionist	40-50	DRC	Kayange Health Centre	Health issues in the study area	Formal Interview	3	3	0
14	21/01/2022	Nurses Receptionist	30-55	DRC	Rubumba Health Centre	Health issues in the study area	Formal Interview	5	1	4
15	22/01/2022	Head of the Village Committee Members Head of Development Pastor	72 40-65	DRC	Kayenge	Socio-ecomic and cultural profile of village	Focus Group	7	5	2
16	22/01/2022	Villagers	28-53	DRC	Kayenge	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	4	4	0
17	22/01/2022	Villagers	26-59	DRC	Kayenge	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	4	0	4
18	22/01/2022	Vulnerable Villagers	60-70	DRC	Kayenge	Vulnerability	Focus Group	5	2	3
19	23/01/2022	Head of the Village Village Committee Members	57 50-70	DRC	Nachihembe	Socio-ecomic and cultural profile of village	Focus Group	5	4	1
20	23/01/2022	Villagers	25-45	DRC	Nachihembe	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	5	0	5
21	23/01/2022	Villagers	35-45	DRC	Nachihembe	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	6	0
22	23/01/2022	Vulnerable Villagers	50-80	DRC	Nachihembe	Vulnerability	Focus Group	4	0	4
23	24/01/2022	Receptionist Nutritionist Nurse Nurse PRECODESA	37-48	DRC	Ibambiro Health Centre	Health issues in the study area	Formal Interview	5	5	0
24	25/01/2022	Head of the Village Village Committee Members	27-52	DRC	Ibambiro	Socio-ecomic and cultural profile of village	Focus Group	6	6	0
25	25/01/2022	Villagers	35-45	DRC	Ibambiro	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	0	6
26	25/01/2022	Villagers	27-53	DRC	Ibambiro	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	8	8	0
27	25/01/2022	Vulnerable Villagers	30-90	DRC	Ibambiro	Vulnerability	Focus Group	4	0	4
28	27/01/2022	Village Committee Members	47-80	DRC	Nachirongwe	Socio-ecomic and cultural profile of village	Focus Group	6	6	0

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#	Date	Occupation	Estimated Age	Country	Village	Subject of Interview	Interview Type	Total Number of Interviewees	Male Interviewees	Female Interviewees
29	27/01/2022	Villagers	25-50	DRC	Nachirongwe	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	0	6
30	27/01/2022	Villagers	27-51	DRC	Nachirongwe	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	6	0
31	27/01/2022	Vulnerable Villagers	45-60	DRC	Nachirongwe	Vulnerability	Focus Group	5	2	3
32	27/01/2022	Village Committee Members	40-67	DRC	Ruduha	Socio-ecomic and cultural profile of village	Focus Group	6	6	0
33	27/01/2022	Villagers	46-49	DRC	Ruduha	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	4	0	4
34	27/01/2022	Villagers	35-45	DRC	Ruduha	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	5	5	0
35	27/01/2022	Vulnerable Villagers	48-60	DRC	Ruduha	Vulnerability	Focus Group	4	2	2
36	27/01/2022	Nurses	45-60	DRC	Ruduha Health Centre	Health issues in the study area	Formal Interview	3	3	0
37	28/01/2022	Village Committee Members	30-47	DRC	Bujenjeri	Socio-ecomic and cultural profile of village	Focus Group	5	5	0
38	28/01/2022	Villagers	25-35	DRC	Bujenjeri	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	0	6
39	28/01/2022	Villagers	38-77	DRC	Bujenjeri	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	6	0
40	28/01/2022	Vulnerable Villagers	60-77	DRC	Bujenjeri	Vulnerability	Focus Group	5	1	4
41	28/01/2022	Village Committee Members	26-75	DRC	Rushebeyi	Socio-ecomic and cultural profile of village	Focus Group	5	5	0
42	28/01/2022	Villagers	36-56	DRC	Rushebeyi	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	3	0	3
43	28/01/2022	Villagers	35-59	DRC	Rushebeyi	Livelihoods, land tenure, vulnerability and gender dynamics	Focus Group	6	6	0
44	28/01/2022	Vulnerable Villagers	36-90	DRC	Rushebeyi	Vulnerability	Focus Group	5	2	3
					Total			215	125	90

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List of interviews during the Qualitative Social Survey in Rwanda:

#	Date	Role / Occupation	Estimated Age	Country	Village Name	Subject of Interview	Interview Type	No. Total Interviewees	Male Interviewees	Female Interviewees
1	19/01/2022	Fishermen and Farmers	20-40	Rwanda	Nyange Cell riverside	River use and ecosystem services	Informal discussion	6	2	4
2	21/01/2022	Main Nurse	35	Rwanda	Mushaka Health Centre, Rwingobog	Health issues in the study area	Formal Interview	1	0	1
3	21/01/2022	Executive Secretary of Murya Cell	40	Rwanda	Murya Cell Office, Gatchuriro	Socio-economic and culture profile of the Cell	Formal Interview	2	1	1
4	21/01/2022	Social Economic and Development Officer of Murya Cell	40							
5	21/01/2022	Director of Health Centre	30	Rwanda	Centre de sante de Nzahaha	Health issues in the study area	Formal Interview	1	1	0
6	21/01/2022	Nyienzi Cell Executive Secretary	30	Rwanda	Rugunga Nienji Cell Office	Socio-economic and cultural profile of the Cell	Formal Interview	1	1	0
7	22/01/2022	Health Worker	30	Rwanda	Nyagahanga	Socio-ecomic and cultural profile of village	Focus group	6	5	1
		Head of Village	50							
		Village Committee Members	40							
		Social and Economic Officer of the Committee	40							
8	22/01/2022	Health Worker	50	Rwanda	Rhyagashitsi	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	4	0	4
		Villagers	30-60							
9	22/01/2022	Head of Village	30	Rwanda	Rhyagashitsi	Socio-economic and cultural profile of village	Focus group	2	2	0
		Head of Security	30							
10	22/01/2022	Villagers	40	Rwanda	Rhyagashitsi	Socio-economic and cultural profile of village	Focus group	3	3	0
11	23/01/2022	Farmers	40	Rwanda	Downstream Riverside	River use and ecosystem services	Informal discussion	10	5	5
	24/01/2022	Farmers	40 and 60	Rwanda	Stretch from reservoir to powerhou	River use and ecosystem services	Informal discussion	6	3	3
	25/01/2022	Executive Secretary of Pera Cell	30	Rwanda	Bugarama	Socio-economic and cultural profile of the Cell	Formal Interview	1	1	0
12	25/01/2022	Villagers	30-50	Rwanda	Nyagahanga	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	3	0	3
13	25/01/2022	Villagers	40	Rwanda	Nyagahanga	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	4	4	0
14	25/01/2022	Head of Village	25	Rwanda	Kabusunzu	Socio-economic and cultural profile of village	Focus group	4	3	1
		Head of Security	25							
		Head of Information	30							
		Head of Social Welfare	35							
15	25/01/2022	Head of Village / Health Worker	55	Rwanda	Gatebe	Socio-economic and cultural profile of village	Focus group	5	0	5
		Villager	45							
		Head of Social Welfare - Health Worker	35							
		Head of Development	45							
		Villager	50							
16	25/01/2022	Villagers	30-45	Rwanda	Gatebe	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	6	6	0
17	26/01/2022	Villagers	20	Rwanda	Ruganzo	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	6	0	6
		Animatrice de sante	60							
		Villagers	40-50							
18	27/01/2022	Executive Secretary Nyange Cell	50	Rwanda	Bugarama	Demograhic and socio-economic characteristics of Cell	Formal Interview	1	1	0
19	27/01/2022	Head of Village	30	Rwanda	Ruganzo	Socio-economic and cultural profile of village	Focus group	5	5	0
		Village Counselor	30							
		Head of Security	30							

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#	Date	Role / Occupation	Estimated Age	Country	Village Name	Subject of Interview	Interview Type	No. Total Interviewees	Male Interviewees	Female Interviewees
		Head of Information	40							
		Head of Welfare	40							
20	27/01/2022	Villagers	30-50	Rwanda	Ruganzo	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	3	3	0
21	28/01/2022	COCAGI Director	50	Rwanda	Gishoma	Coffee farming and cooperative selling	Formal Interview	1	1	0
22	28/01/2022	Villagers	30-40	Rwanda	Kabusunzu	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	3	3	0
23	28/01/2022	Villagers	40-45	Rwanda	Kabusunzu	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	3	0	3
24	29/01/2022	Health of Social Welfare	35	Rwanda	Mwaro	Socio-economic and cultural profile of village	Focus group	4	2	2
		Head of Village and Health Worker	40							
		Head of Security	50							
		Head of Information	40							
25	29/01/2022	Health Worker	40	Rwanda	Mwaro	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	3	0	3
		Villagers	40							
26	29/01/2022	In Charge of Compensated Plots	40	Rwanda	Mwaro	Livelihoods, land tenure, vulnerability and gender dynamics	Focus group	3	3	0
		Villagers	40-50							
27	30/01/2022	Batwa Communitya Leader	55	Rwanda	Gatchuriro	Socio-economic and cultural profile of the Historically Marginalised People of Rwanda	Focus group	18	9	9
		Wife of Community Leader	50							
		Members of the Batwa Community	20-60							
28	31/01/2022	Agronomist Nzahaha Sector	45	Rwanda	Nzahaha Sector	Farming practices	Formal Interview	1	1	0
29	31/01/2022	Agronomist Bugarama Sector	40	Rwanda	Bugarama Sector	Farming practices	Formal Interview	1	1	0
30	01/02/2022	Head of Village	40	Rwanda	Mubombo	Downstream flooding and agriculture	Focus group	21	15	6
		Head of Security	40							
		Head of Information	40							
		Farmers	20-50							
31	01/02/2022	Head of Village	60	Rwanda	Gombaniro	Downstream flooding and agriculture	Focus group	29	14	15
		Villagers	20-50							
32	25/01/2022	Head of health centre	40	Rwanda	Bugarama	Health issues in the study area	Formal interview	1	1	0
33	01/02/2022	Director of Rice Cooperative Bugarama	40	Rwanda	Bugarama	Rice farming	Formal interview	1	1	0
34	01/02/2022	Head of Ryankana Cell	45	Rwanda	Mubombo		Formal Interview	1	1	0
					Total			170	98	72

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E.2 Socioeconomic Survey Questionnaire

PUBLIC DISCLOSURE AUTHORIZED

Ruzizi III quantitative households survey

Field	Question	Answer
1. Introduction		
date *(required)*	Date	
country *(required)*	Country:	RW Rwanda CG Congo
enumerator *(required)*	Enumerator number:	R1 R1 R2 R2 R3 R3 R4 R4 R5 R5 R6 R6 R7 R7 CG1 CG1 CG2 CG2 CG3 CG3 CG4 CG4 CG5 CG5 CG6 CG6 CG7 CG7 CG8 CG8 CG9 CG9 CG10 CG10 CG11 CG11 CG12 CG12 CG13 CG13 CG14 CG14
sector-grp *(required)*	Sector / groupement:	NZ Nzahaha BU Bugarama KG Karhongo KA Kamanyola
cell *(required)*	Cell / Locality	MU Murya NI Nyenji NG Niange PE Pera BG Bugano KF Kafunda MP Mparo RO Rohero RU Rubumba OTH1 other IB Ibambiro RD Ruduha OTH2 Other
cell_other	specify: *Question relevant when: selected(${cell} , 'OTH1') or selected(${cell} , 'OTH2')*	
village *(required)*	Village	Nyagahanga Nyagahanga Gisheke Gisheke Ryagashyitsi Ryagashyitsi 1 Other Ruganzu Ruganzu Gasharu Gasharu 11 Other Gatebe Gatebe 10 Other Kabusunzu Kabusunzu 2 Other Bugano Bugano CHEMIKONYI CHEMIKONYI CHIHEMBE CHIHEMBE KABEBERA KABEBERA KIBENGA KIBENGA MANDA MANDA NACHIHEMBE NACHIHEMBE 3 Other BUJENJERE BUJENJERE NACIRHONGWE NACIRHONGWE

Field	Question	Answer
		4 Other KAFUNDA KAFUNDA KAFUNDA_2 KAFUNDA 2 LULENGERA LULENGERA NAKAROBA NAKAROBA 5 Other Rubumba Rubumba 6 Other Rugenge Rugenge 7 Other Rurambira Rurambira 8 other Rushebeyi Rushebeyi 9 Other
village_other	Specify the village's name *Question relevant when: selected(${village} , '1') or selected(${village} , '2') or selected(${village} , '3') or selected(${village} , '4') or selected(${village} , '5') or selected(${village} , '6') or selected(${village} , '7') or selected(${village} , '8') or selected(${village} , '9') or selected(${village} , '10') or selected(${village} , '11') or selected(${cell} , 'OTH1') or selected(${cell} , 'OTH2')*	
GPS	Enumerator, please record the GPS coordinates of the interview. *GPS coordinates can only be collected when outside.*	
consent_text	**Introduction** Hello. My name is [Enumerator, stae your name] I am working for ***the Ruzizi III hydropower project.*** We are currently carrying out a socioeconomic survey. This survey is based on free and informed prior consent. Participation in this survey is not mandatory in any ways. This survey aims at collecting information about the local socioeconomic situation before the start of the project construction. This will allow to better understand and mitigate the project impacts. Your participation in this survey is completely voluntary and you are free to choose whether to be in it or not. If you agree to participate, you can choose to stop at any time or to skip any questions you do not want to answer. If you choose not to consent, or to withdraw from the interview at any time, there will not be any consequence or loss of benefits to which you would be otherwise entitled. Your study data will be handled as confidentially as possible. If results of this study are published or presented, individual names, and other personally identifiable information will not be used and no identifying information will be shared with any third party. The information will be utilized only for the development of the Socioeconomic studies for the Ruzizi III hydropower project, and confidentiality of the information will strictly be adhered. The interview will be based around the household. A household is distinct from a family. In this survey the UN definition of household is used, i.e. that it is defined as “one or more persons living together who make common provision for food or other essentials”.	
Consent *(required)*	Do you consent to be interviewed?	1 Yes 0 No 99 No answer
ConsentNo	Thank you for your time. [end of the interview] *Question relevant when: selected(${Consent} , '0')*	
questionnaire		
questionnaire > Identification du ou des codes UPI		
note_upi	Enquêteur: trouvez le code UPI du ménage parmi la liste des personnes à enquêter et inscrivez le dans les pages suivantes. S’il y a plusieurs code UPI, inscrivez autant de code UPI qu’il y a de parcelles affectées pour TOUS les membres du ménage (mari et femme peuvent parfois avoir 2 codes UPI différents)	
questionnaire > Identification du ou des codes UPI > Code_UPI (1)		(Repeated group)
upi	UPI code (from sampling list)	
questionnaire > 2. Identification of survey respondents		
NameRespondent *(required)*	Name of the respondent	
SurnameRespondent *(required)*	Surname of the respondent	
Gender *(required)*	Gender of the respondent	M Male F Female
HouseholdHeadYesNo *(required)*	Are you the head of the household?	1 Yes 0 No 99 No answer
RelationRespondent *(required)*	What is your relationship to the head of the household? *Question relevant when: selected(${HouseholdHeadYesNo} , '0')*	0 husband 1 wife 2 son or daughter 3 parent 4 other
NameHeadHousehold *(required)*	Name of the head of the household *Question relevant when: selected(${HouseholdHeadYesNo} , '0')*	
SurnameHeadHousehold *(required)*	Surname of the head of the household	

Field	Question	Answer
	Question relevant when: selected(${HouseholdHeadYesNo} , '0')	
GenderHeadHousehold *(required)*	What is the head of the household's gender? *Question relevant when: selected(${HouseholdHeadYesNo} , '0')*	M Male F Female
questionnaire > 3. Information on the household and household members		
Num_HH_members *(required)*	How many people live in this household, including you? *(Le ménage comprend tous les gens dormant sous le même toit et partageant les repas)*	
note_HH_roster	Enumerator: start with the head of households in the next question	
questionnaire > 3. Information on the household and household members > 4.1 Information on the household members (1)		(Repeated group)
NameHHMembers *(required)*	Name	
SurnameHHMembers *(required)*	Surname	
GenderHouseholdMembers *(required)*	[SurnameHHMembers] Gender	M Male F Female
AgeHouseholdMembers *(required)*	[SurnameHHMembers] Age *Response constrained to: .>=0 and .<=110*	
HouseholdMembersEducation *(required)*	[SurnameHHMembers] Level of education	1 None (illiterate) 2 Primary 3 Secondary 4 University 5 Other 99 Do not know
ReligionHouseHolderMembers *(required)*	[SurnameHHMembers] Religion	1 Catholic 2 Protestant 3 Pentecotist 4 Anglican 5 Adventist 6 Jehovah Witnesses 7 Methodist 8 Islam 99 Other
Specify_religion *(required)*	Please specify *Question relevant when: selected(${ReligionHouseHolderMembers} , '99')*	
HouseholdMembersNationality *(required)*	[SurnameHHMembers] Nationality	1 Rwandan 2 Congolese 3 Other
Specify_nationality *(required)*	Please specify *Question relevant when: selected(${HouseholdMembersNationality} , '3')*	
HasDisability *(required)*	Does [SurnameHHMembers] have a disability?	1 Yes 0 No 99 No answer
DisabilibyHouseholdMembers *(required)*	Which kind of disability does [SurnameHHMembers] have ? *Question relevant when: selected(${HasDisability} , '1')*	1 Sight (blind/severe visual limitation) 2 Hearing (deaf/profoundly hard of hearing) 3 Communication (speech impairment) 4 Physical (e.g. needs wheelchair, crutches or prosthesis; limb, hand usage limitations) 5 Intellectual (serious difficulties in learning)
Ethnicity *(required)*	What is the ethnic group of the head of household? *Question relevant when: selected(${country} , 'CG')*	1 Bashi 2 Banyindu 3 Bafuliru 4 Barundi 5 Babembe 6 Banyamulenge 7 Batwa 99 Other
Specify_ethnicity *(required)*	Please specify *Question relevant when: selected(${Ethnicity} , '99')*	
questionnaire > Land Tenure		
total_landsize *(required)*	What is the total size of land cultivated by your household in hectares? *(calculate for the total of household members, including both the lands affected and not affected by the Project) If the interviewee does not know or does not want to answer, indicate '999'*	
land_title *(required)*	On how many hectares do you have a legal landholding title? *If the interviewee does not know or does not want to answer, indicate '999' If the household does not have any legal title, indicated '0'*	
name_title *(required)*	Whose name is on the land title? *Question relevant when: ${land_title} > 0*	1 Husband 2 Wife

Field	Question	Answer
		3 Children
land_customaryproperty *(required)*	On how many hectares do you have a customary property right? *If the interviewee does not know or does not want to answer, indicate '999'* *Question relevant when: selected(${country} , 'CG')*	
land_customaryusage *(required)*	On how many hectares do you have a customary usage right? *If the interviewee does not know or does not want to answer, indicate '999'* *Question relevant when: selected(${country} , 'CG')*	
land_rentpaying *(required)*	On how many hectares to do pay rent ? *If the interviewee does not know or does not want to answer, indicate '999'*	
questionnaire > Land Tenure > renting-land		
Group relevant when: ${land_rentpaying} > 0		
rentpayment	Who pays rent?	1 Husband 2 Wife 3 Children
rent_amount	What is the monthly amount of the rent ? *(Rwanda: Francs Rwandais / Congo: Franc congolais)*	
rentedland_work	Who works on the rented field?	1 Husband 2 Wife 3 Children
nyiragabura *(required)*	On how many hectares do you cultivate through the nyiragabura system (Rwanda) or the Bwasa (Congo) ?	
land_workers *(required)*	Aside from family members, do you have any paid workers who work on your land?	1 Yes 0 No 99 No answer
workers_howmany *(required)*	How much do you pay daily (in total for all workers) when you employ someone or several persons on your fields? *Question relevant when: selected(${land_workers} , '1')*	
landaffected *(required)*	Do you cultivate any land that will not be affected by the Project	1 Yes 0 No 99 No answer
notaffected_hectares *(required)*	How many hectares that you are cultivating will not be impacted by the Project? *Enumerator, if the surveyed person does not want to or know how to respond, indicate '999'* *Question relevant when: selected(${landaffected} , '1')*	
questionnaire > Home		
rooms	How many rooms are used for sleeping in this house?	
house_owned *(required)*	Does anyone in your household own the house you are living in ?	1 Yes 0 No 99 No answer
house_rented	Does anyone in your household pay rent for the house you are living in ? *Question relevant when: selected(${house_owned} , '0')*	1 Yes 0 No 99 No answer
house_rented_amount	How much is the monthly rent for the house ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs).* *Question relevant when: selected(${house_owned} , '0')*	
physical_displacement	Is your house affected by the Project ?	1 Yes 0 No 99 No answer
physical_displacement_picture	Could I take a picture of your affected house ? *Enumerator, if the surveyed person refuses, do not insist. If she/he accepts, take a photo with your telephone.* *Question relevant when: selected(${physical_displacement} , '1')*	
questionnaire > banking		
bank	Does at least one of the household members have a bank account?	1 Yes 0 No 99 No answer
bank_who	If yes, who? *Question relevant when: selected(${bank} , '1')*	1 the husband 2 the wife 3 the husband and wife together 4 someone else 98 Do not know
microcredit	Does at least one of the household members have a loan with a microcredit organisation? *(SACCO au Rwanda)*	1 Yes 0 No 99 No answer
microcredit_who	If yes, who? *Question relevant when: selected(${microcredit} , '1')*	1 the husband 2 the wife 3 the husband and wife together 4 someone else 98 Do not know
questionnaire > Agriculture		
questionnaire > Agriculture > agriculture_list		
cultures	How many kilograms do you harvest for each crop?	

Field	Question	Answer
Manioc	Manioc (kg)	
Maize	Maize (kg)	
Beans	Beans (kg)	
Bananas	Bunch of Bananas	
coffee	Coffee (kg)	
fertilizers *(required)*	Do you use fertilisers on your field ?	1 Yes 0 No 99 No answer
fertilizers_chem_kg	If you use chemical fertilisers, how many kg per year ? *Question relevant when: selected(${fertilizers} , '1')*	
fertilizers_orga_kg	If you use organic fertilisers, how many kg per year ? *Question relevant when: selected(${fertilizers} , '1')*	
sellingmarket_yesno *(required)*	Do you sell your harvest at the market?	1 Yes 0 No 99 No answer
sellingmarket_lasttime	If you sell part of your harvest at the market, when was the last time that you sold any of your produce ? *Question relevant when: selected(${sellingmarket_yesno} , '1')*	1_month last month 2-3_months 2 or 3 months ago 4-8_months between 4 and 8 months ago 9-12_months between 9 and 12 months ago last_year last year 2_years_ago 2 years ago more_than_2_years_ago more than 2 years ago dnk I do not know.
products_whichones *(required)*	Which agricultural products do you sell? *Question relevant when: selected(${sellingmarket_yesno} , '1')*	manioc manioc maize maize bananas bananas vegetables vegetables fruits fruits coffee coffee yam yam potatoes potatoes beans beans other other
products_other	specify which other product:	
market_howmuchmoney *(required)*	How much money did you get last time you sold products at the market? *(Rwanda: Rwandan Francs / Congo: Congolese Francs).* *Question relevant when: selected(${sellingmarket_yesno} , '1')*	
sellingcoop_yesno *(required)*	Do you ever sell your harvest to a cooperative?	1 Yes 0 No 99 No answer
sellingcoop_lastime	If you sell some of your harvest to a cooperative, when was the last time you sold some? *Question relevant when: selected(${sellingcoop_yesno} , '1')*	1_month last month 2-3_months 2 or 3 months ago 4-8_months between 4 and 8 months ago 9-12_months between 9 and 12 months ago last_year last year

Field	Question	Answer
		2_years_ago — 2 years ago
		more_than_2_years_ago — more than 2 years ago
		dnk — I do not know.
sellingcoop_whichproducts *(required)*	Which agricultural products have you sold to a cooperative? *Question relevant when: selected(${sellingcoop_yesno} , '1')*	manioc — manioc maize — maize bananas — bananas vegetables — vegetables fruits — fruits coffee — coffee yam — yam potatoes — potatoes beans — beans other — other
sellingcoop_otherspecify	Specify which other product: *Question relevant when: selected(${sellingcoop_whichproducts} , 'other')*	
sellingcoop_howmuch	How much money did you make last time you sold a product to a cooperative? *(Rwanda: Rwandan Francs / Congo: Congolese Francs)* *Question relevant when: selected(${sellingcoop_yesno} , '1')*	
cooperative_memberornot	Are you a member of the cooperative(s) where you have sold your harvest? *Question relevant when: selected(${sellingcoop_yesno} , '1')*	1 — Yes 0 — No 99 — No answer
field_ruzizi	Do you have any fields along the Rusizi riverbank?	1 — Yes 0 — No 99 — No answer
irrigation_yesno *(required)*	Do you irrigate your fields close to the Rusizi river? *Question relevant when: selected(${field_ruzizi} , '1')*	1 — Yes 0 — No 99 — No answer
irrigation_method *(required)*	How do you irrigate your fields close to the Rusizi? *Question relevant when: selected(${irrigation_yesno} , '1')*	0 — Water pump 1 — Irrigation canals 2 — Fetching water with buckets
questionnaire > Fishing		
fishing_yesno *(required)*	Does anyone fish in your household?	1 — Yes 0 — No 99 — No answer
fishing_howoften *(required)*	How often do you fish? *Question relevant when: selected(${fishing_yesno} , '1')*	0 — Multiple times a week 1 — Once a week 2 — Once per month 3 — Less than once per month
fish_selleat *(required)*	After fishing, do you eat or sell the fish? *Question relevant when: selected(${fishing_yesno} , '1')*	0 — I fish mainly to sell 1 — I fish mainly to eat the fish 2 — both
sellingfish_lasttime *(required)*	When was the last time you sold fish? *Question relevant when: selected(${fish_selleat} , '0') or selected(${fish_selleat} , '2')*	1_month — last month 2-3_months — 2 or 3 months ago 4-8_months — between 4 and 8 months ago 9-12_months — between 9 and 12 months ago last_year — last year 2_years_ago — 2 years ago more_than_2_years_ago — more than 2 years ago dnk — I do not know.

Field	Question	Answer
fishsell_gain *(required)*	How much money did you get last time you sold fish ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs).* *Question relevant when: selected(${fish_selleat} , '0') or selected(${fish_selleat} , '2')*	
questionnaire > Other activities		
activities_cash *(required)*	Beyond agriculture, which are the other activities of household members that bring you some money?	0 Petit trade / shop 1 Renting out land or house 2 Salary 3 Paid agricultural work 4 Transportation (bycicle / motorcycle) 5 Livestock farming 98 other 99 no answer
activities_other	Please specify the activities concerned. *Question relevant when: selected(${activities_cash} , '98')*	
income_trade	How much do you get from commerce per month ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs). Enumerator, the income of this activity needs to be estimated for the total number of household members.* *Question relevant when: selected(${activities_cash} , '0')*	
income_land_rent	How much do you get from renting out your land or house per month ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs). Enumerator, the income of this activity needs to be estimated for the total number of household members.* *Question relevant when: selected(${activities_cash} , '1')*	
income_salary	How much do you get from your salary per month ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs). Enumerator, the income of this activity needs to be estimated for the total number of household members.* *Question relevant when: selected(${activities_cash} , '2')*	
income_agricultural_work	How much do you get from working on a field per month ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs). Enumerator, the income of this activity needs to be estimated for the total number of household members.* *Question relevant when: selected(${activities_cash} , '3')*	
income_transport	How much do you get from transportation activities per month ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs). Enumerator, the income of this activity needs to be estimated for the total number of household members.* *Question relevant when: selected(${activities_cash} , '4')*	
income_livestock	How much do you get from [activities_other] per month ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs). Enumerator, the income of this activity needs to be estimated for the total number of household members.* *Question relevant when: selected(${activities_cash} , '5')*	
income_other	How much do you get from [activities_other] per month ? *(Rwanda: Rwandan Francs / Congo: Congolese Francs). Enumerator, the income of this activity needs to be estimated for the total number of household members.* *Question relevant when: selected(${activities_cash} , '98')*	
questionnaire > Use of the Rusizi river		
riviere_utilisation *(required)*	How does your household use the Rusizi river?	1 Take water for drinking 2 Bathing 3 Take water to cook 4 Preparation of manioc 5 Washing clothes 6 Fish farming 7 Baptism / Praying 99 Other
river_other	Please specify the activities concerned. *Question relevant when: selected(${riviere_utilisation} , '99')*	
questionnaire > Cattle breeding		
questionnaire > Cattle breeding > Livestock_		
CowNumber	Number of cows owned by the household	
CowPurpose	Are they for commercial purpose or home consumption? *Question relevant when: ${CowNumber} > 0*	1 Consumption in the household 2 Sale 3 Both 4 Other
selling_cow	How much money do you gain from this sale each month? *Question relevant when: selected(${CowPurpose} , '2') or selected(${CowPurpose} , '3')*	
GoatNumber	Number of goat owned by the household	
GoatPurpose	Are they for commercial purpose or home consumption? *Question relevant when: ${GoatNumber} > 0*	1 Consumption in the household 2 Sale 3 Both 4 Other
selling_goat	How much money do you gain from this sale each month? *(Rwanda: Rwandan Francs / Congo: Congolese Francs)* *Question relevant when: selected(${GoatPurpose} , '2') or selected(${GoatPurpose} , '3')*	
ChickenNumber	Number of chicken owned by the household	
ChickenPurpose	Are they for commercial purpose or home consumption?	1 Consumption in the household

Field	Question	Answer
	Question relevant when: ${ChickenNumber} > 0	2 Sale 3 Both 4 Other
selling_chicken	How much money do you gain from this sale each month? *(Rwanda: Rwandan Francs / Congo: Congolese Francs)* *Question relevant when: selected(${ChickenPurpose} , '2') or selected(${ChickenPurpose} , '3')*	
PigNumber	Number of pigs owned by the household	
PigPurpose	Are they for commercial purpose or home consumption? *Question relevant when: ${PigNumber} > 0*	1 Consumption in the household 2 Sale 3 Both 4 Other
selling_pig	How much money do you gain from this sale each month? *(Rwanda: Rwandan Francs / Congo: Congolese Francs)* *Question relevant when: selected(${ChickenPurpose} , '2') or selected(${ChickenPurpose} , '3')*	
OtherAnimal	Do you have any other animals?	1 Yes 0 No 99 No answer
other_animal_specify	Please specify the animal *Question relevant when: selected(${OtherAnimal} , '1')*	
other_animal_number	Number of [other_animal_specify] *Question relevant when: selected(${OtherAnimal} , '1')*	
other_animal_use	[other_animal_specify] is for commercial purpose or home consumption? *Question relevant when: selected(${OtherAnimal} , '1')*	1 Consumption in the household 2 Sale 3 Both 4 Other
other_animal_use_specify	Please specify *Question relevant when: selected(${other_animal_use} , '4')*	
questionnaire > Hunting		
chasse_menage	Does anyone in your household hunt?	1 Yes 0 No 99 No answer
chasse_animaux	Which type of animal do you hunt ? *Question relevant when: selected(${chasse_menage} , '1')*	0 monkeys 1 Antilopes 2 Other
selloreat_chasse	Do you eat or sell the animals that you hunt? *Question relevant when: selected(${chasse_menage} , '1')*	0 I hunt mainly to sell 1 I hunt mainly to eat the fish 2 both
questionnaire > Ecosystemic Resources		
plantes_medicinales *(required)*	Do you collect medicinal plants close to the river?	1 Yes 0 No 99 No answer
cuisine_wood *(required)*	What do you use to cook?	0 Firewood 1 Charcoal 2 Gas
bois_riviere *(required)*	How often do you cut wood close to the river? *Question relevant when: selected(${cuisine_wood} , '0')*	0 Never 1 Multiple times a week 2 Once per week 3 Once per week
questionnaire > Health		
malaria	Has anyone in this household had malaria in the last three months?	1 Yes 0 No 99 No answer
malaria_traitement	Where did you treat malaria? *Question relevant when: selected(${malaria} , '1')*	0 Never treated 1 Health worker 2 Health Centre 3 Hospital 4 with medicinal herbs or plants 99 Do not know 98 no answer
health_issues	Has anyone in this household, including children, had one of these diseases or problems in the last three months?	1 Diarhea 2 respiratory infection
frequence_sante	How many times have you been to a health centre in the past year (2021)?	0 Never been 1 1 time 2 2 times 3 3 times 4 more than 3 times
marche_sante	How long does it take you to get to this place?	1 less than 30 minutes

Field	Question	Answer		
	Question relevant when: selected(${frequence_sante} , '2') or selected(${frequence_sante} , '1')		2	between 30 and 1 hour
			3	between 1 and 2 hours
			4	more than 2 hours
			99	Do not know
questionnaire > Expenditures				
depenses_combien	How much money do you spend for each of these items? *(Rwanda: Rwandan Francs / Congo: Congolese Francs)*			
expenses_food	Food			
expense_school	School Fees			
expenses_workers	Workers on the fields *Question relevant when: selected(${land_workers} , '0')*			
expenses_health	Health			
expenses_equipment	Agricultural equipment			
expenses_rent	Rent *Question relevant when: ${land_rentpaying} > 0*			
expenses_water	Water			
expenses_electricity	Electricity			
questionnaire > Assets				
assets_list *(required)*	Which of these articles do you own?		0	Telephone
			1	Television
			2	Radio
			3	Electricity
			4	Sink at home
			5	Toilet at home
			6	Irrigation pump
			7	Bycicle
			8	Motorbike
			9	car
questionnaire > Drinking water				
water_source	Which is the main source of drinking water used in your household?		1	The Ruzizi river
			2	another river close to the village
			3	a spring
			4	a tap / water point
water-time	How much time does it take you to fetch water and come back?		1	less than 30 minutes
			2	between 30 and 1 hour
			3	between 1 and 2 hours
			4	more than 2 hours
			99	Do not know
water_frequency	How often do household memebers go fetch water?		1	several times every day
			2	once a day
			3	once every 2 days
			99	Do not know
questionnaire > Vulnerability				
vulnerable_meals *(required)*	How many meals a day do you have?			
vulnerable_food_shortage *(required)*	Have there been days where you did not eat in the last month?		1	Yes
			0	No
			99	No answer
vulnerable_allowances *(required)*	Do you get any assistance from the Government? *Question relevant when: selected(${country} , 'RW')*		1	Yes
			0	No
			99	No answer
assistance_whichtype *(required)*	Which type of assistance do you get from the Government? *Question relevant when: selected(${vulnerable_allowances} , '1')*		0	Genocide Survivors Support and Assistance Fund
			1	Public Works
			2	Cash Transfer
			3	Ubudehe Credit Scheme
			4	One cow per poor family programme
			5	Free Basic Education Programme
			6	Subsidised Health Insurance
			7	In-kind Social Care
			8	Social Housing Programme
			9	Vision UMURENGE Project
			10	Rwanda Demobilisation and Reintegration Commission
			99	Other
assistance_other	précisez de quel autre programme il s'agit *Question relevant when: selected(${assistance_whichtype} , '99')*			

Field	Question	Answer
hh_category	In which category is your household? *Question relevant when: selected(${country} , 'RW')*	1 Category 1 2 Category 2 3 Category 3 4 Category 4
genocide_survivor *(required)*	Is anyone in your household a genocide survivor? *Question relevant when: selected(${country} , 'RW')*	1 Yes 0 No 99 No answer
batwas *(required)*	Are you part of the Batwa community?	1 Yes 0 No 99 No answer
end_note	Thank you for your time. Have a good time.	

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F. Complementary Data - Ecosystem Services

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F.1 Ecosystem Services Scoping Process

The tables below identify the potential impacts caused by the Project that may affect the provision of services by ecosystem (direct impacts) and/or the impacts that may prevent the beneficiaries from obtaining/accessing the services provided by the ecosystems. For each potential impact, the beneficiaries are identified. When a potential impact is linked to a beneficiary, then the ecosystem service is scoped in. When there is a potential impact on an ecosystem service but no beneficiary, that ecosystem service is scoped out and will not be assessed further.

Table F-1 – Identification of beneficiaries of potentially impacted ecosystem services provided by Lotic ecosystem

Ecosystem services	Beneficiaries	Project's potential impact	Scoped in or scoped out
Provisioning services			
Fishing/Aquaculture	> Fishers > A significant number of fishers were met during the field survey.	The project could have an impact on fish abundance.	Scoped in
Freshwater (Water for domestic purposes, industrial purposes and transportation of goods and people)	> The Ruzizi River is used by some local communities to have access to water for domestic purposes. > Local communities' abstract water from the river to water vegetables crops. > Livestock farmers also water their cattle at the river. > A significant number of fishponds used for fish farming are located along the Ruzizi River, mainly along the river section located close to the Burundi border, in RDC.	The project could prevent locals from accessing the river for domestic purposes. The project could impact the fish farming activities by impacting the water level. A too low water level could prevent the fishponds from filing up and thus threaten the fish farming activity.	Scoped in
Cultural services			
Traditional practices	> Local communities > One prayer site is located on an island downstream the reservoir area has been identified.	> The reservoir impoundment or the dam wall might impact the prayer site.	Scoped in
Aesthetic Value	> Local communities > There is no tourism in the area	> The project is not likely to impact on the landscape which is already anthropized.	Scoped out
Intrinsic value of biodiversity	> Scientific community	> The project is not likely to impact on the fish diversity.	Scoped out
Regulating services			
Climate regulation: local regional and global	> Local communities	> The Project will not impact on any climate regulation role played by the river	Scoped out
Regulation of water timing and flows	> Local communities	> The Project under hydropeaking operation is likely to impact on the timing and magnitude of water runoff, flooding, and aquifer recharge	Scoped in
Erosion regulation	> Local communities farming near the riverbanks or in the floodplain	> The Project is predicted to increase riverbank and bed erosion through sediment trapping in the reservoir. Over time, farmers will lose part of their arable land along the riverbanks.	Scoped in
Natural hazards regulation	> Local communities	> The Project might impact normal flood variability, due to hydropeaking.	Scoped in

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Ecosystem services	Beneficiaries	Project's potential impact	Scoped in or scoped out
Disease and pest regulation	> Local communities	> The Project could lead to an increased quantity of dormant waters, especially due to the reservoir, and could create suitable conditions for waterborne diseases.	Scoped in
Supporting services			
Nutrient cycling	> Local communities especially fishers and farmers	> The Project is predicted to reduce the contribution of nutrients in suspended sediment downstream, with effects on fisheries productivity and floodplain farming downstream of the dam	Scoped in
Water cycling	> Local communities	> The Project might impact water cycles to downstream river	Scoped in
Soil formation	> Local communities especially farmers and fishers	> The Project will trap sediments in the reservoir and reduce sediment delivery to the downstream river reaches where it would reduce deposition on floodplains affecting fishers and farmers.	Scoped in
Habitat Provision	> Local communities especially fishers	> The Project will impact the aquatic ecosystems located in the dewatered stretch between the reservoir and the powerhouse.	Scoped in

Table F-2 - Identification of beneficiaries of potentially impacted ecosystem services provided by Riparian ecosystem

Ecosystem services	Beneficiaries	Project's potential impact	Scoped in/scoped out
Provisioning services			
Game meat	> No beneficiaries > Interviews highlighted that villagers do not hunt. Hippos are the main wild animals mentioned during the interviews, but none of them are being hunted for their meat.	> Project is not likely to reduce the number of wild animals in the area.	Scoped out
Honey, fruits and mushrooms	> Local communities from villages where there is communal land.	> Project will impact tree plantations located within the riparian fringe and may reduce or restrict access for people to collect honey, fruits and mushrooms	Scoped in
Medicinal plants, natural medicines	> Some locals are collecting medicinal plants. Medicinal plants can be found in all types of ecosystems, including anthropized one (e.g. crops).	> Project will flood the medicinal plants used by locals located in the reservoir area but will not impact those located downstream the dam. It could prevent people from collecting medicinal plant in affected areas.	Scoped in
Cultivated crops	> Local communities especially farmers cultivating in the reservoir area	> Project will flood the cultivated plots located in the reservoir area.	Scoped in
Livestock farming	> Local communities > Cattle	> Cattle are not grazing within the riparian area and will not be therefore impacted.	Scoped out
Fishing	> Fishers > A significant number of fishers were met during the field survey.	> Project could have an impact on the riparian vegetation and reduce fish abundance.	Scoped in

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Ecosystem services	Beneficiaries	Project's potential impact	Scoped in/scoped out
Freshwater (Water for domestic purposes, industrial purposes and transportation of goods and people)	> The Ruzizi river is used by local communities to have access to water for domestic purposes. > Livestock farmers also water their cattle at the river.	> Project will not prevent communities to fetch water	Scoped out
Biomass fuel	> Some locals collect small piece of wood used as biomass fuel for cooking. > Some local are producing charcoal near the riverbanks	> Project will flood the riparian vegetation located within the reservoir area and prevent locals from collecting biomass fuel.	Scoped in
Cultural services			
Intrinsic value of biodiversity	> Scientific community	> The Project is not likely to impact on bird species.	Scoped in
Regulating services			
Climate regulation: local regional and global	> Local communities	> The Project will not have effect on climate regulation.	Scoped out
Regulation of water timing and flows	> Local communities	> The project will not impact on the role played by the riparian vegetation to attenuate floods.	Scoped out
Erosion regulation	> Local communities > Locals are cultivating in the floodplain	> The riparian vegetation that stabilises riverbanks against natural flooding could become eroded by sediment trapping in the dam	Scoped in
Pollination	> Local communities especially farmers	> The Project will not prevent the vegetation to host incest pollinators	Scoped out
Natural hazards regulation	> Local communities > Floodplain has a high value for Flood regulation.	> The Project will not affect the floodplain vegetation.	Scoped out
Supporting services			
Water cycling	> Local communities	> The project will not prevent the floodplain vegetation to play a filter role by removing contaminants	Scoped out
Nutrient cycling	> Local communities especially fishers	> The Project will not prevent floodplain wetland vegetation to capture nutrients from upstream.	Scoped out
Soil formation	> Local communities	> The Project will impact on soil formation through capturing sediment in the reservoir resulting in erosion of riverbank and fringing riparian vegetation.	Scoped in
Habitat Provision	> Local communities especially fishers	> The Project will affect riparian vegetation within the reservoir area and therefore potentially affect local communities fishing in that area.	Scoped in

Table F-3 - Identification of beneficiaries of potentially impacted ecosystem services provided by Hillslope ecosystem

Ecosystem services	Beneficiaries	Project potential impacts	Scoped in or scoped out
Provisioning services			

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Ecosystem services	Beneficiaries	Project potential impacts	Scoped in or scoped out
Honey, fruits and mushrooms	> Local communities. People do not regularly collect honey, wild fruits, or mushrooms. Local communities rely on crops.	> No beneficiaries.	Scoped out
Medicinal plants, natural medicines	> Local communities. Some locals are collecting medicinal plants. Medicinal plants can be found in all types of ecosystems, including anthropized one (e.g. crops).	> Project will impact some areas of woodland/grassland area located on hillslopes. However, it is not expected that this could prevent people from collecting medicinal plant in affected areas because the medicinal plants are found both near the river and away from the river.	Scoped out
Livestock farming	> Local communities, especially cattle keepers	> Cattle are grazing everywhere on hillslope areas. The Project is not likely to impact significantly grassland surfaces on hillslopes. However, it could reduce the grazing land area for cattle.	Scoped in
Timber and wood products	> Local communities	> The project area only comprises small patches of woodland. The project might affect beneficiaries by preventing local communities to have access to remaining woodlands.	Scoped in
Biomass fuel	> Local communities	> The project area only comprises small patches of woodland. It is not expected that the project might affect beneficiaries by preventing local communities to have access to remaining woodlands.	Scoped out
Cultural services			
Intrinsic value of biodiversity	> Scientific community	> Project will impact woodland/grassland area. However, it will not impact on species of high value.	Scoped out
Regulating services			
Regulation of air quality, and climate	> Local communities	> The Project will impact some woodland patches (very limited surfaces) but it will not have consequence on air quality regulation.	Scoped out
Climate regulation: local regional and global	> Local communities	> The Project will impact some woodland patches (very limited surfaces) but it will not have consequence on carbon storage.	Scoped out
Regulation of water timing and flows	> Local communities especially fishers	> The Project will impact some woodland patches (very limited surfaces) but it will not prevent the minor role woodland played in regulating water flows.	Scoped out
Erosion regulation	> Local communities especially farmers	> The Project will impact some woodland patches (very limited surfaces) but it will not prevent the global role woodland played in protecting erosion.	Scoped out
Pollination	> Local communities especially farmers	> The Project will impact some woodland patches (very limited surfaces) but it will not prevent pollination on a broader scale.	Scoped out
Natural hazards regulation	> Local communities	> The Project will impact some woodland patches (very limited surfaces) but it will not prevent its stabiliser role on a broader scale.	Scoped out

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Ecosystem services	Beneficiaries	Project potential impacts	Scoped in or scoped out
Pest regulation	> Local communities	> The Project will impact some woodland patches (very limited surfaces) but will not prevent its role on pest regulation on a broader scale.	Scoped out
Supporting services			
Nutrient cycling	> Local communities	> The Project will impact some woodland patches (very limited surfaces) but the grassland nutrient could be found in other woody area.	Scoped out
Water cycling	> Local communities especially fishers	> The Project will impact some woodland patches (very limited surfaces) but it will still contribute to water cycling on a broader scale.	Scoped out
Soil formation	> Local communities	> The Project will impact some woodland patches (very limited surfaces) but it will still contribute to soil formation a broader scale.	Scoped out
Habitat Provision	> Local communities especially fishers	> The Project will impact some woodland patches (very limited surfaces) but it will not impact on the diversity of plants and birds and animals.	Scoped out

Table F-4 - Identification of beneficiaries of potentially impacted ecosystem services provided by Anthropized ecosystem

Ecosystem services	Beneficiaries	Project potential impact	Scoped in or scoped out
Provisioning services			
Honey, fruits and mushrooms	> Local communities	> Project will impact tree plantations and may reduce or restrict access for people to collect fruits.	Scoped in
Cultivated crops	> Local communities especially farmers	> Project will impact agricultural land and could therefore impact people livelihood.	Scoped in
Regulating services			
Climate regulation: local regional and global	> Local communities	> The Project will impact some residential and agricultural land but it will not have consequence on climate regulation.	Scoped out
Pollination	> Local communities especially farmers	> The Project will impact some agricultural plots that contribute to pollination, but it will not impact pollination process on a broader scale.	Scoped out
Supporting services			
Nutrient cycling	> Local communities	> The Project will impact some agricultural land located in anthropized areas but it will not prevent cultivated areas, including in the floodplain, to contribute to nutrient cycling.	Scoped out
Habitat Provision	> Local communities	> The Project will impact some residential and agricultural land but it will not impact on the diversity of plants and birds and animals.	Scoped out

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G. Environmental Flow Assessment Complementary Data

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G.1 Introduction

The EFA as presented is informed by the IFC Good Practice Handbook (The 'Handbook') on Environmental Flows for Hydropower Projects.

The Handbook does not provide instructions for implementing a specific methodology for undertaking an environmental flow assessment, nor does it address the selection of stakeholders and the negotiation on environmental flow allocations or how to implement environmental flows. It does however provide useful guidance on what constitutes an environmental flow, that is, *"the quantity, frequency, timing, and quality of water and sediment flows necessary to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems"* (The Handbook, page 5).

Importantly, The Handbook also states that environmental flows *"should be a subset of the natural flow regime of the river, taking into account intra-annual and inter-annual variability of flow, and should not be limited to simple minimum low flow specification"* and that *"they are selected to maintain riverine ecosystem services or values … at some pre-agreed or negotiated condition that is grounded in a consultative process with stakeholders"* (The Handbook, page 16).

Table G-1 and Figure G-1 summarise the importance of seasonal and inter-annual environmental flow variation, highlighting the important functions associated with dry-wet transition, onset and duration of seasons, floods, and dry periods.

Table G-1 Importance of Different parts of the Flow Regime (after The Handbook)

Period	Function
Dry-wet transition	- Distribute sediments and nutrients flushed from watershed - Distribute seeds - Support migration of adults and larvae
Onset and duration of seasons	- Cues fruiting and flowering - Cues migration / breeding - Supports life history patterns - Support development life-stages
Floods	- Dictate channel form - Flush and deposit sediment and debris - Promote habitat diversity - Support flood plains - Distribute seeds - Facilitate connectivity - Control terrestrial encroachment
Dry periods	- Promote in-channel growth - Support invertebrate larval stages

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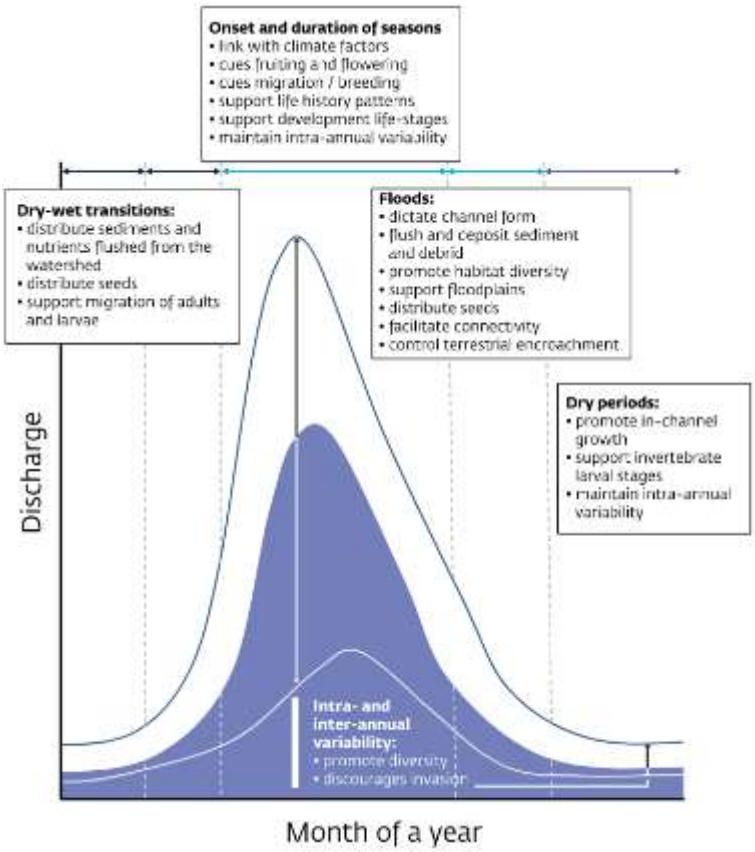

Figure G-1 Importance of Different Parts of the Flow Regime (after The Handbook, page 17)

The Handbook also presents a decision tree for assisting in the selection of an appropriate level of detail for an EFA, related to the evaluated impact of the design and operation of the hydropower project (Figure G-2). Importantly, this differentiates the recommended assessment resolution based on various criteria including: i) extent of dewatered reach; ii) hydropeaking operation; iii) potential trans-boundary or trans-basin issues; iv) ecosystem type affected; v) significance of social dependence; vi) relative location in a cascade system; vii) presence of critical habitat; and viii) modified habitat.

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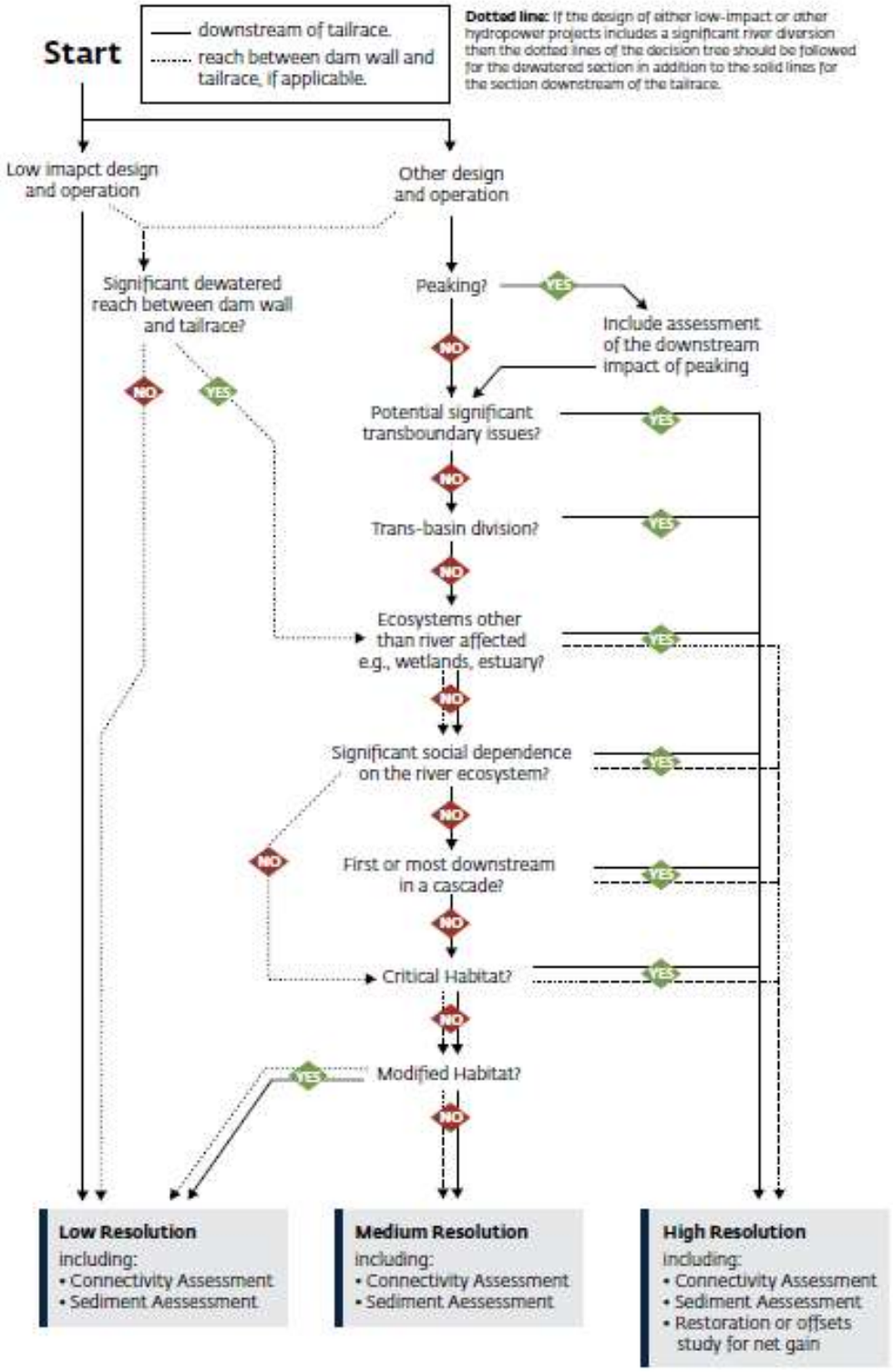

Figure G-2 EFlow Assessment Decision Tree (after The Handbook page xii)

An important definition is 'low-impact design and operation', considered by The Handbook to be synonymous with "hydropower plants that release downstream into the same river, with a short or no diversion, have 48 hours or less dry-season storage and do not make peaking-power releases." The proposed Ruzizi III design and operation can be categorised according to The Handbook as a "Group 3 Medium storage, diversion returning to same river and peaking power" project. The indicative impacts associated with such a design are given in Table 1 of The Handbook, and are repeated herein in Table G-2.

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Table G-2 Indicative Impacts Associated with a 'Ruzizi III'-type Project (after The Handbook, page 26)

			Indicative Impact
Dewatered reach	Impact on Dry Season	n/a	Large
	Impact on Wet Season	n/a	Small
Downstream of Tailrace	Impact on Dry Season Flow	On tributary	Minimal
		Mainstream upstream of large tributary	Small
		Mainstream downstream of large tributary	Medium
	Impact on Wet Season Flow	On tributary	Large
		Mainstream upstream of large tributary	Small
		Mainstream downstream of large tributary	Medium
	Impact on Timing of Season	On tributary	Small
		Mainstream upstream of large tributary	Small
		Mainstream downstream of large tributary	Medium
Longitudinal Connectivity	Upstream Barrier Effect	On tributary	Small
		Mainstream upstream of large tributary	Medium
		Mainstream downstream of large tributary	Large
	Downstream Barrier Effect	On tributary	Small
		Mainstream upstream of large tributary	Medium
		Mainstream downstream of large tributary	Large

However, it is important to note that the indicative impacts presented are generalizations and that, importantly for Ruzizi III, *"hydropower projects … may not cause significant additional environmental impacts in rivers that are already seriously impacted."* (The Handbook, page 25).

The Handbook provides a useful summary of EFlow assessment methods, summarising their key attributes, level of resolution and categorisation – as hydrological, hydraulic, habitat simulation, or holistic. Key attributes also consider if the method is prescriptive or interactive – prescriptive methods seek to recommend a single flow value or flow regime whereas interactive methods operate in the realm of Integrated Water Resource Management (IWRM) and explicitly recognise the contested nature of the decision-making process and the need for greater inclusion of stakeholders in this.

Resolution level varies from "very low" to "high", from application of the (hydrological) "The Tennant Method" / "New England Aquatic Base-flow (ABF) Method" to a variety of medium/high habitat simulation/holistic methods (including, *inter alia*, PHABSIM, The Building Block Methodology (BBM), DRIFT).

Although classified as a hydrological "very low" resolution approach, "The Tennant Method" provides useful context in which to assess higher resolution approaches:

- 10% of the Mean Annual Flow (MAF) is recommended as a minimum flow to sustain short-term habitat – but for longer-term considerations is also associated with severe degradation.
- 30% of the Mean Annual Flow (MAF) is recommended as a good baseflow required to sustain good survival habitat for most aquatic lifeforms.
- 60% of the Mean Annual Flow (MAF) is recommended to provide excellent / outstanding habitat during primary growth periods and for recreational users.

Importantly, the recommended percentage mean annual flow statistics are also related to physical instream flow parameters – width, depth, and velocity – considered "vital to the well-

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being of aquatic organisms and their habitat". Table G-3 provides a summary of the functional relationship between percentage mean annual flow and physical instream flow parameters.

The Tennant Method also recommends the seasonal variation of flows – to either bi-annual or quarterly values – but recommends against the use of monthly variation. Importantly, it also explicitly recognises the importance of inter-annual variation of flows such that "fish, wildlife, and aquatic resources share surpluses and shortages of water equitably with other users" – a central tenet of IWRM.

Table G-3 The Tennant Method: Functional Relationship between %MAF and physical instream parameters[2]

Percentage Mean Annual Flow	Average Area (%)	Average Depth (m)	Average Velocity (m/s)
10% MAF	60%	0.30	0.25
30% MAF	65%	0.45	0.45
60% MAF	85%	0.60	0.50
100% MAF	100%	0.60	0.60
200% MAF	110%	0.90	1.00

It is also worth mentioning that the Handbook also emphasises the importance of aligning the timing of the EFlow assessment (and ESIA) with the wider project planning program.

"The scope and method for the EFlows Assessment should be agreed at the earliest engineering stages (concept and prefeasibility) … The outputs of the EFlows Assessment and ESIA should feed into the engineering feasibility stage, leading to negotiation with stakeholders, and decisions on the nature of the development, the condition of the downstream river, the EFlows, and the final design features and operating rules to achieve this."

The Handbook, pages 44-45

Failure to undertake an EFlow assessment at the appropriate time can have significant consequences:

"Often, the results of the EFlows Assessment are only fed into the operating rules after the ESIA has been completed and the environmental license awarded, which may result in the EFlows not being achievable or the developer seeing EFlows released as power lost. The same issue applies to other findings of ESIAs, which may be produced too late in the planning process to influence design or operational rules."

The Handbook, page 45.

[2] After Figure 1 "Average Width, Depth and Velocity from Ten Field Tests of Instream Flow Regimens using The Montana Method and U.S;G.S Hydrology Data" (Tennnant, 1975). Data has been converted from imperial to approximate metric units, and width ("percent of substrate covered with water") converted to wetted area.

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G.2 Assessment of EFlows

G.2.1 The Dewatered Reach

G.2.1.1 Hydrological and Hydraulic Characteristics

Figure G-3 summarises the hazard classification[3] of the dewatered reach for different flow conditions between 10 m³/s (current minimum flow) and 160 m³/s (current peak flow), where class 1 is "very low" hazard and class 6 is "very high" hazard. It can be seen that, as expected, hazard generally increases with flow magnitude (as both depth and velocity increase):

- At a flow rate of 10 m³/s, 34.4% of the reach is considered to be at a hazard rating of 3 or less, and 12.7% is of the reach is considered to be at a hazard rating of 4 or more; and
- At a flow rate of 160 m³/s, 3.4% of the reach is considered to be at a hazard rating of 3 or less, and 96.6% is of the reach is considered to be at a hazard rating of 4 or more.

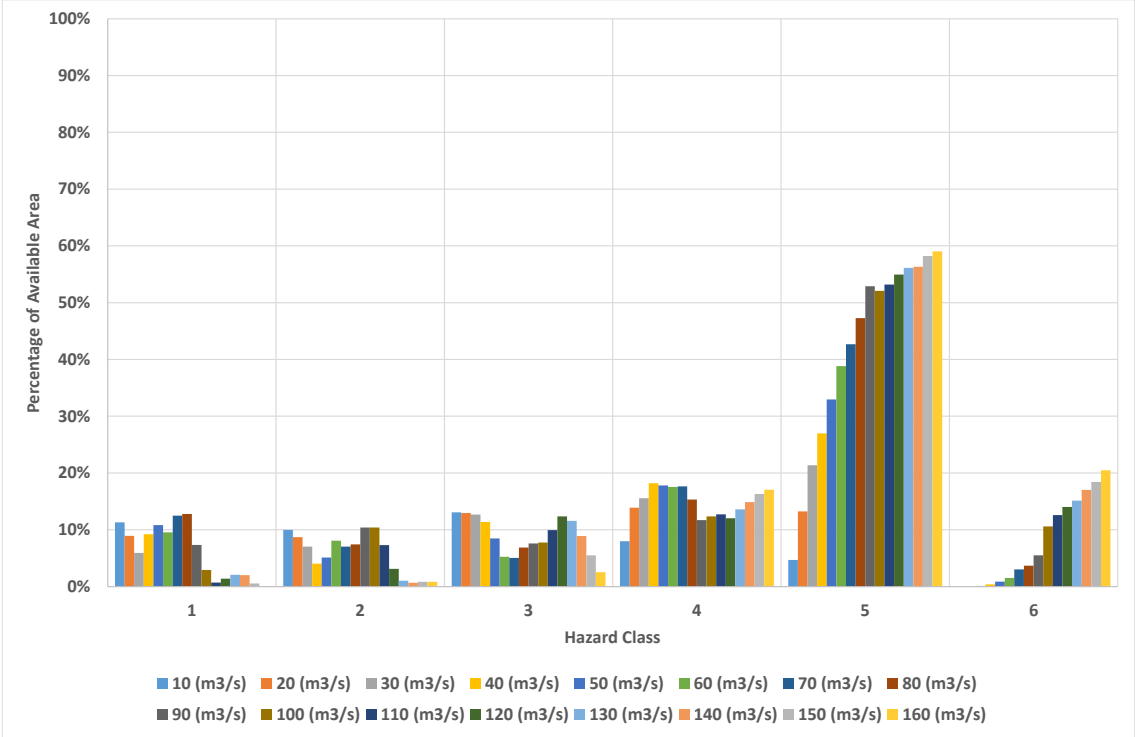

Figure G-3 Variation of Dewatered Reach Hazard Under Different Flow Conditions

G.2.1.2 Geomophological, Ecological and Social Context

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G.2.1.3 Indicators Linked to Hydrological and Hydraulic Characteristics

Table G-4 provides and overall summary of the ecological and social functional relationships with hydrological and hydraulic characteristics within the dewatered reach.

The change in hydrological and hydraulic characteristics are predicted to result in significant increase in-channel sedimentation and a significant improvement in aquatic ecology for non-migratory / migratory fish and macro-invertebrates.

[3] In this assessment of hazard, the reach water depth and velocity data has also been combined using the classification system developed by the Australian Water Research Laboratory (WRL TR2014/07). This definition of hazard is particularly relevant to considering social impacts such as community health and safety impacts.

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Table G-4 Summary of Ecological and Social Functional Relationship / Impacts within the dewatered reach

Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Geomorphology			
Increased channel erosion Stable channel bed due to large bed material, cemented bed material (calcrete) and bedrock. Small gravel and sand bars present, but frequent flow level fluctuations have armoured the bed, so low potential for further channel incision.	Flow	Moderate FR/I	Due to the stable largely immobile bed, erosion along the channel should be localised.
	Elevation / Depth	Moderate FR/I	Reduced energy will slow the armouring process down.
	Velocity	Moderate FR/I	Reduced energy will slow the armouring process down.
	Area	Minor FR/I	Reduced energy will slow the armouring process down.
	Ramping Rates	No / Insignificant FR/I	N/A
Increased sedimentation in channel Lateral sediment inputs could overwhelm the transport capacity of the reduced flow, resulting in sedimentation (coarse sediment bars downstream of tributaries and fine sediment blankets in slack waters) in low velocity habitats. Extreme mass movements of sediment, such as landslides could block the channel, resulting in back flooding. Due to the reduced flow rate, the dam will fill slower (longer period of damming) and cut/entrain through the deposited material at a lower rate.	Flow	Moderate FR/I	Incompetence to transport lateral sediment inputs, possible creation of gravel and sand bars along the channel margins creating new habitats. This could increase the habitat diversity that was lost due to bed armouring.
	Elevation / Depth	Minor FR/I	Reduced energy due to reduction in flow depth.
	Velocity	Moderate FR/I	Reduced energy due to reduced flow velocity.
	Area	Moderate FR/I	Reduced total transport due to a reduced area to transport sediment.
	Ramping Rates	Significant FR/I	Sporadic large inputs from landslides could result in longer damming and back flooding of the channel due to reduced flow rates. Smaller mass movements can lead to fan type deposits with unconsolidated sediment – possible risk of people and livestock getting stuck in unconsolidated fine sediment.
Bank erosion Bank erosion is generally associated with reduced longitudinal sediment input, possibly leading to channel erosion and associated bank collapse and/or direct fluvial erosion. The fixed nature and large clast size of the banks are unlikely to be eroded due to the reductions in sediment load and flow energy. The banks have been exposed to high velocity flows with frequent variations in water level, thus erosion has already taken place along sensitive reaches. Some localised bank erosion might take place as vegetation and agriculture change along the banks. The riverbanks are low in elevation, so the risk is fairly low if bank erosion should take place.	Flow	Minor FR/I	Reduced flow, thus low possibility of fluvial erosion (banks are not inundated).
	Elevation / Depth	No / Insignificant FR/I	Reduced depth of flows, so no impact.
	Velocity	No / Insignificant FR/I	Reduced velocity, so no impact on bank erosion.
	Area	No / Insignificant FR/I	Reduced area, so reduced impact on bank erosion.
	Ramping Rates	Minor FR/I	Possible destabilisation with changes in vegetation communities and increased agricultural activities on drier banks.

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Aquatic Ecology			
Non-migratory fish: abundance and diversity Lotic riffle-rapid fish guild.	Flow		
	Elevation / Depth	Significant FR/I	POSITIVE: Sub-daily variation in depths repeatedly dewater riffle-rapid habitats leading to mortality and stranding of fishes living in these habitats. Future stabilization of depth variations would reduce fish mortality. This would have a significant positive impact on this guild provided there was adequate inundation of riffle-rapid habitats.
	Velocity	Significant FR/I	POSITIVE: Sub-daily variations in velocities reduce the interstitial delivery of well-oxygenated water through bed elements following down-ramping. Lower dissolved oxygen concentrations which may impair growth and development of eggs and larvae. Stabilization of flows would have a significant positive impact on this guild.
	Area	Significant FR/I	POSITIVE: The total available area of habitat controls the size of fish populations living in any particular reach. A reduced area as a result of a minimum flow of 10 m^3/s would have a significant negative impact on overall population size, but this would be mitigated by the positive impact associated with flow stabilization.
	Ramping Rates		
Migratory fish: abundance and diversity Lotic lithophilic fish guild.	Flow		
	Elevation / Depth	Significant FR/I	POSITIVE: Sub-daily variation in depths lead to dewatering of shallows and fish strandings or entrapment particularly of juvenile fish in this guild seeking cover and feeding opportunities in marginal slack water habitats. Stabilization of the flow would reduce mortality from strandings and have a significant positive effect on fishes in this guild.
	Velocity	Significant FR/I	POSITIVE: Increased velocities during up-ramping displace juvenile and adult fish into the main channel where they will be subject to higher predation rates and reduced feeding opportunities. Stabilization of the flow would reduce the sub-lethal effects of displacement and have a significant positive effect on fishes in this guild.
	Area	Significant FR/I	POSITIVE: The total available area of habitat controls the size of fish populations living in any reach. A reduced area as a result of a minimum flow of 10 m^3/s would have a significant negative impact on overall population size, but this would be mitigated by the positive impact associated with flow stabilization.
	Ramping Rates		

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Macro-invertebrates: abundance and diversity Both are expected to increase compared to the current operation because stable daily and sub-daily water levels will improve the quality of instream habitats, particularly for taxa that are sensitive to hydraulic conditions. Stable hydraulic conditions and clear water released from the Ruzizi III are also likely to create conditions suitable for growth of submerged aquatic plants, such as *Potamogeton schweinfurthii*, and this will increase the availability of substrates for macro-invertebrate colonisation.	Flow	Minor FR/I	Outside normal operation, periodic flushing of sediments could impact negatively on aquatic macro-invertebrates in the dewatered zone, but such flushing is likely to occur infrequently and after several years of operation.
	Elevation / Depth		
	Velocity	Significant FR/I	POSITIVE: Reduced daily and sub-daily variability in velocity will improve the quality of instream habitat for aquatic macro-invertebrate colonisation.
	Area	No / Insignificant FR/I	Reduced wetted area will have no impact on aquatic macro-invertebrates compared to the current operation because none of the wetted area above the current minimum water level is inundated long enough for aquatic macro-invertebrates to colonise.
	Ramping Rates		
Terrestrial Ecology			
Riparian vegetation: abundance and diversity The two types of riparian vegetation currently present in this reach, namely Riparian Thicket and Riparian Wetland, will be impacted in different ways by the project-related changes to the river that are likely to occur. This is mainly because of the differing ecological characteristics of the species in each habitat, such as the proportion of species requiring a constant wet bank or flow-dependent species. Riparian Wetlands have the higher proportion of these species and are thus more likely to be impacted as changes in depth and area of the river result in changes to the availability of a wet bank and accessibility of riparian species to flowing water. Neither habitat is dependent on the other and merely occupy different microhabitats in the riparian zone.	Flow	Minor FR/I	Changes in timing of flows are likely to be of short duration (hydropeaking) and thus unlikely to have a significant impact on riparian vegetation. The flows are already influenced by the hydropeaking regime of Ruzizi II so do not reflect the natural seasonal flows of the river.
	Elevation / Depth	Minor FR/I	Changes in water depth may reduce the opportunities for the few flow-dependent species in Riparian Thicket to have access to water through their roots. The drawdown away from the banks could also reduce the amount of available wet bank for Riparian Wetland species, which is linked to the Area characteristic described below.
	Velocity	Minor FR/I	Severe reduction in velocity, particularly during low flows, will potentially result in higher levels of sedimentation since less energy will be available for keeping sediment mobile. This could provide more habitat for *Phragmites* wetlands but less suitable habitat for Riparian Thicket, which doesn't establish well on loose alluvial sediments. Reduced velocity could result in reduced dispersal of seed of certain Riparian Thicket species although this would be a minor impact given that this habitat is already severely fragmented in this reach.
	Area	Moderate FR/I	Severe reduction in area of available wet bank, with a completely dry bank during periods of low flow, will result in a reduction in the amount of Riparian Wetland in this reach. At a low flow of 10m^3/sec only 44% of the potential maximum wet bank will be available, so it is possible that reduction of more than 50% of the current extent of Riparian Wetland could take place.
	Ramping Rates	No / Insignificant FR/I	Not relevant to riparian vegetation.

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Riparian fauna: abundance and diversity The riparian fauna assemblage is associated with the two vegetation types described above, as well as open water habitat in the river. The species composition of the faunal assemblage is currently dominated by widespread habitat generalists and overall species richness is low. Changes in flow, depth and velocity are likely to impact riparian fauna species.	Flow	Minor FR/I	Severe reduction in flow will reduce fish and invertebrate prey base and most likely cause riparian fauna to migrate to other reaches. However, this could have implications in those reaches where habitats and niches are already occupied.
	Elevation / Depth	Minor FR/I	Severe reduction in depth will reduce amount of foraging habitat and possibly availability of fish and invertebrate prey base. Riparian fauna will most likely migrate to other reaches.
	Velocity	Minor FR/I	Severe reduction in velocity may make the fish and invertebrate prey base more accessible to piscivorous mammal and avifauna species, which could be a minor positive impact.
	Area	Minor FR/I	Severe reduction in area will reduce fish and invertebrate prey base and most likely cause riparian fauna to migrate to other reaches. However, if the reduction in area results in isolated pools forming in which fish and inverts are concentrated, this could create temporary feeding areas for riparian fauna.
	Ramping Rates	No / Insignificant FR/I	Not relevant to riparian fauna.
Social			
Consumptive Water Use Local communities are frequently using this stretch of the river for domestic water collection and irrigation with buckets. Water is generally not collected for drinking in this area. Social reliance on this stretch of the river for consumptive use is moderate.	Flow	Minor FR / I	No significant impact on the availability of water or difficulty of access to the river for local populations.
	Elevation / Depth	Minor FR / I	As above
	Velocity	Minor FR / I	As above
	Area	Minor FR / I	As above
	Ramping Rates	N/A	N/A
Non-Consumptive Water Use: Fishing Local communities are currently using this stretch of the river infrequently for casual fishing activities.	Flow	Minor RF / I	Positive impact on fishing activities due to lower variability in elevation and velocity, slightly offset by reduced wetted area (refer to Aquatic Ecology above), will result in a minor positive impact on fishing activities in the dewatered reach.
	Elevation / Depth	Minor RF / I	As above
	Velocity	Minor RF / I	As above
	Area	Minor RF / I	As above
	Ramping Rates	N/A	N/A
Community Safety Local communities do not regularly physically enter or cross the river due to the hazardous nature of this stretch, aside from regular crossing to reach a praying spot downstream of the future dam. Social exposure to river crossing hazards is high.	Flow	No / Insignificant FR/I	Overall insignificant impact on safety for local communities, as the positive impact caused by lower variability of flow is offset by low levels of social reliance on river crossing.
	Elevation / Depth	No / Insignificant FR/I	See above
	Velocity	No / Insignificant FR/I	See above
	Area	No / Insignificant FR/I	See above
	Ramping Rates	N/A	N/A

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G.2.2 The Hydropeaking Reach Downstream Ruzizi III

G.2.2.1 Flow condition seasonality

The Feasibility Study presents optimised operation of the Ruzizi II and Ruzizi III facilities for different non-exceedance probabilities that relate to different reservoir inflow conditions. These inflow conditions can be compared with the monthly inflows to Ruzizi III to better understand the likely seasonality of their occurrence. Such seasonality varies according to whether a longer-term "Average", "dry period" or "wet period" is being considered, and also the prevailing inter-annual conditions within such longer-term periods of different flow conditions.

The hydrology baseline includes an assessment of the inter-annual and intra-annual variability of monthly inflows. This variability is summarised below in Table G-5. The reported daily flow conditions have been "assigned" to each of the monthly inflows to illustrate when the flow conditions are likely to occur. The following colour-coded codes have been used:

- < VD: The monthly flow is less than the "Very Dry" flow conditions;
- VD-D: The monthly flow is between the "Very Dry" and "Dry" flow conditions;
- D-N: The monthly flow is between the "Dry" and "Normal" flow conditions;
- N-W: The monthly flow is between the "Normal" and "Wet" flow conditions;
- W-VW: The monthly flow is between the "Wet" and "Very Wet" flow conditions; and
- >VW: The monthly flow is greater than the "Very Wet" flow conditions.

For example, it can be seen that under normal "longer-term dry period" conditions, it tends to be "Dry to Normal" in February to July, less than "Very Dry" in October and November, and "Very Dry to Dry" for the remainder of the year. Under normal "longer-term wet period" conditions, it tends to be "Normal to Wet" in February to July, and "Normal to Dry" in August to January. This understanding of seasonality (intra-annual conditions) and inter-annual conditions is an important dimension when considering the ecological and social impacts associated with the prevailing hydrological and hydraulic conditions.

Table G-5 Inter-annual and Intra-annual Variability of Ruzizi III Inflows

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Longer-Term Dry Period													
Dry (m^3/s)	68.0	70.0	71.9	73.9	76.0	76.0	74.9	69.0	65.0	63.0	64.9	66.0	70.9
Scenario	< VD	< VD	< VD	< VD	< VD	< VD	< VD	< VD	< VD	< VD	< VD	< VD	< VD
Normal (m^3/s)	83.0	85.0	85.5	87.0	89.0	89.5	87.0	83.0	79.0	76.5	77.0	79.5	83.0
Scenario	VD-D	D-N	D-N	D-N	D-N	D-N	D-N	VD-D	VD-D	< VD	< VD	VD-D	VD-D
Wet (m^3/s)	98.3	100	101	104	107	107	105	99.3	95.0	92.2	94.0	97.0	98.2
Scenario	D-N	D-N	D-N	D-N	D-N	D-N	D-N	D-N	D-N	D-N	D-N	D-N	D-N
Longer-Term Wet Period													
Dry (m^3/s)	84.0	92.1	93.4	95.9	101	101	97.9	87.9	78.9	75.9	77.9	83.7	90.9
Scenario	VD-D	D-N	D-N	D-N	D-N	D-N	D-N	D-N	VD-D	< VD	< VD	VD-D	D-N
Normal (m^3/s)	108	111	115	117	121	122	116	106	97.0	93.0	96.0	102	109
Scenario	D-N	N-W	N-W	N-W	N-W	N-W	N-W	D-N	D-N	D-N	D-N	D-N	N-W
Wet (m^3/s)	135	135	139	146	152	151	142	131	119	116	119	129	131
Scenario	W-VW	W-VW	W-VW	> VW	> VW	> VW	> VW	N-W	N-W	N-W	N-W	N-W	N-W

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G.2.2.2 Downstream Ruzizi III powerhouse release location

A Hydrological and Hydraulic Characteristics

Table G-6 provides an overall summary of the key modelled hydrological and hydraulic characteristics for this reach. Characteristics are presented for a range of hydrological conditions and for the baseline and future (post project) scenarios. The 'normal' hydrological conditions results are highlighted for clarity. Key attributes of hydrological and hydraulic characteristics are discussed for each characteristic in turn.[4]

Table G-6 Downstream Ruzizi III Powerhouse Location – Hydrology and Hydraulics Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Flow Summary										
Maximum Flow (m^3/s)	160	164	162	164	**163**	**164**	165	164	166	164
Minimum Flow (m^3/s)	12	11	12	11	**26**	**13**	57	40	76	62
Flow Range (m^3/s)	148	151	150	153	**138**	**151**	107	123	89	102
Elevation Summary										
Maximum Elevation (mAOD)	979.62	979.64	979.63	979.64	**979.64**	**979.64**	979.65	979.64	979.65	979.64
Minimum Elevation (mAOD)	977.95	977.91	977.96	977.91	**978.31**	**977.98**	978.80	978.57	979.01	978.86
Elevation Range (m)	1.67	1.73	1.67	1.73	**1.33**	**1.66**	0.85	1.07	0.64	0.78
Velocity Summary										
Maximum Velocity (m/s)	2.48	2.50	2.49	2.50	**2.50**	**2.50**	2.51	2.50	2.51	2.50
Minimum Velocity (m/s)	1.18	1.16	1.18	1.16	**1.38**	**1.19**	1.74	1.58	1.88	1.77
Velocity Range (m/s)	1.30	1.34	1.31	1.34	**1.12**	**1.31**	0.77	0.92	0.63	0.73
Cross-section Area Summary										
Maximum Area (m^2)	64.5	65.4	65.1	65.4	**65.3**	**65.4**	65.6	65.5	66.0	65.5
Minimum Area (m^2)	10.1	9.4	10.4	9.4	**18.3**	**10.6**	32.8	25.3	40.4	34.8
Area Range (m^2)	54.4	56.0	54.7	56.0	**47.0**	**54.8**	32.9	40.2	25.5	30.6
Ramp-Up Summary										
60-min ramp-up (cm/min)	2.2	2.8	2.2	2.8	**2.0**	**2.7**	1.4	1.8	1.1	1.3
30-min ramp-up (cm/min)	4.4	5.7	4.4	5.7	**3.8**	**5.5**	2.5	3.5	1.8	2.5
15-min ramp-up (cm/min)	7.9	10.7	7.8	10.7	**6.7**	**10.3**	3.7	6.5	2.5	4.6

[4] Ramp-up and ramp-down statistics are presented for three separate durations – 60 minutes, 30 minutes, and 15 minutes. The rates presented are the average rates that occur over each of these durations, and thus give an indication of the magnitude and duration of the change.

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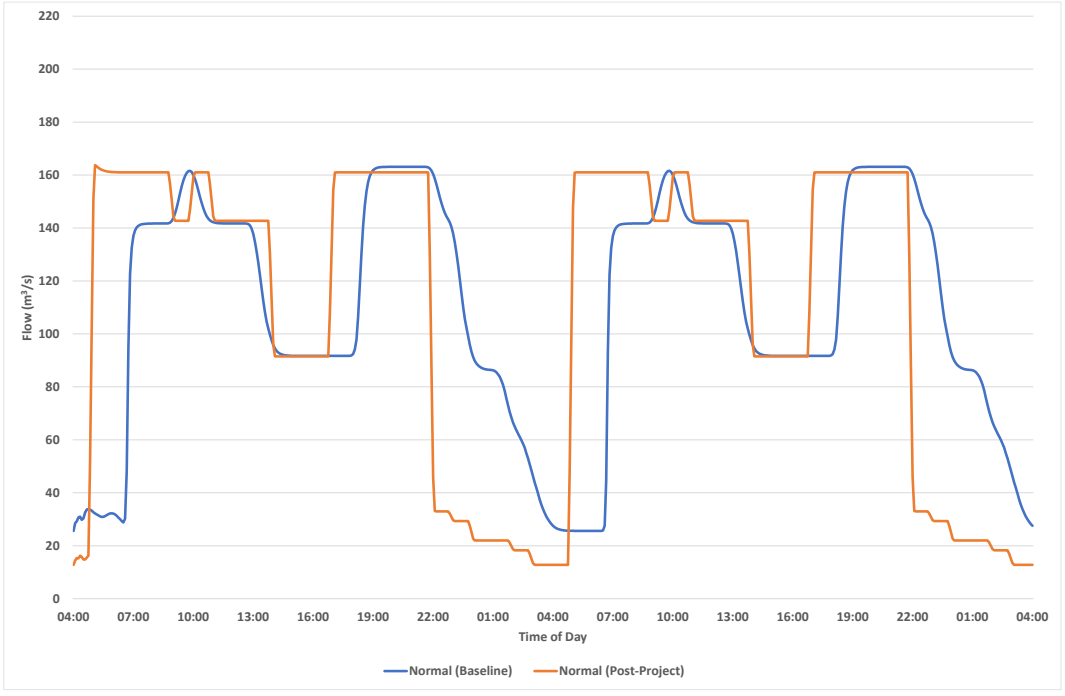
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.8	-2.0	-0.7	-2.4	**-0.6**	**-1.9**	-0.6	-0.6	-0.4	-0.4
30-min ramp-down (cm/min)	-0.8	-4.0	-0.8	-4.7	**-0.7**	**-3.9**	-0.7	-1.1	-0.5	-0.8
15-min ramp-down (cm/min)	-0.9	-6.9	-0.8	-8.2	**-0.7**	**-6.5**	-0.8	-1.9	-0.6	-1.4

Table G-7 and Figure G-4 show that the future maximum flow is similar to the current maximum flow under all flow conditions, but that the future minimum flow tends to be lower than the current minimum flow for normal to very wet conditions. As such, the change in flow range, i.e., the change in the amount of daily variation of flow, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

More generally however, it is also notable that the minimum flow is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall flow range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-7 Downstream Ruzizi III Powerhouse Location – Flow Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Flow (m^3/s)	160	164	162	164	**163**	**164**	165	164	166	164
Minimum Flow (m^3/s)	12	11	12	11	**26**	**13**	57	40	76	62
Flow Range (m^3/s)	148	151	150	153	**138**	**151**	107	123	89	102



Normal

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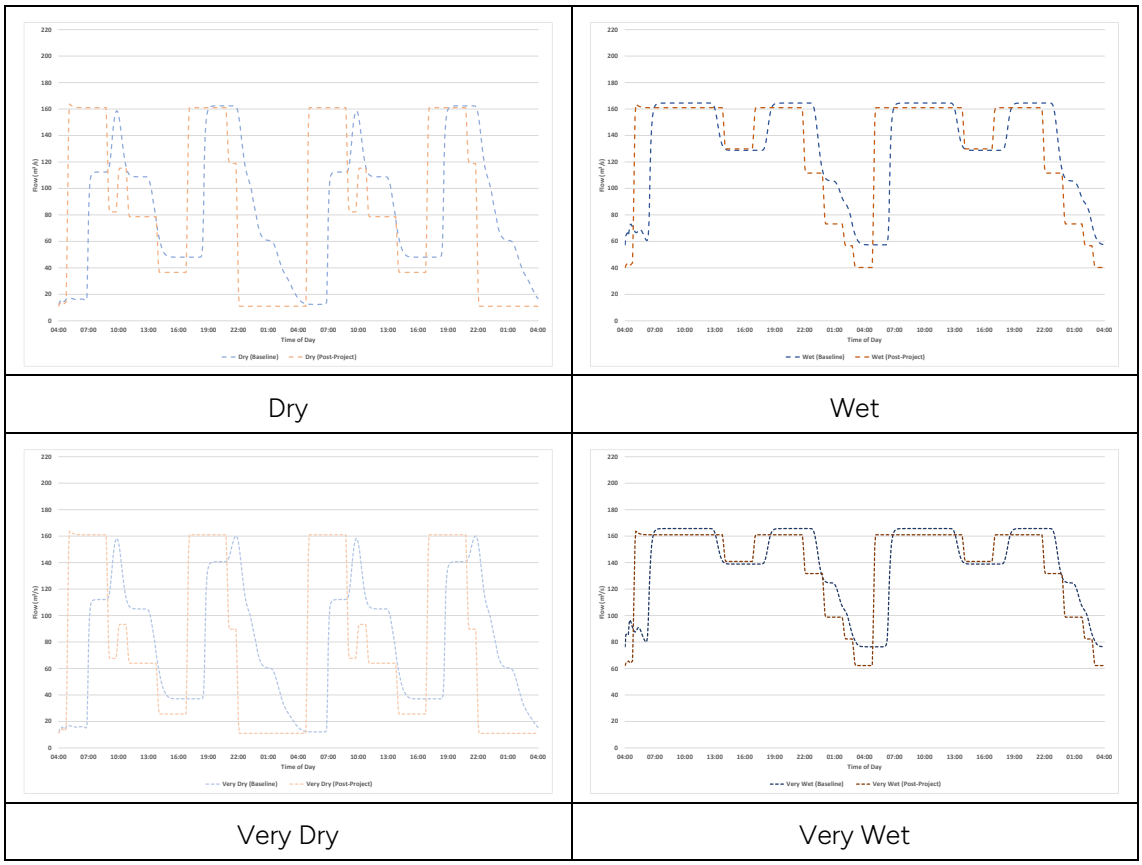

Figure G-4 Downstream Ruzizi III Powerhouse Location – Flow Summary

Table G-8 and Figure G-5 show that the future maximum level (and hence depth) is similar to the current maximum level under all flow conditions, but that the future minimum level tends to be lower than the current minimum level for normal to very wet conditions. As such, the level range, i.e., the amount of daily water level variation, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the water level daily variation increases by 33 cm under normal conditions (from a daily variation of 1.33 m to 1.66 m) primarily due to the reduction in minimum water levels.

As with the flow conditions, the minimum elevation is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall elevation range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-8 Downstream Ruzizi III Powerhouse Location – Level Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Elevation (mAOD)	979.62	979.64	979.63	979.64	**979.64**	**979.64**	979.65	979.64	979.65	979.64
Minimum Elevation (mAOD)	977.95	977.91	977.96	977.91	**978.31**	**977.98**	978.80	978.57	979.01	978.86
Elevation Range (m)	1.67	1.73	1.67	1.73	**1.33**	**1.66**	0.85	1.07	0.64	0.78

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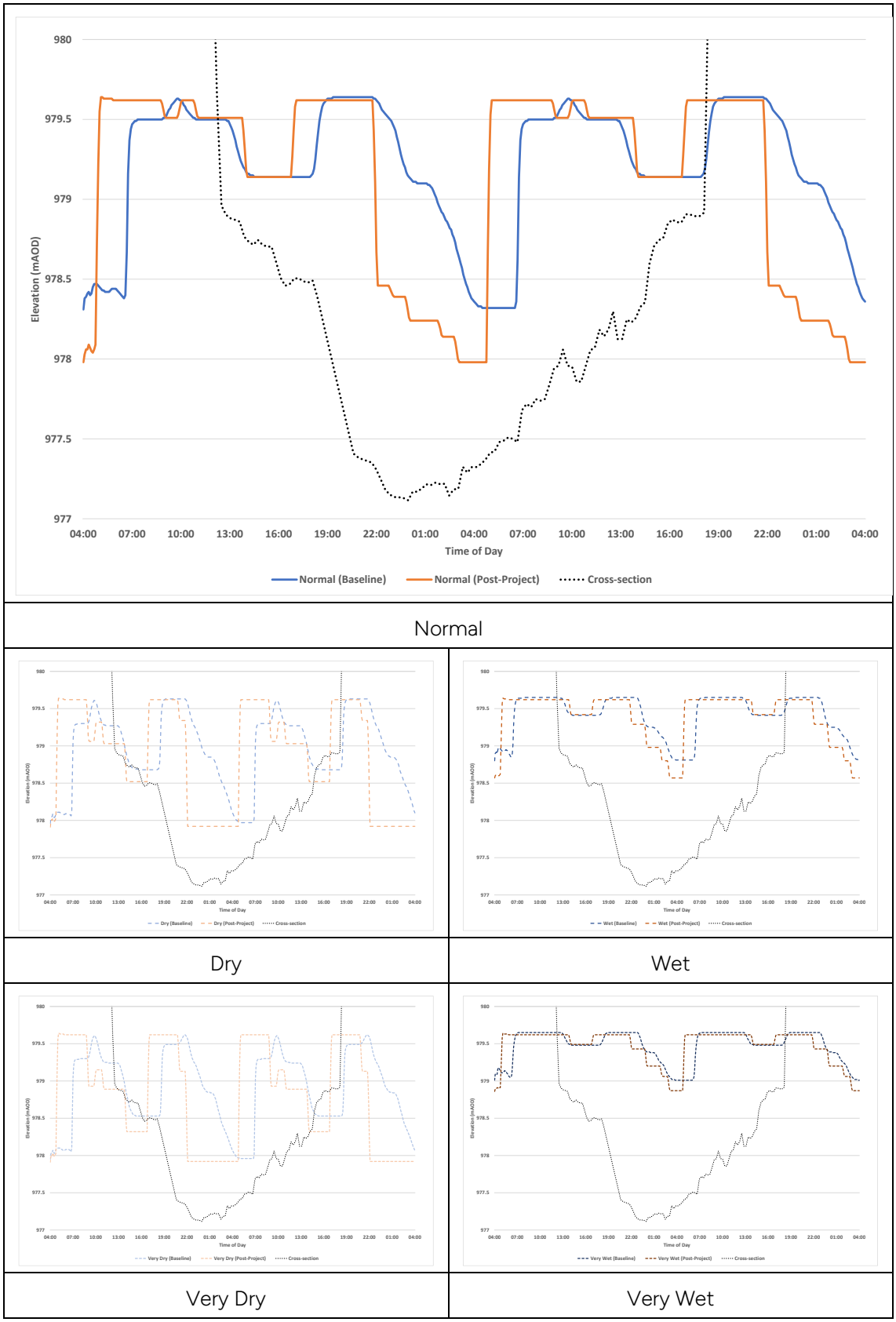

Figure G-5 Downstream Ruzizi III Powerhouse Location – Level Summary

As with the flow and elevation variation, Table G-9 and Figure G-6 show that the future maximum velocity is similar to the current maximum velocity under all flow conditions, but that the future minimum velocity tends to be lower than the current minimum velocity for normal to very wet

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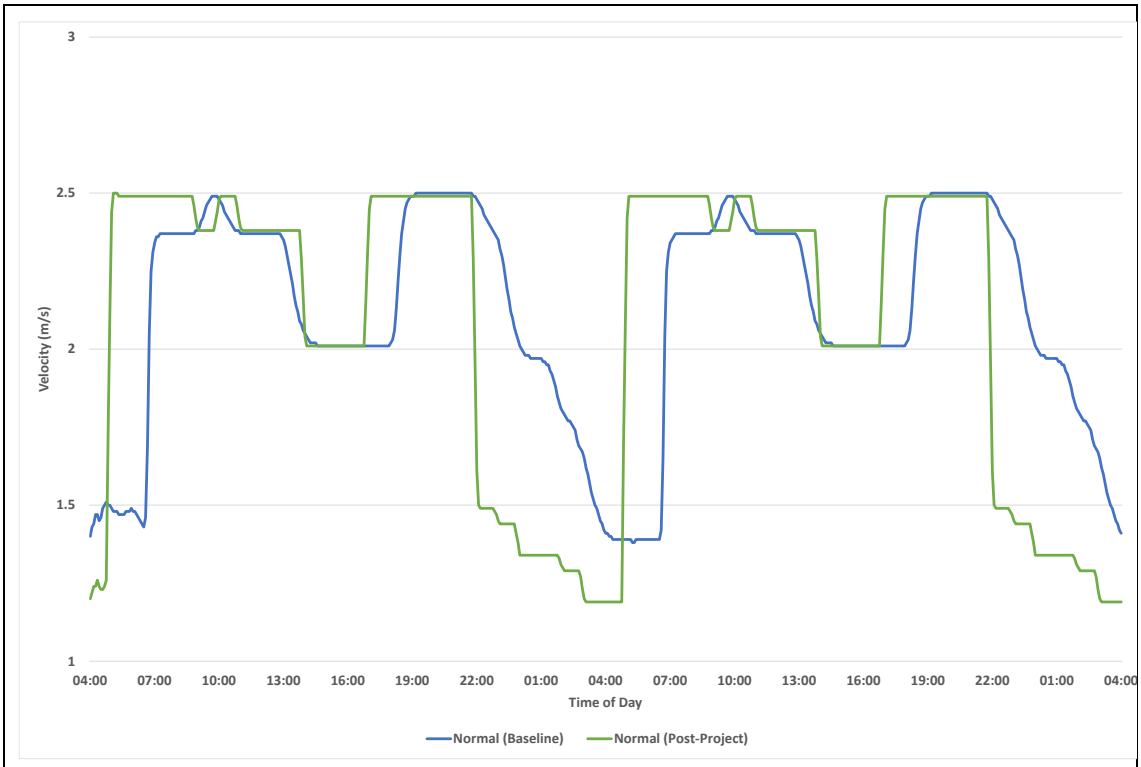
conditions. As such, the velocity range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the velocity daily variation increases by 0.19 m/s under normal conditions (from a daily variation of 1.12 m to 1.31 m) due to the reduction in minimum velocity.

The minimum velocity is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall velocity range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-9 Downstream Ruzizi III Powerhouse Location – Velocity Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Velocity (m/s)	2.48	2.50	2.49	2.50	**2.50**	**2.50**	2.51	2.50	2.51	2.50
Minimum Velocity (m/s)	1.18	1.16	1.18	1.16	**1.38**	**1.19**	1.74	1.58	1.88	1.77
Velocity Range (m/s)	1.30	1.34	1.31	1.34	**1.12**	**1.31**	0.77	0.92	0.63	0.73



Normal

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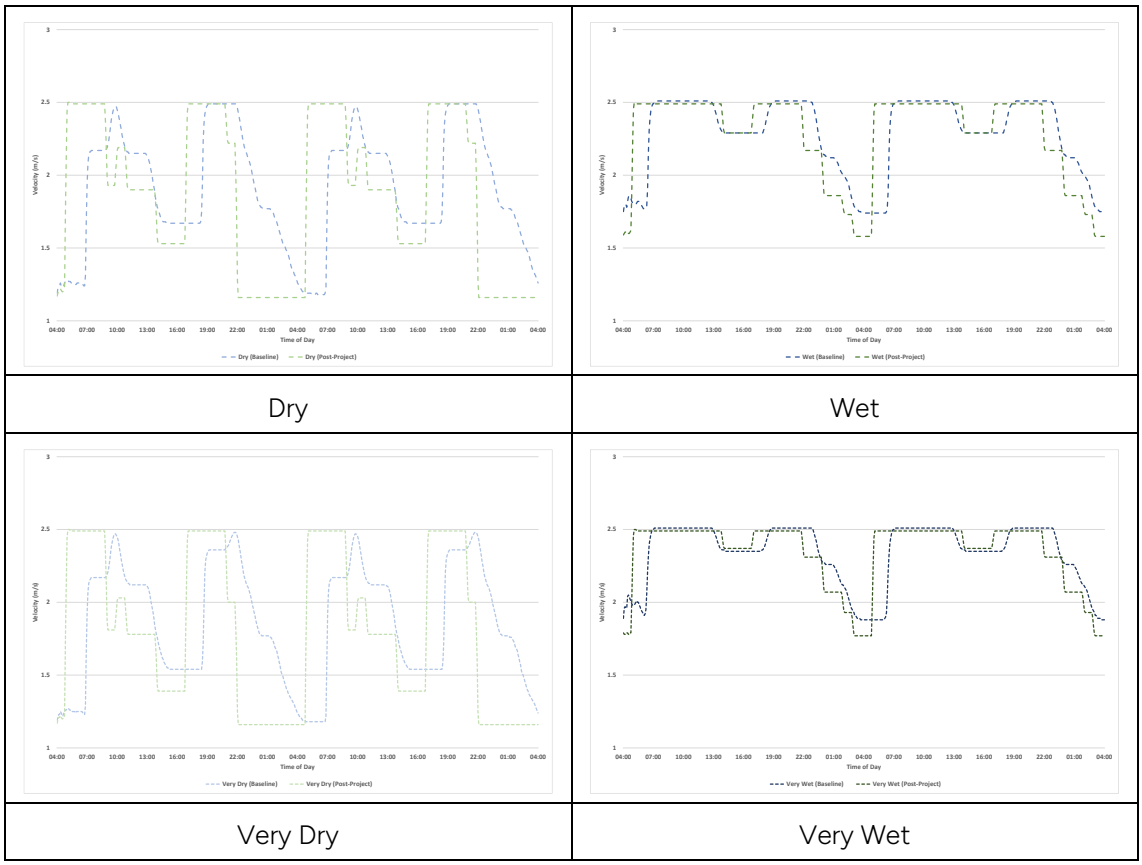

Figure G-6 Downstream Ruzizi III Powerhouse Location – Velocity Summary

Table G-10 and Figure G-7 show the maximum, minimum, and daily range in wetted cross-section area, providing an indication of the overall habitat area available. As with the other hydrological and hydraulic characteristics presented, the future maximum area is similar to the current maximum area under all flow conditions, but that the future minimum area tends to be lower than the current minimum area for normal to very wet conditions. As such, the area range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the area daily variation increases by 7.8 m^2 in the normal conditions (from a daily variation of 47 m^2 to 54.8 m^2) due to the reduction in minimum area.

The minimum area is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall area range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-10 Downstream Ruzizi III Powerhouse Location – Cross-section Area Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Area (m^2)	64.5	65.4	65.1	65.4	**65.3**	**65.4**	65.6	65.5	66.0	65.5
Minimum Area (m^2)	10.1	9.4	10.4	9.4	**18.3**	**10.6**	32.8	25.3	40.4	34.8
Area Range (m^2)	54.4	56.0	54.7	56.0	**47.0**	**54.8**	32.9	40.2	25.5	30.6

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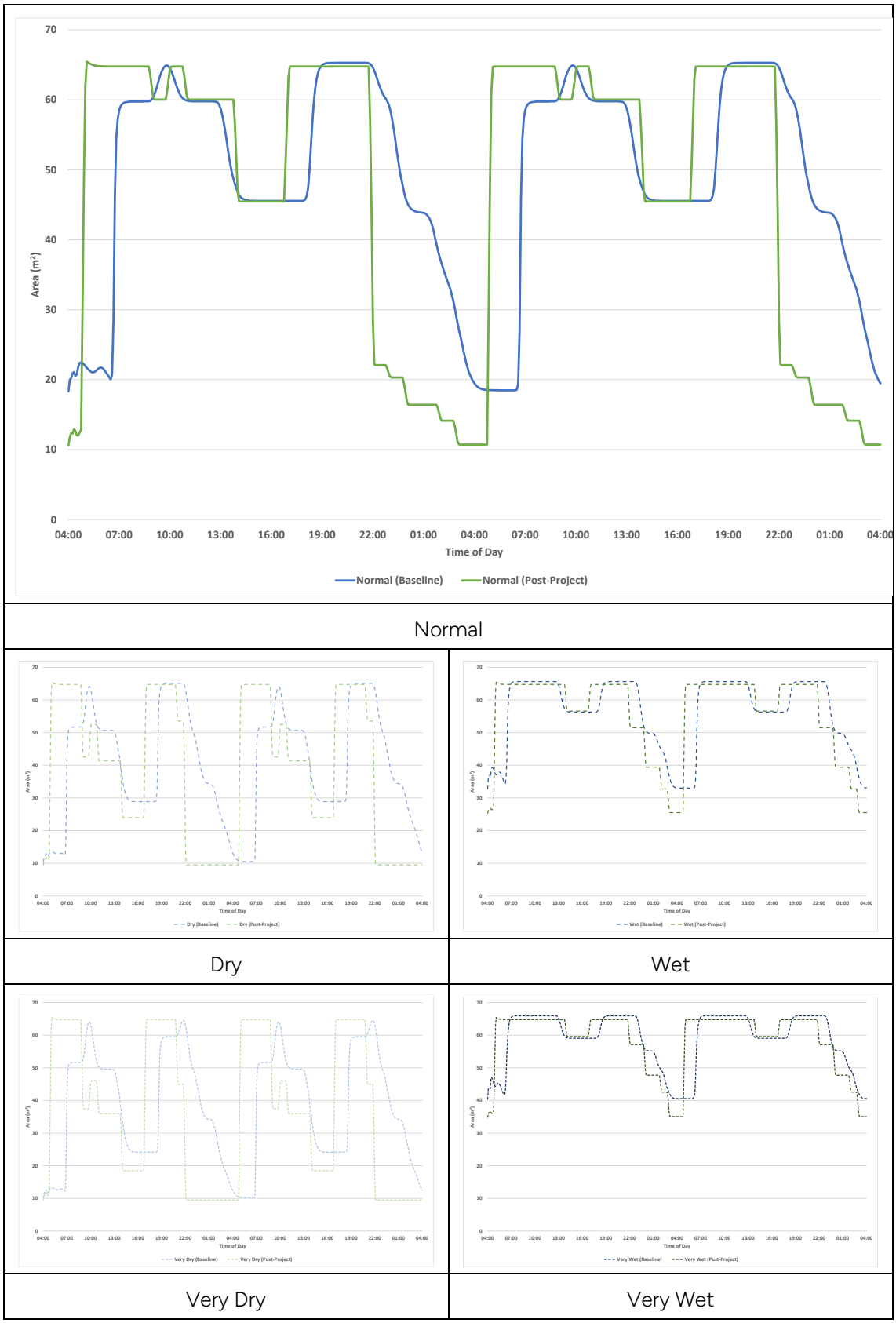

Figure G-7 Downstream Ruzizi III Powerhouse Location – Cross-section Summary

Table G-11 provides a summary of the average vertical ramp-up rates and ramp-down rates experienced over different critical durations.

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It can be seen that both the ramp-up and ramp-down rates are greatest for both the current and future scenarios over the shorter 15-minute duration, i.e., the changes in water level tend to occur over very short periods of time. Ramp up rates tend to be higher than ramp-down rates.

It is also notable that vertical ramp-up rates tend to be higher in the very dry to normal conditions than they are in the wet to very conditions, in large part reflecting the greater changes in flow and levels experienced in these conditions. It is also notable that future ramp-up and ramp-down rates tend to be greater than current ramp-up and ramp-down rates. This is a reflection of the operating conditions for Ruzizi III where it is understood that operation changes between "off-peaking" and "peaking" will be quicker than they currently are at Ruzizi II.

Table G-11 Downstream Ruzizi III Powerhouse Location – Ramp-up and Ramp-down Rates Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Ramp-Up Summary										
60-min ramp-up (cm/min)	2.2	2.8	2.2	2.8	**2.0**	**2.7**	1.4	1.8	1.1	1.3
30-min ramp-up (cm/min)	4.4	5.7	4.4	5.7	**3.8**	**5.5**	2.5	3.5	1.8	2.5
15-min ramp-up (cm/min)	7.9	10.7	7.8	10.7	**6.7**	**10.3**	3.7	6.5	2.5	4.6
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.8	-2.0	-0.7	-2.4	**-0.6**	**-1.9**	-0.6	-0.6	-0.4	-0.4
30-min ramp-down (cm/min)	-0.8	-4.0	-0.8	-4.7	**-0.7**	**-3.9**	-0.7	-1.1	-0.5	-0.8
15-min ramp-down (cm/min)	-0.9	-6.9	-0.8	-8.2	**-0.7**	**-6.5**	-0.8	-1.9	-0.6	-1.4

B Geomophological, Ecological and Social Context

[This section is intentionally left blank].

C Indicators Linked to Hydrological and Hydraulic Characteristics

Table G-12 provides and overall summary of the ecological and social functional relationship with hydrological and hydraulic characteristics downstream of the Ruzizi III powerhouse location.

The change in hydrological and hydraulic characteristics are predicted to result in significant increase in social community safety impacts (due to increased ramp-up rates).

Table G-12 Summary of Ecological and Social Functional Relationship / Impacts at Downstream Ruzizi III powerhouse location

Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Geomorphology			
Increased channel erosion The channel is largely composed of large immobile clasts, calcrete or bedrock. This makes the channel bed resistant to incision. Hydro peaking and reductions in	Flow	Moderate FR/I	Frequent and high amplitude changes in flow are likely to drive bed erosion, but the bed is stable, so no significant changes are expected. Possibly some localised erosion of mobile gravel and sand bars.
	Elevation / Depth	Moderate FR/I	As above
	Velocity	Moderate FR/I	As above
	Area	Minor FR/I	As above

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
longitudinal sediment connectivity has resulted in possible bed erosion and bed armouring over the past decades.	Ramping Rates	No / Insignificant FR/I	No adverse effect envisaged.
Increased sedimentation in channel Due to the reduced sediment supply downstream of the dam, and the increase in the frequency of high energy flows, it is unlikely that sedimentation will take place. Localised sedimentation might take place in slack waters.	Flow	Moderate FR/I	Reduction in sedimentation due to the frequent high energy flows.
	Elevation / Depth	Moderate FR/I	As above
	Velocity	Moderate FR/I	As above
	Area	Minor FR/I	As above
	Ramping Rates	No / Insignificant FR/I	No nett increase in sedimentation due to changes in ramping rate.
Bank erosion The banks are largely composed of boulders and cobbles with a finer gravel, sand and silt matrix. The banks are not steep or high and relatively stable and immobile. The banks have been exposed to hydropeaking for decades, thus bank erosion might have stabilised over time.	Flow	Moderate FR/I	Possible localised erosion of finer bank material.
	Elevation / Depth	Moderate FR/I	Higher water depth is unlikely to accelerate bank erosion. Some localised bank slumping might occur as the banks will be wetted to a higher elevation, increasing the mass of and hydraulic pressure in the banks.
	Velocity	Moderate FR/I	High flow velocities could increase fluvial erosion of the finer material along the banks, but this is expected to be localised.
	Area	No / Insignificant FR/I	
	Ramping Rates	Minor FR/I	Fast changes in water level could drive localised bank slumping as the banks are wetted during high flows, Subsequent lowering of the water level leads to hydraulic head and pressure to build up in the bank matrix, increasing the chances of mass failure of the fine bank material. As the banks are low angled, low in height and course in nature it is unlikely to increase bank erosion along most of the reach.
Aquatic Ecology			
Non-migratory fish: abundance and diversity Lotic riffle-rapid fish guild.	Flow		
	Elevation / Depth	Minor FR/I	Sub-daily depth fluctuations risk dewatering riffle-rapid habitats leading to mortality of fishes living in these areas. Shallower minimum depths during the ramp-down phase in a future hydropeaking scenario will increase the risks of this occurring. The change from present day is expected to produce a minor detectable change in the fish community due to the existing hydropeaking effects.
	Velocity	Minor FR/I	Sub-daily variations in velocities reduce the interstitial delivery of

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			well-oxygenated water through bed elements during the down-ramping phase. Lower dissolved oxygen concentrations may impair growth and development of eggs and larvae and cause stress for adult fish in this guild. The change from present day is expected to produce a minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Area	Minor FR/I	The total available area of habitat controls the size of fish populations living in any reach. Hydropeaking will effectively reduce the liveable aquatic habitat to the minimum flow present in the river during the ramp-down phase. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Ramping Rates	Minor FR/I	Both present day and future ramp-down rates exceed recommended maximum rate of -0.15 cm/m that leads to a high risk of stranding and entrapment. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
Migratory fish: abundance and diversity Lotic lithophilic fish guild.	Flow		
	Elevation / Depth	Minor FR/I	Sub-daily variation in depths lead to dewatering of shallows particularly of juvenile fish in this guild seeking cover and feeding opportunities in marginal slack water habitats. Shallower minimum depths during the ramp-down phase in a future hydropeaking scenario will increase the risks of this occurring. The change from present day is expected to produce a minor detectable change in the fish community due to the existing hydropeaking effects.
	Velocity	Minor FR/I	Increased velocities during up-ramping displace juvenile and adult fish in this guild into the main channel where they will be subject to higher predation rates and reduced feeding opportunities. Sudden unseasonal increases in velocities will disrupt migration and spawning and contribute to additional swimming costs over the migration period. The proposed

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Area	Minor FR/I	The total available area of habitat controls the size of fish populations living in any reach. Hydropeaking will effectively reduce the liveable aquatic habitat to the minimum flow present in the river during the ramp-down phase. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Ramping Rates	Minor FR/I	Both present day and future ramp-down rates exceed recommended maximum rate of -0.15 cm/m that leads to a high risk of stranding and entrapment. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
Macro-invertebrates: abundance and diversity These are expected to remain unchanged compared to the current operation because of the large variation in daily and sub-daily water levels.	Flow	Minor FR/I	Outside normal operation, periodic flushing of sediments could impact negatively on aquatic macro-invertebrates in this reach, but such flushing is likely to occur infrequently and after several years of operation.
	Elevation / Depth	No / Insignificant FR/I	Conditions in the reach will not be significantly different from present to detect a measurable change in the macro-invertebrate community.
	Velocity	No / Insignificant FR/I	As above
	Area	No / Insignificant FR/I	None of the wetted area above the current and future minimum water level is inundated long enough for aquatic macro-invertebrates to colonise.
	Ramping Rates	N/A	N/A. Ramping rates are irrelevant to macro-invertebrates because they are essentially sedentary and respond to the absolute change in hydraulic conditions, but not the rate of change.
Terrestrial Ecology			
Riparian vegetation: abundance and diversity There is almost no Natural Habitat along on the riverbanks between the powerhouse and	Flow	Minor FR/I	Changes in timing of flows are likely to be of short duration (hydropeaking) and thus unlikely to have a significant impact on riparian vegetation. The flows are already influenced by the hydropeaking regime of Ruzizi II

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Bugarama, with most Riparian Wetlands present on a few islands in the river. These wetlands have species that are dependent on a wet bank and are thus likely to be impacted by changes in depth and area of the river result in changes to the availability of a wet bank.			so do not reflect the natural seasonal flows of the river. In addition, there is very limited natural habitat remaining along this reach.
	Elevation / Depth	No / Insignificant FR/I	Changes in water depth will increase the drawdown away from the banks which would reduce the amount of available wet bank for Riparian Wetland species, which is linked to the Area characteristic described below.
	Velocity	No / Insignificant FR/I	Severe reduction in velocity, particularly during low flows, will potentially result in higher levels of sedimentation since less energy will be available for keeping sediment mobile. This could provide more habitat for *Phragmites* wetlands but less suitable habitat for Riparian Thicket, which doesn't establish well on loose alluvial sediments. Reduced velocity could result in reduced dispersal of seed of certain Riparian Thicket species although this would be a minor impact given that this habitat is already severely fragmented in this reach.
	Area	Minor FR/I	Minor reduction in area of available wet bank in comparison with current conditions, could result in a minor reduction in the extent of Riparian Wetland in this reach.
	Ramping Rates	No / Insignificant FR/I	These rates would not really have any effect on riparian vegetation at all.
Riparian fauna: abundance and diversity. The species-poor riparian fauna assemblage is associated with the fragments of Riparian Wetland on islands, as well as open water habitat in the river. The species composition of the faunal assemblage is currently dominated by widespread habitat generalists and overall species richness is low. Changes in flow, depth and velocity are likely to impact riparian fauna species. Hippopotamus occurs infrequently upstream of the Bugarama – Kamanyola Bridge and is not resident along this reach.	Flow	Minor FR/I	Reduction in flow will reduce fish and invertebrate prey base and most likely cause riparian fauna to migrate to other reaches. However, this could have implications in those reaches where habitats and niches are already occupied. Riparian fauna assemblage already depauperate in this reach so cumulative impact will probably be minimal.
	Elevation / Depth	Minor FR/I	Reduction in depth will result in minor loss of foraging habitat and possibly availability of fish and invertebrate prey base. Riparian fauna assemblage already depauperate in this reach so cumulative impact will probably be minimal.
	Velocity	Minor FR/I	Reduction in velocity may make the fish and invertebrate prey base more accessible to piscivorous mammal and avifauna species, which could be a minor positive impact. The impact will be minor because the assemblage is currently species-poor and less

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			diverse than the other reaches in the project area.
	Area	Minor FR/I	Reduction in area will reduce fish and invertebrate prey base and most likely cause riparian fauna to migrate to other reaches. However, if the reduction in area results in isolated pools forming in which fish and inverts are concentrated, this could create temporary feeding areas for riparian fauna and a short-term minor positive impact.
	Ramping Rates	Minor FR/I	Ramping rates, which are already a feature of this reach of the river will be significantly quicker than the current baseline given the proximity of the reach to Ruzizi III. Even so, the majority of the riparian fauna are highly mobile and would not be at risk to rapidly rising or dropping water levels.
Social			
Consumptive Water Use: Local communities are currently using water from this stretch regularly, as the only available source of domestic water supply. Social reliance on this stretch of the river for consumptive water use is high.	Flow	No / Insignificant FR/I	No discernible change on the availability of, and access to, consumptive water use by local communities, as conditions will not be significantly different from the ones observed at present.
	Elevation / Depth	No / Insignificant FR/I	As above
	Velocity	No / Insignificant FR/I	As above
	Area	No / Insignificant FR/I	As above
	Ramping Rates	No / Insignificant FR/I	As above
Non-Consumptive Water Use: Fishing Local communities are currently fishing regularly in this stretch. One Tilapia fish farming industry currently exists, with ponds covering a small area of 0.1 hectares.	Flow	No / Insignificant FR/I	Insignificant impact on fishing activities due to non-discernible effects on fish population (refer to Aquatic Ecology section). Insignificant impact on fish farming activities in this stretch, due to the small size and low water needs of fish farming operations.
	Elevation / Depth	No / Insignificant FR/I	As above
	Velocity	No / Insignificant FR/I	As above
	Area	No / Insignificant FR/I	As above
	Ramping Rates	Moderate FR/I	Critical ramp-down rates are expected to be exceeded during future operations in dry and normal conditions, increasing the danger of fish stranding which could threaten the quantity of fish available for fishing.
Community Safety: Local communities frequently cross the river in this stretch. Additionally, villagers are	Flow	Minor FR/I	Minor changes from current conditions, as the flow and elevation are already influenced by the operation of Ruzizi II.
	Elevation / Depth	Minor FR/I	See above

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
physically entering the river on a regular basis for recreational purposes, baptisms and medicinal / spiritual practices. Social exposure to hazards due to the river's flow and velocity are high.	Velocity	Significant FR/I	Higher velocity may result in significant hazards for community safety.
	Area	N/A	N/A
	Ramping Rates	Significant FR/I	Critical ramp-up rates will be exceeded in very dry to wet conditions in the short term and are expected to be exceeded in dry to normal conditions in future operation. This may mean that ramp-up rates will be higher for around 6 months at first, and around 10 months in the long run. This is likely to have a strong impact on community safety when entering and crossing the river.

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G.2.2.3 Upstream Bugarama Bridge / Kamanyola Monitoring Station

A Hydrological and Hydraulic Characteristics

Table G-13 provides an overall summary of the key modelled hydrological and hydraulic characteristics for this reach. Characteristics are presented for a range of hydrological conditions and for the baseline and future (post project) conditions. The 'normal' hydrological conditions results are highlighted for clarity. Key attributes of hydrological and hydraulic characteristics are discussed for each characteristic in turn. [5]

Table G-13 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Hydrology and Hydraulics Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Flow Summary										
Maximum Flow (m^3/s)	160	162	162	162	**163**	**162**	165	162	166	162
Minimum Flow (m^3/s)	12	11	12	11	**26**	**13**	57	40	76	62
Flow Range (m^3/s)	148	151	150	151	**138**	**149**	107	122	89	100
Elevation Summary										
Maximum Elevation (mAOD)	947.55	947.57	947.57	947.57	**947.58**	**947.57**	947.59	947.57	947.60	947.57
Minimum Elevation (mAOD)	945.74	945.71	945.75	945.71	**946.09**	**945.76**	946.62	946.37	946.83	946.67
Elevation Range (m)	1.81	1.86	1.82	1.86	**1.49**	**1.81**	0.97	1.20	0.77	0.90
Velocity Summary										
Maximum Velocity (m/s)	1.86	1.87	1.87	1.87	**1.87**	**1.87**	1.87	1.87	1.88	1.87
Minimum Velocity (m/s)	0.83	0.81	0.84	0.81	**1.05**	**0.85**	1.30	1.18	1.43	1.33
Velocity Range (m/s)	1.03	1.06	1.03	1.06	**0.82**	**1.02**	0.57	0.69	0.45	0.54
Cross-section Area Summary										
Maximum Area (m^2)	86.0	86.8	87.0	86.8	**87.3**	**86.8**	87.8	86.9	88.2	86.9
Minimum Area (m^2)	14.5	13.6	14.8	13.6	**24.4**	**15.1**	44.3	34.2	53.3	46.6
Area Range (m^2)	71.5	73.2	72.2	73.2	**62.8**	**71.7**	43.5	52.7	34.9	40.3
Ramp-Up Summary										
60-min ramp-up (cm/min)	2.4	3.1	2.4	3.1	**2.2**	**3.0**	1.6	2.0	1.3	1.5
30-min ramp-up (cm/min)	4.7	6.2	4.7	6.2	**4.4**	**6.0**	3.0	4.0	2.2	2.9
15-min ramp-up (cm/min)	8.7	12.1	8.7	12.1	**7.9**	**11.7**	4.8	7.4	3.1	4.9

[5] Ramp-up and ramp-down statistics are presented for three separate durations – 60 minutes, 30 minutes, and 15 minutes. The rates presented are the average rates that occur over each of these durations, and thus give an indication of the magnitude and duration of the change.

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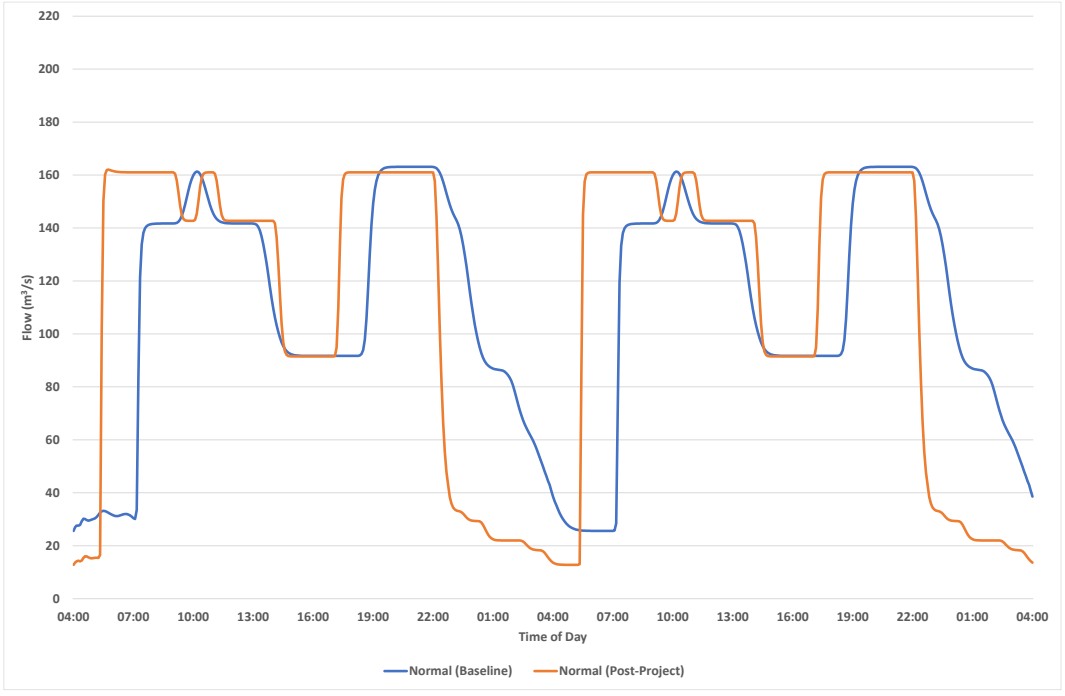
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.7	-2.0	-0.7	-2.3	**-0.7**	**-2.1**	-0.7	-0.7	-0.5	-0.5
30-min ramp-down (cm/min)	-0.8	-2.5	-0.8	-2.9	**-0.7**	**-3.1**	-0.8	-1.3	-0.6	-0.9
15-min ramp-down (cm/min)	-0.9	-3.0	-0.8	-3.0	**-0.8**	**-3.7**	-0.9	-1.7	-0.7	-1.3

Table G-14 and Figure G-8 show that the future maximum flow is similar to the current maximum flow under all flow conditions, but that the future minimum flow tends to be lower than the current minimum flow for normal to very wet conditions. As such, the change in flow range, i.e., the change in the amount of daily variation of flow, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

More generally however, it is also notable that the minimum flow is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall flow range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-14 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Flow Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Flow (m^3/s)	160	162	162	162	**163**	**162**	165	162	166	162
Minimum Flow (m^3/s)	12	11	12	11	**26**	**13**	57	40	76	62
Flow Range (m^3/s)	148	151	150	151	**138**	**149**	107	122	89	100



Normal

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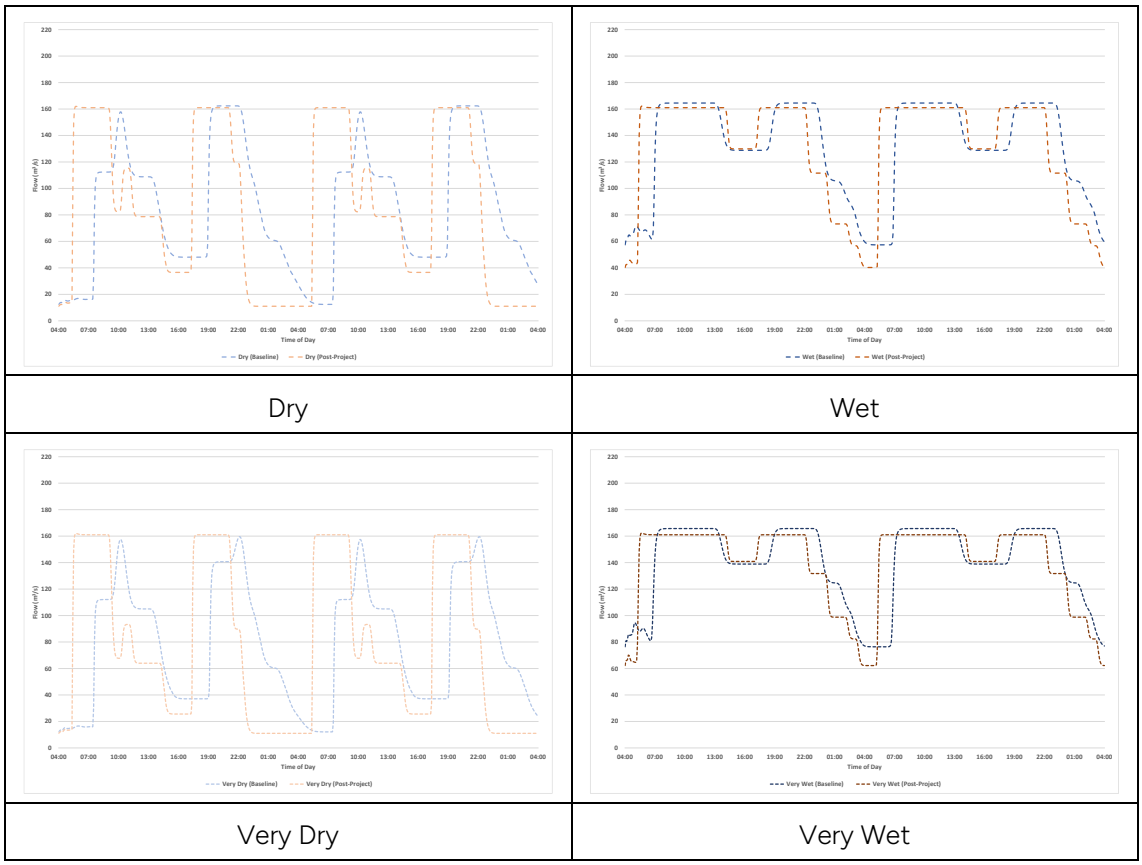

Figure G-8 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Flow Summary

Table G-15 and Figure G-9 show that the future maximum level (and hence depth) is similar to the current maximum level under all flow conditions, but that the future minimum level tends to be lower than the current minimum level for normal to very wet conditions. As such, the level range, i.e., the amount of daily water level variation, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the water level daily variation increases by 32 cm under normal conditions (from a daily variation of 1.49 m to 1.81 m) primarily due to the reduction in minimum water levels.

As with the flow conditions, the minimum elevation is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall elevation range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-15 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Level Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Elevation (mAOD)	947.55	947.57	947.57	947.57	**947.58**	**947.57**	947.59	947.57	947.60	947.57
Minimum Elevation (mAOD)	945.74	945.71	945.75	945.71	**946.09**	**945.76**	946.62	946.37	946.83	946.67
Elevation Range (m)	1.81	1.86	1.82	1.86	**1.49**	**1.81**	0.97	1.20	0.77	0.90

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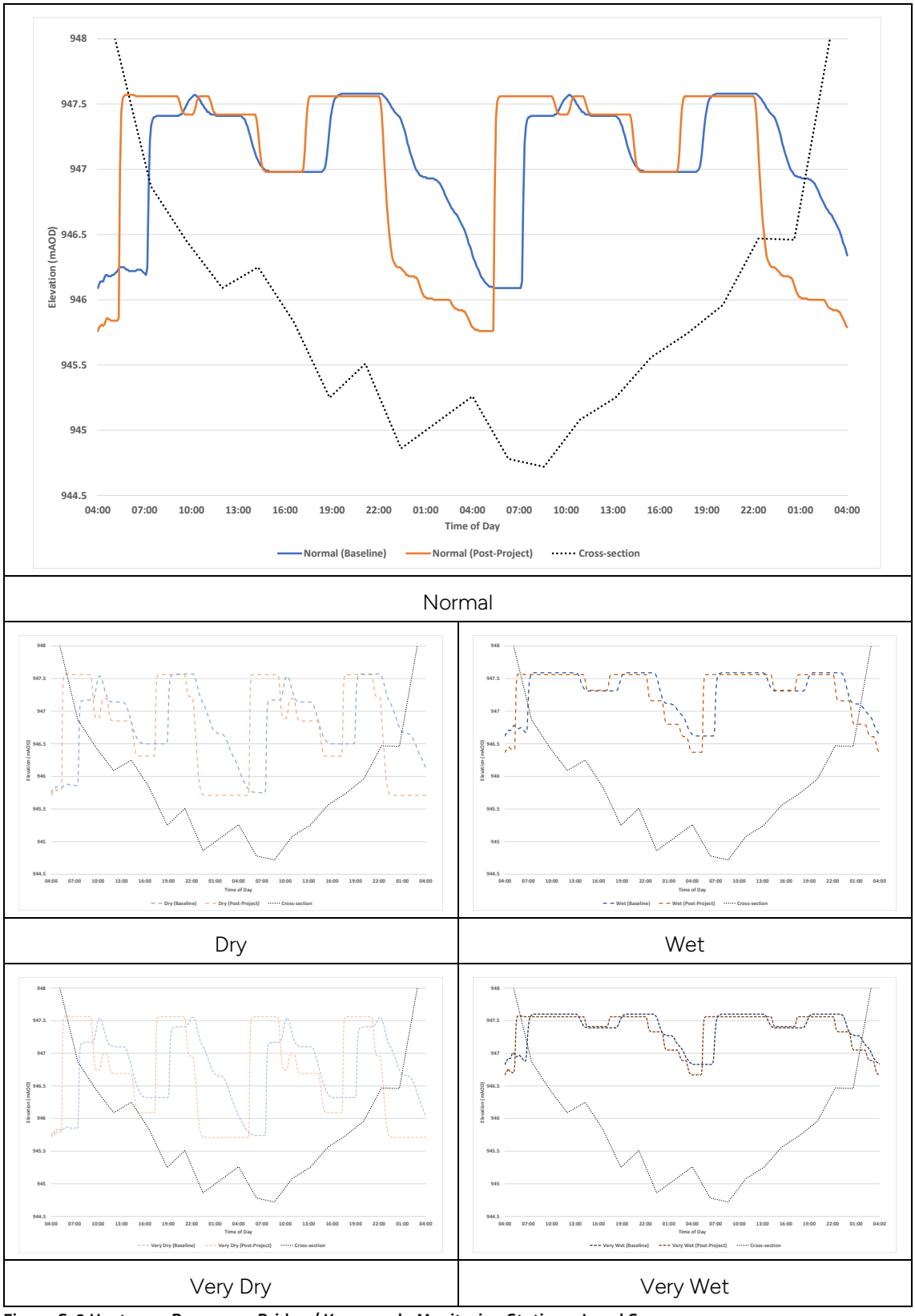

Figure G-9 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Level Summary

As with the flow and elevation variation, Table G-16 and Figure G-9 show that the future maximum velocity is similar to the current maximum velocity under all flow conditions, but that the future minimum velocity tends to be lower than the current minimum velocity for normal to very wet conditions. As such, the velocity range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

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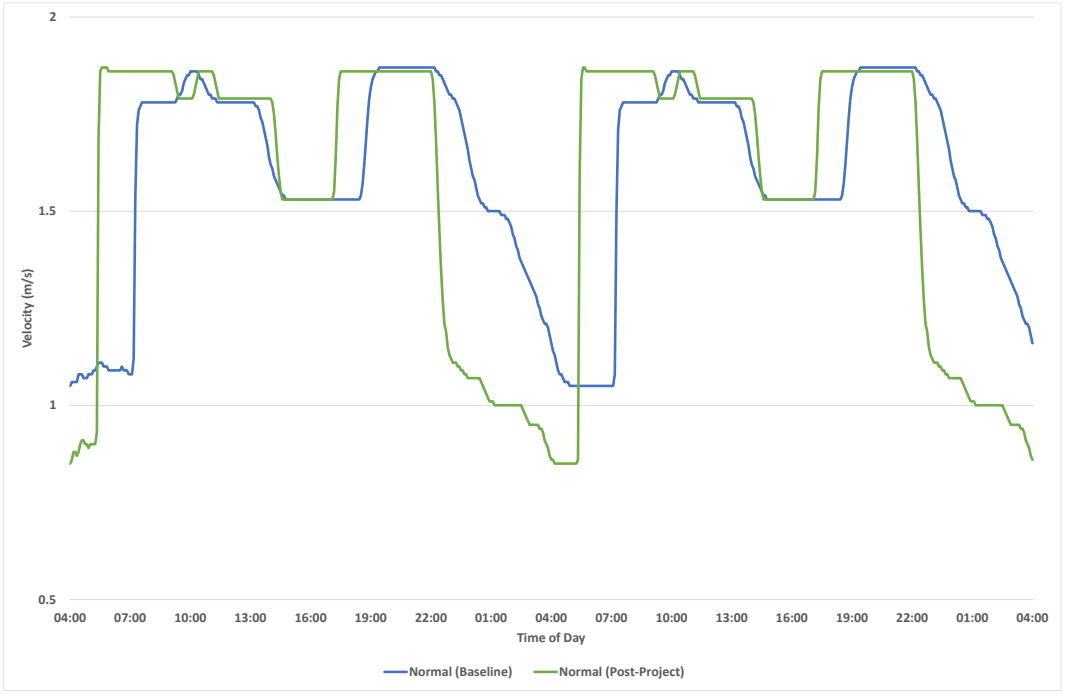
For example, the velocity daily variation increases by 0.20 m/s under normal conditions (from a daily variation of 0.82 m to 1.02 m) due to the reduction in minimum velocity.

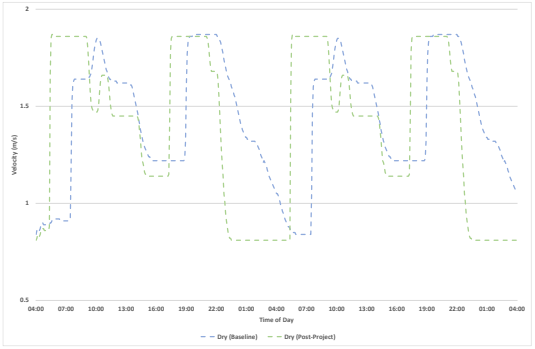
The minimum velocity is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall velocity range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-16 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Velocity Summary

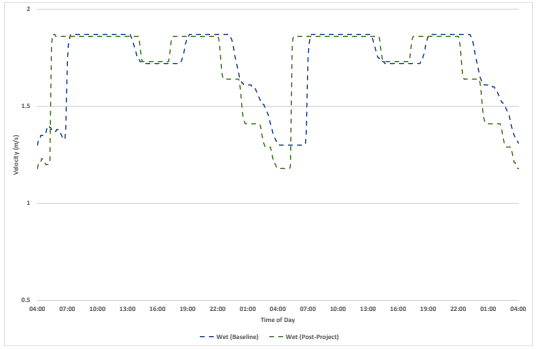
	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Velocity (m/s)	1.86	1.87	1.87	1.87	**1.87**	**1.87**	1.87	1.87	1.88	1.87
Minimum Velocity (m/s)	0.83	0.81	0.84	0.81	**1.05**	**0.85**	1.30	1.18	1.43	1.33
Velocity Range (m/s)	1.03	1.06	1.03	1.06	**0.82**	**1.02**	0.57	0.69	0.45	0.54



Normal



Dry



Wet

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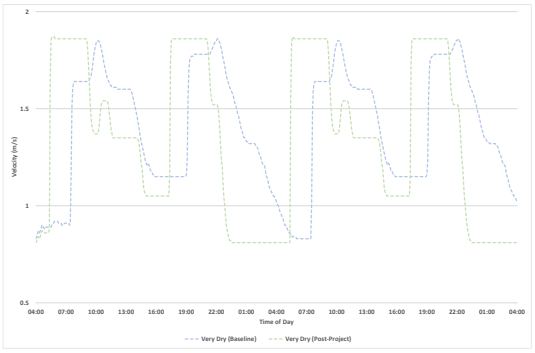
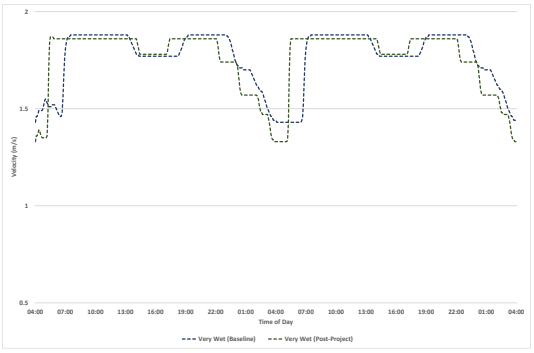


Very Dry



Very Wet

Figure G-10 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Velocity Summary

Table G-17 and Figure G-11 show the maximum, minimum, and daily range in wetted cross-section area, providing an indication of the overall habitat area available. As with the other hydrological and hydraulic characteristics presented, the future maximum area is similar to the current maximum area under all flow conditions, but that the future minimum area tends to be lower than the current minimum area for normal to very wet conditions. As such, the area range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the area daily variation increases by 11.1 m^2 in the normal conditions (from a daily variation of 62.8 m^2 to 71.7 m^2) due to the reduction in minimum area.

The minimum area is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall area range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-17 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Cross-section Area Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Area (m^2)	86.0	86.8	87.0	86.8	**87.3**	**86.8**	87.8	86.9	88.2	86.9
Minimum Area (m^2)	14.5	13.6	14.8	13.6	**24.4**	**15.1**	44.3	34.2	53.3	46.6
Area Range (m^2)	71.5	73.2	72.2	73.2	**62.8**	**71.7**	43.5	52.7	34.9	40.3

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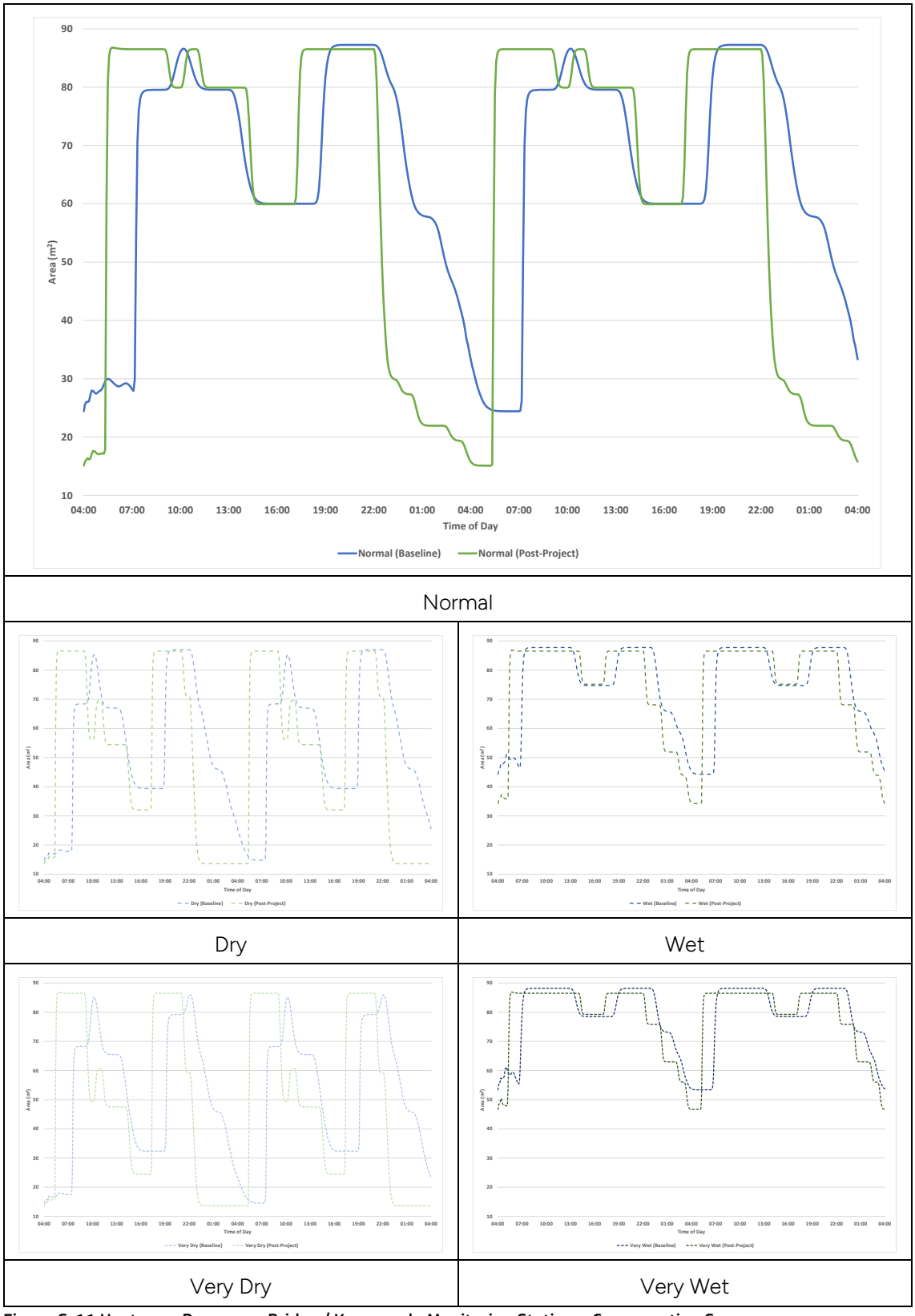

Figure G-11 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Cross-section Summary

Table G-18 provides a summary of the average vertical ramp-up rates and ramp-down rates experienced over different critical durations.

It can be seen that both the ramp-up and ramp-down rates are greatest for both the current and future scenarios over the shorter 15-minute duration, i.e., the changes in water level tend to occur over very short periods of time. Ramp up rates tend to be higher than ramp-down rates.

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It is also notable that vertical ramp-up rates tend to be higher in the very dry to normal conditions than they are in the wet to very conditions, in large part reflecting the greater changes in flow and levels experienced in these conditions. It is also notable that future ramp-up and ramp-down rates tend to be greater than current ramp-up and ramp-down rates. This is a reflection of the operating conditions for Ruzizi III where it is understood that operation changes between "off-peaking" and "peaking" will be quicker than they currently are at Ruzizi II.

Table G-18 Upstream Bugarama Bridge / Kamanyola Monitoring Station – Ramp-up & Ramp-down rates Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Ramp-Up Summary										
60-min ramp-up (cm/min)	2.4	3.1	2.4	3.1	2.2	3.0	1.6	2.0	1.3	1.5
30-min ramp-up (cm/min)	4.7	6.2	4.7	6.2	4.4	6.0	3.0	4.0	2.2	2.9
15-min ramp-up (cm/min)	8.7	12.1	8.7	12.1	7.9	11.7	4.8	7.4	3.1	4.9
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.7	-2.0	-0.7	-2.3	-0.7	-2.1	-0.7	-0.7	-0.5	-0.5
30-min ramp-down (cm/min)	-0.8	-2.5	-0.8	-2.9	-0.7	-3.1	-0.8	-1.3	-0.6	-0.9
15-min ramp-down (cm/min)	-0.9	-3.0	-0.8	-3.0	-0.8	-3.7	-0.9	-1.7	-0.7	-1.3

B Geomophological, Ecological and Social Context

[This section is intentionally left blank].

C Indicators Linked to Hydrological and Hydraulic Characteristics

Table G-19 provides and overall summary of the ecological and social functional relationship with hydrological and hydraulic characteristics upstream Bugarama Bridge / Kamanyola Monitoring Station.

The change in hydrological and hydraulic characteristics are predicted to result in significant increase in social community safety impacts (due to increased ramp-up rates).

Table G-19 Summary of Ecological and Social Functional Relationship / Impacts at Upstream Bugarama Bridge / Kamanyola Monitoring Station

Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Geomorphology			
Increased channel erosion The channel is largely composed of large immobile clasts, calcrete or bedrock. This makes the channel bed resistant to incision. Hydro peaking and reductions in longitudinal sediment connectivity has resulted in possible bed erosion and bed armouring.	Flow	Moderate FR/I	Frequent and high amplitude changes in flow (shear stress) are likely to drive bed erosion, but the bed is stable, so no significant changes are expected. Possibly some localised erosion of mobile gravel and sand bars.
	Elevation / Depth	Moderate FR/I	As above
	Velocity	Moderate FR/I	As above
	Area	Minor FR/I	As above
	Ramping Rates	No / Insignificant FR/I	No adverse effect envisaged.

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Increased sedimentation in channel Due to the reduced sediment supply downstream of the dam, and the increase in the frequency of high energy flows, it is unlikely that sedimentation will take place. Localised sedimentation might take place in slack waters.	Flow	Moderate FR/I	Reduction in sedimentation due to the frequent high energy flows.
	Elevation / Depth	Moderate FR/I	As above
	Velocity	Moderate FR/I	As above
	Area	Minor FR/I	As above
	Ramping Rates	No / Insignificant FR/I	No nett increase in sedimentation due to changes in ramping rate.
Bank erosion The banks are largely composed of boulders and cobbles with a finer gravel, sand and silt matrix. The banks are not steep or high and relatively stable and immobile. The banks have been exposed to hydropeaking for decades, thus bank erosion might have stabilised over time.	Flow	Moderate FR/I	Possible localised erosion of finer bank material.
	Elevation / Depth	Moderate FR/I	Increased water depth is unlikely to accelerate bank erosion. Some localised bank slumping might occur due to higher elevation of bank wetting.
	Velocity	Moderate FR/I	High flow velocities could increase fluvial erosion of the finer material along the banks, but this is expected to be localised.
	Area	No / Insignificant FR/I	
	Ramping Rates	Minor FR/I	Fast changes in water level could drive localised bank slumping as the banks are wetted during high flows, Subsequent lowering of the water level leads to hydraulic head and pressure to build up in the bank matrix, increasing the chances of mass failure of the fine bank material. As the banks are largely low angled, low in height and course in nature it is unlikely to increase bank erosion along most of the reach.
Aquatic Ecology			
Non-migratory fish: abundance and diversity Lotic riffle-rapid fish guild.	Flow		
	Elevation / Depth	Minor FR/I	Sub-daily depth fluctuations risk dewatering riffle-rapid habitats leading to mortality of fishes living in these areas. Shallower minimum depths during the ramp-down phase in a future hydropeaking scenario will increase the risks of this occurring. The change from present day is expected to produce a minor detectable change in the fish community due to the existing hydropeaking effects.
	Velocity	Minor FR/I	Sub-daily variations in velocities reduce the interstitial delivery of well-oxygenated water through bed elements during the down-ramping phase. Lower dissolved oxygen concentrations may impair growth and development of eggs and larvae and cause stress for adult fish in this guild. The change from present day is expected to produce a minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Area	Minor FR/I	The total available area of habitat controls the size of fish populations

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			living in any reach. Hydropeaking will effectively reduce the liveable aquatic habitat to the minimum flow present in the river during the ramp-down phase. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Ramping Rates	Minor FR/I	Both present day and future ramp-down rates exceed recommended maximum rate of -0.15 cm/m that leads to a high risk of stranding and entrapment. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
Migratory fish: abundance and diversity Lotic lithophilic fish guild.	Flow		
	Elevation / Depth	Minor FR/I	Sub-daily variation in depths lead to dewatering of shallows particularly of juvenile fish in this guild seeking cover and feeding opportunities in marginal slack water habitats. Shallower minimum depths during the ramp-down phase in a future hydropeaking scenario will increase the risks of this occurring. The change from present day is expected to produce a minor detectable change in the fish community due to the existing hydropeaking effects.
	Velocity	Minor FR/I	Increased velocities during up-ramping displace juvenile and adult fish in this guild into the main channel where they will be subject to higher predation rates and reduced feeding opportunities. Sudden unseasonal increases in velocities will disrupt migration and spawning and contribute to additional swimming costs over the migration period. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Area	Minor FR/I	The total available area of habitat controls the size of fish populations living in any reach. Hydropeaking will effectively reduce the liveable aquatic habitat to the minimum flow present in the river during the ramp-down phase. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Ramping Rates	Minor FR/I	Both present day and future ramp-down rates exceed recommended maximum rate of -0.15 cm/m that

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			leads to a high risk of stranding and entrapment. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
Macro-invertebrates: abundance and diversity These are expected to remain unchanged compared to the current operation because of the large variation in daily and sub-daily water levels.	Flow	Minor FR/I	Outside normal operation, periodic flushing of sediments could impact negatively on aquatic macro-invertebrates in this reach, but such flushing is likely to occur infrequently and after several years of operation.
	Elevation / Depth	No / Insignificant FR/I	Conditions in the reach will not be significantly different from present to detect a measurable change in the macro-invertebrate community.
	Velocity	No / Insignificant FR/I	As above
	Area	No / Insignificant FR/I	None of the wetted area above the current and future minimum water level is inundated long enough for aquatic macro-invertebrates to colonise.
	Ramping Rates	N/A	N/A. Ramping rates are irrelevant to macro-invertebrates because they are essentially sedentary and respond to the absolute change in hydraulic conditions, but not the rate of change.
Terrestrial Ecology			
Riparian vegetation: abundance and diversity Even though this reach of the Ruzizi River is in a densely settled area, there is slightly more Riparian Wetland habitat than along the previous reach, mostly on scattered islands but also occasionally in narrow strips along riverbanks. Riparian Thicket is poorly represented. Riparian Wetlands have species that are dependent on a wet bank and are thus likely to be impacted by changes in depth and area of the river result in changes to the availability of a wet bank.	Flow	No / Insignificant FR/I	Flows will be much the same as the baseline during peak flows and up to 70% of the baseline during off peak flows. It is unlikely that the project-related changes to flow will have any significant impacts on riparian vegetation.
	Elevation / Depth	No / Insignificant FR/I	Water levels during peak flows will be very similar to baseline situation, whereas off peak levels will be 30 cm lower in a normal year. It is unlikely that the minor project-related changes to depth will have any significant impacts on maintenance of riparian vegetation in this reach of the river.
	Velocity	No / Insignificant FR/I	Velocity will be much the same as the baseline during peak flows and up to 70% of the baseline during off peak flows. It is unlikely that the project-related changes to flow will have any significant impacts on riparian vegetation.
	Area	No / Insignificant FR/I	Extent of wetted area is likely to be similar to the current baseline in a normal year during peak times, and less during off speak flows, where levels will drop to 30 cm lower than baseline. It is unlikely that the minor project-related changes to wetted area will have any significant impacts on maintenance of riparian vegetation in this reach of the river.

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
	Ramping Rates	No / Insignificant FR/I	Ramp-up and ramp down rates will be shorter than baseline situation. But this is unlikely to have a significant effect on riparian vegetation.
Riparian fauna: abundance and diversity The riparian avifauna, mammal and herpetofauna assemblages have higher species richness in this reach compared to upstream reaches. The species composition of the faunal assemblage is currently dominated by widespread habitat generalists and overall species richness is low. Changes in flow, depth and velocity will have a negligible impact on riparian fauna species. The small population of Hippopotamus that is resident along this reach is unlikely to be impacted by minor changes in flow, depth, velocity, area, and ramping rates.	Flow	No / Insignificant FR/I	Flows will be much the same as the baseline during peak flows and up to 70% of the baseline during off peak flows. It is unlikely that the project-related changes to flow will have any significant impacts on the riparian faunal assemblage, which is already species-poor as a result of extensive habitat modification.
	Elevation / Depth	No / Insignificant FR/I	Water levels during peak flows will be very similar to baseline situation, whereas off peak levels will be 30 cm lower in a normal year. It is unlikely that the minor project-related changes to depth will impact on available foraging habitat for riparian fauna, including Hippo.
	Velocity	No / Insignificant FR/I	Velocity will be much the same as the baseline during peak flows and up to 70% of the baseline during off peak flows. It is unlikely that the project-related changes to flow will have any significant impacts on the accessibility of the fish and invertebrate prey base compared to the current situation, result in a negligible impact on riparian fauna.
	Area	No / Insignificant FR/I	Extent of wetted area is likely to be similar to the current baseline in a normal year during peak times, and less during off speak flows, where levels will drop to 30 cm lower than baseline. It is unlikely that the minor project-related changes to wetted area will have any significant impacts on the amount of foraging and breeding habitat for riparian fauna in this reach of the river, including Hippo.
	Ramping Rates	No / Insignificant FR/I	Ramp-up and ramp down rates will be shorter than the baseline situation. But given the fact that the majority of the riparian fauna are highly mobile, this is unlikely to have a significant effect on riparian fauna.
Social			
Consumptive Water Use Local communities in this stretch are currently using the river for domestic and drinking water supply. Social reliance on the river for consumptive water use is high.	Flow	No / Insignificant FR/I	No discernible change on the availability of, and access to, consumptive water use by local communities, as conditions will not be significantly different from the ones observed at present.
	Elevation / Depth	No / Insignificant FR/I	As above
	Velocity	No / Insignificant FR/I	As above
	Area	No / Insignificant FR/I	As above
	Ramping Rates	No / Insignificant FR/I	As above

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Non-Consumptive Water Use: Fishing Local communities are currently fishing regularly in this stretch.	Flow	No / Insignificant FR/I	Insignificant impact on fishing activities due to non-discernible effects on fish population (refer to Aquatic Ecology section).
	Elevation / Depth	No / Insignificant FR/I	As above
	Velocity	No / Insignificant FR/I	As above
	Area	Moderate FR/I	Critical ramp-down rates are expected to be exceeded during future operations in dry and normal conditions, increasing the danger of fish stranding which could threaten the quantity of fish available for fishing.
Community Safety Local communities cross the river regularly in this stretch. Additionally, villagers are physically entering the river on a regular basis for recreational purposes, and medicinal / spiritual practices. Social exposure to hazards due to the river's flow and velocity are high.	Flow	Minor FR/I	Minor changes from current conditions, as the flow and elevation are already influenced by the operation of Ruzizi II.
	Elevation / Depth	Minor FR/I	As above
	Velocity	Significant FR/I	Higher velocity may result in significant hazards for community safety.
	Area	N/A	N/A
	Ramping Rates	Significant FR/I	Critical ramp-up rates will be exceeded in very dry to wet conditions in the short term and are expected to be exceeded in dry to normal conditions in future operation. This may mean that ramp-up rates will be higher for around 6 months at first, and around 10 months in the long run. This is likely to have a strong impact on community safety when entering and crossing the river.

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G.2.2.4 Upstream Rubyiro tributary to Downstream Burundi Border/Ruhwa Tributary

A Hydrological and Hydraulic Characteristics

A.1 Upstream Rubyiro Tributary

Table G-20 provides an overall summary of the key modelled hydrological and hydraulic characteristics for this reach. Characteristics are presented for a range of hydrological conditions and for the baseline and future (post project) conditions. The 'normal' hydrological conditions results are highlighted for clarity. Key attributes of hydrological and hydraulic characteristics are discussed for each characteristic in turn. [6]

Table G-20 Upstream Rubyiro Tributary – Hydrology and Hydraulics Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Flow Summary										
Maximum Flow (m^3/s)	158	161	162	161	**163**	**161**	165	161	166	161
Minimum Flow (m^3/s)	12	11	12	11	**26**	**13**	57	40	76	62
Flow Range (m^3/s)	146	150	150	150	**138**	**148**	107	121	89	99
Elevation Summary										
Maximum Elevation (mAOD)	929.80	929.83	929.84	929.83	**929.84**	**929.83**	929.86	929.83	929.87	929.83
Minimum Elevation (mAOD)	927.82	927.77	927.83	927.77	**928.21**	**927.84**	928.77	928.51	929.01	928.83
Elevation Range (m)	1.98	2.06	2.01	2.06	**1.63**	**1.99**	1.09	1.32	0.86	1.00
Velocity Summary										
Maximum Velocity (m/s)	1.63	1.64	1.65	1.64	**1.65**	**1.64**	1.65	1.64	1.66	1.64
Minimum Velocity (m/s)	0.61	0.60	0.61	0.60	**0.79**	**0.62**	1.07	0.93	1.20	1.10
Velocity Range (m/s)	1.02	1.04	1.04	1.04	**0.86**	**1.02**	0.58	0.71	0.46	0.54
Cross-section Area Summary										
Maximum Area (m^2)	97.2	98.2	98.7	98.2	**98.9**	**98.3**	99.5	98.4	100.0	98.4
Minimum Area (m^2)	19.8	18.4	20.1	18.4	**32.5**	**20.6**	53.7	43.3	63.5	56.3
Area Range (m^2)	77.4	79.8	78.5	79.8	**66.4**	**77.6**	45.8	55.0	36.5	42.1
Ramp-Up Summary										
60-min ramp-up (cm/min)	2.6	3.4	2.6	3.4	**2.4**	**3.3**	1.8	2.2	1.4	1.7
30-min ramp-up (cm/min)	5.1	6.8	5.1	6.8	**4.7**	**6.6**	3.3	4.3	2.4	3.1

[6] Ramp-up and ramp-down statistics are presented for three separate durations – 60 minutes, 30 minutes, and 15 minutes. The rates presented are the average rates that occur over each of these durations, and thus give an indication of the magnitude and duration of the change.

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15-min ramp-up (cm/min)	8.9	12.7	9.0	12.7	**7.6**	**12.0**	4.6	7.1	3.1	4.7
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.7	-1.5	-0.7	-1.8	**-0.7**	**-2.0**	-0.7	-0.7	-0.5	-0.5
30-min ramp-down (cm/min)	-0.8	-2.1	-0.8	-1.9	**-0.8**	**-2.4**	-0.8	-1.2	-0.6	-0.8
15-min ramp-down (cm/min)	-0.8	-2.3	-0.8	-2.1	**-0.8**	**-2.6**	-0.8	-1.3	-0.8	-1.0

Table G-21 and Figure G-12 show that the future maximum flow is similar to the current maximum flow under all flow conditions, but that the future minimum flow tends to be lower than the current minimum flow for normal to very wet conditions. As such, the change in flow range, i.e., the change in the amount of daily variation of flow, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

More generally however, it is also notable that the minimum flow is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall flow range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-21 Upstream Rubyiro Tributary – Flow Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Flow (m^3/s)	158	161	162	161	**163**	**161**	165	161	166	161
Minimum Flow (m^3/s)	12	11	12	11	**26**	**13**	57	40	76	62
Flow Range (m^3/s)	146	150	150	150	**138**	**148**	107	121	89	99

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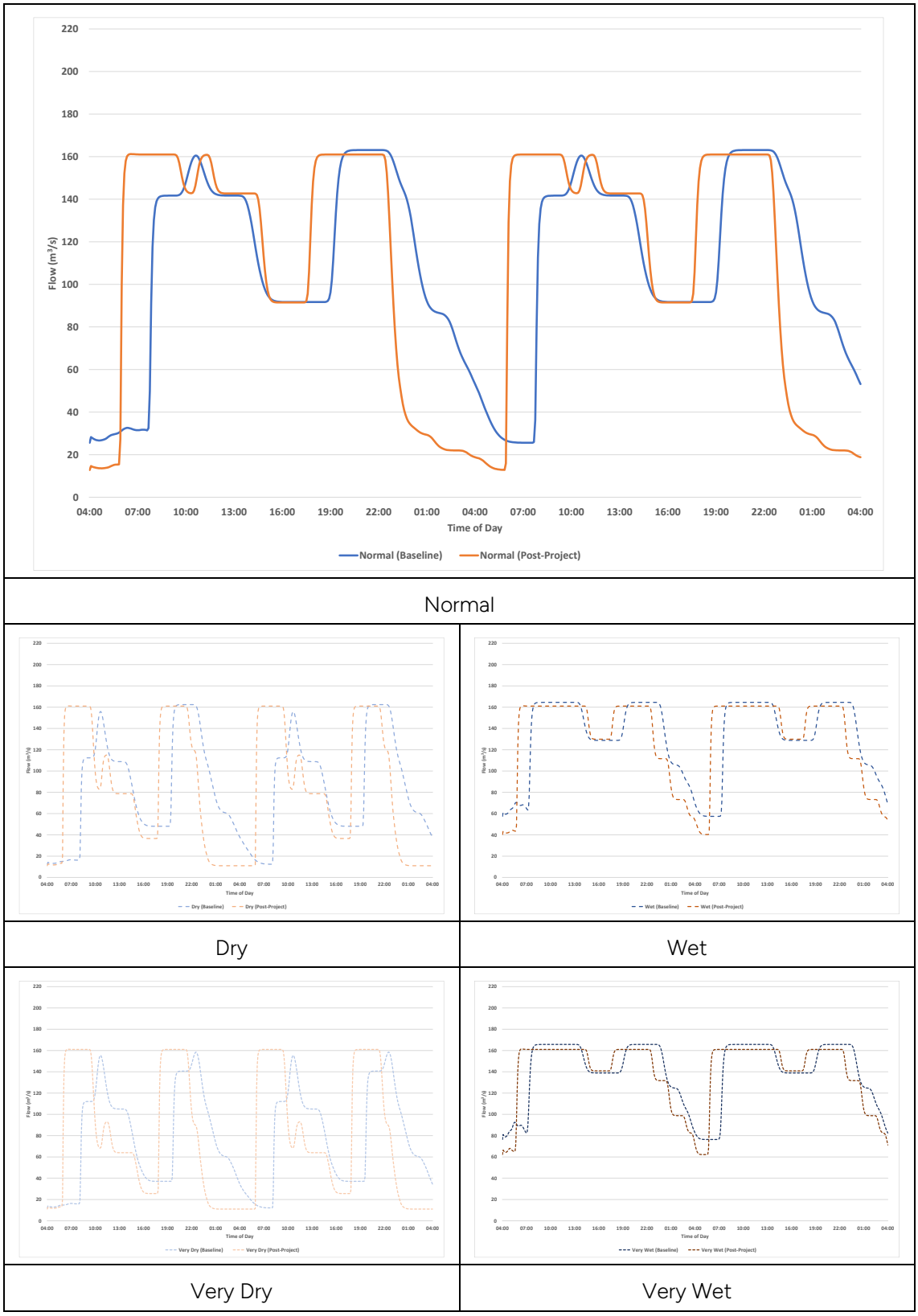

Figure G-12 Upstream Rubyiro Tributary – Flow Summary

Table G-22 and Figure G-13 show that the future maximum level (and hence depth) is similar to the current maximum level under all flow conditions, but that the future minimum level tends to be lower than the current minimum level for normal to very wet conditions. As such, the level range, i.e., the amount of daily water level variation, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

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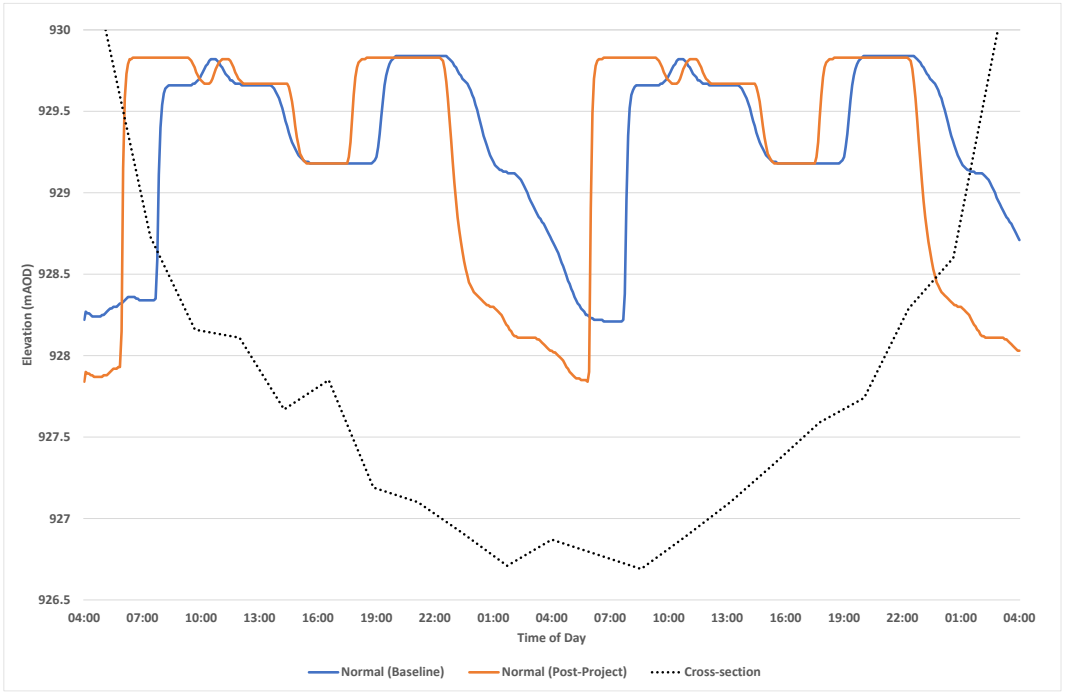
For example, the water level daily variation increases by 36 cm under normal conditions (from a daily variation of 1.63 m to 1.99 m) primarily due to the reduction in minimum water levels.

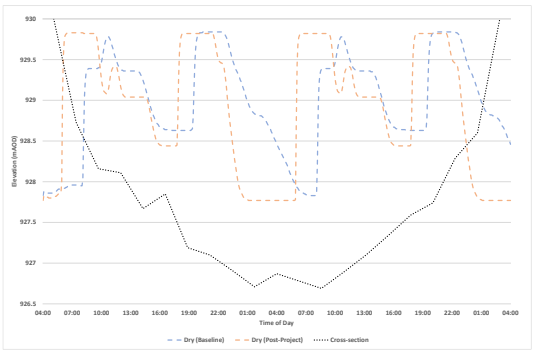
As with the flow conditions, the minimum elevation is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall elevation range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-22 Upstream Rubyiro Tributary – Level Summary

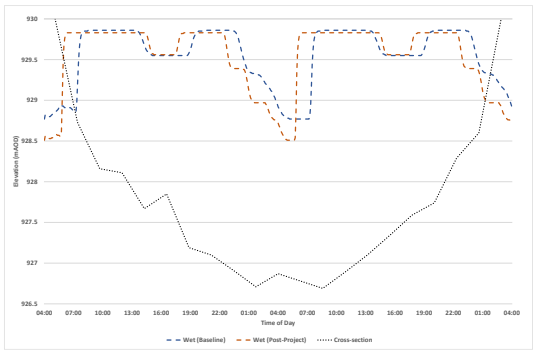
	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Elevation (mAOD)	929.80	929.83	929.84	929.83	**929.84**	**929.83**	929.86	929.83	929.87	929.83
Minimum Elevation (mAOD)	927.82	927.77	927.83	927.77	**928.21**	**927.84**	928.77	928.51	929.01	928.83
Elevation Range (m)	1.98	2.06	2.01	2.06	**1.63**	**1.99**	1.09	1.32	0.86	1.00



Norma



Dry



Wet

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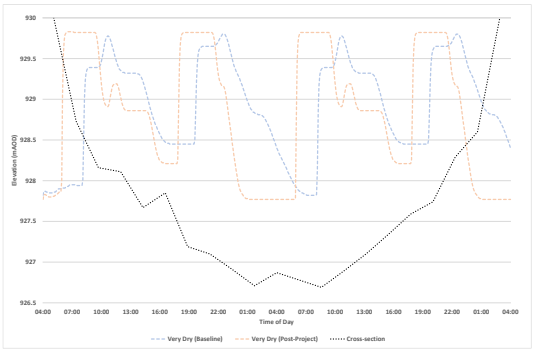
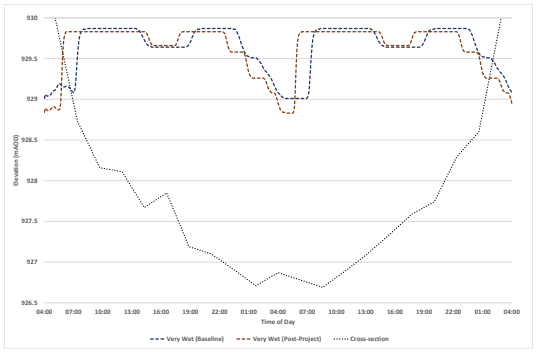


Very Dry



Very Wet

Figure G-13 Upstream Rubyiro Tributary – Level Summary

As with the flow and elevation variation, Table G-23 and Figure G-10 show that the future maximum velocity is similar to the current maximum velocity under all flow conditions, but that the future minimum velocity tends to be lower than the current minimum velocity for normal to very wet conditions. As such, the velocity range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the velocity daily variation increases by 0.16 m/s under normal conditions (from a daily variation of 0.86 m to 1.02 m) due to the reduction in minimum velocity.

The minimum velocity is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall velocity range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-23 Upstream Rubyiro Tributary – Velocity Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Velocity (m/s)	1.63	1.64	1.65	1.64	**1.65**	**1.64**	1.65	1.64	1.66	1.64
Minimum Velocity (m/s)	0.61	0.60	0.61	0.60	**0.79**	**0.62**	1.07	0.93	1.20	1.10
Velocity Range (m/s)	1.02	1.04	1.04	1.04	**0.86**	**1.02**	0.58	0.71	0.46	0.54

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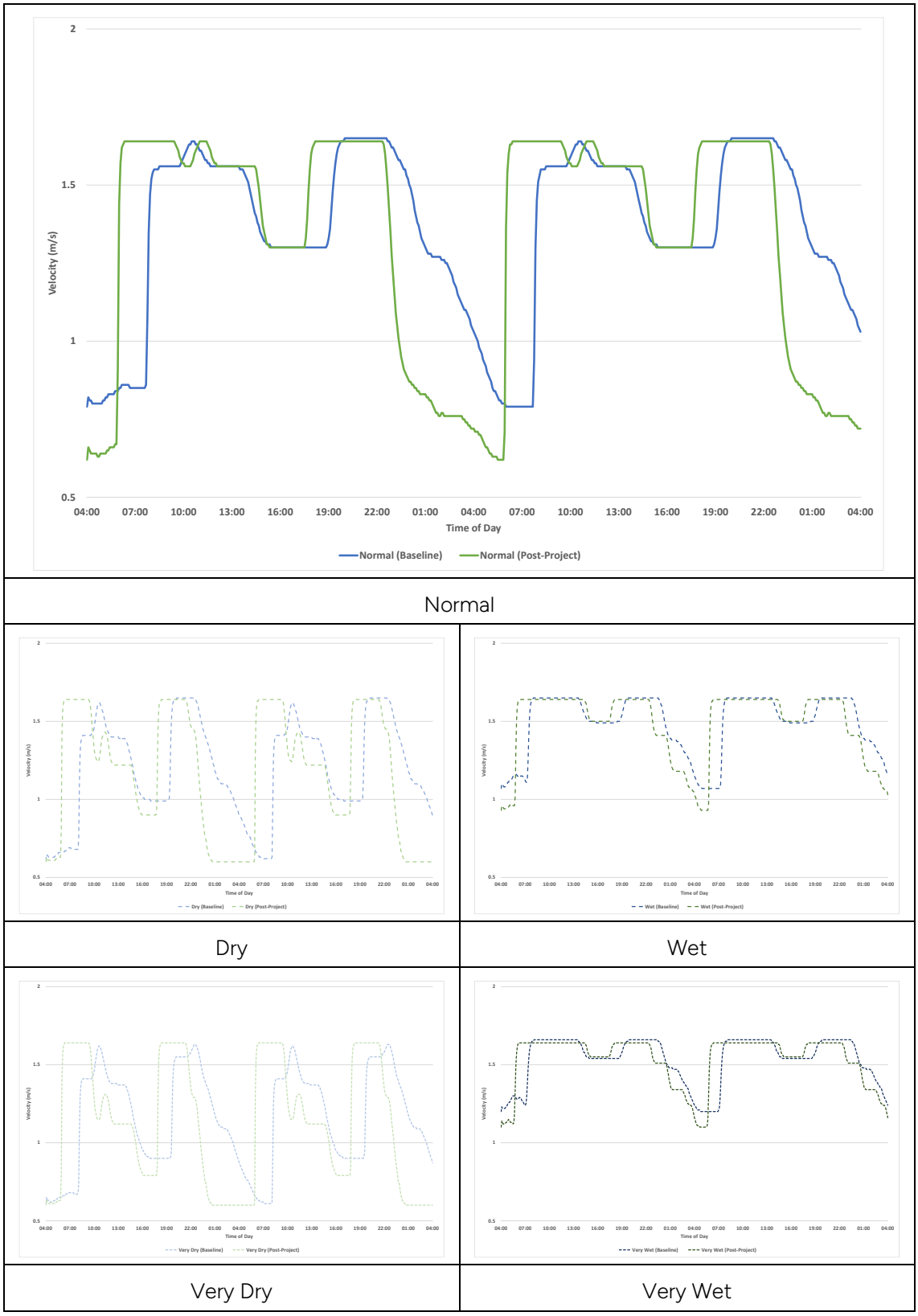

Figure G-14 Upstream Rubyiro Tributary – Velocity Summary

Table G-24 and Figure G-15 show the maximum, minimum, and daily range in wetted cross-section area, providing an indication of the overall habitat area available. As with the other hydrological and hydraulic characteristics presented, the future maximum area is similar to the current maximum area under all flow conditions, but that the future minimum area tends to be

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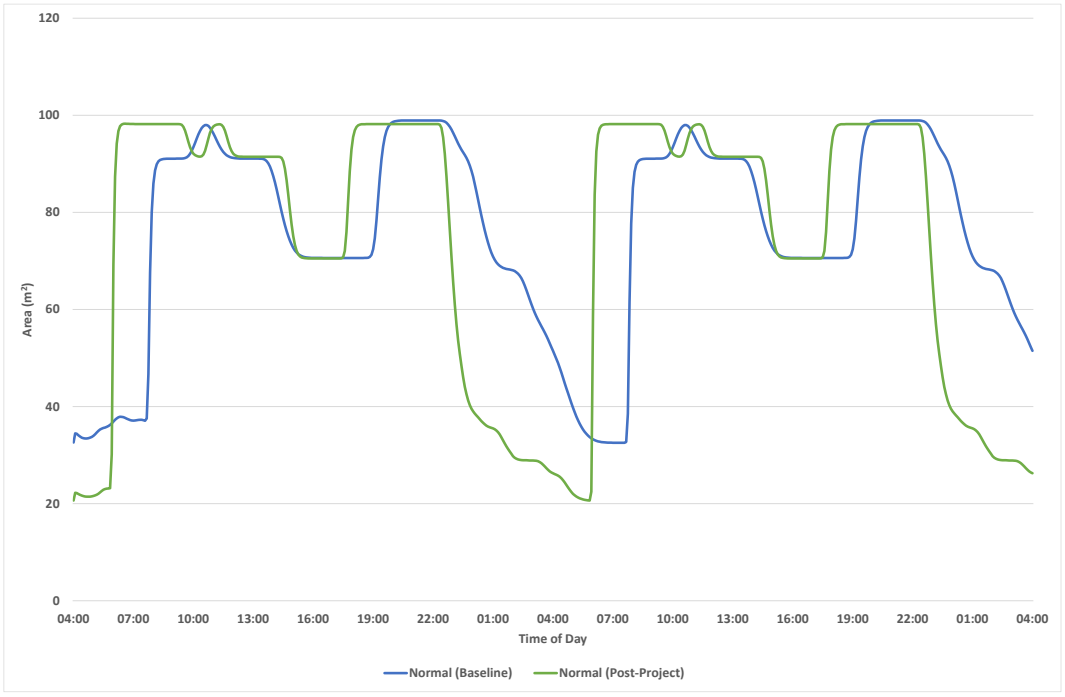
lower than the current minimum area for normal to very wet conditions. As such, the area range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the area daily variation increases by 11.2 m^2 in the normal conditions (from a daily variation of 66.4 m^2 to 77.6 m^2) due to the reduction in minimum area.

The minimum area is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall area range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-24 Upstream Rubyiro Tributary – Cross-section Area Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Area (m^2)	97.2	98.2	98.7	98.2	**98.9**	**98.3**	99.5	98.4	100.0	98.4
Minimum Area (m^2)	19.8	18.4	20.1	18.4	**32.5**	**20.6**	53.7	43.3	63.5	56.3
Area Range (m^2)	77.4	79.8	78.5	79.8	**66.4**	**77.6**	45.8	55.0	36.5	42.1



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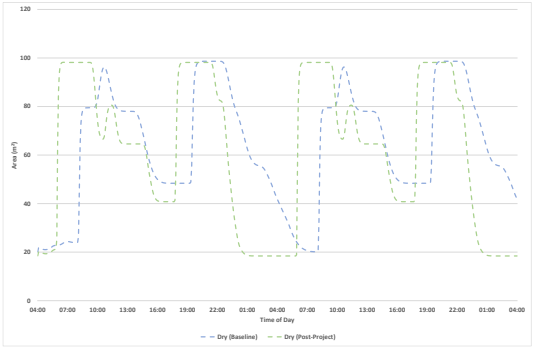
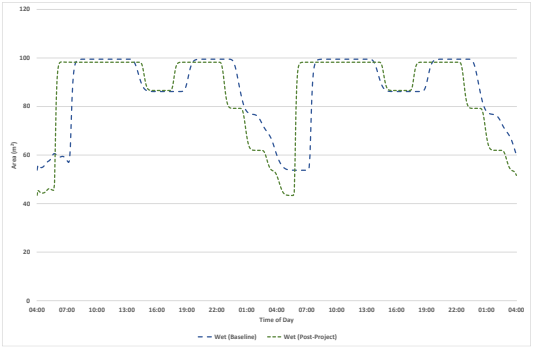


Dry



Wet

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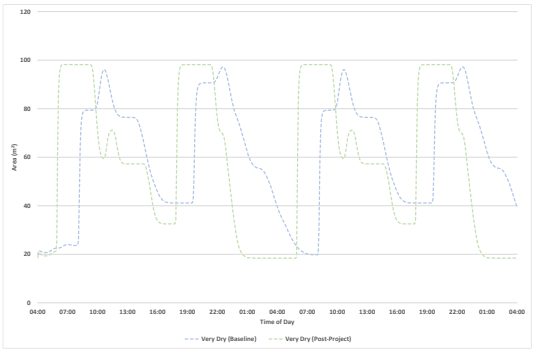
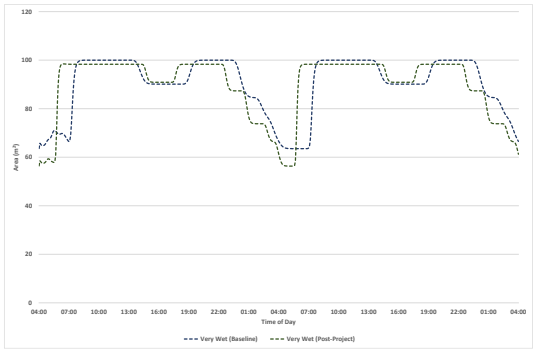


Very Dry



Very Wet

Figure G-15 Upstream Rubyiro Tributary – Cross-section Summary

Table G-25 provides a summary of the average vertical ramp-up rates and ramp-down rates experienced over different critical durations.

It can be seen that both the ramp-up and ramp-down rates are greatest for both the current and future scenarios over the shorter 15-minute duration, i.e., the changes in water level tend to occur over very short periods of time. Ramp up rates tend to be higher than ramp-down rates.

It is also notable that vertical ramp-up rates tend to be higher in the very dry to normal conditions than they are in the wet to very conditions, in large part reflecting the greater changes in flow and levels experienced in these conditions. It is also notable that future ramp-up and ramp-down rates tend to be greater than current ramp-up and ramp-down rates. This is a reflection of the operating conditions for Ruzizi III where it is understood that operation changes between "off-peaking" and "peaking" will be quicker than they currently are at Ruzizi II.

Table G-25 Upstream Rubyiro Tributary – Ramp-up and Ramp-down Rates Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Ramp-Up Summary										
60-min ramp-up (cm/min)	2.6	3.4	2.6	3.4	**2.4**	**3.3**	1.8	2.2	1.4	1.7
30-min ramp-up (cm/min)	5.1	6.8	5.1	6.8	**4.7**	**6.6**	3.3	4.3	2.4	3.1
15-min ramp-up (cm/min)	8.9	12.7	9.0	12.7	**7.6**	**12.0**	4.6	7.1	3.1	4.7
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.7	-1.5	-0.7	-1.8	**-0.7**	**-2.0**	-0.7	-0.7	-0.5	-0.5
30-min ramp-down (cm/min)	-0.8	-2.1	-0.8	-1.9	**-0.8**	**-2.4**	-0.8	-1.2	-0.6	-0.8
15-min ramp-down (cm/min)	-0.8	-2.3	-0.8	-2.1	**-0.8**	**-2.6**	-0.8	-1.3	-0.8	-1.0

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A.2 Upstream Burundi border / Ruhwa tributary

Table G-26 provides an overall summary of the key modelled hydrological and hydraulic characteristics for this reach. Characteristics are presented for a range of hydrological conditions and for the baseline and future (post project) conditions. The 'normal' hydrological conditions results are highlighted for clarity. Key attributes of hydrological and hydraulic characteristics are discussed for each characteristic in turn.

Table G-26 Upstream Burundi Border / Ruhwa Tributary – Hydrology and Hydraulics Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Flow Summary										
Maximum Flow (m^3/s)	162	165	167	166	**170**	**168**	176	173	181	176
Minimum Flow (m^3/s)	16	15	17	16	**33**	**20**	69	52	91	77
Flow Range (m^3/s)	146	150	150	150	**138**	**148**	107	121	89	99
Elevation Summary										
Maximum Elevation (mAOD)	920.01	920.02	920.03	920.02	**920.04**	**920.03**	920.07	920.06	920.09	920.07
Minimum Elevation (mAOD)	918.81	918.79	918.83	918.81	**919.06**	**918.87**	919.41	919.27	919.58	919.46
Elevation Range (m)	1.20	1.23	1.20	1.21	**0.98**	**1.16**	0.66	0.79	0.51	0.58
Velocity Summary										
Maximum Velocity (m/s)	2.30	2.32	2.33	2.32	**2.34**	**2.33**	2.37	2.35	2.39	2.37
Minimum Velocity (m/s)	1.15	1.12	1.17	1.14	**1.40**	**1.23**	1.74	1.59	1.88	1.77
Velocity Range (m/s)	1.15	1.20	1.16	1.18	**0.94**	**1.10**	0.63	0.76	0.51	0.60
Cross-section Area Summary										
Maximum Area (m^2)	70.5	71.3	71.9	71.6	**72.7**	**72.1**	74.2	73.3	75.5	74.3
Minimum Area (m^2)	13.7	13.1	14.4	13.6	**22.7**	**15.8**	38.1	31.6	47.2	42.3
Area Range (m^2)	56.8	58.2	57.5	57.9	**50.0**	**56.4**	36.1	41.7	28.3	32.0
Ramp-Up Summary										
60-min ramp-up (cm/min)	1.6	2.0	1.6	2.0	**1.4**	**1.9**	1.1	1.3	0.8	0.9
30-min ramp-up (cm/min)	3.1	4.0	3.1	4.0	**2.8**	**3.8**	1.9	2.5	1.3	1.8
15-min ramp-up (cm/min)	5.7	7.5	5.7	7.4	**5.0**	**7.1**	2.7	4.3	1.7	2.5
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.5	-0.8	-0.4	-1.0	**-0.4**	**-1.1**	-0.4	-0.4	-0.3	-0.3

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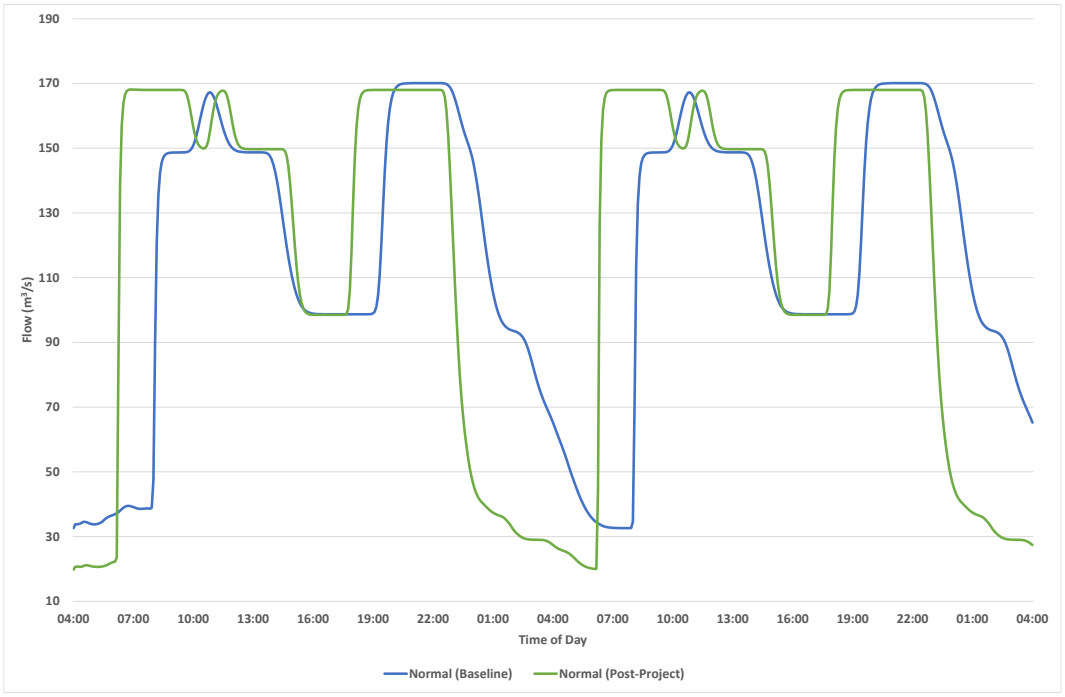
30-min ramp-down (cm/min)	-0.5	-1.1	-0.5	-1.1	**-0.4**	**-1.3**	-0.4	-0.6	-0.3	-0.4
15-min ramp-down (cm/min)	-0.5	-1.2	-0.5	-1.1	**-0.5**	**-1.3**	-0.5	-0.7	-0.3	-0.5

Table G-27 and Figure G-16 show that the future maximum flow is similar to the current maximum flow under all flow conditions, but that the future minimum flow tends to be lower than the current minimum flow for normal to very wet conditions. As such, the change in flow range, i.e., the change in the amount of daily variation of flow, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

More generally however, it is also notable that the minimum flow is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall flow range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-27 Upstream Burundi Border / Ruhwa Tributary – Flow Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Flow (m^3/s)	162	165	167	166	**170**	**168**	176	173	181	176
Minimum Flow (m^3/s)	16	15	17	16	**33**	**20**	69	52	91	77
Flow Range (m^3/s)	146	150	150	150	**138**	**148**	107	121	89	99



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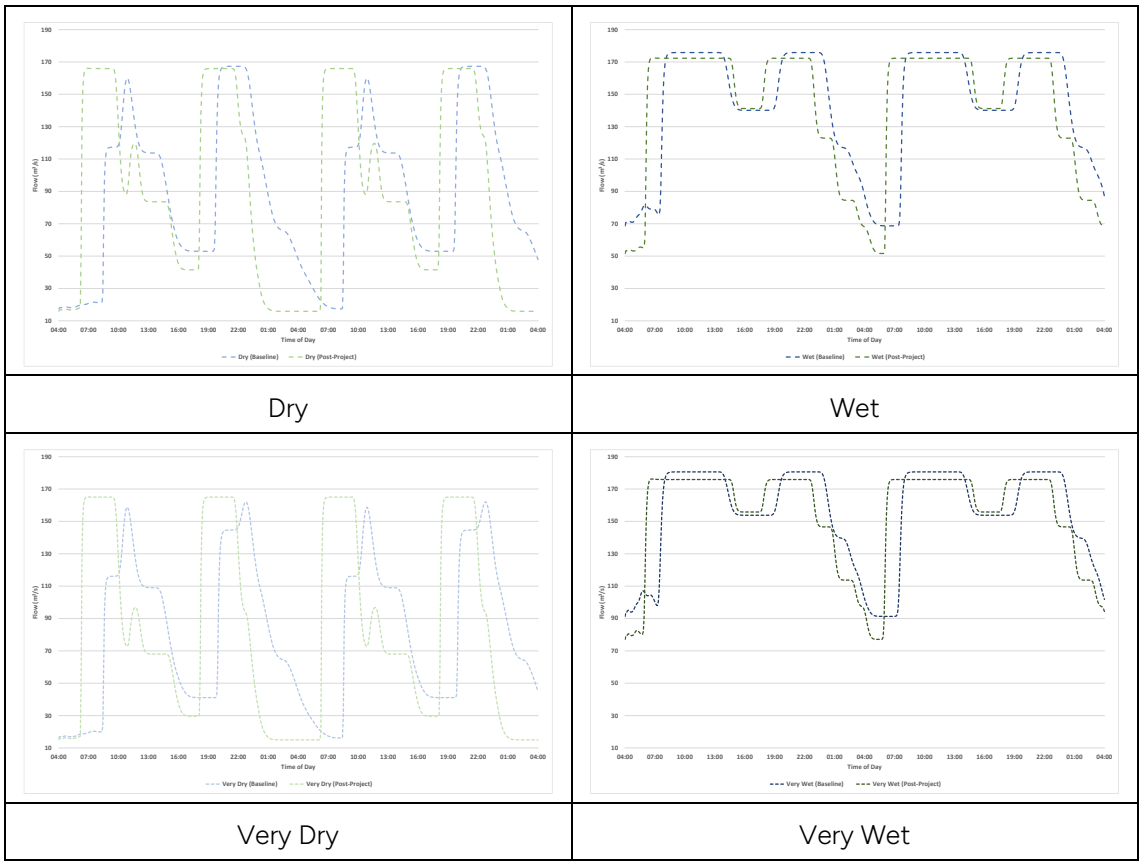

Figure G-16 Upstream Burundi Border / Ruhwa Tributary – Flow Summary

Table G-28 and Figure G-17 show that the future maximum level (and hence depth) is similar to the current maximum level under all flow conditions, but that the future minimum level tends to be lower than the current minimum level for normal to very wet conditions. As such, the level range, i.e., the amount of daily water level variation, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the water level daily variation increases by 18 cm under normal conditions (from a daily variation of 0.98 m to 1.16 m) primarily due to the reduction in minimum water levels.

As with the flow conditions, the minimum elevation is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall elevation range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-28 Upstream Burundi Border / Ruhwa Tributary – Level Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Elevation (mAOD)	920.01	920.02	920.03	920.02	**920.04**	**920.03**	920.07	920.06	920.09	920.07
Minimum Elevation (mAOD)	918.81	918.79	918.83	918.81	**919.06**	**918.87**	919.41	919.27	919.58	919.46
Elevation Range (m)	1.20	1.23	1.20	1.21	**0.98**	**1.16**	0.66	0.79	0.51	0.58

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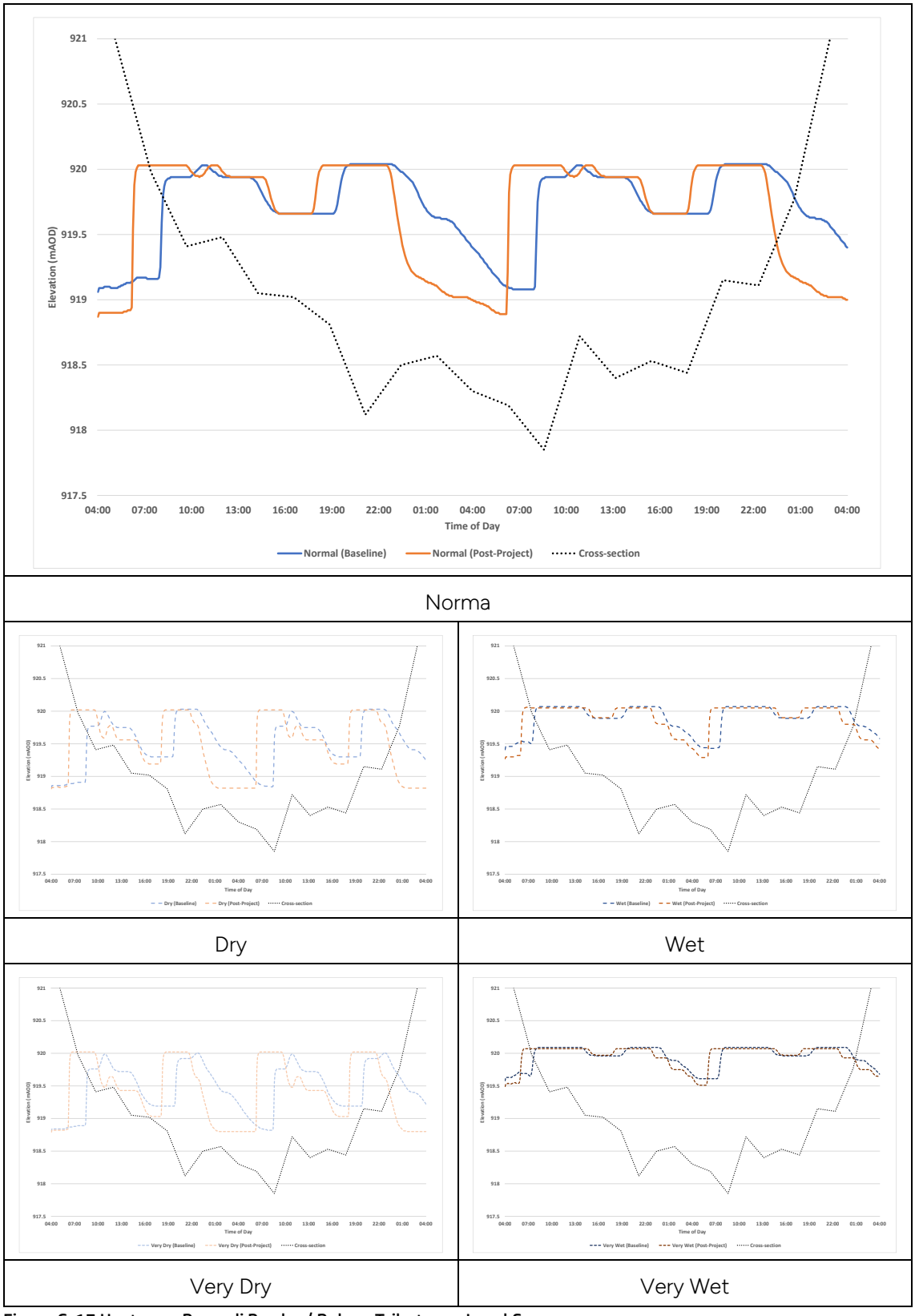

Figure G-17 Upstream Burundi Border / Ruhwa Tributary – Level Summary

As with the flow and elevation variation, Table G-29 and Figure G-18 show that the future maximum velocity is similar to the current maximum velocity under all flow conditions, but that the future minimum velocity tends to be lower than the current minimum velocity for normal to very wet conditions. As such, the velocity range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

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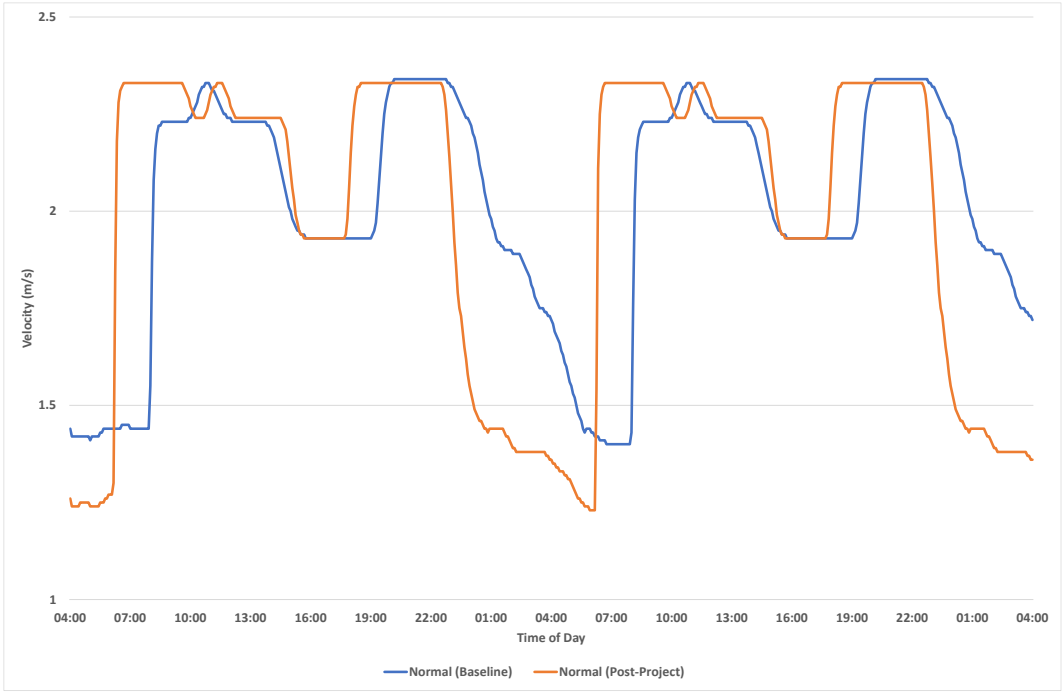
For example, the velocity daily variation increases by 0.16 m/s under normal conditions (from a daily variation of 0.94 m to 1.10 m) due to the reduction in minimum velocity.

The minimum velocity is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall velocity range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-29 Upstream Burundi Border / Ruhwa Tributary – Velocity Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Velocity (m/s)	2.30	2.32	2.33	2.32	**2.34**	**2.33**	2.37	2.35	2.39	2.37
Minimum Velocity (m/s)	1.15	1.12	1.17	1.14	**1.40**	**1.23**	1.74	1.59	1.88	1.77
Velocity Range (m/s)	1.15	1.20	1.16	1.18	**0.94**	**1.10**	0.63	0.76	0.51	0.60



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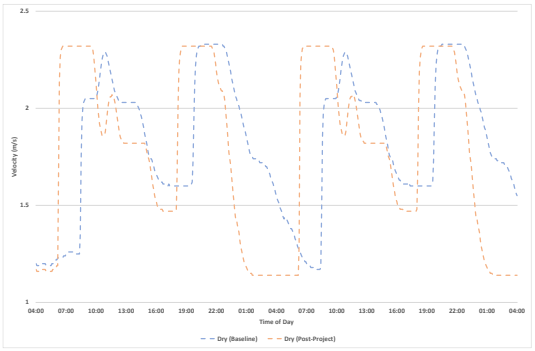
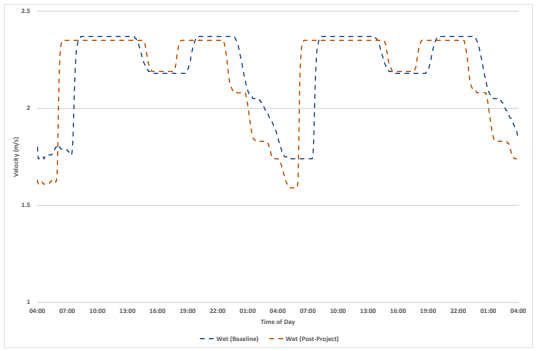


Dry



Wet

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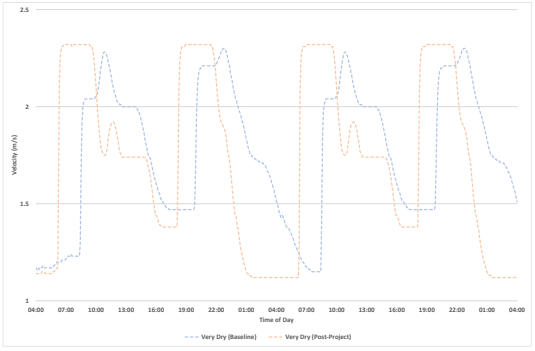

Very Dry	Very Wet

Figure G-18 Upstream Burundi Border / Ruhwa Tributary – Velocity Summary

Table G-30 and Figure G-19 show the maximum, minimum, and daily range in wetted cross-section area, providing an indication of the overall habitat area available. As with the other hydrological and hydraulic characteristics presented, the future maximum area is similar to the current maximum area under all flow conditions, but that the future minimum area tends to be lower than the current minimum area for normal to very wet conditions. As such, the area range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the area daily variation increases by 6.4 m^2 in the normal conditions (from a daily variation of 50.0 m^2 to 56.4 m^2) due to the reduction in minimum area.

The minimum area is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall area range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-30 Upstream Burundi border / Ruhwa Tributary – Cross-section Area Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Area (m^2)	70.5	71.3	71.9	71.6	**72.7**	**72.1**	74.2	73.3	75.5	74.3
Minimum Area (m^2)	13.7	13.1	14.4	13.6	**22.7**	**15.8**	38.1	31.6	47.2	42.3
Area Range (m^2)	56.8	58.2	57.5	57.9	**50.0**	**56.4**	36.1	41.7	28.3	32.0

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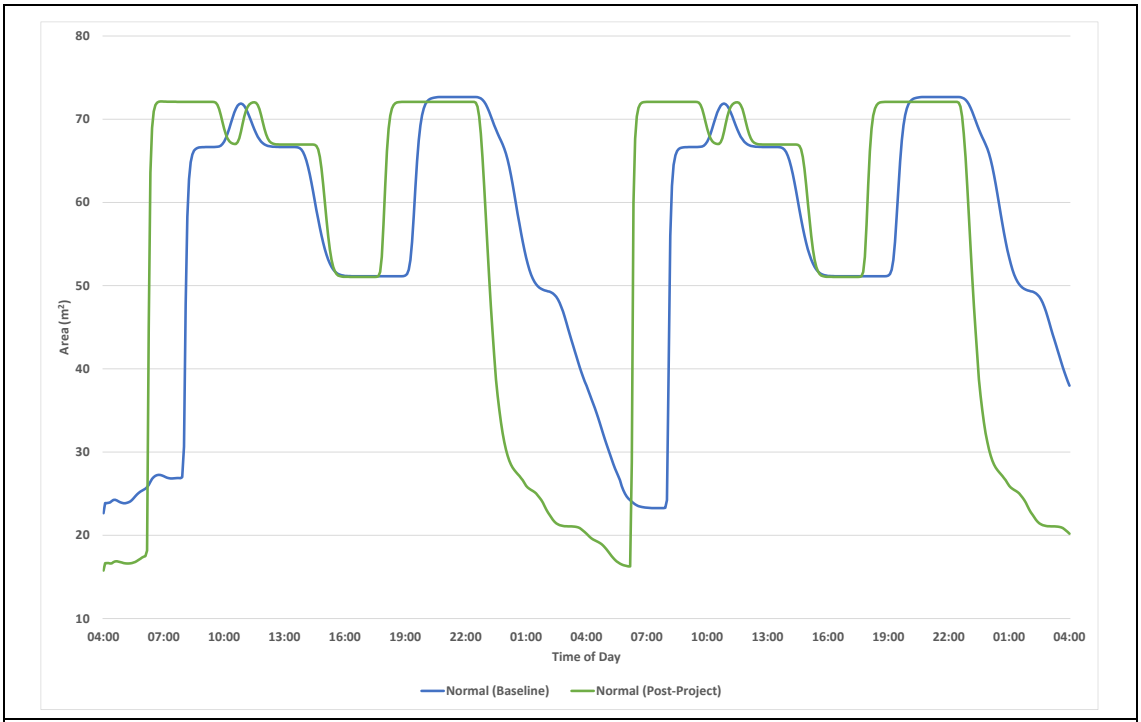
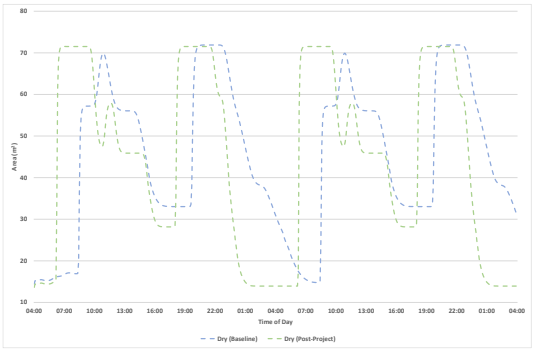
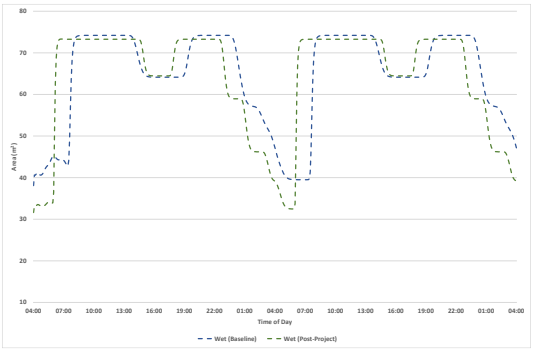
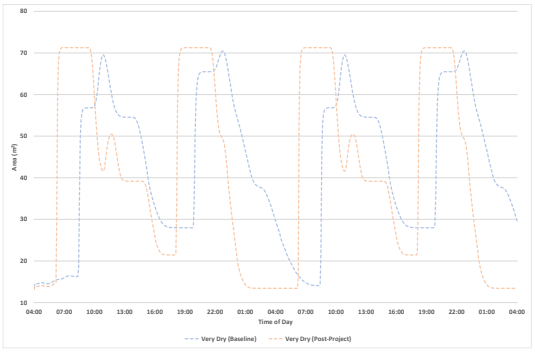


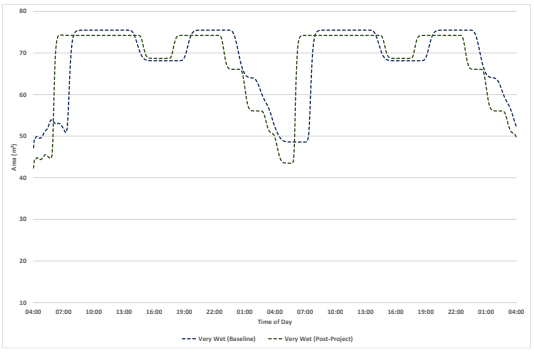
Normal





Dry | Wet





Very Dry | Very Wet

Figure G-19 Upstream Burundi Border / Ruhwa Tributary – Cross-section Summary

Table G-31 provides a summary of the average vertical ramp-up rates and ramp-down rates experienced over different critical durations.

It can be seen that both the ramp-up and ramp-down rates are greatest for both the current and future scenarios over the shorter 15-minute duration, i.e., the changes in water level tend to occur over very short periods of time. Ramp up rates tend to be higher than ramp-down rates.

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It is also notable that vertical ramp-up rates tend to be higher in the very dry to normal conditions than they are in the wet to very conditions, in large part reflecting the greater changes in flow and levels experienced in these conditions. It is also notable that future ramp-up and ramp-down rates tend to be greater than current ramp-up and ramp-down rates. This is a reflection of the operating conditions for Ruzizi III where it is understood that operation changes between "off-peaking" and "peaking" will be quicker than they currently are at Ruzizi II.

Table G-31 Upstream Burundi Border / Ruhwa Tributary – Ramp-up and Ramp-down Rates Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Ramp-Up Summary										
60-min ramp-up (cm/min)	1.6	2.0	1.6	2.0	**1.4**	**1.9**	1.1	1.3	0.8	0.9
30-min ramp-up (cm/min)	3.1	4.0	3.1	4.0	**2.8**	**3.8**	1.9	2.5	1.3	1.8
15-min ramp-up (cm/min)	5.7	7.5	5.7	7.4	**5.0**	**7.1**	2.7	4.3	1.7	2.5
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.5	-0.8	-0.4	-1.0	**-0.4**	**-1.1**	-0.4	-0.4	-0.3	-0.3
30-min ramp-down (cm/min)	-0.5	-1.1	-0.5	-1.1	**-0.4**	**-1.3**	-0.4	-0.6	-0.3	-0.4
15-min ramp-down (cm/min)	-0.5	-1.2	-0.5	-1.1	**-0.5**	**-1.3**	-0.5	-0.7	-0.3	-0.5

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A.3 Downstream Burundi border / Ruhwa Tributary

Table G-32 provides an overall summary of the key modelled hydrological and hydraulic characteristics for this reach. Characteristics are presented for a range of hydrological conditions and for the baseline and future (post project) conditions. The 'normal' hydrological conditions results are highlighted for clarity. Key attributes of hydrological and hydraulic characteristics are discussed for each characteristic in turn.

Table G-32 Downstream Burundi border / Ruhwa Tributary – Hydrology and Hydraulics Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Flow Summary										
Maximum Flow (m^3/s)	171	174	178	177	**185**	**183**	200	197	213	209
Minimum Flow (m^3/s)	25	24	28	27	**48**	**35**	93	76	124	110
Flow Range (m^3/s)	146	150	150	150	**138**	**148**	107	121	89	99
Elevation Summary										
Maximum Elevation (mAOD)	908.82	908.84	908.86	908.85	**908.89**	**908.89**	908.97	908.95	909.02	909.00
Minimum Elevation (mAOD)	907.65	907.62	907.70	907.68	**907.95**	**907.81**	908.37	908.23	908.57	908.48
Elevation Range (m)	1.17	1.22	1.16	1.17	**0.94**	**1.08**	0.60	0.72	0.45	0.52
Velocity Summary										
Maximum Velocity (m/s)	2.91	2.93	2.95	2.95	**3.00**	**2.99**	3.09	3.07	3.16	3.13
Minimum Velocity (m/s)	1.59	1.58	1.63	1.61	**1.93**	**1.73**	2.33	2.19	2.55	2.45
Velocity Range (m/s)	1.32	1.35	1.32	1.34	**1.93**	**1.26**	2.33	0.88	2.55	0.68
Cross-section Area Summary										
Maximum Area (m^2)	58.7	59.3	60.2	60.0	**61.8**	**61.4**	64.9	64.2	67.5	66.6
Minimum Area (m^2)	15.3	14.8	16.9	16.2	**24.5**	**20.0**	39.6	34.3	48.0	44.2
Area Range (m^2)	43.4	44.6	43.4	43.8	**37.3**	**41.4**	25.3	30.0	19.5	22.4
Ramp-Up Summary										
60-min ramp-up (cm/min)	1.6	2.0	1.5	2.0	**1.4**	**1.8**	1.0	1.2	0.8	0.9
30-min ramp-up (cm/min)	3.1	4.0	3.0	3.9	**2.8**	**3.6**	1.8	2.3	1.2	1.6
15-min ramp-up (cm/min)	5.7	7.7	5.5	7.5	**4.9**	**6.8**	2.7	3.8	1.6	2.4
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.5	-0.9	-0.4	-1.0	**-0.4**	**-1.1**	-0.4	-0.4	-0.3	-0.3

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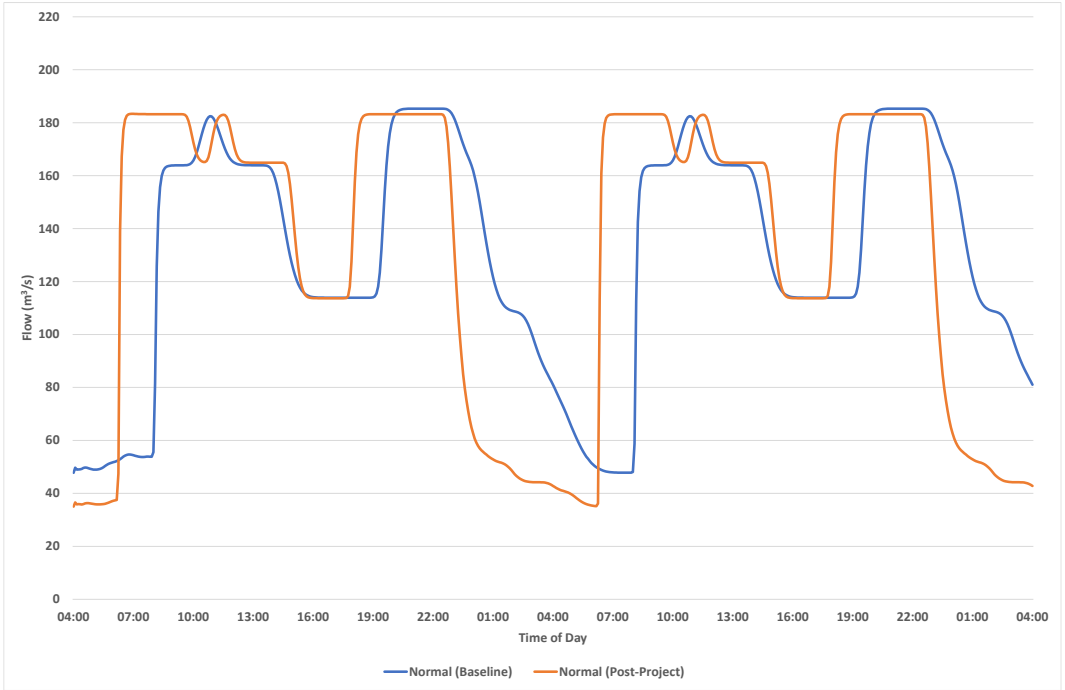
30-min ramp-down (cm/min)	-0.5	-1.1	-0.4	-1.1	**-0.4**	**-1.3**	-0.4	-0.6	-0.3	-0.4
15-min ramp-down (cm/min)	-0.5	-1.1	-0.5	-1.1	**-0.5**	**-1.3**	-0.4	-0.7	-0.3	-0.5

Table G-33 and Figure G-20 show that the future maximum flow is similar to the current maximum flow under all flow conditions, but that the future minimum flow tends to be lower than the current minimum flow for normal to very wet conditions. As such, the change in flow range, i.e., the change in the amount of daily variation of flow, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

More generally however, it is also notable that the minimum flow is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall flow range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-33 Downstream Burundi Border / Ruhwa Tributary – Flow Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Flow (m^3/s)	171	174	178	177	**185**	**183**	200	197	213	209
Minimum Flow (m^3/s)	25	24	28	27	**48**	**35**	93	76	124	110
Flow Range (m^3/s)	146	150	150	150	**138**	**148**	107	121	89	99



Normal

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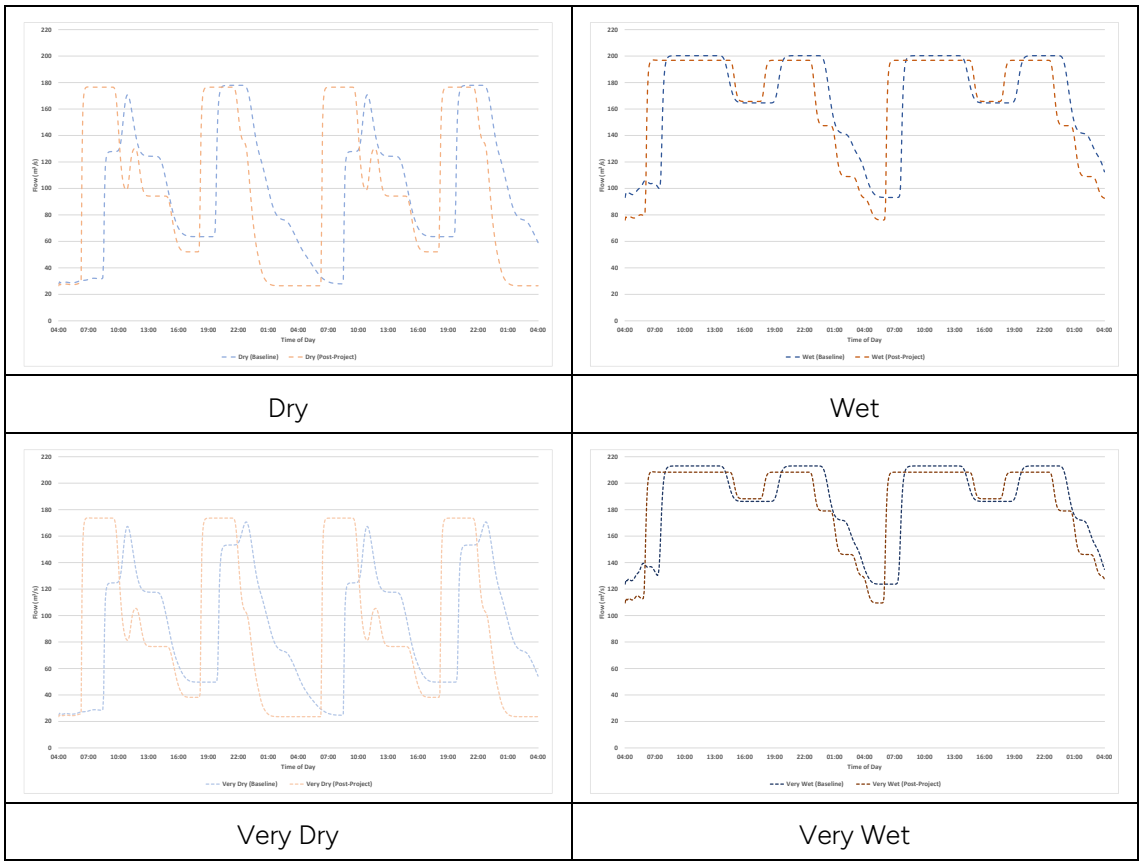

Figure G-20 Downstream Burundi Border / Ruhwa Tributary – Flow Summary

Table G-34 and Figure G-21 show that the future maximum level (and hence depth) is similar to the current maximum level under all flow conditions, but that the future minimum level tends to be lower than the current minimum level for normal to very wet conditions. As such, the level range, i.e., the amount of daily water level variation, tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the water level daily variation increases by 14 cm under normal conditions (from a daily variation of 0.94 m to 1.08 m) primarily due to the reduction in minimum water levels.

As with the flow conditions, the minimum elevation is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall elevation range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-34 Downstream Burundi border / Ruhwa Tributary – Level Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Elevation (mAOD)	908.82	908.84	908.86	908.85	**908.89**	**908.89**	908.97	908.95	909.02	909.00
Minimum Elevation (mAOD)	907.65	907.62	907.70	907.68	**907.95**	**907.81**	908.37	908.23	908.57	908.48
Elevation Range (m)	1.17	1.22	1.16	1.17	**0.94**	**1.08**	0.60	0.72	0.45	0.52

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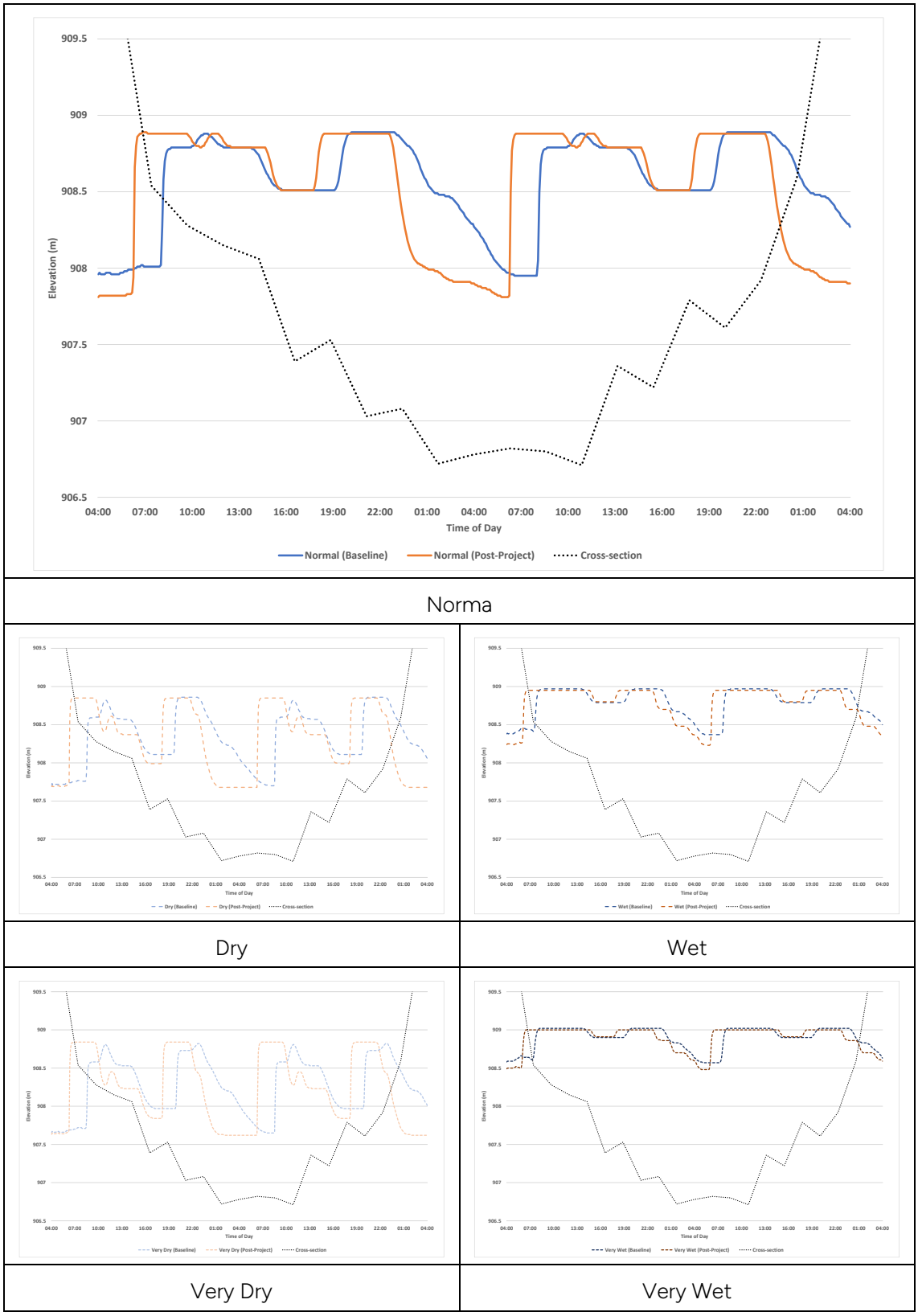

Figure G-21 Downstream Burundi Border / Ruhwa Tributary – Level Summary

As with the flow and elevation variation, Table G-35 and Figure G-22 show that the future maximum velocity is similar to the current maximum velocity under all flow conditions, but that the future minimum velocity tends to be lower than the current minimum velocity for normal to very wet conditions. As such, the velocity range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

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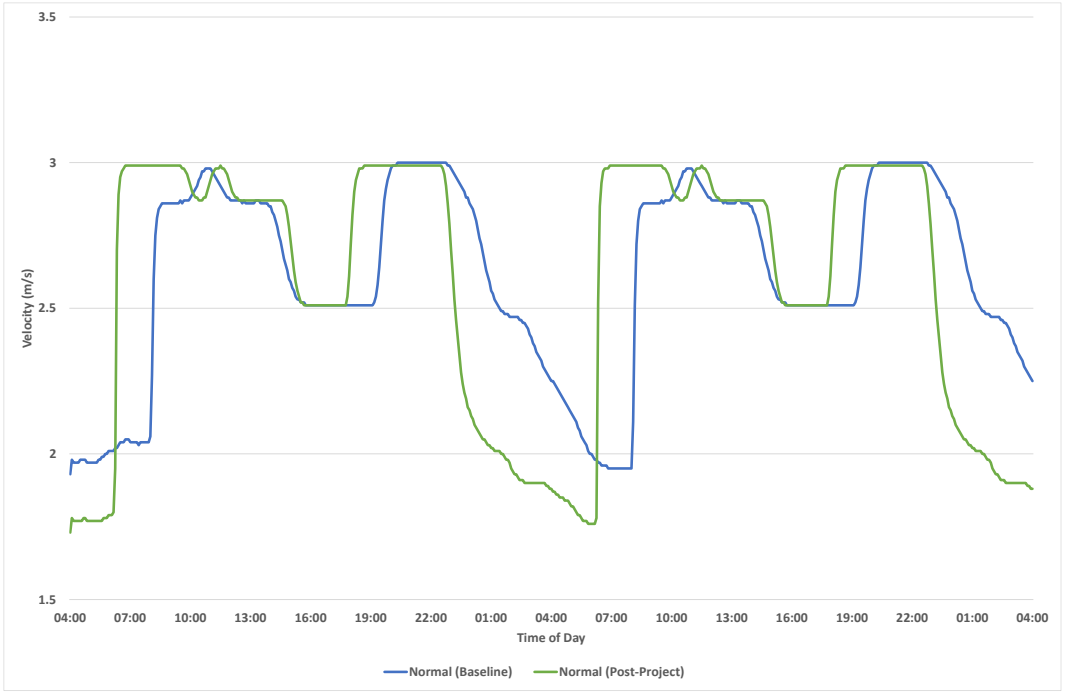
For example, the velocity daily variation increases by 0.19 m/s under normal conditions (from a daily variation of 1.07 m to 1.26 m) due to the reduction in minimum velocity.

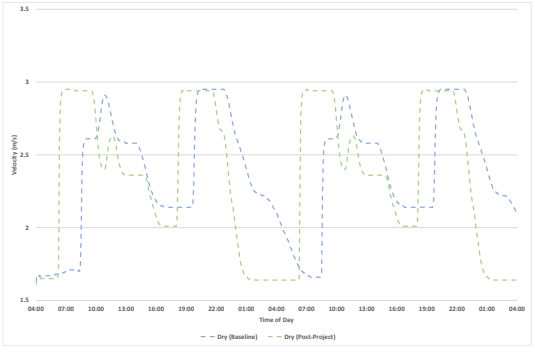
The minimum velocity is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall velocity range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-35 Downstream Burundi border / Ruhwa Tributary – Velocity Summary

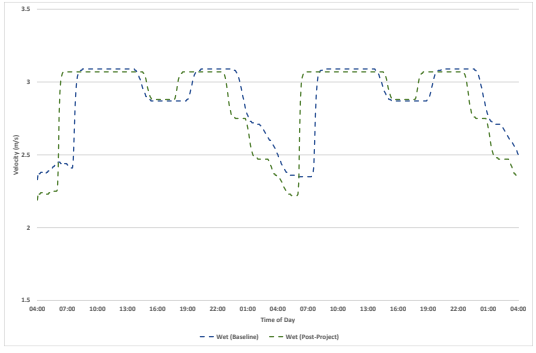
	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Velocity (m/s)	2.91	2.93	2.95	2.95	**3.00**	**2.99**	3.09	3.07	3.16	3.13
Minimum Velocity (m/s)	1.59	1.58	1.63	1.61	**1.93**	**1.73**	2.33	2.19	2.55	2.45
Velocity Range (m/s)	1.32	1.35	1.32	1.34	**1.07**	**1.26**	2.33	0.88	2.55	0.68



Normal



Dry



Wet

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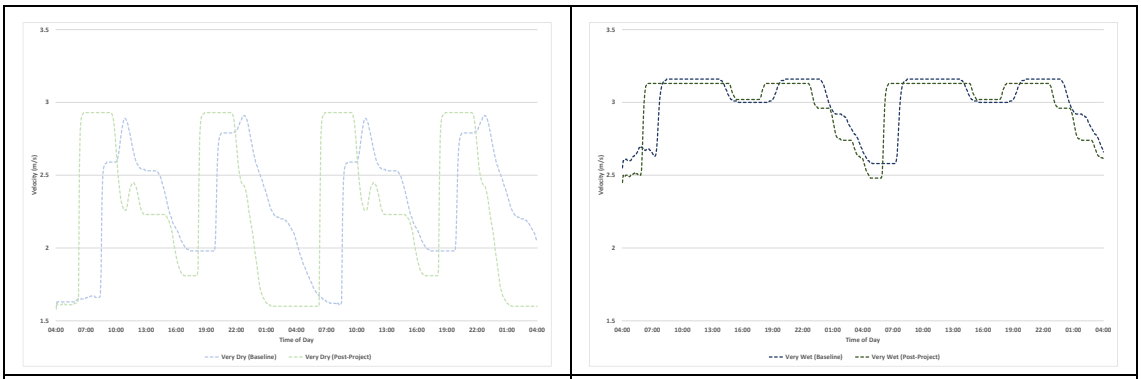

Figure G-22 Downstream Burundi border / Ruhwa Tributary – Velocity Summary

Table G-36 and Figure G-23 show the maximum, minimum, and daily range in wetted cross-section area, providing an indication of the overall habitat area available. As with the other hydrological and hydraulic characteristics presented, the future maximum area is similar to the current maximum area under all flow conditions, but that the future minimum area tends to be lower than the current minimum area for normal to very wet conditions. As such, the area range tends to be higher under the future post Ruzizi III scenario in normal to very wet conditions.

For example, the area daily variation increases by 4.1 m^2 in the normal conditions (from a daily variation of 37.3 m^2 to 41.4 m^2) due to the reduction in minimum area.

The minimum area is higher (in both the current and future scenarios) for the normal to very wet conditions than it is for the very dry to dry conditions. As such, the overall area range is less in the normal to very wet conditions than it is in the very dry to dry conditions.

Table G-36 Downstream Burundi Border / Ruhwa Tributary – Cross-section Area Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Maximum Area (m^2)	58.7	59.3	60.2	60.0	**61.8**	**61.4**	64.9	64.2	67.5	66.6
Minimum Area (m^2)	15.3	14.8	16.9	16.2	**24.5**	**20.0**	39.6	34.3	48.0	44.2
Area Range (m^2)	43.4	44.6	43.4	43.8	**37.3**	**41.4**	25.3	30.0	19.5	22.4

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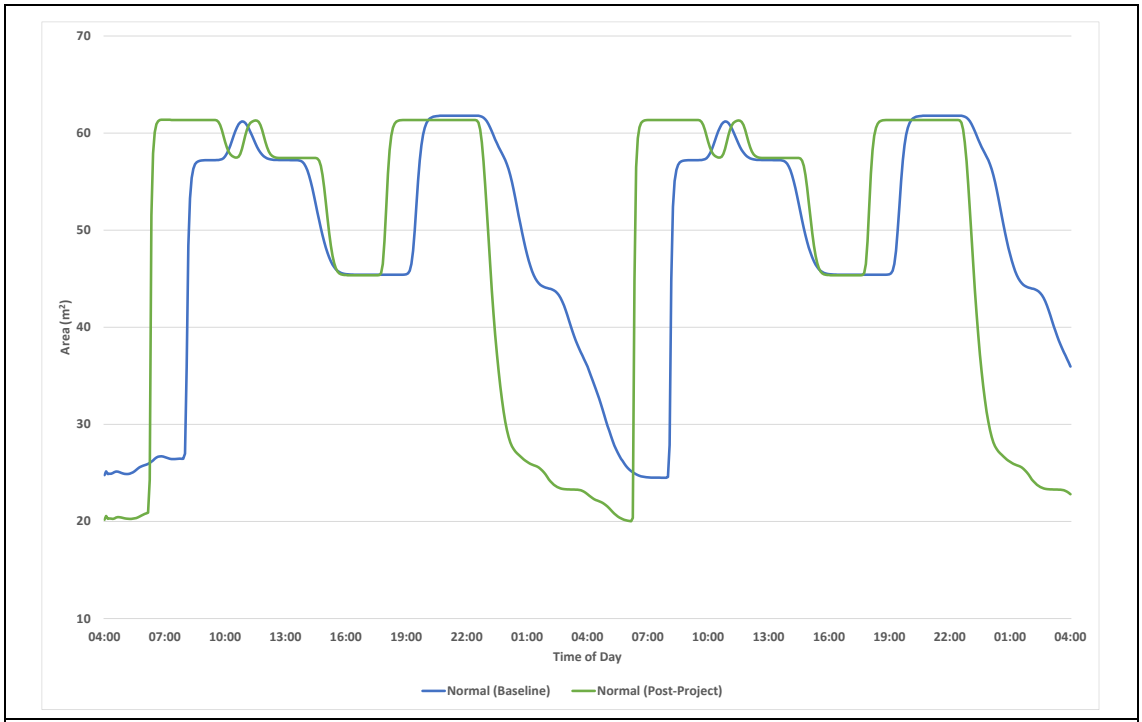
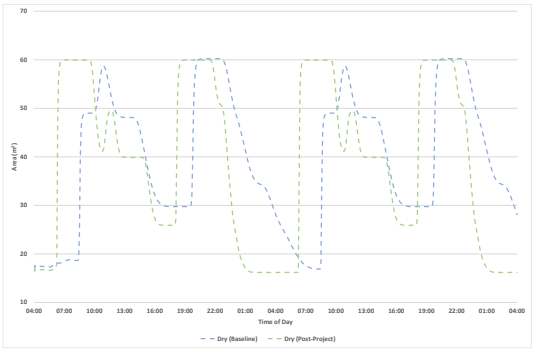
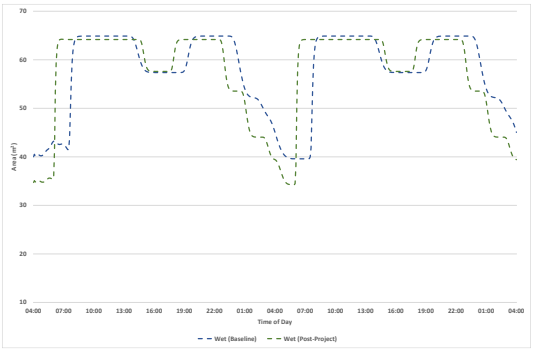
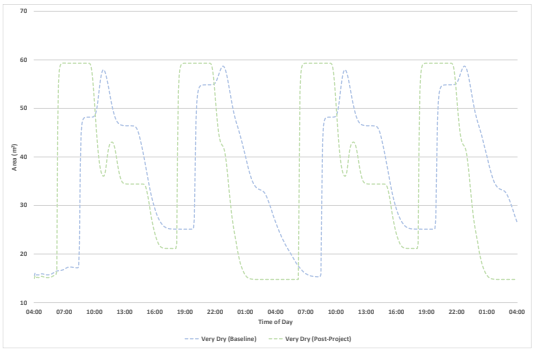


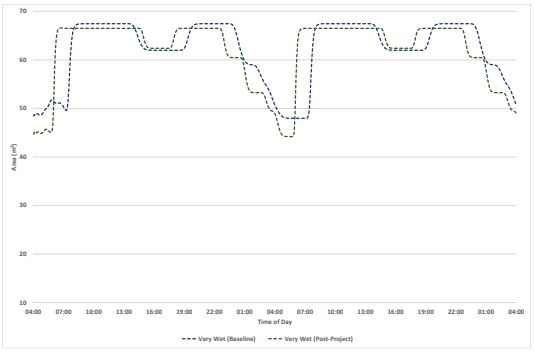
Normal





Dry | Wet





Very Dry | Very Wet

Figure G-23 Downstream Burundi Border / Ruhwa Tributary – Cross-section Summary

Table G-37 provides a summary of the average vertical ramp-up rates and ramp-down rates experienced over different critical durations.

It can be seen that both the ramp-up and ramp-down rates are greatest for both the current and future scenarios over the shorter 15-minute duration, i.e., the changes in water level tend to occur over very short periods of time. Ramp up rates tend to be higher than ramp-down rates.

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It is also notable that vertical ramp-up rates tend to be higher in the very dry to normal conditions than they are in the wet to very conditions, in large part reflecting the greater changes in flow and levels experienced in these conditions. It is also notable that future ramp-up and ramp-down rates tend to be greater than current ramp-up and ramp-down rates. This is a reflection of the operating conditions for Ruzizi III where it is understood that operation changes between "off-peaking" and "peaking" will be quicker than they currently are at Ruzizi II.

Table G-37 Downstream Burundi border / Ruhwa Tributary – Ramp-up and Ramp-down Rates Summary

	Very Dry		Dry		Normal		Wet		Very Wet	
	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future	Baseline	Future
Ramp-Up Summary										
60-min ramp-up (cm/min)	1.6	2.0	1.5	2.0	**1.4**	**1.8**	1.0	1.2	0.8	0.9
30-min ramp-up (cm/min)	3.1	4.0	3.0	3.9	**2.8**	**3.6**	1.8	2.3	1.2	1.6
15-min ramp-up (cm/min)	5.7	7.7	5.5	7.5	**4.9**	**6.8**	2.7	3.8	1.6	2.4
Ramp-Down Summary										
60-min ramp-down (cm/min)	-0.5	-0.9	-0.4	-1.0	**-0.4**	**-1.1**	-0.4	-0.4	-0.3	-0.3
30-min ramp-down (cm/min)	-0.5	-1.1	-0.4	-1.1	**-0.4**	**-1.3**	-0.4	-0.6	-0.3	-0.4
15-min ramp-down (cm/min)	-0.5	-1.1	-0.5	-1.1	**-0.5**	**-1.3**	-0.4	-0.7	-0.3	-0.5

B Geomophological, Ecological and Social Context

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C Indicators Linked to Hydrological and Hydraulic Characteristics

Table G-38 provides and overall summary of the ecological and social functional relationship with hydrological and hydraulic characteristics for the reach just upstream of the Rubyiro confluence to the Burundi border, just downstream of the Ruhwa tributary.

The change in hydrological and hydraulic characteristics are predicted to result in significant increase in social community safety impacts (due to increased ramp-up rates), although it is noted that the increased social community safety impacts notably reduce along the length of this reach.

Table G-38 Summary of Ecological and Social Functional Relationship / Impacts at Upstream Upstream Rubyiro Tributary to Downstream Burundi Border / Ruhwa Tributary

Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
Geomorphology			
Increased channel erosion The channel is largely composed of large immobile clasts, calcrete or bedrock. This makes the channel bed resistant to incision. Hydro peaking and reductions in longitudinal sediment connectivity has	Flow	Moderate FR/I	Frequent and high amplitude changes in flow is likely to drive bed erosion, but the bed is stable, so no significant changes are expected. Possibly some localised erosion of mobile gravel and sand bars.
	Elevation / Depth	Moderate FR/I	As above
	Velocity	Moderate FR/I	As above
	Area	Minor FR/I	As above

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
resulted in possible bed erosion and bed armouring	Ramping Rates	No / Insignificant FR/I	No adverse effect envisaged.
Increased sedimentation in channel Due to the reduced sediment supply downstream of the dam, and the increase in the frequency of high energy flows, it is unlikely that sedimentation will take place. Localised sedimentation might take place in slack waters	Flow	Moderate FR/I	Reduction in sedimentation (fine substrate habitat) due to the frequent high energy flows.
	Elevation / Depth	Moderate FR/I	As above
	Velocity	Moderate FR/I	As above
	Area	Minor FR/I	As above
	Ramping Rates	No / Insignificant FR/I	No nett increase in sedimentation due to changes in ramping rate.
Bank erosion The banks are largely composed of boulders and cobbles with a finer gravel, sand and silt matrix. The banks are not steep or high and relatively stable and immobile. The banks have been exposed to hydropeaking for decades, thus bank erosion might have stabilised over time	Flow	Moderate FR/I	Possible localised erosion of finer bank material.
	Elevation / Depth	Moderate FR/I	Increased water depth is unlikely to accelerate bank erosion. Some localised bank slumping might occur due to higher elevations of bank wetting.
	Velocity	Moderate FR/I	High flow velocities could increase fluvial erosion of the finer material along the banks, but this is expected to be localised.
	Area	No / Insignificant FR/I	
	Ramping Rates	Minor FR/I	Fast changes in water level could drive localised bank slumping as the banks are wetted during high flows, Subsequent lowering of the water level leads to hydraulic head and pressure to build up in the bank matrix, increasing the chances of mass failure of the fine bank material. As the banks are largely of a low angle, low in height and course in nature it is unlikely to increase bank erosion along most of the reach.
Aquatic Ecology			
Non-migratory fish: abundance and diversity Lotic riffle-rapid fish guild.	Flow		
	Elevation / Depth	Minor FR/I	Sub-daily depth fluctuations risk dewatering riffle-rapid habitats leading to mortality of fishes living in these areas. Shallower minimum depths during the ramp-down phase in a future hydropeaking scenario will increase the risks of this occurring. The change from present day is expected to produce a minor detectable change in the fish community due to the existing hydropeaking effects.
	Velocity	Minor FR/I	Sub-daily variations in velocities reduce the interstitial delivery of well-oxygenated water through bed elements during the down-ramping phase. Lower dissolved oxygen concentrations may impair growth and development

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			of eggs and larvae and cause stress for adult fish in this guild. The change from present day is expected to produce a minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Area	Minor FR/I	The total available area of habitat controls the size of fish populations living in any reach. Hydropeaking will effectively reduce the liveable aquatic habitat to the minimum flow present in the river during the ramp-down phase. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Ramping Rates	Minor FR/I	Both present day and future ramp-down rates exceed recommended maximum rate of -0.15 cm/m that leads to a high risk of stranding and entrapment. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
Migratory fish: abundance and diversity Lotic lithophilic fish guild.	Flow		
	Elevation / Depth	Minor FR/I	Sub-daily variation in depths lead to dewatering of shallows particularly of juvenile fish in this guild seeking cover and feeding opportunities in marginal slackwater habitats. Shallower minimum depths during the ramp-down phase in a future hydropeaking scenario will increase the risks of this occurring. The change from present day is expected to produce a minor detectable change in the fish community due to the existing hydropeaking effects.
	Velocity	Minor FR/I	Increased velocities during up-ramping displace juvenile and adult fish in this guild into the main channel where they will be subject to higher predation rates and reduced feeding opportunities. Sudden unseasonal increases in velocities will disrupt migration and spawning and contribute to additional swimming costs over the migration period. The proposed increase in the future rate of change will increase the risks of stranding occurring and

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Area	Minor FR/I	The total available area of habitat controls the size of fish populations living in any reach. Hydropeaking will effectively reduce the liveable aquatic habitat to the minimum flow present in the river during the ramp-down phase. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
	Ramping Rates	Minor FR/I	Both present day and future ramp-down rates exceed recommended maximum rate of -0.15 cm/m that leads to a high risk of stranding and entrapment. The proposed increase in the future rate of change will increase the risks of stranding occurring and produce minor detectable change in the fish community due to the effects of the existing hydropeaking regime.
Macro-invertebrates: abundance and diversity These are expected to remain unchanged compared to the current operation because of the large variation in daily and sub-daily water levels.	Flow	Minor FR/I	Outside normal operation, periodic flushing of sediments could impact negatively on aquatic macro-invertebrates in this reach, but such flushing is likely to occur infrequently and after several years of operation.
	Elevation / Depth	No / Insignificant FR/I	Conditions in the reach will not be significantly different from present to detect a measurable change in the macro-invertebrate community.
	Velocity	No / Insignificant FR/I	As above
	Area	No / Insignificant FR/I	None of the wetted area above the current and future minimum water level is inundated long enough for aquatic macro-invertebrates to colonise.
	Ramping Rates	N/A	N/A. Ramping rates are irrelevant to macro-invertebrates because they are essentially sedentary and respond to the absolute change in hydraulic conditions, but not the rate of change.
Terrestrial Ecology			
Riparian vegetation: abundance and diversity Even though this reach of the Ruzizi River is in a densely settled area, there is greater complexity of riparian habitats compared to upstream reaches,	Flow	No / Insignificant FR/I	Flows will be much the same as the baseline during peak flows and over 90% of the baseline during off peak flows. It is unlikely that the project-related changes to flow will have any significant impacts on riparian vegetation.

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
primarily because of the presence of large islands and associated braided river channels, and an extensive system of fishponds along the right bank. Some flow-dependent species are present in the scattered fragments of Riparian Thicket and species dependent on a wet bank are present in the Riparian Wetland community. While these species may be impacted in the upper reaches of the project, the changes in flow, velocity, depth and wetted area in this reach are minor and thus unlikely to have a significant impact.	Elevation / Depth	No / Insignificant FR/I	Water levels will be very similar to baseline situation during peak flows and less than 14 cm lower than the baseline during off peak flows in a normal year. It is unlikely that the minor project-related changes to depth will have any significant impacts on maintenance of riparian vegetation in this reach of the river.
	Velocity	No / Insignificant FR/I	Velocity will be much the same as the baseline during peak flows and over 90% of the baseline during off peak flows. It is unlikely that the project-related changes to flow will have any significant impacts on riparian vegetation.
	Area	No / Insignificant FR/I	Extent of wetted area is likely to be similar to the current baseline in a normal year during peak times, and marginally less during off peak flows. It is unlikely that the minor project-related changes to wetted area will have any significant impacts on maintenance of riparian vegetation in this reach of the river.
	Ramping Rates	No / Insignificant FR/I	Ramp-up and ramp down rates will be shorter than baseline situation. But this is unlikely to have a significant effect on riparian vegetation.
Riparian fauna: abundance and diversity The riparian avifauna, mammal and herpetofauna assemblages have higher species richness in this reach compared to upstream reaches. The species composition of the faunal assemblage is currently dominated by widespread habitat generalists and overall species richness is low. Changes in flow, depth and velocity will have a negligible impact on riparian fauna species. The small population of Hippopotamus that is resident along this reach is unlikely to be impacted by minor changes in flow, depth, velocity, area, and ramping rates.	Flow	No / Insignificant FR/I	Flows will be much the same as the baseline during peak flows and over 90% of the baseline during off peak flows. It is unlikely that the project-related changes to flow will have any significant impacts on the riparian faunal assemblage, which is already species-poor as a result of extensive habitat modification.
	Elevation / Depth	No / Insignificant FR/I	Water levels will be very similar to baseline situation during peak flows and less than 14 cm lower than the baseline during off peak flows in a normal year. It is unlikely that the minor project-related changes to depth will impact on available foraging habitat for riparian fauna, including Hippo. The lack of suitable breeding habitat for large, ground-nesting waterbirds means that none of these species are likely to be impacted through flooding of nests during increases in water level, which would have been a significant impact had such habitat been present.
	Velocity	No / Insignificant FR/I	Velocity will be much the same as the baseline during peak

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			flows and over 90% of the baseline during off peak flows. It is unlikely that the project-related changes to flow will have any significant impacts on the accessibility of the fish and invertebrate prey base compared to the current situation, result in a negligible impact on riparian fauna.
	Area	No / Insignificant FR/I	Extent of wetted area is likely to be similar to the current baseline in a normal year during peak times, and less during off speak flows, where levels will drop to 30 cm lower than baseline. It is unlikely that the minor project-related changes to wetted area will have any significant impacts on the amount of foraging and breeding habitat for riparian fauna in this reach of the river, including Hippo.
	Ramping Rates	No / Insignificant FR/I	Ramp-up and ramp down rates will be shorter than the baseline situation. But given the fact that the majority of the riparian fauna are highly mobile, this is unlikely to have a significant effect on riparian fauna.
Social			
Consumptive Water Use Local communities in this stretch are currently using the river for domestic and drinking water supply. Social reliance on the river for consumptive water use is high.	Flow	No / Insignificant FR/I	No significant impact on the availability of, and access to, consumptive water use by local communities, as conditions will not be significantly different from the ones observed at present.
	Elevation / Depth	No / Insignificant FR/I	As above
	Velocity	No / Insignificant FR/I	As above
	Area	No / Insignificant FR/I	As above
	Ramping Rates	No / Insignificant FR/I	As above
Non-Consumptive Water Use: Fishing Local communities are currently fishing regularly in this stretch. Local communities are currently farming fish in a number of ponds alimented by the Ruzizi on a surface of around 5-6 hectares.	Flow	No / Insignificant FR/I	Insignificant impact on fishing activities due to non-discernible effects on fish population (refer to Aquatic Ecology section). Overall changes in the flow as opposed to current conditions are not expected to cause discernible changes in the availability of, or access to, water for fish farming activities.
	Elevation / Depth	No / Insignificant FR/I	As above
	Velocity	No / Insignificant FR/I	As above
	Area	No / Insignificant FR/I	As above
	Ramping Rates	Moderate FR/I	Critical ramp-down rates are expected to be exceeded during future operations in dry

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Indicator & Brief Description	Hydrological / Hydraulic Characteristic	Functional Relationship / Impact (FR/I)	Comment related to future change expected
			and normal conditions, increasing the danger of fish stranding which could threaten the quantity of fish available for fishing. Overall changes in the flow as opposed to current conditions are not expected to cause discernible changes in the availability of, or access to, water for fish farming activities.
Community Safety Local communities cross the river regularly in this stretch. Additionally, villagers are physically entering the river on a regular basis for recreational purposes, and medicinal / spiritual practices. Social exposure to hazards due to the river's flow and velocity are high.	Flow	Minor FR/I	Minor changes from current conditions, as the flow and elevation are already influenced by the operation of Ruzizi II.
	Elevation / Depth	Minor FR/I	As above
	Velocity	Significant FR/I	Higher velocity may result in significant hazards for community safety.
	Area	N/A	N/A
	Ramping Rates	Significant FR/I	Critical ramp-up rates will be exceeded in very dry to wet conditions in the short term and are expected to be exceeded in dry to normal conditions in future operation. This may mean that ramp-up rates will be higher for around 6 months at first, and around 10 months in the long run. This is likely to have a strong impact on community safety when entering and crossing the river.

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G.3 EFlow Assessment: Assumptions and Uncertainties

A key component in the EFlow assessment is the conceptualisation and development of a hydraulic model that is used to provide the hydraulic characterisation of the study area.

The hydraulic modelling approach that has been adopted in the EFlow assessment has been based on a comprehensive review of and application of existing data. No new field data – other than the photographic and video record of the Ruzizi River and laser measure readings of selected channel features obtained during the hydrological field trip – has been obtained.

Key datasets used in the conceptualisation and development of the hydraulic model of the study area are as listed below:

- ADCP and Total Station cross-section data at 68 locations focused on the reach between the Ruzizi III reservoir and the powerhouse tail race (Tiger Engineering Company Limited, January 2021).
- A HEC-RAS 1D hydraulic model of the reach between the Ruzizi III reservoir and the powerhouse tail race, based on use of the ADCP / Total Station cross-section data and local LiDAR DTM data (Tractebel, December 2020).
- Upstream of Bugarama Bridge, 2 m photogrammetry DTM data (Fichtner, 2009).
- Downstream of Bugarama Bridge, 30 m ALOS DSM data.
- Google satellite imagery.
- The photographic and video record of the Ruzizi River and laser measure readings of selected channel features obtained during the hydrological field trip.

Importantly, it is instructive to note that data quality varies spatially across the study area. At a broad level, it can be said that data quality is reasonable for the reach between the Ruzizi III dam and powerhouse tail race (the dewatered reach) but poor for the reach below the powerhouse tail race (the hydropeaking reach).

The identification of the hydraulic characteristics in the hydropeaking reach is therefore associated with a high level of uncertainty.

However, even in the dewatered reach, the geomorphological heterogeneity of the river and associated flow conditions (often turbulent and super-critical) mean that the hydraulic characterisation of the reach based on the available data must be subject to careful interpretation. That is to say, the identification of micro-habitat and meso-habitat scale wetted area, depths, and velocities, important for assessing the health of the aquatic ecosystem under different flow regimes, cannot be fully resolved.

The application of the HEC-RAS 1D hydraulic model in the dewatered reach, and the development of 1D hydraulic model using synthetic cross-sections of the reach from Ruzizi II to the confluence with the Ruwha River is summarised in the Hydrology section of the Environmental Baseline Situation chapter. The hydraulic characterisation of the dewatered reach and the hydropeaking reach – based on surveyed cross-sections and synthetic cross sections respectively – is described within the Environmental Flow Assessment chapter. Additional reporting on the dewatered reach – where data quality is reasonable – is provided herein.

The ADCP / Total Station surveyed data was reviewed and short sections of “deep”, “shallow”, and “wide” cross-sections were identified. Cross-sections and modelled water levels were extracted from the HEC-RAS model at these locations.

Figure G-24 and Figure G-25 show the location, cross-section profiles and 1D modelled water levels (for flows of 10 m^3/s, 110 m^3/s, and 160 m^3/s) for a “deep” sub-reach within the dewatered reach. Maximum water depths in this reach vary from 1.21-2.02 m (at 10 m^3/s), through 3.09-3.56 m (at 110 m^3/s), to 3.51-3.99 m (at 160 m^3/s), i.e., water levels vary by approximately 2-2.3 m over the identified flow range.

The cross-sections and modelled water levels also illustrate clearly that the width of the wetted portion of the river varies significantly over the modelled flow range.

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Figure G-24 Dewatered reach: Deep Cross-section Sub-reach

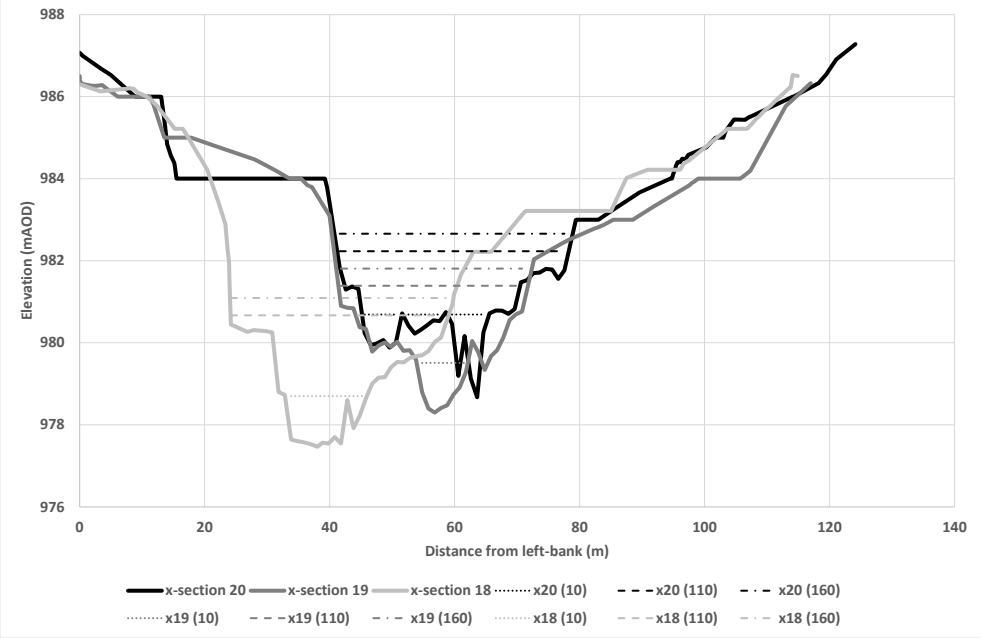

Figure G-25 Dewatered reach: Deep Cross-section Sub-reach - Results

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Figure G-26 and Figure G-27 show the location, cross-section profiles and 1D modelled water levels (for flows of 10 m^3/s, 110 m^3/s, and 160 m^3/s) for a "shallow" sub-reach within the dewatered reach. Maximum water depths in this reach vary from 0.42-1.48 m (at 10 m^3/s), through 1.26-2.68 m (at 110 m^3/s), to 1.46-2.99 m (at 160 m^3/s), i.e., water levels vary by approximately 1-2.5 m over the identified flow range, and depths are approximately 1-2 m shallower than in the "deep" sub-reach.

It can also be seen that there is notable variation in river geomorphology in this sub-reach, with channel braiding and in-river islands present. The cross-sections and modelled water levels also illustrate clearly that the width of the wetted portion of the river varies significantly over the modelled flow range.

Figure G-26 Dewatered reach: Shallow Cross-section Sub-reach

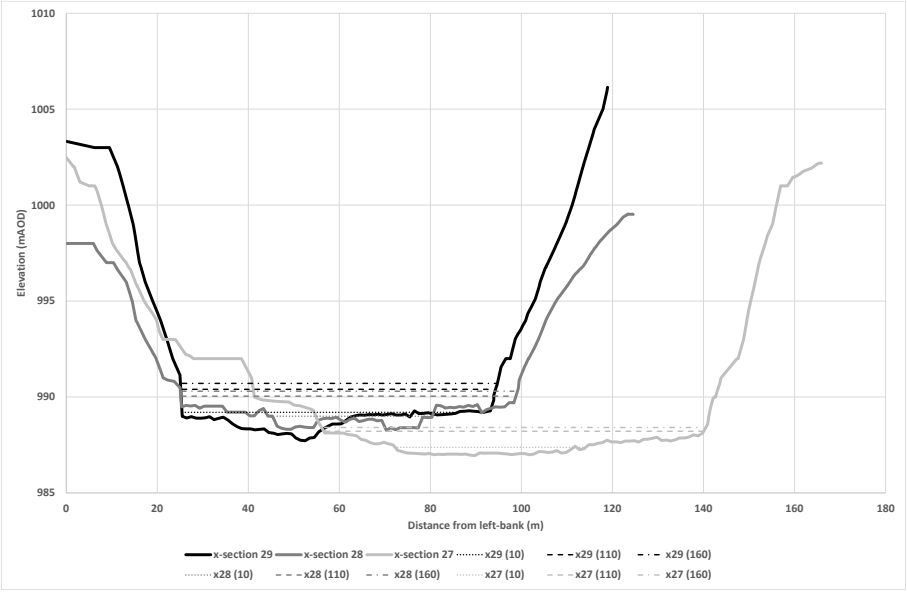

Figure G-27 Dewatered reach: Shallow Cross-section Sub-reach - Results

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Figure G-28 and Figure G-29 show the location, cross-section profiles and 1D modelled water levels (for flows of 10 m^3/s, 110 m^3/s, and 160 m^3/s) for a "wide" sub-reach within the dewatered reach. Maximum water depths in this reach vary from 0.65-1.60 m (at 10 m^3/s), through 1.78-3.00 m (at 110 m^3/s), to 2.04-3.26 m (at 160 m^3/s), i.e., water levels vary by approximately 1.4-1.6 m over the identified flow range. Depths are deeper than in the "shallow" sub-reach but shallower than in the "deep" sub-reach.

Again, it can be seen that there is notable variation in river geomorphology in this sub-reach, channel braiding and in-river islands are again present.

Figure G-28 Dewatered reach: Wide Cross-section Sub-reach

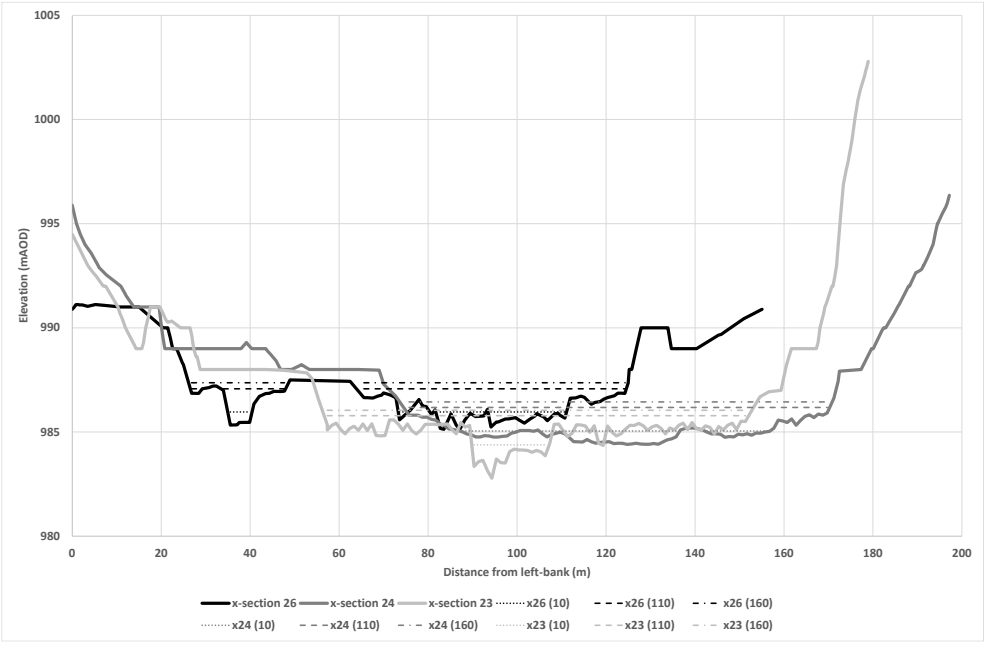

Figure G-29 Dewatered reach: Wide Cross-section Sub-reach - Results

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It is important to note that a 1D hydraulic model will only report cross-section average estimates of velocity. The variation in channel shape suggested by the "deep", "shallow", and "wide" sub-reach data presented is such that cross-section average velocity significantly over-estimates real-world velocities near the riverbanks and under-estimates real-world velocities in the deeper (central) part of the channel.

It is also important to note that a 1D hydraulic model will only report depth and velocity information at the location of modelled cross-sections. It is 'blind' to conditions between cross-sections and implicitly assumes that the surveyed cross-section is generally representative of conditions along the length of the river between successive cross-sections. This degree to which this assumption holds true is an important consideration with respect to model utility.

The limitations of adopting a 1D hydraulic model approach for estimating depths and velocities in a heterogenous river environment can be illustrated by comparing results with those obtained from a 2D hydraulic model. A short sub-reach of the Ruzizi River – centred on the location of Ruzizi III reservoir – containing a variety of geomorphological conditions was selected to illustrate this.

Figure G-30 shows a 1.5 km heterogenous reach of the Ruzizi River centred on the Ruzizi III dam reservoir. It includes an upstream relatively flat area with extensive channel braiding, a narrow steep cascade of turbulent water that meanders sharply left, leading to a wide pool area before the river turns right towards a second straight, steep, turbulent, cascade reach. Downstream of the first cascade reach, a secondary side channel leading towards the second cascade is visible. The ADCP / Total Station surveyed cross-sections are shown. In the upper part of the reach, it is notable that the surveyed cross-sections do not fully represent the multiple flow paths of the river. The turbulent cascades are also poorly represented by the cross-sections – only a single cross-section has been taken in the lower cascade. Channel sinuosity is also poorly represented by the cross-sections.

Figure G-30 Ruzizi III Reservoir Area

A 2D hydraulic model has been constructed in TUFLOW based on the available LiDAR data and surveyed cross-section data in this reach. The LiDAR representation of the main channel was compared with the cross-section data to best inform the representation of the river channel. As

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the LiDAR data does not fully represent the river channel conveyance capacity adequately, the surveyed cross-sections were used to inform the 'burning in' of an appropriately scaled river channel.

Notwithstanding the data uncertainty associated with a 2D model build, Figure G-31, Figure G-32, and Figure G-33 show maximum depths and velocities in the modelled reach, illustrating the wide variation of depths and velocities.

Figure G-31 shows maximum depths colour-coded and different velocities represented by arrows of different size and orientation. This provides a clear overview of how depths and velocities vary both between cross-sections, and also across the width of the river.

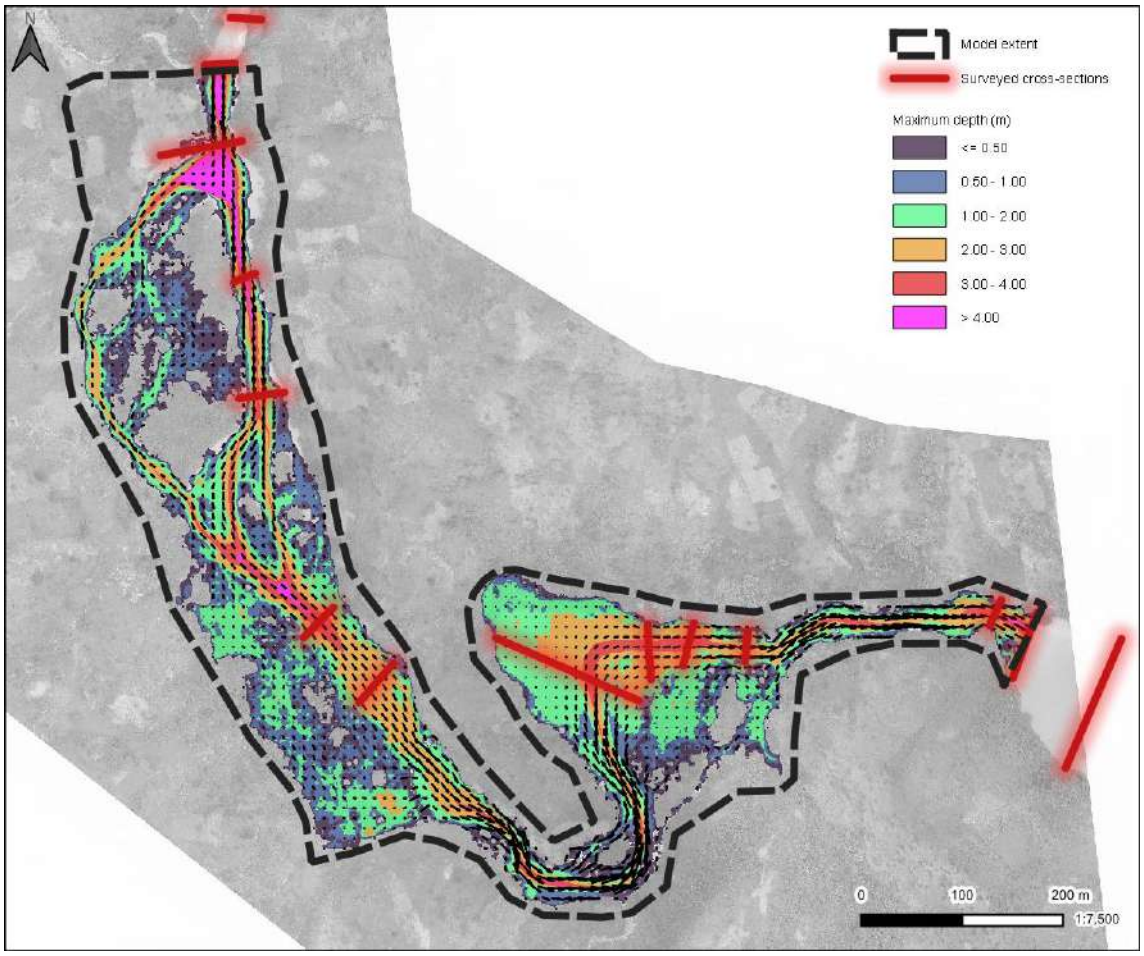

Figure G-31 2D Model Results – Overview

Figure G-32 provides greater focus in the upper part of the reach. Colour-coded depths and velocity arrows are represented on the left, colour-coded velocities and velocity arrows are represented on the right. This again more clearly illustrates the differences in depths and velocities between and along cross-sections, in particular, how depths and velocity vary due to river bifurcation and the presence of in-river islands.

Figure G-33 provides greater focus in the lower part of the reach. Colour-coded depths and velocity arrows are represented on the left, colour-coded velocities and velocity arrows are represented on the right. In particular, this demonstrates how the depths and velocities in the cascade systems differ from those in areas where the cross-sections were surveyed. Variations in depths and velocities across the cross-sections, particularly in the pool area between the two cascades is also fully apparent.

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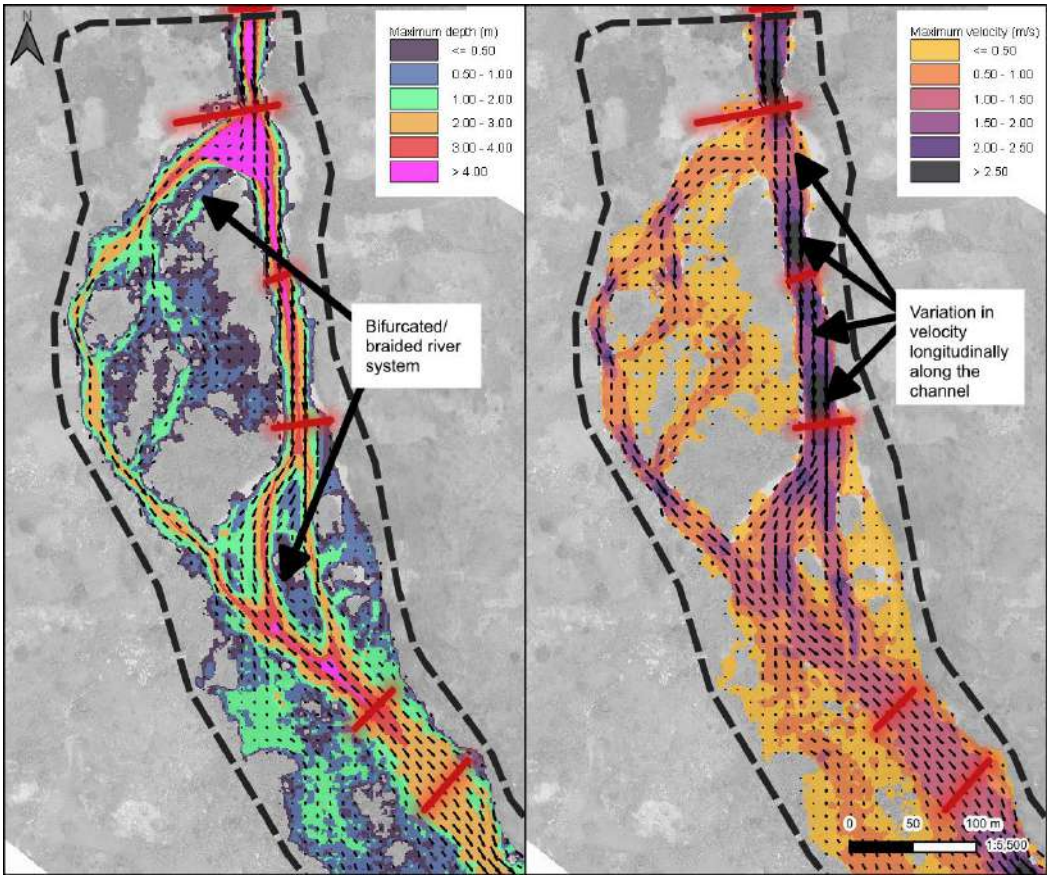

Figure G-32 2D Model Results – Upper Reach Depths and Velocities

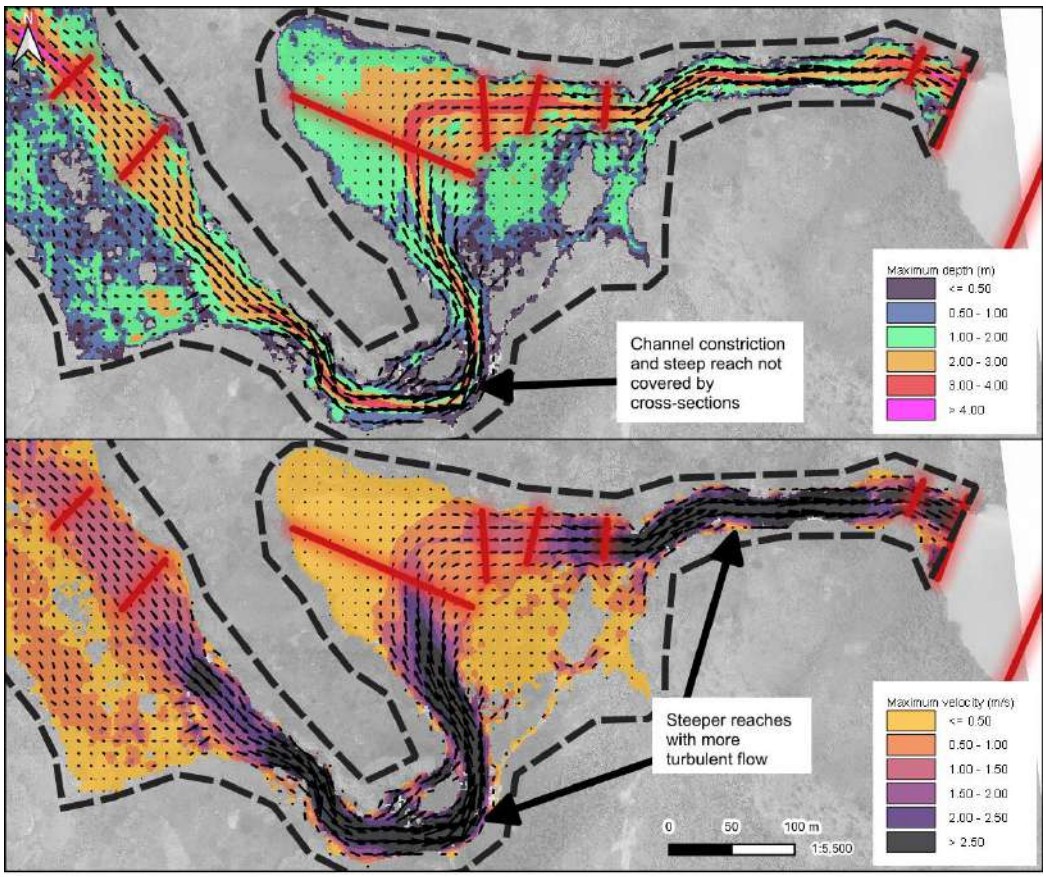

Figure G-33 2D Model Results – Lower Reach Depths and Velocities

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The assessment of EFlow hydraulic model assumptions and limitations has sought to illustrate some key factors in the EFlow assessment decision making process. The selection of a suitable hydraulic model used to determine the hydraulic characterisation of a river is subject to data constraints but should also be determined by an assessment of requirements and overall uncertainty.

The application of 1D hydraulic modelling is considered suitable in situations where there is relatively low variability of hydraulic characteristics, at a scale at which such variability is determined not to be a critical aspect of the decision-making process, and/or at a stage of a project in which the associated uncertainty is commensurate with the overall project objectives. As such, the use of broad scale 1D hydraulic modelling is considered appropriate for the current EFlow assessment.

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H. Employer's Environmental and Social Requirements

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Part 2

Section VII - Employer's Requirements

Section VII.6 – Environmental and Social Requirements

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1 General Provisions

1) The Employer's Environmental and Social requirements (ESR) stated in this Section represent the minimum requirements to be met by the Contractor and each of its affiliates, subcontractors, and sub-contracted consultants for the performance of the Works. The Contractor may propose changes to the requirements subject to approval by the Employer prior to their implementation.

2) The ESR refer to:

- Protection of the natural environment (water, air, soil, vegetation, biological diversity, landscape, etc.).
- Protection of people and populations and their assets exposed to the general disturbance caused by the Works.

2 Management Systems

2.1 Applicable Legislation and Regulations

1) The Contractor shall comply with all national, regional, and local government environmental and social (E&S) Laws in force in each of the Contracting States, including among others:

    a. Burundi:

2) Law No 1/09 dated 2021 March 25 on the Environment

3) Law No 1/02 dated 2012 March 26 on the Water Code in Burundi,

4) Law No 1/10 dated 2011 May 30 on the Creation and Management of Protected Areas

5) Law No 1/07 dated 2016 July on the Forest Code

    a. DR Congo:

6) Constitution of the DRC dated 2006 February 18

7) Law No 11/009 dated 2011 July 9 on the fundamental principles of environmental protection

8) Law No 15/026 dated 2015 December 31 on water

9) Law No 011-2002 dated 2002 August 29 on the Forest Code

    a. Rwanda:

10) Constitution of the Republic of Rwanda dated 2015

        i. Law No 48/2018 dated 2018 August 13 on the Environment;

        ii. Law No 49/2018 dated 2018 August 13 on the Use and Management of Water Resources in Rwanda;

iii. Ministerial Order No 007/16.01 dated 2010 July 15 determining the length of land located on the shores of Lakes and Rivers forming part of the public domain.

11) Regional Conventions:

12) Convention on the Sustainable Management of Lake Tanganyika (2003); Gestion Conjointe des Ressources en Eau de la Rivière Ruzizi (ABAKIR).

13) In addition, the Contractor shall comply with the following (in no particular order of precedence):

a) Employer's Environmental and Social Management System, inclusive of Environmental and Social Impact Assessment (ESIA) and Management Plans (ESMP). The Contractor and its Subcontractors shall implement the relevant mitigation measures stipulated in the environmental and social impact assessments provided to the Contractor, unless otherwise directed by the Employer. The Contractor shall specify measures for compliance with standards and other regulatory limitations in the Contractor's construction environmental and social management plan and HSES programme. The Employer will assist in identifying mitigation measures relevant to the Contractor.

b) Authority Permits as applicable.

c) Lender's E&S policies and standards:

a. The 2012 IFC Performance Standards.

b. World Bank Environmental and Social Framework and Security Framework (2018)

c. The EIB standards (V 10.0 dated October 2018)

d) The most restrictive norms, standards, and discharge limit values among those imposed by the legislation of the Contracting States and those recommended by international organisations specialized in environmental and social protection, including:

a. The World Bank, including the IFC and its Environmental, Health and Safety guidelines available from http://www.ifc.org/ehsguidelines.

b. The World Health Organization (WHO).

c. The International Labour Organization (ILO).

d. UN Guiding Principles on Business and Human Rights.

e. Good Practice for Hydropower Projects: Environmental, Health and Safety Approaches for Hydropower Projects, IFC March 2018.

e) The contractor and its subcontractors must comply with national, regional and international laws on Gender-Based Violence (GBV), including sexual exploitation and abuse (SEA), sexual harassment and child labour. To this end, they must comply with international texts relating to (i) the United Nations Resolution 48/104 on the Declaration

on the Elimination of Violence against Women, (ii) the Resolution 2011/33 on Prevention, protection and international cooperation against the use of new information technologies to abuse and/or exploit children, (iii) the Resolution 44/25 of 20 November 2989 on the rights of the child. In the event of disagreement between applicable national laws, international laws, donor safeguard policies and/or these clauses, the most stringent requirements shall apply.

2.2 Management of Sub-Contractors

1) The Contractor is responsible for ensuring that all its sub-contractors comply with all the environmental and social requirements described below. The Contractor shall be held responsible for all non-compliance related to the activities of his sub-contractors under this contract.

2) The Contractor is to ensure that all subcontractors and vendors are aware of E&S requirements as applicable to them and ensure that these E&S requirements are included in their contracts, scopes of works, design, and execution procedures as well as implementation plans. This include incorporating E&S requirements into procurements activities and reviews and payments for services.

3) The Contractor shall provide details on how they select and manage their subcontractors (local, international and others) particularly in determining if they have systems in place to follow the necessary environmental, social and safety requirements, including mechanisms to prevent and manage cases of GBV as well as mechanisms to manage GBV sensitive and non-sensitive complaints.

4) Contractors shall provide typical organization charts and procedures showing how Environment, Social and Labour issues are managed at site level, including management and monitoring of subcontractors' performance.

5) The E&S Specifications apply to the Contractor and unless explicitly agreed with the Employer, all Subcontractors and Service Providers used for the execution of the Works. The EPC Contractor is fully liable for all actions, non-compliance and negligence by Subcontractors, their representatives, employees, and workers, to the same degree as it would be held liable for its own actions, non-compliance or negligence or that of its own representatives, employees or workers.

2.3 Resources Allocated to Environmental and Social Management

The human resources requirements specified hereafter represent the minimum resources required for E&S management by the Contractor. The Employer shall, at reasonable intervals or when the Contractor's performance requires, audit the E&S performance of the Contractor.

a) Environmental & Social Compliance Manager

The Contractor shall recruit an Environmental & Social Manager (the "E&S Manager") in charge at project level for coordinating the implementation of environmental, social and safety safeguards during implementation of the Project. The E&S Manager shall:

a. speak, read and write English and French fluently;

b. hold a university degree (BAC + 5) in an environmental engineering field or any related discipline with a complementary training or certificate in environmental assessment;

c. Have at least 10 years professional experience in the field of environmental and social assessment and/or health, safety and security for the implementation and monitoring of environmental and social aspects of development projects;

d. Have knowledge of environmental, occupational health, and safety issues for energy projects;

e. Have a good knowledge of the environmental rules and procedures of the main donors (e.g., World Bank, African Development Bank) regarding environmental and social safeguards;

f. reside at the Site for the duration of the Works;

g. Ability to write reports, correspondence and messages in French or English

h. Master the use of the most common word processing and spreadsheet software such as Word, Excel, Database, Email and others like PowerPoint, MS Project;

i. Report to the contractor project Director and have the authority to stop the Works when considered unsafe or there is a risk of environmental damages, and allocate resources, personnel and equipment required to take any corrective actions; and

j. maintain close communication with the Employer's E&S Director.

b) Site Environmental & Social Officers

The Contractor shall recruit Environmental & Social Officers (the "E&S Supervisor") to be assigned in each country (DRC and Rwanda) and work shift according to the deployment of the construction activities.

The Site E&S Supervisors represent the E&S Coordinator within Works areas to ensure that the Works are carried out in accordance with the Contract and to record and notify any non-conformities. Gender equity shall be properly enforced, especially as a minimum of two E&S Supervisors will be required from the outset.

Each E&S Supervisor must;

a. Speak, read and write French and English correctly;

b. Hold a university degree (BAC + 3) in an environmental engineering field or any related discipline with additional training or certification in environmental assessment have experience in management of community relations for similar projects.

c. At least 5 years of professional experience in the field of environmental and social assessment and/or Health, Safety and Security for the implementation and monitoring of Environmental and Social Aspects of development projects

d. Have knowledge of environmental, occupational health and safety issues for energy projects

e. Good knowledge of the environmental rules and procedures of the main donors (World Bank, African Development Bank) regarding environmental and social safeguards is an asset

f. Master the use of the most common word processing and spreadsheet software such as Word, Excel, Database, Email and others like Power Point, MS Project

g. Speaking Swahili and/or Kinyarwanda is an asset

c) Community Relation Supervisors

The Contractor shall recruit two local Community Relation Supervisors (the "CR Supervisor") responsible for relations with external stakeholders (Project Affected Persons-PAPs, Neighbourhood Residents, Administrative Authorities, Representatives of economic activities located in the Project area) as well as with the Project employees for all relational issues of each other. The CR Supervisor shall, amongst other things:

a. liaise closely with the Employer's Community Relations team and be responsible for resolving community grievances in a timely manner where the Contractor is responsible;

b. reside permanently at the Site

c. Must be fluent in French and English; Fluency in either local language, Swahili or Kinyarwanda is an asset;

d. participate in labour recruitment;

e. Have a university degree in social sciences or other related fields with additional training or certification in environmental and social assessment;

f. Have At least 5 years professional experience in the field of social and gender evaluation;

g. Have a Good knowledge of the rules and procedures of the main donors (African Development Bank or World Bank) regarding social and gender safeguards is recommended;

h. Have the ability to write reports in French, and to read, understand and write messages and correspondence in English;

i. Knowledge of existing laws and regulations in the three CEPGL countries on the management of social and gender issues is an asset;

j. have experience in management of community relations for harmonious conflict resolution in development projects.

k. Have the Ability to interact constructively in multidisciplinary teams with technical experts, engineers, local administration, project PAPs and civil society;

l. Have a working knowledge of the most common computer software (word processing and spreadsheet, database, e-mail).

The Contractor shall inform relevant administrations and local authorities of the existence of the CR Supervisor when required and provide them with the contact details.

d) CESMP Environmental & Social Monitoring Experts

The Contractor shall recruit E&S Experts (each an "E&S Expert") as required to support the E&S supervisors in areas where external expertise is required by (i) reviewing the E&S implications of the construction alternatives; (ii) training relevant contractor personnel in the incidental finding procedure (as defined below); (iii) responding to incidental finds; (iv) reporting incidental finds in accordance with the incidental finding procedure; and (v) providing oversight during topsoil removal. Each E&S Experts must:

a. Have at least experience in environmental and social assessment in similar projects;

b. Hold a university degree (BAC + 3) in an environmental engineering field or any related discipline with additional training or certification in environmental assessment;

c. A good knowledge of the environmental rules and procedures of the main donors (World Bank, African Development Bank) regarding environmental and social safeguards is an asset;

d. Be fluent in English and French;

e) Monitoring Equipment

Portable equipment for water, air, soil, dust, sound and vibration monitoring shall be provided by the Contractor to perform at minimum the monitoring of the following parameters:

a. For water & wastewater: In situ measurement of temperature, pH, EC, turbidity, dissolved oxygen.

b. Air monitoring: Portable equipment for in situ measurement of particulate matters (TSP, PM10),.

c. Sound and vibration measurement: dB and peak particle velocity

d. Soil – compaction and waterlogging probes.

2.4 Data Management

The Contractor shall implement a data management system to manage health, safety, environmental and social aspects on the Project. All health, safety, environment and social aspects shall be recorded in the data base, including reports, monitoring data, test results, data recording, grievances, incidents,

etc. The Contractor shall transfer relevant data in a suitable format for interaction with Employer's data management system.

To this end, and for the environmental monitoring of the sites, the company must have a fully equipped permanent laboratory allowing daily, weekly, or monthly monitoring (to be specified according to requirements) of:

a. River water quality (SS, dissolved oxygen, pH, temperature, conductivity, turbidity, etc.);
b. Water abatement rates at the outlet of settling tanks, crushers and concrete plants (TSS and PH in particular);
c. Water quality at the outlet of decanters and treatment systems;
d. Dust load levels in the air in the vicinity of some construction sites;
e. Noise and vibration levels in the vicinity of quarries, drilling sites, crushers ;
f. Levels of land remediation by phyto-ecologies.

As for the management of data related to GBV cases, the EPC must implement a GBV data management mechanism that complies with the internationally recognized guidelines, especially regarding data recording, complaints, incidents, while ensuring confidentiality etc.

2.5 Non-Conformities

1) The Contractor and his subcontractors must be familiar with, comply with, and apply the provisions of the Contract, as well as the conditions laid down by the various authorisations or approvals required.
2) The Contractor (including its subcontractors) shall comply with:
    a. All environmental and social provisions applicable to the Project under the financing agreements;
    b. The environmental and social safeguard policies of the Lenders applicable to the Project;
    c. Mitigation measures from the ESIA/ESMP and RAP;
    d. The laws and regulations of the CEPGL countries (Burundi, Democratic Republic of Congo, Rwanda) in force and applicable to the Project;
    e. National, regional and international texts relating to gender-based violence (GBV), i.e., sexual exploitation and abuse (SEA), sexual harassment and exploitation of children at work.
    f. The implementation of the environmental and social requirements by the Contractor will be audited by the Employer in association with representatives of the Contracting States and lenders to the Project.

3) The Employer will notify the Contractor in writing of all cases of failure or non performance of environmental and social measures. The Contractor shall remedy any failure to comply with the requirements notified to him, within the time stipulated in the notice. The resumption of work or additional work resulting from non-compliance shall be at the Contractor's expense.

4) The Contractor shall record all environmental incidents and social issues including GBV incidents as well and non-conformities using an environmental incident reporting procedure as defined by the Employer's Environmental, Social, Health and Safety Supervisor (ESHSS). The environmental incident reporting procedure shall identify, evaluate, investigate, correct, and document environmental incidents and non-conformities. Any E&S incident must be reported to the Employer within 24 hours.

5) The register of non-conformities shall be submitted to and reviewed by the Employer's ESHSS. The reporting of GBV cases shall be in accordance with internationally recognised guidelines.

6) The Employer reserves the right to carry out assessment and further investigations of the Contractor's assessments, either in concert with it or independently. These assessments may vary in level between Project level assessments and corporate level assessments.

7) In the event of a non-conformity notified by the Employer, a non-refundable deduction of USD 10,000 for each non-conformity will be made from the Contractor's payment whenever the non-conformity remains open for more than 30 days beyond the closure date stipulated by the Employer in the notice. In such conditions, the Employer may take the necessary measures to ensure, by a third party, the repair of the damage caused to the environment and shall deduct any associated costs from the Contractor's payment. However, the intervention of the Employer will not release the Contractor from his responsibility.

8) If three (3) or more non-conformities remain open for more than 30 days beyond the closure date stipulated by the Employer in the notice, the Employer will notify the Contractor and temporarily withhold three percent (3 %) of all payments due to the Contractor. The full withheld amount shall be released to the Contractor in the next payment after the Contractor closes the non-conformities to the satisfaction of the Employer, and the total number of outstanding non-conformities are below three (3).

3 Documentation

3.1 Construction Environment & Social Management Plan

1) The Contractor shall submit a plan to satisfy the Contractor's E&S obligations as specified in the ESIA and the Employers Project ESMS ("the Construction Environmental and Social Management Plan" (CESMP)).

2) The CESMP shall comprise three parts:

   a) Part 1: Environmental and Social Organisation.

The document shall include the Contractor's Environmental and Social Management System (ESMS) documentation including: (i) establishing the Environmental Management Staff organization chart indicating the person in charge of Health/Safety/Environment for the project; (ii) providing a description of the methods of reducing negative impacts; (iii) establishing the Borrow Pit and Quarry Site Management and Reclamation Plan; (iv) instituting the Water and Sanitation Supply and Management Plan;.

b) Part 2: Environmental and Social Protection.

A site-specific overview of the identified impacts generated by the Project and the mitigation measures. Part 2 shall also describe the Environmental Incident Reporting and Corrective Action plan and the Stakeholder and Community Management procedure.

c) Part 3: Environmental and Social Procedures.

Specific plans and procedures to describe how E&S issues are to be controlled, managed, and reported. Tolerance levels and expected performance targets will be in accordance with national legal requirements, thresholds in E&S IFC (Environmental, Health and Safety guidelines) documentation, WHO and IFO standards. The Contractor shall prepare and implement E&S procedures detailing, for each of the aspects considered, the environmental practices that it will implement to eliminate or reduce potential impacts. The Contractor's E&S performance will be evaluated based on its capacity to implement the measures detailed in the procedures and the results obtained. Each procedure shall include as a minimum:

a. Cross references to applicable legislation.
b. Roles and responsibilities, including name, experience and profile of all staff involved in the environmental, social, health and safety procedures
c. Cross reference to other procedures.
d. Identification of construction activities with potential risks in the field of concern.
e. Description of all or some of the mitigation measures proposed in Part 2, including specific management plans relating at minimum to (i) hazardous substances and hydrocarbons, (ii) solid waste, (iii) dust emission and air pollution, (iv) spillage control, water and sanitation, (v) topsoil and quarry/borrow pits exploitation and reinstatements
f. Implementation, monitoring and adaptive management process.
g. Technical description or measurement / monitoring methods.
h. Timeframe.

3) The Contractor shall submit the CESMP to the Employer not less than 30 days prior to the planned start of construction activity for the Works. Each site to be stripped will be provided with a specific Management Plan showing, among others

a. The exact boundaries of the si.te ;

b. Access routes and checkpoints ;

c. Erosion and sediment management and control procedures;

d. The organisation of the clearing: preserved wooded areas, cleared areas, usable wood storage areas, forest waste burning areas, phasing of operations;

e. Storage areas for topsoil, earthworks and other materials;

f. The construction activities that will take place on the site: residence/office, material storage, workshops, concrete production;

g. Wastewater and storm water management arrangements;

h. The location of the proposed sampling points for water quality monitoring;

4) The Employer will provide comments to the Contractor within 15 days after receiving the CESMP. If applicable, the Contractor shall submit the revised CESMP, integrating the Employer's comments, to the Employer for review within 7 days after receiving the Employer's comments.

5) No construction activity for the Works shall commence prior to the CESMP being finalised and approved except as authorized by the Employer. The commencement of Works in each area shall be authorised by the Employer only after non-objection of the related E&S procedures.

6) During the Works, unless otherwise agreed with the Employer, the CESMP shall be updated by the Contractor every six months and submitted to the Employer for review. The revised version shall highlight the new elements incorporated in the CESMP.

3.2 Reporting

In addition to the requirements of the above-mentioned Plans, the Contractor shall submit to the Employer the following reports:

a) Ad-hoc reports dealing with a specific environmental and/or social issue as may be requested by the Employer.

b) Report on climate, waste and water management, (classification according to categories of waste and chemicals according to their hazardousness in terms of volumes produced, stored, disposed of), water management, fuel and energy use, on a monthly basis according to a template to be provided by the Employer (see Attachment 1)

c) As part of the monthly progress report, the Contractor shall submit a searchable electronic report providing:

a. Summary of all E&S initiatives implemented in relation to the Works and specified key performance indicators.

b. The results of monitoring analysis (drinking water, wastewater, storm-water, discharge from sedimentation ponds, air quality, dust, noise, light pollution etc.) carried out during the month.

c. The status of environmental non-compliances and non-conformities opened or closed during the month including GBV related incidents.

d. The status of community grievances opened or closed during the month.

e. Particular activities carried out during the last week and scheduled for the coming month.

f. Monitoring internal E&S training and awareness activities.

d) Half-yearly reports showing:

a. A summary of the E&S activities of the semester;

b. The main difficulties encountered and the remedial actions implemented;

c. Monitoring of E&S indicators ;

d. Monitoring of E&S non-conformities;

e. Monitoring of waste and chemical volumes.

e) Documentation of the evolution of the project site showing the changes in the state of all work areas from the start of the work until the issue of the Takeover Certificate. This documentation is mainly made up of dated and geo-referenced colour photographs taken every week from a constant angle and viewpoint.

4 Construction Practices

The following sections expand on the content required in the various documents listed in Annex 1.

4.1 Site Inspections

1) The E&S Compliance Manager will carry out an E&S inspection of the Works on a weekly basis jointly with the Employer in addition to the continuous E&S monitoring missions that are carried out by the E&S inspectors during the entire duration of the works. A detailed written report/checklist will be drafted by the Contractor for each weekly inspection, in a format approved by the Employer, addressing NC detected and best industry practices. The report shall be submitted to the Employer within three (3) days of the inspection.

2) NC and good practices shall be documented, with relevant evidence explicitly indicating the location, date of inspection and a brief description of the NC/good practice in question.

3) An adaptive management approach will be demonstrated.

4) The Employer may, as required by the Project, request additional E&S inspections to be undertaken by the Contractor.

5) By contractual provision, the Lender's E&S Advisor (LESA) will carry out regular performance monitoring, expected on a quarterly basis. The Contractor shall assist and participate in the Lender's monitoring process by being available to answer queries, to provide supporting information and to assist the Client in reviewing and clarifying Lender monitoring reports and

closing actions as required. The Contractor cannot refuse access to site or documentation to the LESA unless there is a safety constraint (blasting, etec..).

4.2 Training

1) The Contractor shall prepare and implement an E&S training programme for its personnel as part of the CESMP. Training for each role is identified through a comprehensive training and competency / skills matrix covering the training that will be required for each role. The training activities are to be documented in the monthly progress report.

2) Training sessions are two-fold: induction sessions for starting the Works, and technical training as required in relation to the execution of the Works. Induction sessions are organised for each Personnel and shall cover as a minimum:

   a. Rules of procedure and code of good conduct.

   b. Protection of biodiversity in the project area.

   c. Protection of biodiversity in areas adjacent to the Site.

   d. Pollution prevention and environmental protection measures both inside and outside the Site.

   e. Risks relating to sexually transmitted diseases.

   f. Basic health: combating waterborne diseases and improving hygiene.

   g. Asset damage procedure in the event of accident

   h. Relationship with the local communities.

   i. Regular tool-box-talks on relevant and topical issues and related to incident reporting figures.

   j. Procedures for the prevention and management of GBV cases.

   k. Procedures to be followed in case of complaints related to the works (Complaints Management Mechanisms – CMM)

   l. Management of physical cultural resources in case of chance finds, pollution prevention and environmental protection measures

4.3 Protection of the Environment

1) Protection of Adjacent Areas

Unless instructed otherwise by the Employer, the Contractor shall use construction methods and means of protection that ensure no adverse effects on vegetation, soils, groundwater, biodiversity, natural drainage and the water quality in the areas adjacent to the Site for the entire duration of the Works.

2) Biodiversity

   a) Hunting and fishing are strictly prohibited as well as consumption of meat of wild animals (bush meat). The Contractor will prepare, execute, and document a Biodiversity Awareness

Program for the Contractor's personnel. Prohibitions will be formulated in the internal regulations of the company and of the contractors, accommodation sites of all workers with controlled access, canteen and commissary with household proteins and compliance with other measures specified in the ESMP.

b) Excavations and trenches shall be covered or a means of egress provided when not in use to mitigate risk to animals.

c) Prior to any deforestation or stripping work, the Contractor shall submit all administrative authorisations that may be requested by the local authorities;

d) In the process of establishing Site Management Plans, sensitive areas shall be located and mapped to avoid clearing.

e) Burning of wood or charcoal for cooking is prohibited. More generally, burning of any material shall not be permitted in accordance with the management plan for deforestation and stripping activities. A site management plan will specify activities that are allowed or not in the camps and on the site (trade, cooking, relaxation, etc.)

f) The Contractor shall ensure that the minimum ecological flow is always maintained during the Works. The Contractor shall install a gauging station and suitable access downstream of the dam to allow third party monitoring of minimum ecological flow set by the environmental studies.

4.4 Monitoring and Measuring Plan

1. The Contractor shall prepare a Monitoring and Measuring Plan in accordance with the IFC good practice rules for hydro structures. For the construction phase, this plan covers the following points in particular:

- Wastewater discharges-Effluents from worker camp sanitary wastewater
- Stormwater runoff-Total suspended solids (TSS)
- Rock extraction/tunneling discharges-TSS; pH, acid drainage (also referred to as Acid Rock Drainage (ARD)/metals leaching). Applicability depending on results of pre-construction ARD/metals leaching testing/mapping for the presence of Potentially-Acid-Generating (PAG) materials)
- Solid waste-Rock waste and topsoil storage
- Biodiversity-Aquatic and terrestrial ecology surveys, vegetation reinstatement (as relevant, aquatic ecology should be assessed upstream and downstream of effluent discharges during construction)
- Air quality/emissions-Particulate matter at project boundary; black smoke from construction equipment, visible dust at construction sites
- Noise and vibrations at nearest receptor (include pre-blasting surveys of community infrastructure)

2. The monitoring plan will capture elements defined in the ESMP including:

- The precise list of parameters to be measured for each element (PH, dissolved O2, BOD5, SS, piezometric height, sound levels, etc.)
- The frequency of measurements

- Sampling and measurement procedures
- Data recording and archiving

4.5 Effluents

a) General

a) Effluents consist of liquid discharges, including infiltration, transporting a pollutant (dissolved, colloidal or particles).

b) The Contractor shall prepare and implement a Pollution Prevention and Control Plan as part of the CESMP. The plan shall detail Site-specific measures the Contractor will implement during the Works to identify, drain and treat effluents from the Works.

c) Pollution is the introduction of substances or energy into the environment, resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems, and impair or interfere with amenities and other legitimate uses of the environment. The Contractor shall refer to the reference standards (IFC Guidelines, WHO Standards) for water purification based on the applicable thresholds for the discharge of sanitary wastewater after treatment. Depending on the issues under consideration, the levels of analysis are at three levels: (i) In-situ measurements using portable equipment; (ii) In-house laboratory analysis; (iii) Analysis by an accredited laboratory.

d) No effluent shall be discharged by the Contractor, or the Contractor's activities, into water courses or soils without prior treatment and without monitoring of the treatment's performance to guarantee the absence of pollution.

b) Focus on Prevention

a) The Contractor shall primarily focus on pollution prevention. For all activities involving chemicals on Site, a source - pathway - receptor assessment will be carried out by the Contractor and documented, and measures identified to prevent harmful substances entering the pathway at source.

b) The Contractor shall define the actions to be followed to prevent discharge to the environment if harmful substances do end up in the pathway.

c) Wastewater

a) The Contractor shall provide, install and maintain sewage treatment plants or other treatment process for disposal of sewage from all houses, offices, camps and other buildings constructed by the Contractor. Such treatment plants shall be adequately sized for the anticipated sewage loading in accordance with relevant regional and international guidelines.

b) The system shall comply with the relevant statutory requirements and international standards. Sewage treatment plants will be sufficient for the number of personnel resident.

c) Black water and grey water will be treated separately unless the sewage treatment plant is capable of processing both waste streams.

d) Oil separators shall be used for canteens unless the sewage treatment plant is capable of processing the waste.

d) Runoff from Technical Installations

a) Runoff consists of the rainwater flow on the surface or the soil and other technical surfaces at Site.

b) Runoff will be considered as an effluent unless demonstrated otherwise, as documented and substantiated by the Contractor and approved by the Employer.

c) All areas with generators, hydrocarbon storage tanks and refuelling stations shall have impervious surfaces with secondary containment and shall be drained and equipped with an oil separator.

d) Runoff from workshops, parking areas and garages shall be drained and equipped with oil removal treatment to prevent pollution.

e) Effluent from batching activities and cleaning of concrete trucks shall be collected in sedimentation ponds and treated in line with best industry practices. This treatment will be subject to detailed study submitted to the Employer for approval prior to start of the batching plant operation.

f) Sludge resulting from tunnel water settlement ponds, the maintenance of oil separators, and batching plant settling ponds are considered as hazardous waste and shall be disposed of in line with the Waste Management Plan.

e) Water Quality Monitoring

a) The Contractor shall submit a Water Management Plan detailing the location and characteristics (flow, expected quality, discharge frequency) of all sources of effluents and outlets in the natural environment affected by the Contractor's activities. The Employer will monitor effluent quality in accordance with the ESMP.

b) The Employer will detail the effluent quality monitoring plan with the following details, but not limited to:

   a. Location of sampling sites.

   b. Frequency of analysis performed and parameters controlled.

   c. Analytical methods used for the control of each parameter.

   d. Proposed structure of the database for water monitoring results and trending against compliance values.

c) The effluent monitoring will be carried out by the Employer pursuant to and using equipment that complies with the relevant ISO standards, or equivalent as identified in the ESMP.

d) At a minimum, the sampling stations will include the effluent stream prior to discharge, then at 5 m and 10 m down the river or the stream to check for dilution effects. River water will

also be tested upstream from the discharge point to understand to what extent discharges are affecting river water quality.

e) The physical and chemical parameters of the effluent that are monitored are those that are listed in the Contracting States environmental regulations, or if these do not exist, the parameters are based on the recommendations of specialised international organisations. The parameters shall have prior approval from the Employer.

f) As a minimum, the following quality indicators will be monitored by the Employer:

   a. Organic pollution: BOD5, nitrates, phosphates, particularly for effluents from living areas and sanitation systems.

   b. Oils and grease, particularly for drainage water from mechanical activities, hazardous products storage (hydrocarbons), and wastewater from food preparation/consumption areas.

   c. Suspended matter, in drainage water from anti-erosion activity areas and sedimentation ponds.

   d. Suspended matter and pH at the outlet of batching area sedimentation ponds.

   e. Bacterial pollution: Presence of faecal and total coliform in drinking water storage and distribution network.

   f. Groundwater pollution in relation to landfill sites: BOD5, COD, ammoniac nitrogen, nitrates, chlorine, zinc, chromium, lead, mercury.

   g. For all samples, the following parameters shall be measured in situ: temperature, pH, electrical conductivity, turbidity, dissolved oxygen.

g) The Employer will monitor the effluent quality involving the following operations and facilities:

   a. Treated effluent from wastewater treatment plants (lagoons, septic tanks).

   b. Tunnel water.

   c. Sedimentation ponds related to batching plants activities and crusher plants.

   d. Sedimentation ponds related to storm-water at sites considered particularly sensitive.

   e. Drainage water fr.om workshop sites, hazardous products storage sites and food preparation/ consumption areas.

   f. River work sites, with monitoring of the solids content of water upstream and downstream of the works.

   g. Monitoring wells drilled for landfill control.

h) Effluent quality monitoring will be performed according to a variable frequency from weekly to monthly, depending on sites, activities involved and sensitivity.

i) In the event of an incident or non-compliance, monitoring shall take place daily until the results indicate that the pre-incident condition has been achieved.

j) The Employer will prepare submit an effluent quality monitoring report monthly, as part of the monthly progress report, including documentation for the following for each effluent discharge point:

   a. Average flow rates of discharged effluents.

   b. Discharge frequencies and durations over the month.

   c. The physical and chemical quality of the effluent discharged.

   d. Remedial measures required by the Contractor to comply with the relevant requirements.

4.6 Waste

The Contractor is responsible for identifying, collecting, segregating, transporting, disposing and treating all waste produced during the Works at Site. The Contractor shall prepare and implement a Site Waste Management Plan as part of the CESMP. The plan shall be submitted not less than 30 days prior to mobilization to the Site. The plan shall detail all Site-specific measures the Contractor will implement during the Works to identify, collect, transport and treat all waste produced on Site. The plan shall follow the waste management hierarchy as specified in the EU Waste Management Framework.

4.6.1 General Practices

1) The Contractor shall establish a secure centralised waste segregation and management area of sufficient size and to international standards before Works commence. All waste shall be segregated into different waste streams.

2) The Contractor shall establish and maintain a waste register which is at the disposal of the Employer. The register shall record all anticipated types of waste generated by the project, its EU waste code, the quantity, and treatment, i.e., reuse, recycling, disposal options. This register shall subsequently record all actual waste management operations including production, collection, temporary storage, transport, and treatment. The following aspects are to be documented in the register:

   a) Type of waste.

   b) Waste quantities.

   c) Waste code.

   d) Name and address of the third-party waste transporters and waste management facilities receiving waste or parties taking possession of the substances no longer considered as waste.

   e) Name and address of waste transport contractors.

   f) Actual waste treatment.

3) The Contractor shall keep detailed records of the waste manifests for the collection, transport, treatment and/or elimination of waste. The waste register shall be established and available prior to the Contractor's mobilisation to Site.

4) The Contractor shall implement specific waste management practices adapted to the level of danger for human health or the natural environment. Three waste categories are identified the Site and in tracking documents:

   a) Hazardous waste: any waste with one or several dangerous properties as listed in this Part.

   b) Non-hazardous waste: any waste with no properties rendering it hazardous. Non-hazardous waste contaminated by hazardous material will be considered as hazardous waste, unless indicated otherwise by the Employer.

   c) Inert waste: any waste unaffected by any significant physical, chemical or biological modifications, which does not decompose, burn or produce any physical or chemical reaction, is not biodegradable and does not damage any substance with which it comes into contact in a manner likely to cause damage to the environment or human health.

5) The Contractor shall assess the availability of local services and facilities for local recycling and re-use and effectively implements available local recycling or re-use options for waste -for instance, burning of used engine oil in the cement plant CIMERWA in Rusizi District (Rwanda). The Contractor shall engage a qualified company for the collection and the recycling of recyclable materials. Recyclable wastes are to be removed from their temporary storage location on a regular basis, not less frequently than every two months.

6) Waste shall be categorised and stored separately prior to removal from the Site, depending on the level of danger, phase (liquid, solid or gas), the waste management solution to be applied and its potential in terms of recycling or reuse.

7) Waste shall be regularly collected from each area and is to be placed in temporary locations meeting the following criteria:

   a) Located at a distance of over 100 m from any natural sensitive area and over 500 m from any socioeconomic sensitive area (school, market, healthcare centre, water well), with the exception of waste storage areas in camps.

   b) Protected from moving machinery and vehicles, but easy to access for regular collection.

   c) Protected from the possibility of landslides.

   d) Located on a flat surface to prevent infiltrations.

   e) Organic waste shall be covered to prevent access by vermin and to reduce odours.

   f) Stored in containers of the appropriate size, tightness and level of resistance depending on the danger and phase (solid, liquid, gas) of the waste.

   g) Liquid wastes shall be stored with a secondary retention with a volume at least 110% of the largest container.

h) Hazardous waste stored pursuant to approved practices.

i) Should any of the criteria above not be possible then acceptable alternative solutions shall be identified by the Contractor and approved by the Employer prior to execution.

8) Duration of storage in temporary location (time between two collections) shall be logged into the waste register for each temporary waste storage location.

9) The Contractor shall implement measures for protecting waste storage areas from animals.

10) Waste shall be removed from the Site and transported to recycling, treatment and waste management facilities on a regular basis. The frequency of removal shall guarantee:

a) No overflow from containers.

b) No unpleasant odour or emissions which are dangerous for human health.

c) No proliferation of insects, rodents, dogs or other animals which are harmful or dangerous for human health or who predate small mammals and birds.

d) Regular cleaning of containers and surfaces on which they are located.

11) Waste incineration, except medical waste, is prohibited at Site, unless instructed by the Employer.

12) The use of third party waste management services is subject to a documented prior audit of the treatment, storage and recycling facilities by the Contractor, to guarantee the conformity with the provisions of this Part. A copy of the audit report shall be provided to the Employer.

13) The provisions applicable to the Contractor regarding waste management also apply to any third-party waste management contractors. The Employer reserves the right to inspect third party waste management facilities of such contractors and prohibit the Contractor from using the facilities if the facilities do not comply with the specified requirements.

4.6.2 Non-Hazardous Waste Management

1) Non-hazardous waste may be either disposed of in municipal landfill or the Contractor may develop its own landfill sites, subject to approval by the Contracting States authorities and the Employer. If the Contractor uses an existing municipal landfill, this landfill will be subject to a documented audit which demonstrates that the quantity and type of wastes brought by the Contractor does not raise an incremental risk for the environment and community which cannot be handled by the established management of the municipal landfill.

2) Used tires shall be recycled as much as possible by retreading. Non-recyclable tires shall be stored in an orderly stack on a dedicated area within a fixed facility pending their removal from the Site. Tires may used in borrow pits and quarries to stabilise the materials.

3) Burning of all waste including tires the open air is forbidden.

4) If the Contractor develops its own landfill outside of Site, then the landfill shall meet Laws and regulations.

5) If the landfill is developed at Site, then the following specifications apply. The management of non-hazardous waste complies with the following conditions:

a) Non-contaminated inert waste is removed and can be disposed of to landfill with unused backfill material. The location, capacity and environmental protection measures, particularly for water courses, implemented by the Contractor or Subcontractor, will comply with the provisions of this Part.

b) Non-hazardous waste that cannot be recycled and is disposed to landfill shall comply with the following criteria:

a. The bottom of the landfill shall be not closer than 2 m above the highest seasonal level of the water table.

b. The landfill access is always controlled.

c. Depending on the type of waste, walls and base of landfill cells are made impervious by a geo-membrane at least 2.5 mm thick with welded seams, or by a layer of compacted clay with a minimum thickness of 0.5 m and a permeability factor less than 10^{-7} cm/s.

d. Drained for the recovery of leachates.

e. Leachates are treated prior to release in the environment, either by aerobic/anaerobic lagooning treatment or transfer to any other treatment facility.

f. Treated leachate BOD_5 shall not be higher than 50 mg/l.

g. Each landfill cell is surrounded by an external peripheral drainage to minimize drainage water inflow.

h. Regularly compacted and covered by soil to limit odours and the proliferation of insects and rodents.

i. When a landfill cell has reached full capacity, vents are installed to evacuate gases, and the landfill covered by a geo-membrane with a minimum thickness of 1 mm, or a 30 cm layer of compacted clay, and a top layer of 1.5 m of topsoil, which shall be revegetated.

j. At least two piezometers joining the underlying aquifer are installed by the Contractor, one upstream of the landfill and the second downstream, assuming the general direction of the underground water flow. These piezometers allow regular monitoring of the water table depth next to the landfill and regular sampling of underground water for quality analysis and detection of any pollution from the landfill, should it happen.

k. The facility is sized to accommodate the domestic waste production during the construction period as well as the waste production of the Operator's housing during the first 5 years of operation of the Project.

4.6.3 Hazardous Waste Management

1) The Contractor may engage a specialised subcontractor to manage hazardous waste, who is accredited in the Contracting States for this activity. In the absence of an existing waste management solutions for hazardous waste, the Contractor takes the following action:
   a) Medical waste is incinerated in a specific facility constructed and accredited for this purpose.
   b) Used oil, hydrocarbons, lubricants, paints, solvents, and batteries are transported in drums to waste management facilities. Sludge from settling tanks/ponds, septic tanks or oily water skimmers will also be managed in the same way.
   c) Contaminated soils from construction/demolition will be treated, stabilised and disposed to landfill.
   d) Prior approval from the Employer is required before implementing waste management solutions on any other hazardous waste.
   e) The Contractor shall provide documentation on Industrial waste (tyres, batteries, scrap metal, hydrocarbons, etc.) and hazardous waste landfilled at sites other than accredited third-party waste management facilities. The documentation shall include a plan showing the location of landfill sites. The document is to be provided to local authorities whose jurisdiction covers the landfill sites, with a copy to the Employer.

4.7 Handling and Storage of Hazardous Substances

1) A substance is considered dangerous if one or several of its properties render it hazardous.
2) The Contractor shall prepare and implement a Chemical Management Plan that includes a section on dangerous substances, their handling and storage, in accordance with the provisions detailed below. The plan shall detail all Site-specific measures the Contractor will implement during the construction phase to identify and manage hazardous substances planned for use on Site.
3) The procurement policy shall ensure that any alternative to hazardous substances shall be considered where possible following the standard mitigation hierarchy.

4.7.1 Transport and Handling

1) The Contractor shall obtain all necessary authorisations and/or licenses for the storage and use of dangerous substances from local authorities. A copy of the authorisations shall be submitted to the Employer.
2) For each dangerous substance used, the Contractor will implement the recommendations described (i) in the Safety Data Sheets (SDS), and (ii) by the Globally Harmonized System of Classification and Labelling of Chemicals established by the United Nations for hazardous chemicals.
3) All handling or transferring of hazardous substances is to be performed on impervious surfaces equipped with spill retention.

4) Copies of SDS are to be kept on at Site and made available to personnel. These shall be in English and French. The Contractor shall submit copies of all SDS.

5) Storage of Hazardous Substances

   a) Storage areas shall be designed and equipped by the Contractor based, not only on the chemical and physical properties of the products, but also on the types of containers stored, the number of people requiring access, and the quantities of the substance used.

   b) The size of areas allocated for storage will be calculated based on the volume of the hazardous material that will be on site during peak construction for the relevant activity.

   c) The Contractor shall plan for the storage and management of hazardous waste.

   d) Storage areas for hazardous substances shall adhere to strict rules, which will be regularly checked by the E&S Manager. The rules include the following as a minimum:

      a. Access to the storage area is limited to trained and authorised individuals equipped with the appropriate personal protective equipment.

      b. An inventory is maintained up to date and all in/out movements of hazardous product are registered.

      c. SDS must be available for all stored hazardous substances, and the substances must be clearly labelled.

      d. A strict and methodical storage system is implemented (storage plan posted, large or heavy packaging may not be stored at heights, equipment and tools may not be stored in the hazardous substance storage room).

      e. Compliance with product expiry dates and implementation of a disposal procedure for substances which are not needed or which have expired.

      f. Entrances, exits and access to emergency equipment are kept clear at all times.

      g. Storage areas for hazardous substances are clearly identified with warning signs at the entrance. The Contractor displays the storage plan (location of the different products, maximum inventory), a summary of labelling system and information on chemical incompatibilities in English and French.

      h. Chemicals which could react together (leading to explosions, fire, projections or the emission of dangerous gases) are physically separated.

      i. Products that react violently with water are stored to prevent contact with water, even in the event of flooding.

      j. Inflammable products are stored separately in a dedicated area with adequate ventilation at all times.

   e) Buildings used to store large quantities of hazardous substances are to be isolated from other buildings to avoid the spreading of fire. Such buildings are to be constructed using solid

and non-combustible building materials and are to be equipped with evacuation systems and the firefighting equipment. Access to the buildings shall be clear, allowing for rapid evacuation in the event of an accident. The electrical systems shall be reduced to the essential minimum, and access points shall be equipped with adequate lighting (300 lux as minimum).

f) All storage areas for hazardous substances are to be equipped with secondary retentions to retain any spill or leakage from one of the containers stored. The secondary retention volume is defined as a minimum of 110% of the volume of the largest container stored on the site taking into consideration the volume occupied by the stored containers. Secondary containment bunds are to be maintained empty of rainwater.

g) Tanks are to be equipped with level detectors and safety systems to prevent overfilling.

h) Absorbents (neutralising and non-combustible) are to be made available in the storage area to clean up any spills and leaks. Polluted soils are to be removed and managed as hazardous waste.

i) The Contractor shall maintain the storage area at a suitable temperature for hazardous substances to prevent overpressure and bursting of containers.

j) Runoff from worksite areas where hazardous materials are stored or handled is to be collected and routed to an oil-water separator for separation of hydrocarbons before discharge of runoff to the natural environment.

6) Refuelling and Lubrication

a) Refuelling and lubrication of vehicles, machinery and plants shall be to the extent possible at dedicated refuelling stations equipped with impervious platforms. Refuelling shall be included in the Pollution Prevention and Control Plan.

b) Refuelling and lubrication of machinery outside the workshops and refuelling stations is performed using dedicated equipment to minimize risks of leakage and soil contamination. Portable retention equipment shall be used systematically to collect any accidental spill.

c) Refuelling shall be in line with best industry practice.

d) Refuelling tankers, heavy equipment lubrication vehicles on job sites and deposits must not show any visible leaks allowing fuel to escape to the ground from the beginning to the end of the works. These vehicles must be equipped with anti-drip trays and an emergency oil recovery kit comprising a sufficient quantity of absorbent materials (sheets and absorbent booms) and related equipment (shovels, gloves, leakage plugs, etc.) to deal with any situation. These kits will also be present on board all construction site machinery.

e) Fuel supplies must be made in accordance with the recommendations and safety measures recommended by the suppliers

f) On the work sites, the trucks supplying fuel and dangerous products will be transported

g) Fuel supply tanks used on construction sites must be fitted with functional nozzles at the end of the hoses to stop the flow immediately.

h) All cans containing hydrocarbons will be fitted with spouts.

7) Spill Contingency Planning

a) Prior to mobilization on Site, the Contractor shall prepare, submit and implement a spill contingency plan demonstrating its capability and state of readiness for responding and taking appropriate action in the event of a hazardous substance spill.

b) The Pollution Prevention and Control Plan and the Chemical Management Plan shall describe the necessary procedures which include the following: Hazardous materials on-Site: amount normally stored and storage capacity, types and number of storage containers, storage location, SDS for each material, existing preventative measures e.g. secondary containment, fuel handling.

a. Flow chart of response organization.

b. Action Plan: Potential spill sizes and sources for each hazardous material on site, potential environmental or social impacts of spill (include worst case scenario), procedures (including alternative action in case of impeding environmental conditions).

c. Procedures for initial actions.

d. Spill reporting procedures.

e. Procedures for containing and controlling the spill e.g. on land, water, snow, ice, etc.

f. Procedures for transferring, storing, and managing spill-related wastes.

g. Procedures for restoring affected areas.

h. Resources available for responding to spills: On-site resources e.g. spill kits, booms, sorbent materials, earth moving equipment; and Off-site resources e.g. contact numbers for deployment and time estimate.

i. Training Program: Outline of training program, training schedule and record keeping.

c) The locations of adequate and suitable spill response kits shall be identified in the Site Environmental Protection Plans based on the locations of potentially polluting works.

d) All generators and equipment used during construction shall have secondary containment.

4.8 Erosion, Soil & Vegetation

1) The Contractor shall plan earthworks and optimise the management of space to ensure that all cleared surfaces and areas exposed to soil erosion are minimised across the Site. The relevant plans are the Soil Management Plan, the Slope Stability and Erosion Procedure and the Vegetation Clearing and Debris Management Plan.

2) The Contractor shall prepare and implement a plan, as part of the CESMP that details all Site-specific measures to minimize vegetation clearing. Temporary and permanent erosion control techniques shall be described, and consideration given to landslip potential. Suitable drainage design is to be submitted to the Employer for approval before the Contractor commences the Works.

3) Unless authorized otherwise by the Employer, side casting of material during road construction works is not permitted.

4.8.1 Vegetation Clearing

1) As part of the Site Condition survey referenced in Section VII.1 *Scope of Work and General Requirements*, the Contractor and the Employer will map and survey habitat loss areas that are scheduled for reinstatement or landscaping prior to loss to inform the revegetation activities required as part of the Site decommissioning and reinstatement activities.

2) The Contractor shall submit and implement a Vegetation Clearing and Debris Management Plan prior to the start of construction at Site which will provide an overview of clearing activities. Prior to any deforestation or stripping work, the company must have administrative authorisations that may be requested by the supervisory authorities.

3) Burning of wood and debris is not permitted without explicit, written approval by the Employer.

4) If permitted, any vegetation burning associated with biomass removal shall be conducted according to the legal framework and in accordance with a Smoke Management Plan, submitted to the Employer for review with community representatives prior to any burning activities. This plan shall (i) identify smoke sensitivity zones (populated areas), (ii) schedule the burn programme, (iii) identify sensitive time periods, (iv) determine set-back distances, firebreak needs and specify burn procedures (debris pile construction and seasoning, pre-burn protocols, light-up procedures including venting forecasts, ignition criteria and smoke release periods, burn operator training, post-burn protocols).

5) The plan shall include as a minimum: dam sites, quarries, borrow areas, powerhouses, disposal areas, access roads, and power supply lines. For each of the clearing sites, the plan shall describe:

    a. Areas to be cleared in hectares.

    b. Clearing schedule considering constraints on bird and squirrel nesting and bat roosting period.

    c. Methods of clearing.

6) The Vegetation Clearing and Debris Management Plan shall include the following specifications:

    a) What to clear:

    - Within worksites, complete removal of commercial and non-commercial vegetation shall be required, including stumps.

- In all areas where vegetation clearing is required, trees shall be cut not more than about 0.5m from the ground.

b) Clearing Equipment:

- All clearing equipment shall be used by trained and experienced operators, with Personnel Protective Equipment.
- Manual clearing using chain saws shall be performed in zones less than 30 m from areas designated as sensitive by the Employer. These offset distances will be measured horizontal ground distances from the referenced boundaries. Mechanical removal of trees within manual clearing areas may be possible at some locations using appropriate equipment that can reach into the clearing area to remove the material without disturbing the ground and other vegetation (e.g. feller buncher).
- For all other areas, clearing may be performed using a shearing blade or feller-bunchers that shears vegetation off at ground level, accumulates woody and other material on the forest floor, and piles material into windrows in one operation.
- All branches, shrubs and non-merchantable shall be chipped for use as mulch in Site remediation or turned over to the Employer at stockpile areas. The Contractor shall use chipping machine(s) that follow the windrows created by mechanical clearing equipment.

7) The Vegetation Clearing and Debris Management Plan shall describe the measures to re-use the rapidly degradable biomass, non-commercial non-rapidly biomass, and top soil extracted for reinstatement of construction sites located outside the reservoir area (e.g. mulching and chipping, and creation of wood briquettes).

8) Vegetation clearing using chemicals is not permitted.

9) Vegetation clearing using a bulldozer or excavators is not permitted in sensitive areas. Potentially sensitive areas (temporary and permanent rivers, lakes, wetlands, protected areas, etc.) will be identified and that a buffer zone of at least 30m should be maintained between the cleared and stripped areas of the Bull and the sensitive areas.

10) Unless authorized by the Employer, burning vegetation is not permitted.

11) Tree felling, included in the Vegetation Clearing and Debris Management Plan, shall be subject to strict planning to ensure avoidance of nesting periods. The Vegetation Clearing and Debris Management Plan shall clearly specify the schedule and the methodology involved and shall be approved by the Employer prior to commencing the Works. Thereafter deviations from the Plan will be subject to the Management of Change Procedure and be subject to the Employer's approval. The Contractor will be required to retain some flexibility and implement potential changes to the ESMP and CESMP. The cost implications (+/-) of these changes will be tallied and agreed between the Employer and the Contractor.

12) The Contractor shall physically demarcate zones to be cleared using a method approved by the Employer.

13) Clearing shall be undertaken without damage to adjacent non-cleared areas. Topsoil is to be stored within the cleared areas at the edge of the cleared zone or an otherwise agreed location. Clearing shall be undertaken working from the edge of the zone inwards.

14) Wood available from vegetation clearing will be kept available to the Employer with a view of the restitution to local population. Before any burning of felled timber, the company should explore, in consultation with the local authorities, all alternative solutions aimed at selling the timber free of charge to the local population/businesses on accessible sites (edge of tracks) and in a form that can be handled with the means available locally (e.g. logging of barrels).

4.8.2 Floating Debris

1) A floating debris management plan should be drawn up at least three months before impoundment.

2) Access to collect and evacuate floating debris upstream of the dams during first impoundment and operation shall be designed, built and operational prior to reservoir filling. Laydown areas shall be made available downstream of the dam to dispose floating debris which are removed from the reservoir during operation.

3) Floating debris shall be collected and removed from the reservoirs after reservoir filling. Economic trees shall be recovered and stockpiled. Non-marketable trees will be made available to local people.

4.8.3 Topsoil

1) Unless indicated otherwise by the Employer or specified in the relevant permits, the top 20 cm of the soil will be considered as topsoil.

2) Prepare a topsoil management plan for approval by the Owner at least three months before the start of the works.

3) After vegetation clearing, all topsoil from Temporary or Permanent Works areas excluding reservoir area shall be removed and safely stored separately from other excavation spoil and shall be clearly indicated on Site by appropriate signs. The height of stockpiles shall be proposed in the E&S procedures and shall be limited to 3 m for topsoil. Topsoil from the reservoir shall be removed to the extent that may be required for landscaping and site rehabilitation works.

4) Topsoil storage areas shall be monitored to ensure there is no compaction or waterlogging. Should this be the case, the storage piles will be turned over to promote aerobic activity pending their exploitation according to the Management Plan approved by the Employer.

4.8.4 Storm-Water Drainage

1) The gradient of Sites shall allow the collection and drainage of rainwater from the entire surface area to one or several discharge points. No pools of water should be created. An Integrated Erosion and Sedimentation Risk Control Plan will be prepared and incorporate among others i) Flow and flood risk management, ii) Flow and sedimentation risk management, iii) Management of river works, iv) Management of cuttings/backfill..
2) The drainage network is to be inspected regularly against damage caused by scouring, gullying of sediment deposit, channel obstruction and loss of vegetation cover.
3) Rainwater from machinery areas and workshops shall be subject to treatment with oil separators.
4) Monitoring and recording of the effectiveness of the measures implemented (sedimentation devices, etc.) should be in accordance with the Monitoring and Measurement Plan

4.8.5 Silt Fences

1) The Contractor shall install silt fences to slow the flow of water and control sediment transport during road construction works and at the boundaries of the main excavations. Silt fences shall be required for lands with (i) a gradient of more than 20%, (ii) where land is disturbed by the Works and exposed to sheet erosion, and (iii) the surfaces are susceptible to silt erosion.
2) Silt fences shall be installed on the slope or at the base of the slope to protect the natural drainage system from sediment accumulation at levels higher than the natural situation. These barriers shall comply with the following principles:
    a. Made with geotextiles or straw bales or any other means approved by the Employer.
    b. Silt fences are installed following contour lines.
    c. Deployed before the start of the Works and removal of topsoil. Silt fences can be used for the physical demarcation of working areas.
    d. Installed, cleaned, maintained and replaced according to manufacturer recommendations.
    e. Drainage surface area does not exceed 1,000 m² per 30 m of barrier. The length of the slope behind the barrier is less than 30 m, and is not used for flows in excess of 30 l/s.
    f. The extremities of the fence are directed up the slope.
    g. Supporting posts must not be more than 2 m apart and must be sunk at least 75 cm into the ground.
    h. Along the length of the fence, upstream of the posts, a 20 cm wide trench 30 cm deep is excavated to bury the bottom part of the geotextile used for the fence. It must follow the sides of the trench, and must permit an 80 cm width of the geotextile to be buried.

i. If a large amount of sediment accumulates, the bottom part of the fence must be reinforced by a grille which must also be partly buried.

j. The fence is inspected every week and the sediment is removed when it reaches 1/3 of the height of the fence.

4.8.6 Erosion Control on Steep Slopes

1) Erosion control on steep slopes subject to gully erosion shall be carried out by erosion control best industry practices. This issue is frequently observed along slopes of major excavations or spoil areas. These measures shall rely on (i) storm-water control design (peripheral drainage), (ii) design of the slope (including berms), (iii) run-off control by revegetation and (iv) stabilisation of sensitive areas by hard engineering methods.

2) Erosion control techniques to be considered shall be fully described in the Slope Stability and Erosion Control Plan, to be prepared by the Contractor and approved by the Employer, which will include both temporary and permanent erosion control measures.

3) The Erosion and Sedimentation Risk Control Plan shall incorporate, inter alia, the following items: (i) Flow and Flood Risk Management; (ii) Flow and Flood Risk Management; (iii) River Works Management; (iv) Cut and Fill Management. For each of the above headings, the Contractor must indicate: (a) the location of the storage of erosion residues; (b) the maximum heights and slopes of the embankments; (c) the drainage systems; (d) the system of creation of settling basins and sediment traps; (e) the system of flow of materials; (f) the calendar of the periods and phasing of work; (g) the design of the implementation of ecological engineering techniques (including sediment barriers).

4) The effectiveness of erosion control measures will be the subject of a monitoring programme. Universal soil loss equation assessment may be used as a means of quantification.

4.8.7 In-River Works

1) In-river construction works are to be planned by the Contractor to avoid major discharge of sediments or pollution in the river stream to the extent practicable. The Contractor shall detail its methodology regarding sedimentation control in the E&S procedures for (i) river diversion works, (ii) dam site construction, (iii) tailrace channel and (iv)any other in-river works.

2) Biodegradable oils are to be used in plant and equipment operating in watercourses.

4.9 Materials Management and Spoil Disposal Management

4.9.1 General Principles

1) Material excavated at the Site will be re-used as far as their geotechnical properties allow as construction material (after screening or for unselected fill material) to minimize the volume being disposed. The issues here shall be dealt with in the Material Handling and Storage Management Plan.

2) Spoil generated will be classified according to its geotechnical characteristics and engineering properties.

3) It is the responsibility of the Contractor to determine if the chemical and geotechnical properties of excavated material meet relevant specifications for future end use such that they do not cause harm to human health or the environment. This includes the effect that the excavated materials may have on the environment where they are to be reused. Biological factors e.g. presence of invasive species or noxious weeds, as well as the effects of any radioactivity should also be considered. Measures based on a risk assessment should be taken such that there is no adverse effect or risk to humans, animals, or ecosystems. This includes impacts on water, air, plants or other soils.

4) The contamination of groundwater shall be prevented and considered in executing the spoil disposal. Groundwater protection is to be considered in Material Management Plan and all the related Project decisions made regarding the suitability for the reuse of the excavated soils and materials.

4.9.2 Materials Management Plan

1) The Contractor shall prepare and submit a Material Handling and Storage Management Plan that documents how excavated soils and materials are to be handled. This Plan, subject to formal amendments, must be implemented throughout the execution of the Project. The Contractor shall prepare and attach to the Materials Management Plan:

   a) A materials flow chart showing the origin and final destination of materials (top soil, sand, aggregates, rocks, quarry run, spoil) used during the Works. Consolidation/compaction must be considered in the mass balance calculations.

   b) A location plan for the sites and a plan of the sites which identifies where different materials are to be excavated from, stockpile locations (if applicable), where materials are to be treated (if applicable) and where materials are to be reused.

   c) A schematic of proposed materials movement and an estimate of the Project traffic generated by the movements from source to destination, during daily and night time.

   d) The materials flow chart shall highlight what are the quantities of top soil required for the reinstatement of temporary facilities at end of the construction period, and from what site this top soil will be taken for the reinstatement work.

2) The Materials Management Plan must be prepared and submitted prior to movement of excavated soils and materials, and provides the following information:

   a) Details of Contractor's Personnel involved with implementation of the Materials Management Plan.

   b) Description of the excavated materials in terms of potential reuses and relative quantities involved by categories of materials, with a breakdown for each site.

c) Specification for use of materials against which proposed materials will be assessed based on an appropriate risk evaluation or risk assessment at the place excavated materials will be used.

d) Where and, if appropriate, how excavated materials will be stored or temporarily stockpiled for reuse.

e) The intended final destination and reuse of excavated soils and materials, with clear distinction between (i) excavated soil and materials reused for construction purposes and (ii) excavated soils and material that is surplus to requirements or unsuitable for reuse in fill and embankments.

f) How excavated soils and materials are to be tracked to monitor materials movements, including include transfer of loads on Site into stockpiles awaiting use (as appropriate) and final placement.

g) The contingency arrangements that must be put in place.

h) Shortage of top soil must be anticipated for the reinstatement of temporary facilities. The Material Flow Chart will indicate how the top soil and vegetation taken from the reservoir area below full supply level and from the other material storage areas will be re-used to rehabilitate temporary facilities outside of the reservoir area.

4.9.3 Spoil Disposal Management Plan

1) Spoil is defined as any earthen material that is surplus to requirements or unsuitable for reuse in fill and embankments (such as unsuitable rock and soil material) or material that represents a geochemistry hazard.

2) The Contractor shall prepare and implement a plan, as part of the CESMP, that details all measures the Contractor will implement during the Works to minimize the footprint, adverse socio-economic impacts and ecological effects, and to ensure long-term stability and control erosion while stockpiling the material excavated from the Site.

3) The detailed spoil disposal management is covered in this Plan and shall cover the Works but be prepared and implemented for each of the work areas. It shall cover the management of all spoil generated on the Works. The plan shall include the following:

   a) Spoil types.

   b) Spoil strategy to:

      a. Minimize the amount of spoil generated.

      b. Maximise the beneficial reuse of spoil on Site and off Site based on its classification.

      c. Manage the excavation, storage, transport reuse and disposal of spoil to minimise impacts and meet other environmental or social requirements.

   c) Spoil generating activities.

   d) Volumes and sources of spoil per work area.

e) Spoil classification, e.g. virgin excavated natural material, inert fill, potentially contaminated material.

f) Locations of spoil disposal, off Site storage and re-use sites.

g) Transportation of spoil.

h) Storage of spoil.

i) Potential E&S adverse impacts.

j) Management measures and mitigation strategies.

k) Long-term maintenance requirements.

4) For each proposed Spoil Disposal Area, the Contractor shall perform the required site investigations and engineering studies demonstrating:

a) Mass stability and prevention of mass movement during and after construction.

b) Drainage control to ensure safe transfer of flood waters.

c) Maintaining of river or streams flood capacity.

d) Toe reinforcement and angle of slope for each material type.

5) The spoil disposal area design must be in accordance with Contracting States requirements. The Site rehabilitation and revegetation activities of spoil areas will also need to align with spoil permit requirements and Lenders E&S policies.

4.9.4 Non-Waste Spoil

1) Subject to the EIA Environmental Permit conditions, disused quarry areas and borrow areas shall be filled in with excavated material to minimize the opening of new areas for disposal purposes.

2) Before starting operation on the disposal area, a site drainage system shall be put in place.

3) Unless instructed otherwise by the Employer, to ensure stability and resistance to rainwater runoff erosion, spoils disposal areas shall not exceed a height of 6 m, with a maximum slope of 3:2 (H:V). The slope is to be intercepted at a height of 3 m by a berm at least 2 m wide with a peripheral drainage ditch and also header drains where appropriate.

4) For permanent spoils disposal areas, the stockpile is to be shaped and compacted every 30 cm to ensure long-term stability.

5) Should such stable dispositions not be satisfied by the Contractor for any technical reason (for example limited availability of land), the Contractor shall produce a complete design of the spoil disposal supported by appropriate method statement related to drainage, slope stability, spoils compaction, and ultimate reinstatement and revegetation and obtain the approval of the Employer prior to any works on the spoil disposal area.

6) The drainage system shall be lined (rockfill, concrete) at all points where run-off will concentrate and along vertical ditches. Culverts shall be designed through spoil disposal areas where

necessary and open culverts shall be considered where there is a risk of blockage. If closed culverts are used these shall be subject to regular maintenance.

7) The slopes of any permanent spoil disposal shall be vegetated in parallel with the progress of the disposal. For example, when constructing the first berm, the slope between ground level and this first berm shall be immediately covered by preserved topsoil to favour natural vegetation of the slope.

8) Temporary disposal areas in place for more than 60 days are to be protected against runoff erosion by (i) revegetation using fast growing grass species, either by direct seeding or by hydro-seeding, or (ii) using other natural anti-erosion cover, such as geo-jute matting, with prior approval from the Employer. Geo-jute is preferable as an anti-erosion measure.

4.9.5 Treatment Prior to Reuse

1) Other excavated materials may not have the required characteristics for reuse without first being treated. These excavated soils and materials may require further biological, chemical, physical or combination of these treatments that will need to be carried out. These treatment activities should be technically appropriate and in compliance with any required local regulatory requirements or approvals prior to reuse or final disposal.

2) Sludge from sediment ponds needed to treat tunnel waters may fall into this category. These ponds will generate large quantities of very fine sediments which are likely be mixed with concrete waters. Fines whose technical specifications do not allow to be incorporated into concrete (too much clay, for example) will be disposed.

4.9.6 Geochemistry Risk Spoils

1) The Contractor will plan and execute a procedure, relevant to Site conditions, to detect tunnelling spoil, the disposal of which could represent an acid rock draining risk or other geochemistry risks for the environment.

2) Spoil that represents a geochemistry hazards will be managed and disposed of according to best industry practices to prevent pollution of water resources, which may include spoil disposal below the dead storage level of the reservoir.

4.10 Atmospheric Emissions and Dust

1) Emissions refer to any discharge into the air of solid substances, aerosols, gases, radiation, or energy, whether point sources (e.g. incineration stack) or diffuse (e.g. fugitive dust emissions from road use by trucks).

2) Fixed bitumen/asphalt heating plants, bituminous concrete production plants and concrete mixing plants shall comply with national or international standards (WHO, World Bank) on air and water emissions. The Contractor shall provide documentation to prove such compliance (e.g., environmental specifications cited in the technical documentation of the plants). If it is not possible to provide such documentation, the Contractor shall have emission measurements

carried out at its own expense by an approved and independent office to establish compliance with national standards.

3) The Contractor shall prepare and implement an Air Quality and Emissions Management Plan as part of the CESMP. The plan shall detail measures the Contractor will implement during the Works to identify and manage the source of air emissions and dust production resulting from the construction activities including, but not limited to, traffic along the access roads. The plan will also include specific measures for the reduction of the greenhouse gas emissions in compliance with the Lenders E&S standards and proportionate to the potential impacts referring to greenhouse gas emissions.

4) The Contractor shall use Equipment and adopt construction and transport methods with atmospheric emissions that are not in excess of the threshold emission values specified in Law or the IFC Environment, Health and Safety Guidelines, whichever is the most stringent.

5) The Contractor shall document the maintenance records for the Contractor's Equipment. The records will be in English and will be at the disposal of the Employer. The fleet of vehicles or equipment emitting combustion gases shall be maintained at the intervals and according to the methods specified by the manufacturer.

6) The Contractor shall implement dust-reduction measures on the Site and along roads used by Project vehicles.

7) On unpaved roads used by the Contractor's Equipment:

   a) The Contractor shall take action to abate fugitive dust emissions generated by vehicles or mobile equipment in residential areas, bee keeping areas, and on roads within the Site.

   b) The abatement measures shall include, but are not limited to:

      a. The regular spray of water or any other non-hazardous dust suppression agents to maintain humidity of the road and the cohesion of fine particles.

      b. Reduction of vehicle speed in and near sensitive receptor areas.

      c. Covering loaded haulage lorries.

      d. Use of magnesium chloride on the road.

8) The Contractor shall describe in the CESMP the road sections designated for the application of dust suppression measures and the methods and frequencies programmed.

9) When storage, transport and handling of bulk materials are in the open air and exposed to the wind, the Contractor shall implement the necessary dust abatement measures, including one or several of the following techniques: humidification of the surface, covering of the surface, and/or vegetation of the surface.

10) Used engine oil for dust abatement on non-surfaced roads is strictly forbidden.

11) Dust and greenhouse gas emission is to be monitored by the Contractor on a regular basis. Monitoring and recording of air and dust emissions must be in accordance with the Monitoring and Measurement Plan.

4.11 Noise and Vibration

4.11.1 Construction

1) The Contractor shall prepare and implement a Noise & Vibration Control Plan as part of the CESMP.

2) The Contractor shall use equipment and adopt construction and transport methods so as not to generate noise levels in excess of threshold values recommended by local regulations, and organizations or other levels as may be determined in consultations with local communities. As a preventive measure, the Contractor shall regularly maintain machinery and vehicles to minimise engine noise. Similarly, the placement concrete manufacturing and stone crushing infrastructure shall mitigate the harmful effects of noise at housing and work places.

3) Where communities are located close to worksites, camps and access roads and may be affected as a consequence of the Works, the Contractor shall study, propose, implement and monitor the efficiency of, all reasonable and practicable measures to minimize noise resulting from the activity and to minimize the acoustic nuisances to adjacent households during day and night. Noise barriers or acoustic shields shall be considered if Works are close to sensitive receptors. Applicable standards for noise control are: (i) applicable national legislation; (ii) IFC / IFC Environment, Health and Safety Guidelines; (iii) WHO Standards.

4) The Contractor shall prepare noise modelling for the Works with the methodology to be approved by the Employer prior to commencement of noise monitoring. It shall include:

   a) A noise baseline survey to determine the current environmental noise levels at the Works – for day and night. Applicable standards for the baseline survey shall be Australian Standards AS 1055: Acoustics - Description and Measurement of Environmental Noise.

   b) The description of sources of emissions, receptors and scoped-out effects during construction. Main noise generating activities/equipment during night and day time must be listed and level of noise emissions must be determined according to the equipment specifications.

   c) Vibration generating activities, e.g. blasting, must be listed and severity determined and mitigated.

   d) A noise prediction modelling to determine the propagation of construction noise across the Site and predict the ambient day and night noise levels at the facades of the nearest off-worksite receptors/dwellings based on the measurement data taken at Site.

   e) Additional mitigation measures and assessment of mitigated effects.

   f) Maps illustrating baseline, predicted noise levels at nearest receptors with and without additional mitigation measures.

g) Methods statement to design and implement the proposed additional mitigation measures for day and night time

5) The baseline monitoring carried out by the Contractor is only for the purpose of informing the noise modelling study and the design of mitigation measures.

6) If and when required by the Employer, the Contractor shall provide details on noise-generating equipment and facilities planned to be used or installed in the Works during the construction period and the operation phase. For the construction period, this includes all Plant and Equipment to be used during the Works.

7) The Contractor shall monitor the vibration level at buildings nearest to the Works during activities which could generate offset vibration effects. The Contractor shall prepare a pre-construction condition survey for all buildings located within 1 kilometre of any blasting activities. The condition survey will be used to assess the effect of blasting on structures and the scope of any remediation works necessary to repair the effects of blasting.

8) The Works noise levels shall comply with local and international norms and standards and must under no circumstances expose anyone to intensities higher than 80 dBA without proper ear protection.

9) The monitoring and recording of noise pollution shall be in accordance with the Monitoring and Measurement Plan.

4.11.2 Operation

1) Noise impacts are minimized through design adjustment to prevent community health impacts within the limit described in the guidelines for Community Noise established by the WHO.

2) Compliance of the design with the applicable Community Noise standards will be checked by the Employer through independent third-party monitoring of noise at full load and during worst case (for noise) climatic and flow conditions during the first year after commissioning, i.e. those conditions that would result in greatest level and propagation of noise.

3) If operational noise monitoring during the first year exceeds the relevant standards then noise attenuation measures will be identified and installed by the Contractor at no additional Cost.

4.12 Quarry and Borrow Area Management

1) The Contractor shall prepare and implement a Quarry and Borrow Area Management Plan for areas to be exploited for rockfill material, aggregates and rip rap material as well as for the other borrow materials (sand, gravel, laterite clay) that details all the E&S measures to be implemented for the operation of these sites. The plan shall include clear proposals for the phasing of the works and remediation of the borrow areas.

2) If required by the legislation, an Environmental and Social Impact Assessment will be conducted by the Contractor and submitted for approval to the relevant Services. The Contractor shall comply with legal requirements in force in the Countries concerned regarding the opening and

exploitation of quarries, such as Law No 58/2018 of 13/08/2018 on the exploitation of Mines and Quarries in Rwanda.

3) For each quarry and borrow area site, the Quarry and Borrow Area Management Plan shall include the following considerations:
   a) A plan showing the extent to the area to be developed.
   b) A method statement defining the proposed working methods.
   c) The proposed access and haulage routes between the quarry/borrow area and the destination for the extracted material.
   d) A justification for the quantities of material to be extracted, an estimate of the waste materials to be generated and disposal details for such waste materials.
   e) Details of the measures taken to minimize the quarry area and its visual impact on the adjacent area.
   f) Details of the measures to be taken for the long-term reinstatement of the quarry and borrow areas. These shall include re-establishment of vegetation, restoration of natural water courses, avoidance of flooding of the excavated areas, achievement of stable slopes, and avoidance of features which would otherwise constitute a risk to health and safety or a source of environmental pollution.
   g) Measures which are recommended to minimize the significance of each identified impact.
   h) Quarry faces and excavations shall be made safe and buildings, plant, equipment and debris and miscellaneous stockpiles of material shall be removed from the areas.
   i) The identification and delimitation of the quarrying and borrowing areas is essential to avoid encroachment on neighbouring areas, especially if these are sensitive. In case of encroachment, the Contractor is fully responsible for the repair or non-conformity, which is governed by penalties for withholding payment.
4) Materials, other than waste materials, extracted from quarrying and borrow area operations under the Project shall be used exclusively for the Works.
5) The contractor must comply with the requirements of the legal texts in force concerning the opening and exploitation of quarries and the handling of explosives.
6) The contractor will be responsible for all administrative procedures related to the provision of the extraction sites, their restoration and their return at the end of the work phase.

4.13 Site Reinstatement

1) Unless instructed otherwise by the Employer, the Contractor shall reinstate all Temporary Work areas disturbed by the Works, prior to the issuance of the Taking-Over Certificate under Sub-Clause 10.01 [*Taking Over of the Works and Sections*].

2) The Contractor shall prepare and implement a Site Reinstatement Plan as part of the CESMP including the following considerations. As with the preparation of the Borrow Area Operations Plan, the Contractor shall provide clear proposals for the phasing of work during site reclamation.

3) All Temporary Works are to be removed unless instructed otherwise by the Employer. After removal of buildings, structures and rubble, the Contractor shall return the Site to the original or better condition, according to the following provisions:

   a) A detailed survey of the Site shall be carried out before any earthworks commence for approval by the Employer. This survey must record all details of the Site that will need to be restored, including landscape configuration, vegetation mapping of the areas to be lost and characterising them with a floristic species list with abundances, as they will have to be restored post-construction.

   b) Land is contoured to ensure that run-off water drains without eroding soil or stagnating in pools. Unless instructed otherwise by the Employer, the gradients of restored sites (including access roads used for construction) must be similar to the adjacent undisturbed land.

   c) Reinstated sites do not represent hazards for people.

   d) Areas near steep drops shall be indicated with permanent signs.

   e) Holes shall be refilled.

   f) Sharp or unstable items are rendered inoffensive.

   g) Reinforced steel bars which are protruding and no longer needed for construction are removed.

4) Public roads that have been damaged by the Project trucks shall be restored post construction to their pre-construction condition.

5) The Contractor shall undertake landscaping and revegetation of areas disturbed by the Works including power station sites, road excavation and fill slopes, and Temporary Works. Reinstatement work shall be defined as relevant for each area and shall be in two parts:

   a) Technical reinstatement, involving landscaping, slope modelling, decompaction, terracing, permanent erosion control and drainage schemes etc.

   b) Biological reinstatement which involves the spreading of topsoil and seeding/planting the area appropriately.

6) Topsoil and soft biomass set aside from the reservoir area during initial earthworks shall be re-used for rehabilitation of construction sites located outside the reservoir area.

7) Topsoil set aside during initial earthworks shall be evenly spread over areas which have been levelled or where ruts have been cut into compacted areas. The surface of compacted soils on Worksites is to be loosened by scarifying (using rakes or other acceptable methods).

8) Revegetation works shall be planned in advance to ensure sustainable reinstatement and described accordingly in the CESMP: methods, plant species to be used and their origins, activity schedule.

9) Prior approval by the Employer is required regarding the origin of seeds and plants proposed by the Contractor. The species used for revegetation must be of local provenance and suitable for the local environmental and climatic conditions and selected according to the specific rehabilitation programme: stabilisation of backfill, landscaping, drainage, prevention of erosion.

10) Land which was not woodland, including spoil disposal areas, borrow areas, and quarry areas, prior to the Works shall be revegetated suitable for pasture land grass. Revegetation is not required for areas below reservoir or in river areas.

11) A stabilization matrix such as geo-jute shall be installed by the Contactor prior to seeding with pasture species or hay shall collected and spread on the ground.

12) The Contractor shall demonstrate that the species selected for revegetation are not classified as invasive species for the local region.

13) Revegetation shall be undertaken throughout the duration of the Works and is not limited to the reinstatement of Works areas at the end of the Works.

14) Biological reinstatement shall be subject to a detailed monitoring programme that records the effectiveness of vegetation establishment.

15) This clause applies to the side casting of spoil material generated during the excavation works if side-casting has been authorized by the Employer.

4.14 Chance Find Procedure

1) Chance find is defined as physical cultural heritage encountered during the Works.

2) The Contractor shall prepare and implement a Cultural Heritage and Chance Finds Procedure as part of the CESMP. As a minimum, the procedure must contain the following elements:

    a. the procedures for informing and raising awareness of the conduct to be followed in the event of an accidental discovery;

    b. the process for internal notification of any discovery made by the Contractor or by an archaeologist appointed by the Employer;

    c. the procedure for immediate cessation of activities at the discovery site pending the order to resume work given by the Employer;

    d. the setting up of a protective perimeter and the related materialization and surveillance measures;

    e. the communication procedure between the Contractor and the Employer which must be set up on the day of the discovery;

    f. the standard form to be used as a Physical Cultural Resources discovery report

3) The Contactor shall not disturb any chance finds until an assessment by a designated and qualified specialist is made and actions are identified.

4.15 Documentation of the Works Site Conditions

1) The Contractor shall document changes in condition of all Works areas from the start of Works until the issuance of the Taking-Over Certificate. Documentation shall comprise dated and geo-referenced colour photographs taken weekly from a constant angle and viewpoint.
2) The Works areas condition shall be documented as a minimum for the following stages:
   a) Before any disturbance at the start of the Works.
   b) On completion of the Works.
3) The Contractor shall specify in each E&S procedures (i) the list of viewpoints to be used, (ii) areas to be photographed, and (iii) methods used for taking and archiving photographs.
4) Adjacent areas (100 m from the perimeter of the Works area) are included in photographic documentation.
5) Unless instructed otherwise by the Employer, structures to be buried are to be photographed weekly until covered. As a minimum the structures are photographed twice for Works with duration of less than seven (7) days, and at least once a week for Works with a longer duration.
6) Photographs are to be archived in digital format GPS location and provided to the Employer on a monthly basis in format and medium approved by the Employer.
7) The nomenclature of electronic files for photographs shall explicitly indicate the Works area, date and structure documented.

5 Social Management

5.1 Introduction

1) The Employer is ultimately responsible for engaging its stakeholders through a Stakeholder Engagement Plan (SEP) that will be implemented in full alignment with relevant standards and DFI's Operational Safeguards.
2) It is recognized that contractors will need to engage with a range of stakeholders with whom the Employer owns the primary relation and engage them in the course of work interactions. To serve this purpose, the Employer will maintain a master list of stakeholders, meetings records and mapping.
3) Contractors shall identify all the stakeholders that need to be engaged with to execute their work activities, including subcontractors' activities.
4) Contractors shall record interactions and keep the Employer informed of all planned engagements prior to the engagements taking place and give the Employer the option to

participate. Such recording of formal and informal meetings is to be done using the Employer's template forms.

5) All communication with local communities and government agencies, with exception of those required for hiring, will be done through the appropriate Employer responsible person to avoid duplication with the Employer's role.

5.2 Community Grievances

1) The Contractor shall use the project grievance procedure as set up by the Employer. This is designed to record all grievances coming from local communities and other stakeholders (not Workers, whose grievances are managed in a separate system). Construction work related grievances received by contractors from affected communities shall be immediately communicated to the Employer's Environmental and Social Management Division to ensure proper redress and achieve closure in collaboration with contractors and subcontractors whenever required.

2) The Employer shall decide, based on the scope of Works, whether the resolution of the grievance is the responsibility of the Contractor or Employer.

3) Contractor shall maintain a register – Compensation Register – which records how grievances are resolved by the Contractor.

4) The contractor shall develop and have validated by the Employer a procedure for resolving GBV grievances received from affected communities.

5.3 Traffic

1) The Contractor shall prepare and implement a Road Safety Management Plan as detailed in Section VII.6 Health and Safety Requirements for inclusion in the CESMP. The Contractor shall define the characteristics of all the Contractor's Equipment, and identify the main movements envisaged, in the CESMP.

2) The Contractor shall perform a pre-condition survey and video of all roads to be undertaken before the start of any Works, including above ground crossing of utilities and culverts. The pre-condition survey shall be signed-off by the relevant authority as directed by the Employer, prior to Works commencing.

3) The Contractor shall inform the administrative authorities of areas crossed by vehicles and the itinerary and characteristics (frequency of passing, size and weight of trucks, materials carried).

4) The Contractor shall establish and document a procedure to avoid obstruction of local traffic due to Project vehicles during normal operations and in case of accident or heavy vehicle breakdown.

5) The maximum speed of the Contractor's Equipment shall comply with the lowest of the following: the speed limit defined according to the country regulations or the following limit:

- 20 km/h within the Site and inside towns, villages, and hamlets.
- 80 km/h on paved roads outside of towns, villages, hamlets and camps.

6) Seat belts shall be worn at all times.

7) Drivers shall not be permitted to use mobile phones while vehicles are in motion unless wireless hands free is used in accordance with the law.

8) The Contractor shall provide each of its drivers with a map at the appropriate scale of the roads authorised for the execution of the works, clearly indicating the maximum speeds authorised, and ensuring their understanding.

9) Actions to limit and check the speed of all vehicles and machinery used to execute the Works shall be implemented by the Contractor, including on-board GPS trackers. Flag men shall be utilized at key locations crossed by the Contractor's Equipment.

10) It is strictly prohibited to transport people, animals, equipment or products other than those associated with the Project, required for the Works, and the management of Sites, on board any of the Contractor's Equipment. Project personnel shall not be transported mixed with animals or any hazardous substances.

11) The Contractor shall ensure vehicles used to carry materials which could be projected (sand, crushed material, aggregates, selected materials) on public roads are filled without overflowing and that the load is covered with a tarpaulin to ensure the material is contained.

12) There will be zero tolerance for driving under the influence of intoxicating substances, including alcohol or any other drugs. The Contractor's Road Safety Management Plan shall document the implementation of the required monitoring control measures. Mechanisms to screen drivers are to be introduced and controls documented. Drivers found to be under the influence of intoxicating substances, including alcohol or any other drugs shall be dismissed in accordance with the Contractor's disciplinary procedures.

13) The Contractor shall carry out regular inspections along the roads used by Equipment to ensure compliance with the Contract. The Contractor shall record these inspections and the results and transmit a summary of checks carried out for the previous month to the Employer in the monthly progress report.

14) Announcement to the community will be made in advance of heavy and wide loads convoys following a procedure (method of information, target groups, timing) to be approved by the Employer.

5.4 Limiting Public Network Interruptions

1) During the works in urbanised areas (particularly in Kamanyola), the Contractor will make every effort to reduce network interruptions, particularly of drinking water and electricity, in time and space to the strict necessity imposed by the proper execution of the works. When network interruptions are unavoidable, the populations concerned must be given at least 15 calendar days' notice and a reminder will be made again by the contractor to the populations 48 hours before the interruption. The Contractor's approach will include the following steps:

a) Discussion with the operators in order to identify the neighbourhoods, establishments and populations concerned,

b) Notification to the Kamanyola Town Hall, posting in schools or other public buildings on clearly visible outdoor signs, dates, durations, and areas affected by the cuts,

c) Display in the form of symbols or illustrations on market sites and health centres to reach as many women as possible, even those who are illiterate,

d) Personalised warnings from public establishments (hospitals, schools, administrative and military buildings, etc.) and large private establishments (companies),

e) Reminder to the population concerned to cut off water or electricity 48 hours before the actual cut-off;

f) Inform the population that the electricity network must always be considered as being under tension until the official announced time for the cut-off has expired or simply until the electricity is restored. Consequently, warn customers not to leave anything connected to the mains until the power supply is restored.

2) In the event of a water cut, caused by the Contractor's activities, in isolated villages or urban areas that are normally supplied, potable water tanks shall be made available to the affected population at the Contractor's expense.

5.5 Maintaining Access to Homes, Buildings, Businesses and Markets

1) The Contractor shall ensure that local residents and administrative and commercial establishments have access to their homes/buildings at all times by installing footbridges and creating secure pedestrian walkways.

2) On market days, the Contractor shall allow outside vehicles access to the markets.

3) A poster and an information campaign on the subject will be implemented by the Contractor during its mobilization.

4) During market days, as a safety measure and to limit congestion, the works will be interrupted on the section dedicated to the market or reduced to activities that do not require space and are not dangerous, nor will there be any movement of machinery or trucks.

6 Community Health & Safety

1. Damages to people and property caused by the execution of the Works or the procedures used for execution shall be reported to the Employer in accordance with the Community Health and Safety Plan. The Employer shall be informed of any damage caused to people, or the property of individuals, within 3 hours of the event, regardless of the value. The Contractor shall take care of any person affected by a work accident.

2. The developer will assess the risks and effects on the health and safety of the populations affected by the project and will invite the contractor to take care of those who may be considered most vulnerable due to their situation.

6.1 Community Health & Safety Planning

1) The Contractor shall support the Employer in the preparation and implementation of a Community Safety Plan, which shall include regular community meetings on:
   a) Safety and construction hazards, including blasting-related hazards
   b) Announcement in advance of heavy construction activities.
   c) Restriction of access to Site.
   d) Awareness campaigns on traffic related risks, including school children.
   e) Awareness raising campaign for accidents related to the reservoir.
2) The presence of Employer and Contractor's personnel could increase communicable diseases as well as risks related to acts of gender-based violence (rape, sexual assault, early marriage, sexual exploitation). The Contractor shall support the Employer in the preparation and implementation of a Community Health and GBV prevention Plan that governs:
   a) The coordination with local health authorities.
   b) Community awareness raising campaigns for the local community and workers living in the camps on health issues including the risks of gender-based violence via posters, leaflets, through health consultation in clinics, and community meetings.
   c) The monitoring of implementation of personnel's health specifications by Subcontractors.
3) The community awareness raising campaigns for the local community and workers living in the camps on health issues including the risks of gender-based violence will be implemented by the Contractor with the support of local medical staff.
4) The Contractor shall plan and implement measures required to minimize light pollution such as directional floodlights during the Works.

6.2 Reservoir Filling

1) Prior to filling the reservoir, the Contractor shall clear the floodplain, including brush, trees, and stumps, and transport all cleared material outside the perimeter of the reservoir to avoid eutrophication of the reservoir water.
2) The Contractor shall collect and dispose all debris accumulated as a result of the reservoir impoundments.

6.3 Access Restrictions

1) The Contractor shall organize fencing, gates, access restrictions, and control to working sites and warning signs for local communities, tourists or crossing of herders and herds.

2) During the Works, the Contractor shall organize control of access newly installed routes for construction purpose (excluding the public roads rehabilitated or relocated as part of the Project), preventing use of unauthorized vehicles.

3) Access restrictions to riverbed immediately downstream of the dam and the plunge pool will be announced and warning signs about spillage, risk of fall from height and drowning, are to be installed for the construction and operation phases.

4) Access restrictions to riverbed around the tailrace and immediately downstream of the main powerhouse and warning signs against the risk of sudden variation of water level due to powerhouse operation, are to be installed prior to commissioning.

6.4 Maintaining Access

Safe access to existing fields which are away from the Sites and which could be blocked by temporary facilities such as construction camp or site installations will be maintained by the Contractor in consultation with the local communities.

7 Emergency Preparedness Plan

1) The Employer will prepare and implement an Emergency Preparedness Plan in accordance with World Bank requirements. The Contractor shall provide input to the EPP as required by the Employer. The Contractor shall provide details of EPP sub-plans as required for management of Contractor's activities at the Site.

2) The EPP will be structured into two sub-plans:

   a) EPP during construction for Common Hazards and Emergency Situations.

   b) EPP during construction for Cofferdam and Dam Break.

3) The EPP for Common Hazards and Emergency Situations during construction will be structured as such:

   a) Identification of potential emergencies based on hazard assessment.

   b) Procedures to respond to the identified emergency situations.

   c) Procedures to shut down equipment.

   d) Procedures to contain and limit pollution.

   e) Procedures for decontamination.

   f) Procedures for rescue and evacuation, including a designated meeting place outside the facility.

   g) Location of alarms and schedule of maintenance.

   h) List and location of Equipment, facilities and personnel responsible for responding to the emergency (fire-fighting equipment, spill response equipment, personal protection equipment for the emergency response teams, first aid kits and stations).

i) Protocols for the use of the emergency equipment and facilities.

j) Schedule for periodic inspection, testing and maintenance of emergency equipment.

k) Clear identification of evacuation routes and meeting points.

l) Schedule of trainings (drills), including with local emergency response services (e.g. fire fighters).

m) Procedures for emergency drills.

n) Emergency contacts and communication protocols, including with affected communities when necessary, and procedures for interaction with the government authorities.

o) Procedures for periodic review and update of emergency response plans.

4) The EPP for Common Hazards and Emergency Situations during the Works will be prepared and submitted to the Employer for approval not later than four months prior to Commencement Date.

5) The EPP for cofferdam and dam break during construction will be structured as such:

a) Purpose.

b) Project information.

c) Flood studies and inundation maps.

d) Emergency detection, evaluation and classification.

e) Notification flowcharts.

f) Evacuation table.

g) Roles and responsibilities.

h) Emergency alert system.

i) EPP testing and training.

j) EPP contacts.

k) EPP updates.

Attachment 1

Waste management

Waste Description		Source	Quantity disposed	Categories according to their dangerousness .	Destination & treatment (e.g. recycling, landfill)	Follow-up action
Solar modules (panels)						
Construction Waste	**Wood**	e.g.; Shuttering, loading and offloading plates				
	Metal	e.g: Steel fixing, ties of loads				
	Paper/carton	e.g: logistic, offices, PPE				
	Organic	e.g: Rest area				
	Plastic	e.g.: Food wrapping and plastic bottles				
Hazardous Waste	**Concrete/cement waste**	e.g.: Excessive concrete pouring				

	Medical waste	e.g: Clinic				
	Spent Oil	e.g.: Equipment& Generator				
	Oil contaminated soil/spill kits/other	e.g: Contaminated Cloths				
	Misc. (empty paint cans, etc.	e.g: Misc. containers				
	Electronic waste (e.g. cables, inverters etc.)					
Sewage Waste		Bathrooms				

Water management - Water supply and waste water disposal

	Water consumption in m3	**Source**	**Comment on use**
Drinking Water			
Construction freshwater			
Total			

Fuel and energy use

Fuel type	Volume consumed	Units (e.g. litres, kg etc.)	Comment
Diesel for generators/ other stationary machinery			
Diesel for vehicles			
Petrol (gasoline)			
Propane/ LPG			
Acetylene			
Electricity			
Other (please specify)			
Halon Gas (kg)	Amount used		
SF6 Gas (kg)	Amount used		

Labor management

	This Period	Total	Grievances closed	Comments
Workers Grievances				

Variation Orders and Claims

Reason for variation	Suppliers affected	SUM cost change	Comment

PUBLIC DISCLOSURE AUTHORIZED

I. Dam Break Analysis Flood Maps

PUBLIC DISCLOSURE AUTHORIZED

DAM BREAK ANALYSIS

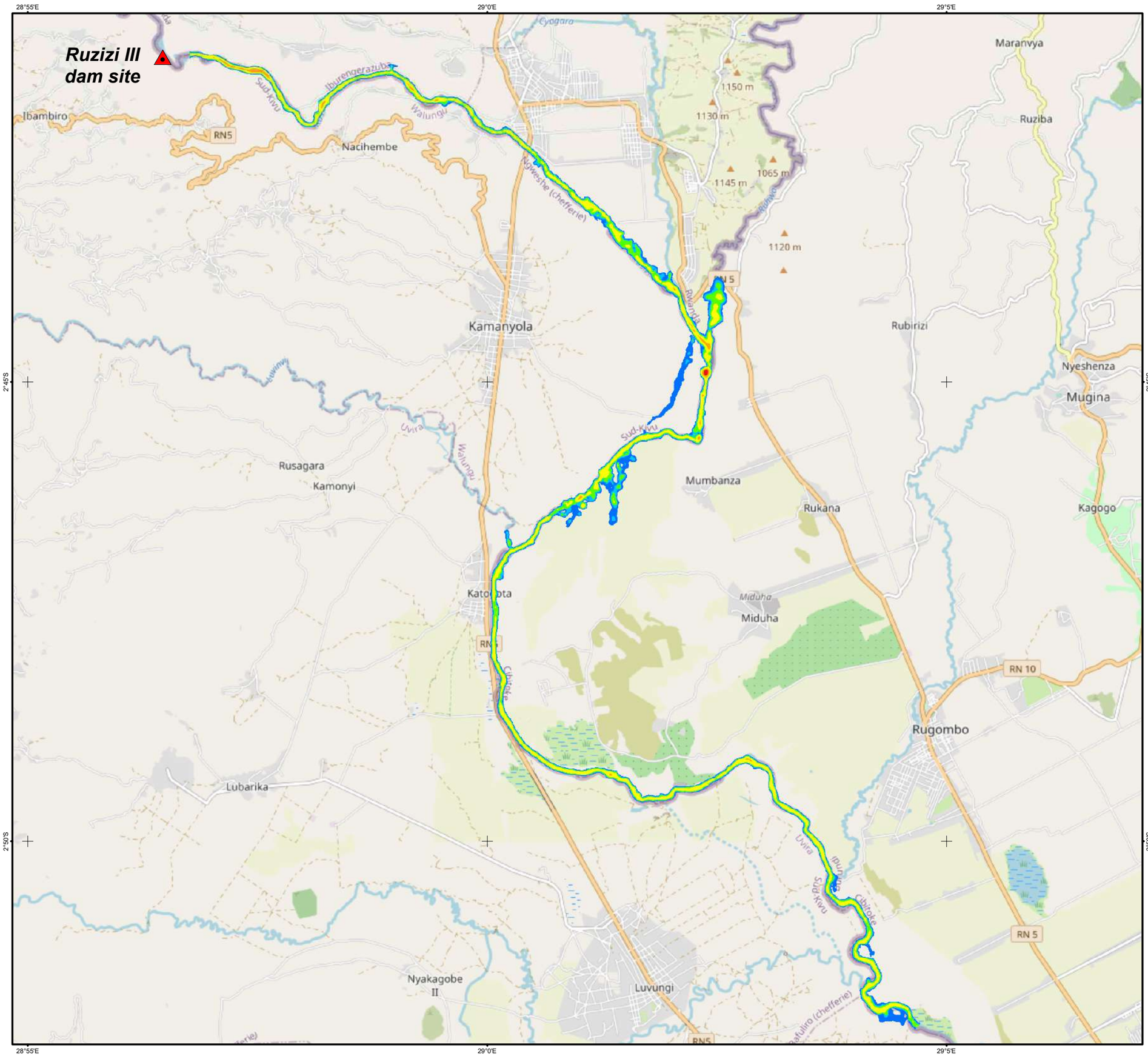
Owner's Engineer Services for the Ruzizi III HEPP Project

Ruzizi III Energy Limited
RWANDA - DEMOCRATIC REPUBLIC OF THE CONGO - BURUNDI

DRAWINGS

Ruzizi III Energy Limited

Drawing reference	Drawing name	Page
RU-DB-NF-001	100-yr Return Period Flood – Maximum height	**3**
RU-DB-CF-001	Cofferdam Failure – Maximum Height	**4**
RU-DB-CF-002	Cofferdam Failure – Maximum Velocity	**5**
RU-DB-CF-003	Cofferdam Failure – Danger Areas	**6**
RU-DB-CF-004	Cofferdam Failure – Propagation Time	**7**
RU-DB-CF-005	Cofferdam Failure – Maximum Height Katogota zoom	**8**
RU-DB-CF-006	Cofferdam Failure – Danger areas Katogota zoom	**9**
RU-DB-SD-001	Sunny Day Dam Break – Maximum Height	**10**
RU-DB-SD-002	Sunny Day Dam Break – Maximum Velocity	**11**
RU-DB-SD-003	Sunny Day Dam Break – Danger Areas	**12**
RU-DB-SD-004	Sunny Day Dam Break – Propagation Time	**13**
RU-DB-SD-005	Sunny Day Dam Break – Maximum Height Katogota zoom	**14**
RU-DB-SD-006	Sunny Day Dam Break – Danger areas Katogota zoom	**15**
RU-DB-FI-001	Flood Induced Dam Break – Maximum Height	**16**
RU-DB-FI-002	Flood Induced Dam Break – Maximum Velocity	**17**
RU-DB-FI-003	Flood Induced Dam Break – Danger Areas	**18**
RU-DB-FI-004	Flood Induced Dam Break – Propagation Time	**19**
RU-DB-FI-005	Flood Induced Dam Break – Maximum Height Katogota zoom	**20**
RU-DB-FI-006	Flood Induced Dam Break – Danger areas Katogota zoom	**21**



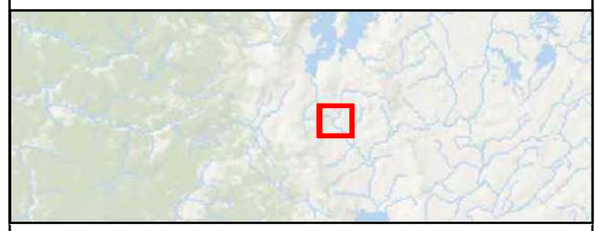
Legend

Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Maximum height (m)

Hauteur maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	03/11/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

100-YR RETURN PERIOD FLOOD — *CRUE CENTENNALE*

Maximum height — *Hauteur maximale*

TRACTEBEL ENGIE

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Référence Externe	Niveau de confidentialité

Fichier informatique .mxd	Echelle	NbFolio	Format
PL001	1:75 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	NF	001	A

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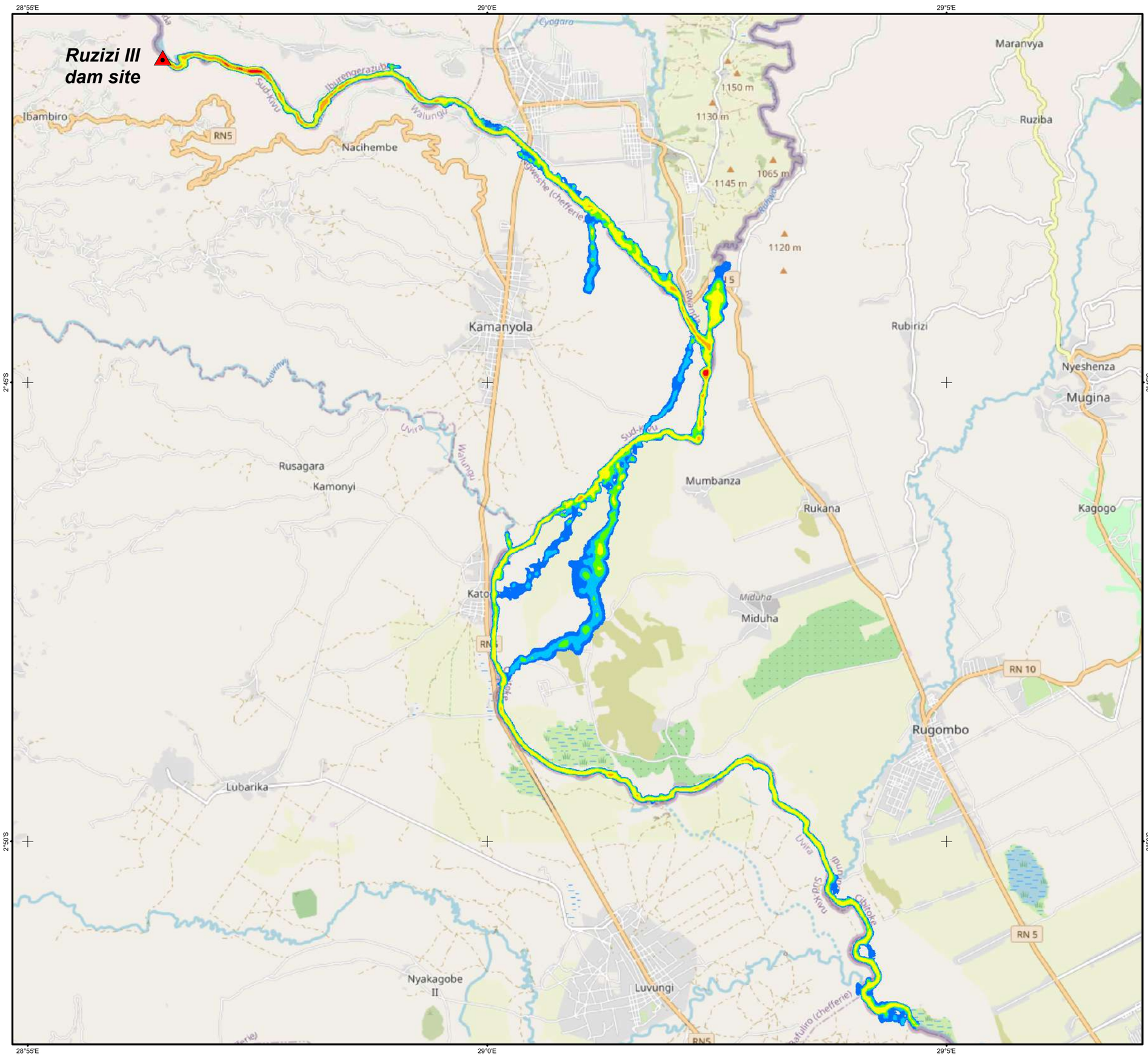


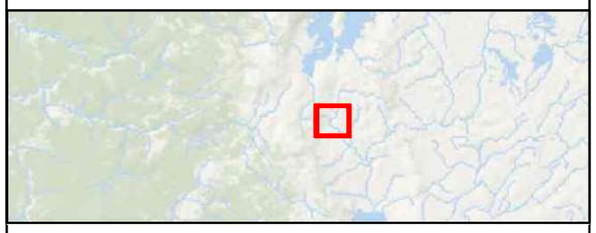
Legend

Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Maximum height (m)

Hauteur maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	03/11/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

COFFERDAM FAILURE — *RUPTURE DU BATARDEAU*

Maximum height — *Hauteur maximale*

TRACTEBEL ENGIE

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Référence Externe	Niveau de confidentialité

Fichier informatique .mxd	Echelle	NbFolio	Format
PL002	1:75 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	CF	001	A

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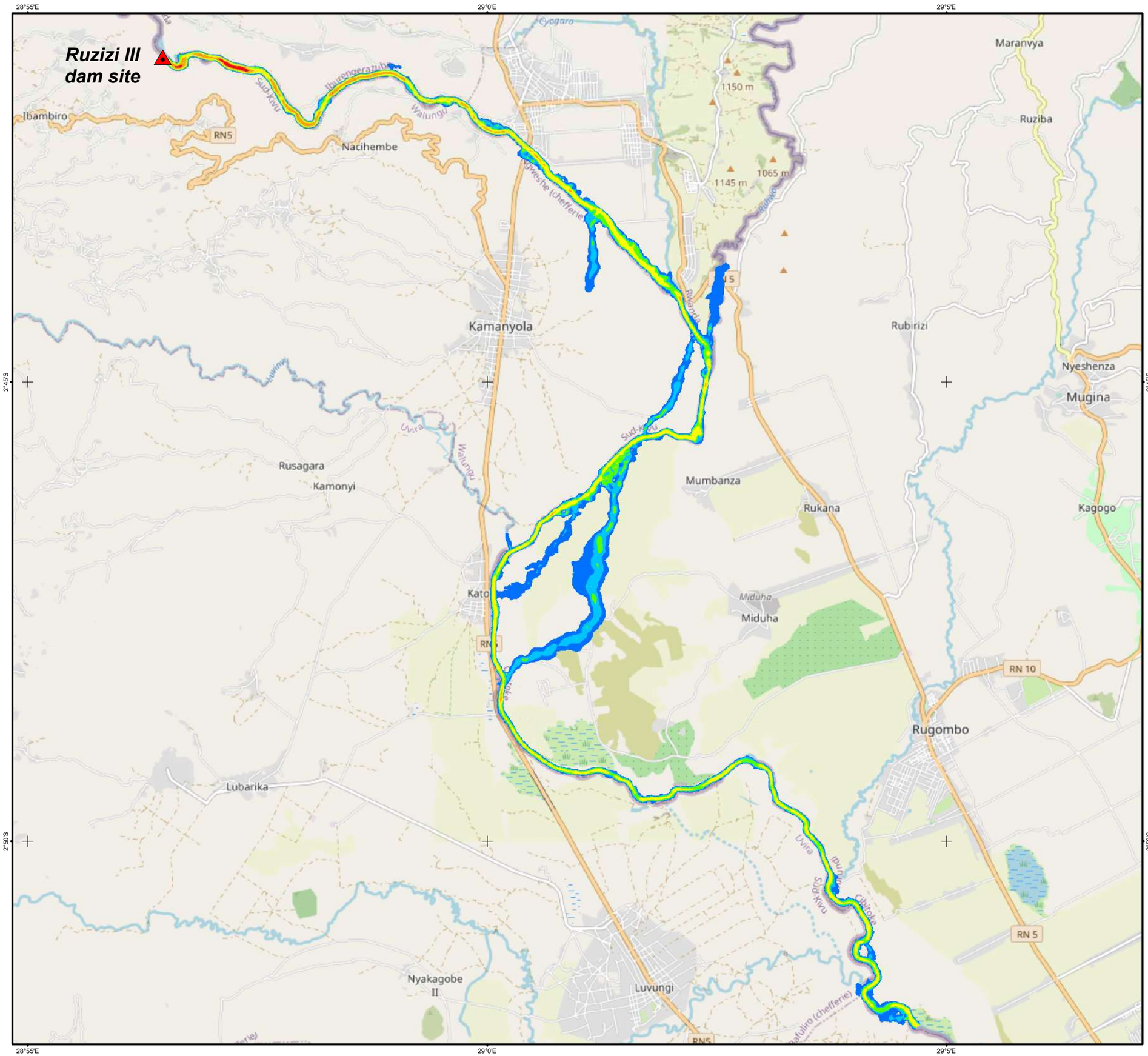


Legend

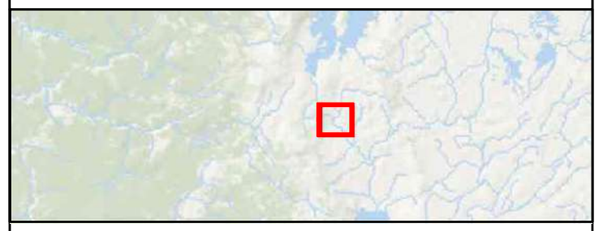
Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Maximum velocity (m/s)

Vitesse maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

Légende



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	08/10/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

COFFERDAM FAILURE — *RUPTURE DU BATARDEAU*

Maximum velocity — *Vitesse maximale*

TRACTEBEL ENGIE

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Fichier informatique .mxd	Echelle	NbFolio	Format
PL003	1:75 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	CF	002	A

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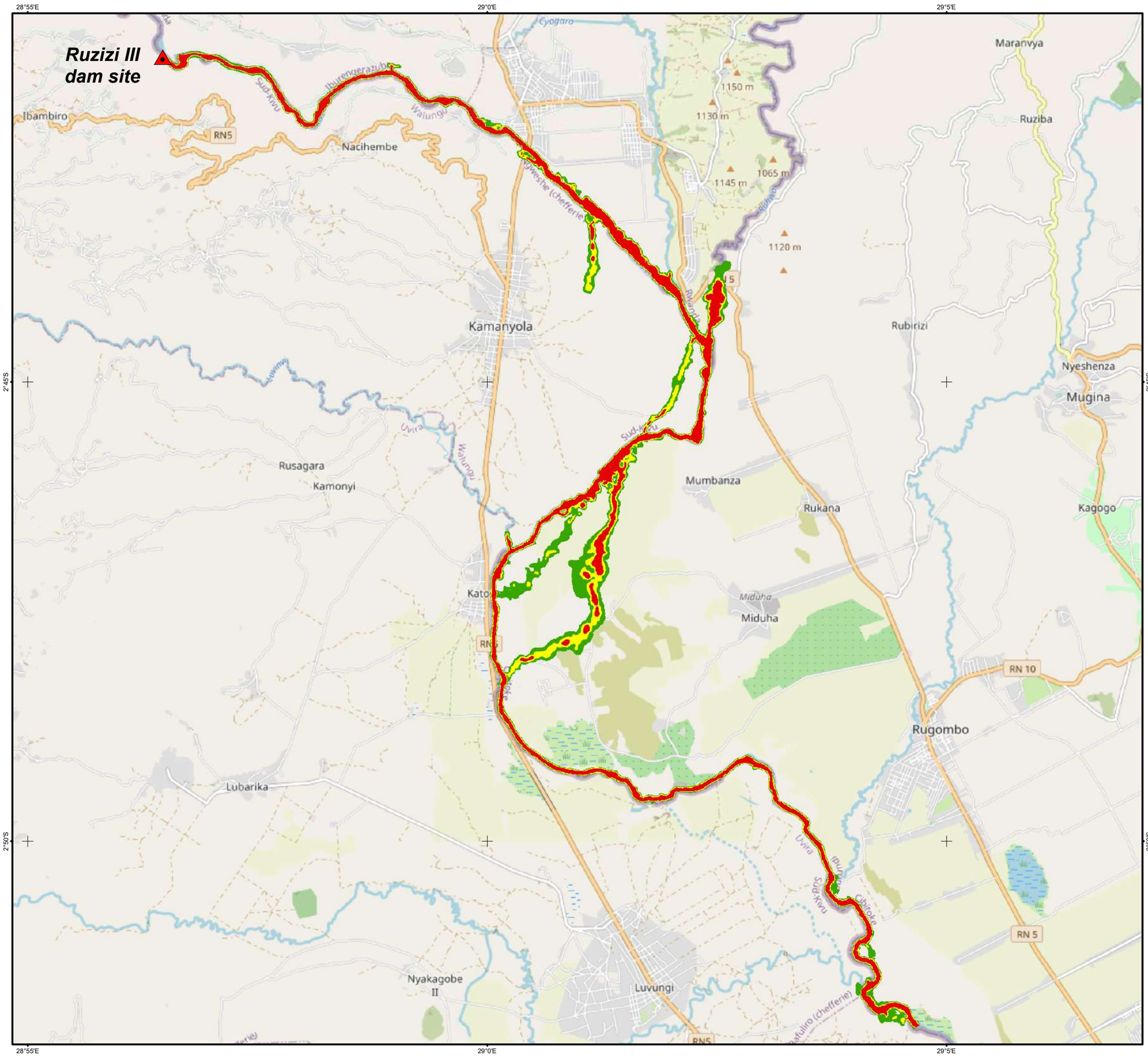


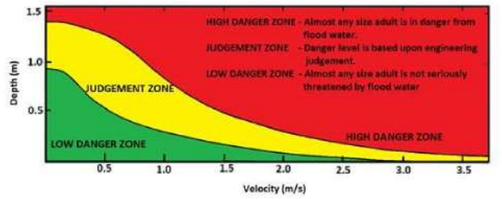
Legend

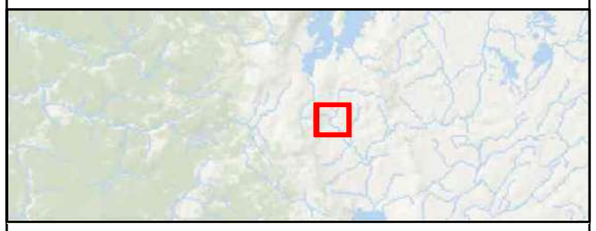
Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Danger areas

Low danger	*Danger faible*
Medium danger	*Danger modéré*
High danger	*Danger fort*

Légende





0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	03/11/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

COFFERDAM FAILURE — *RUPTURE DU BATARDEAU*

Danger areas — *Zones de danger*

TRACTEBEL ENGIE

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Référence Externe		Niveau de confidentialité	

Fichier informatique .mxd	Echelle	NbFolio	Format
PL005	1:75 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	CF	003	A

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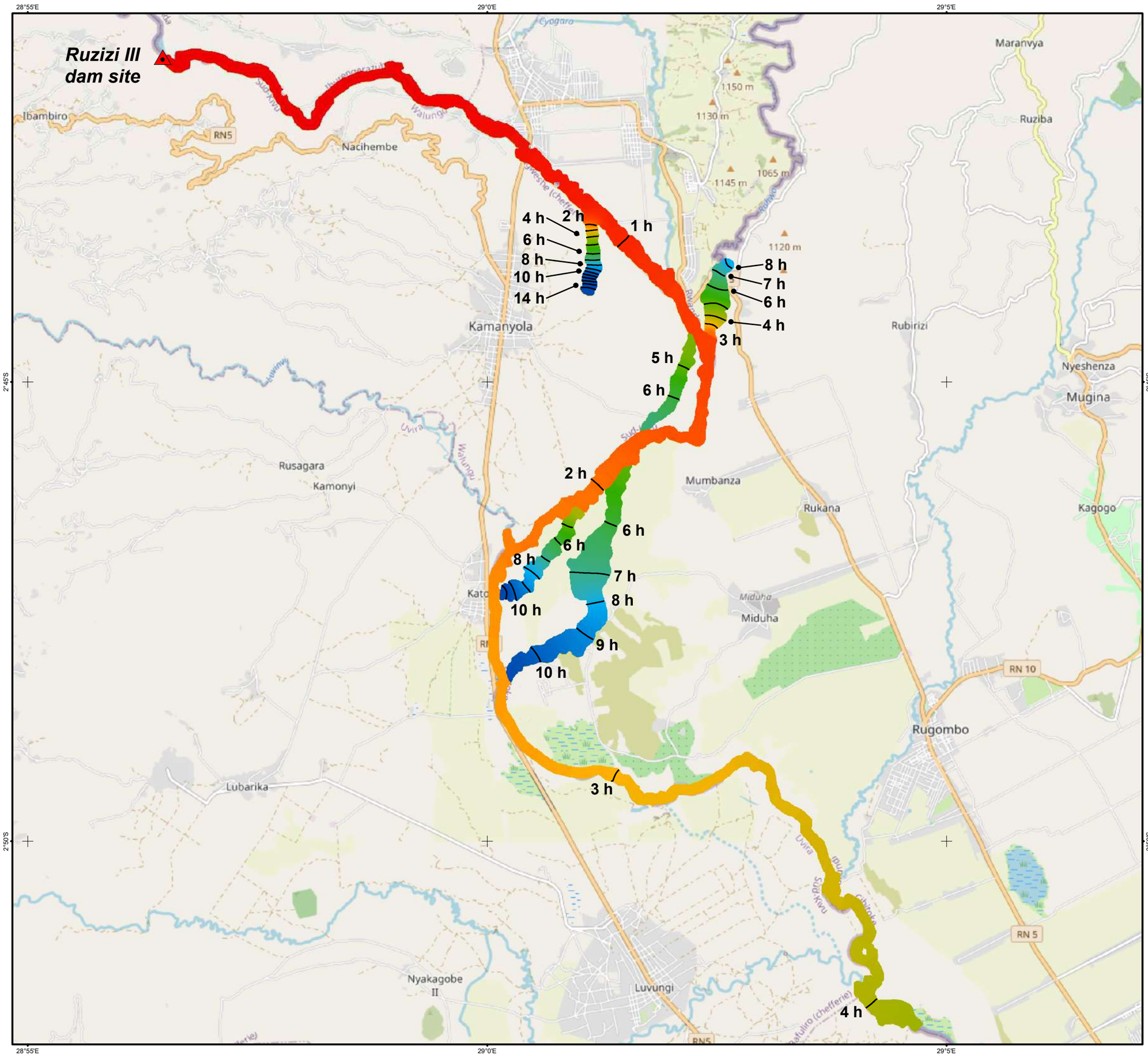
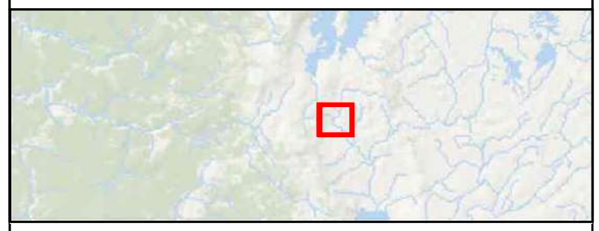


Legend

Ruzizi III dam site	
Main road	
Secondary road	
Other road	
Propagation time (hour)	
Temps de propagation (heure)	
16	
8	
0	

Légende

Barrage de Ruzizi III
Route principale
Route secondaire
Autre route



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	04/11/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

COFFERDAM FAILURE — *RUPTURE DU BATARDEAU*

Propagation time — *Temps de propagation*

TRACTEBEL ENGIE

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Référence Externe		Niveau de confidentialité	

Fichier informatique .mxd	Echelle	NbFolio	Format
PL004	1:75 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	CF	004	A

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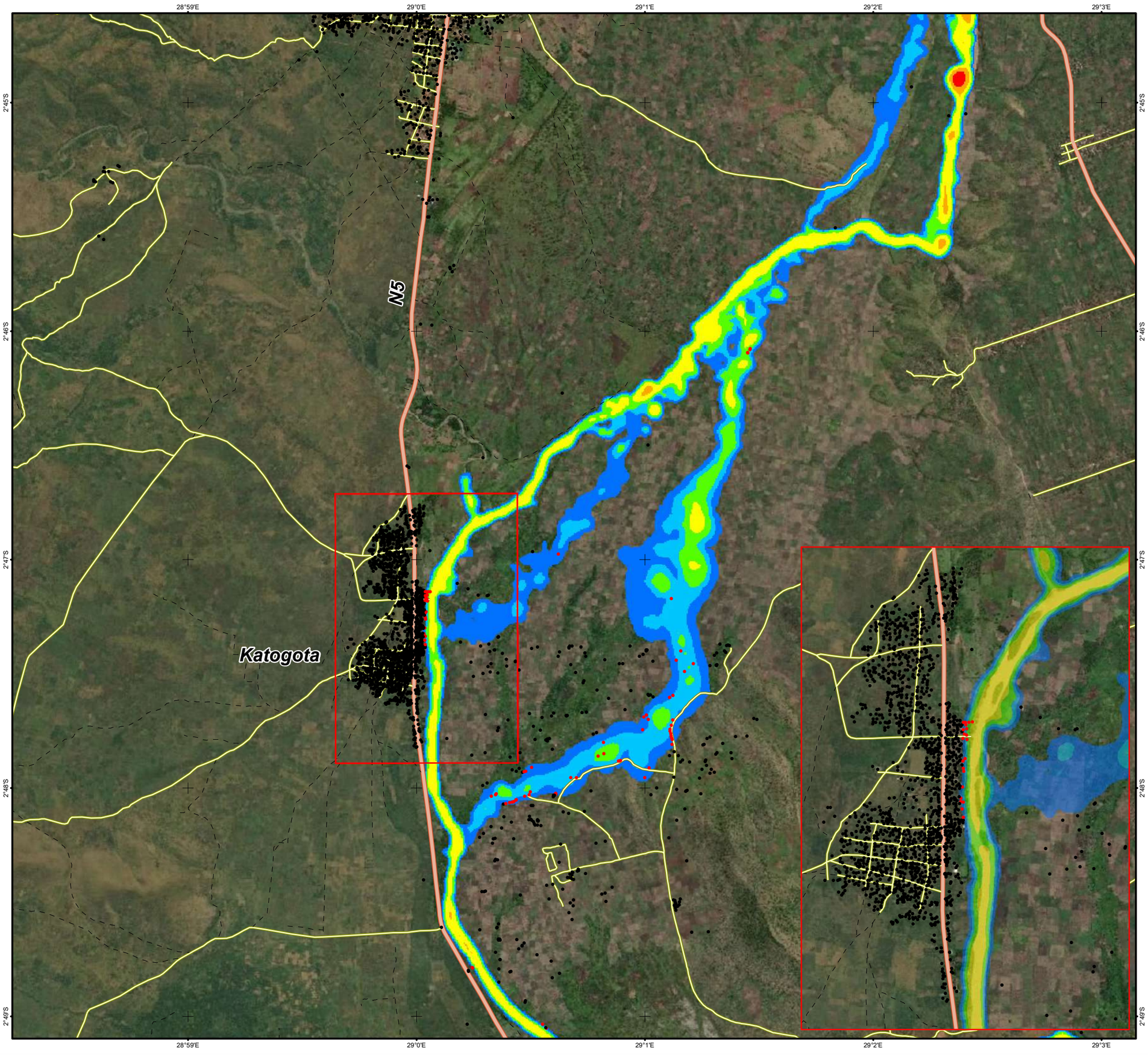

Legend

Ruzizi III dam site	*Barrage de Ruzizi III*
Main road	*Route principale*
Secondary road	*Route secondaire*
Track	*Piste*
Non-impacted building	*Bâtiment non-impacté*
Impacted building	*Bâtiment impacté*

Maximum height (m)

Hauteur maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

0 0.4 0.8 1.2 1.6 2 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	13/11/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

COFFERDAM FAILURE — *RUPTURE DU BATARDEAU*

Maximum height — *Hauteur maximale*

Katogota zoom — *Zoom sur Katogota*

TRACTEBEL ENGIE

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Référence Externe	Niveau de confidentialité

Fichier informatique .mxd	Echelle	NbFolio	Format
PL002	1:30 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	CF	005	A

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28°59'E 29°0'E 29°1'E 29°2'E 29°3'E

2°45'S 2°46'S 2°47'S 2°48'S 2°49'S

N5

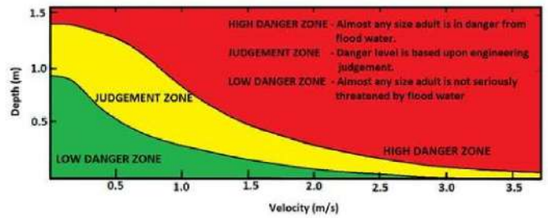
Katogota

Legend / *Légende*

Ruzizi III dam site	*Barrage de Ruzizi III*
Main road	*Route principale*
Secondary road	*Route secondaire*
Track	*Piste*
Non-impacted building	*Bâtiment non-impacté*
Impacted building	*Bâtiment impacté*

Danger areas

Low danger	*Danger faible*
Medium danger	*Danger modéré*
High danger	*Danger fort*



0 0.4 0.8 1.2 1.6 2 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	13/11/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA
RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

COFFERDAM FAILURE — *RUPTURE DU BATARDEAU*

Danger areas
Katogota zoom

Zones de danger
Zoom sur Katogota

TRACTEBEL ENGIE

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Référence Externe	Niveau de confidentialité

Fichier informatique .mxd	Echelle	NbFolio	Format
PL017	1:30 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	CF	006	A

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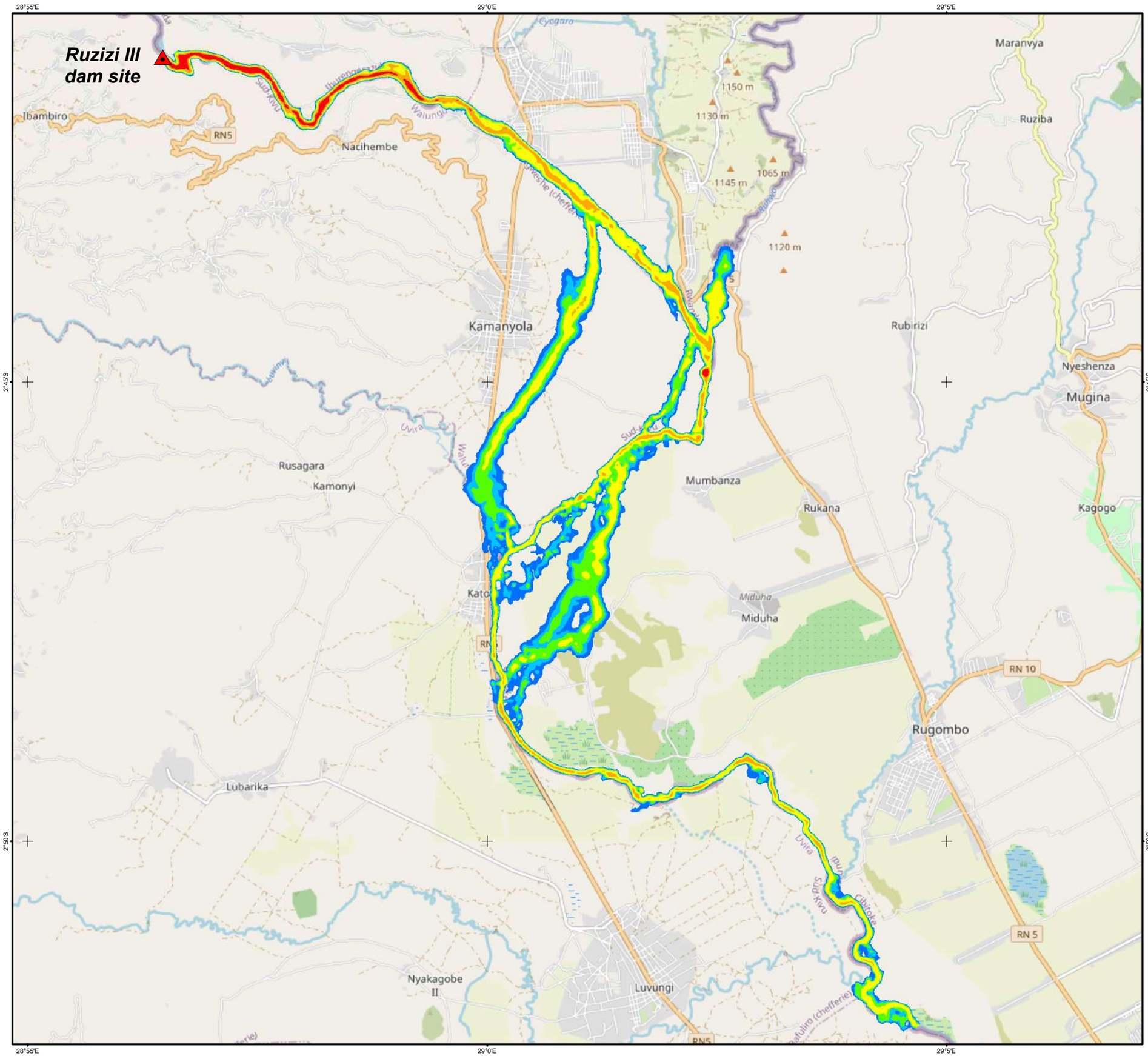


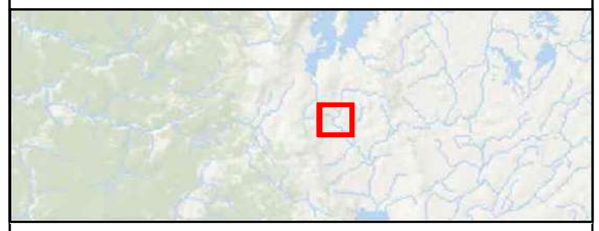
Legend

Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Maximum height (m)

Hauteur maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	03/11/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

SUNNY DAY DAM BREAK — *RUPTURE DU BARRAGE EN CONDITIONS NORMALES*

Maximum height — *Hauteur maximale*

TRACTEBEL ENGIE

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Référence Externe	Niveau de confidentialité

Fichier informatique .mxd	Echelle	NbFolio	Format
PL006	1:75 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	SD	001	A

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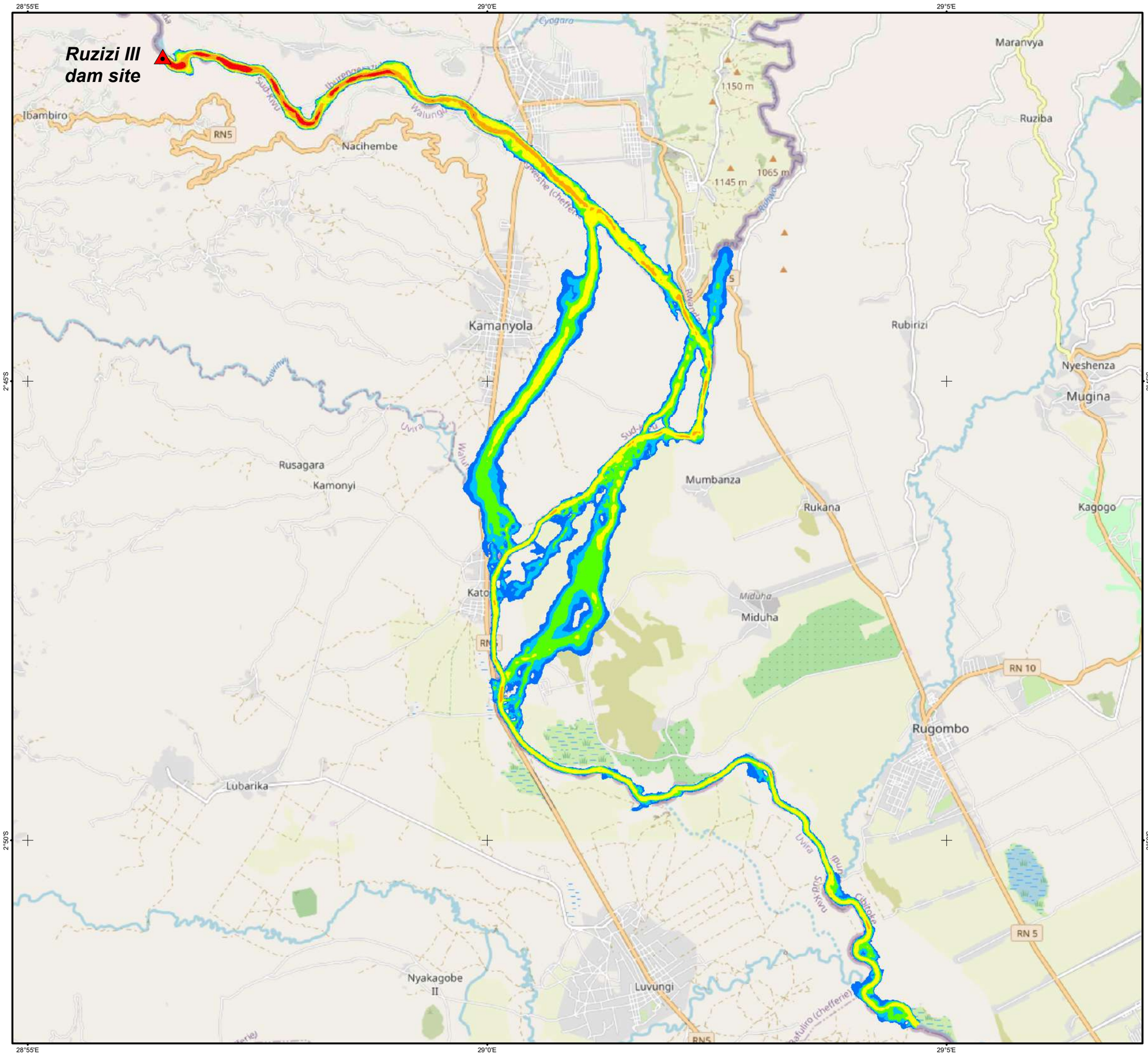


Legend

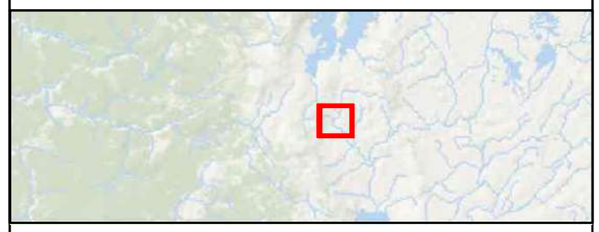
Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Maximum velocity (m)

Vitesse maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

Légende



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	08/10/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

SUNNY DAY DAM BREAK — *RUPTURE DU BARRAGE EN CONDITIONS NORMALES*

Maximum velocity — *Vitesse maximale*

TRACTEBEL ENGIE

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Référence Externe	Niveau de confidentialité

Fichier informatique .mxd	Echelle	NbFolio	Format
PL007	1:75 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	SD	002	A

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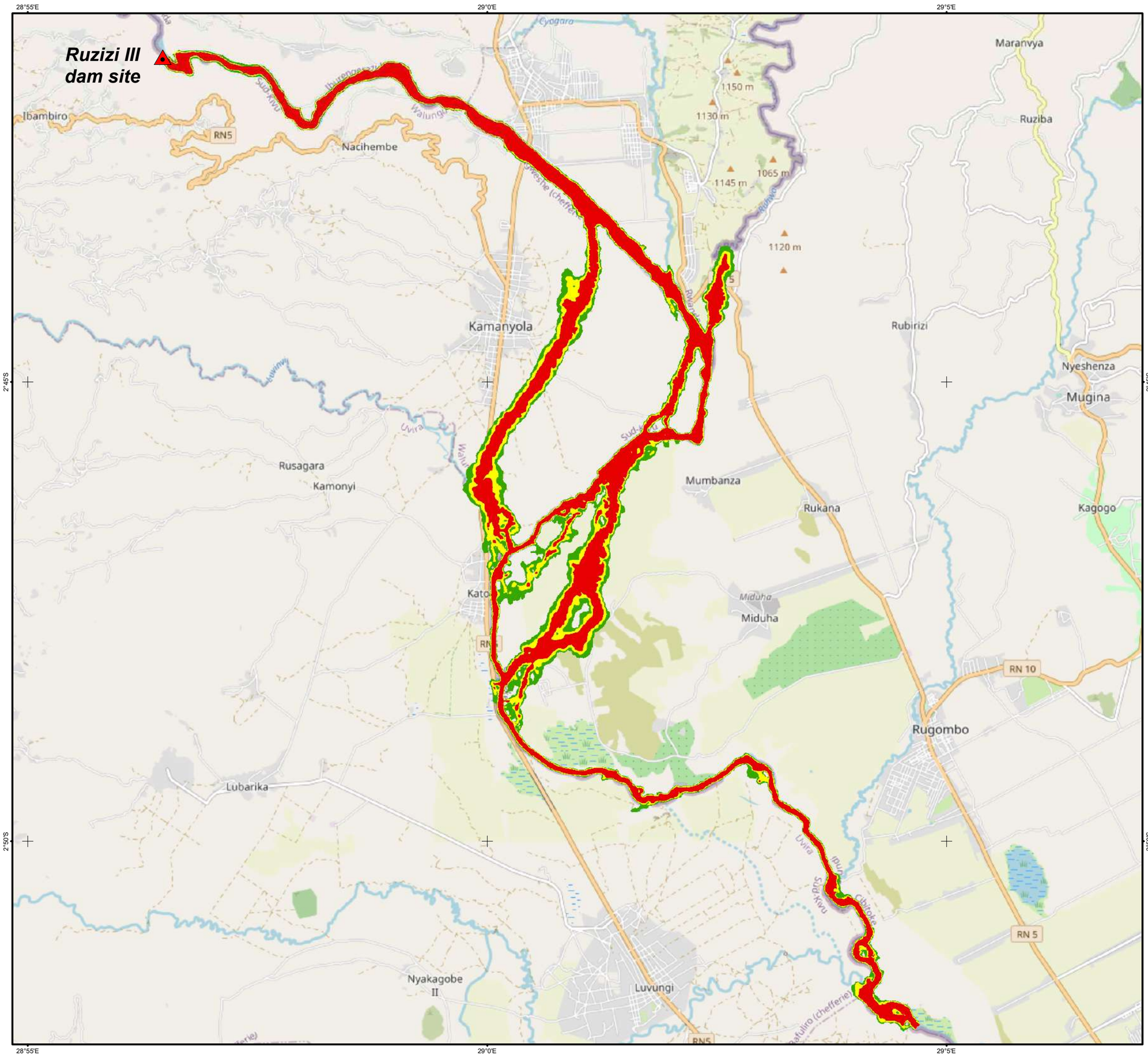


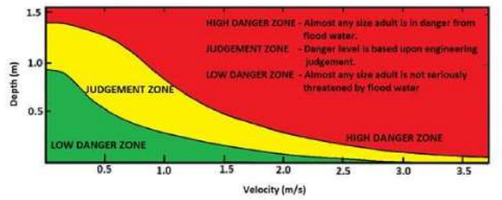
Legend

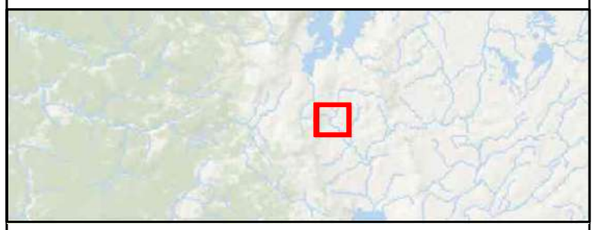
Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Danger areas

Low danger	*Danger faible*
Medium danger	*Danger modéré*
High danger	*Danger fort*

Légende





0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

Rev.	DATE	MODIFICATIONS	STATUT	DESSINE	CONTROLE	APPROUVE
A	03/11/2020	PREMIERE DIFFUSION		NTR	CNI	NFE

Client

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

SUNNY DAY DAM BREAK — *RUPTURE DU BARRAGE EN CONDITIONS NORMALES*

Danger areas — *Zones de danger*

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Référence Externe		Niveau de confidentialité	

Fichier informatique .mxd	Echelle	NbFolio	Format
PL009	1:75 000	1/1	A3

Imputation	Découpe technique	Emetteur
P.014690.0001	WATER	AFR

Indicatif Projet	Type	Numéro	Rév.
RU-DB	SD	003	A

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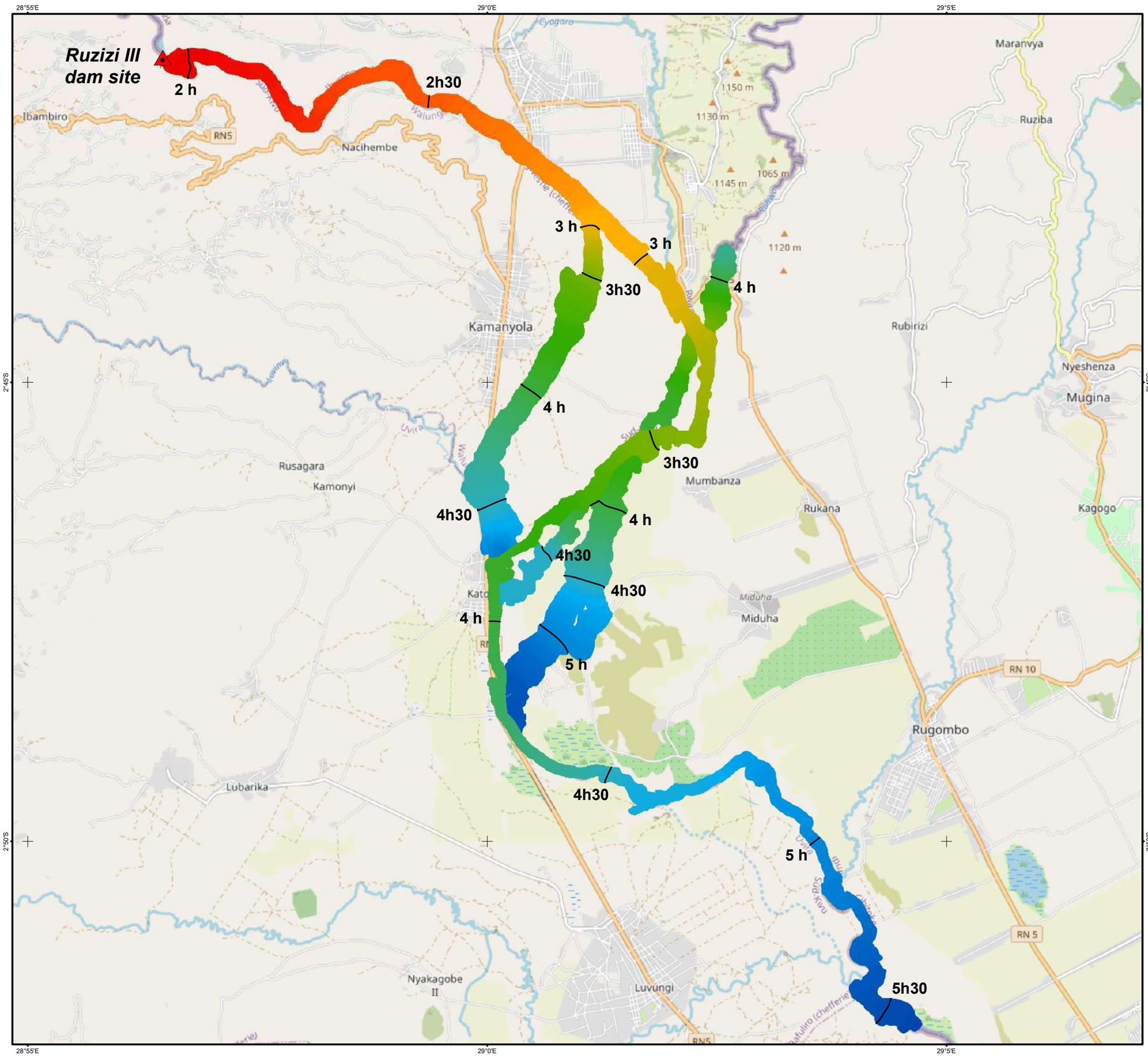


Legend

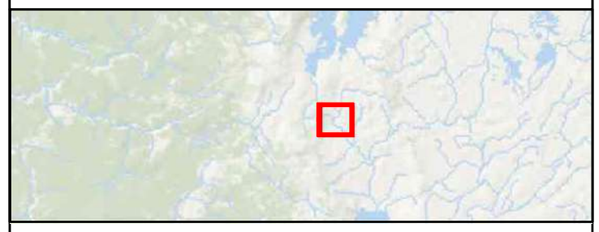
Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Légende

Propagation time (hour)

Temps de propagation (heure)

6
4
2



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

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Client

REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

SUNNY DAY DAM BREAK — *RUPTURE DU BARRAGE EN CONDITIONS NORMALES*

Propagation time — *Temps de propagation*

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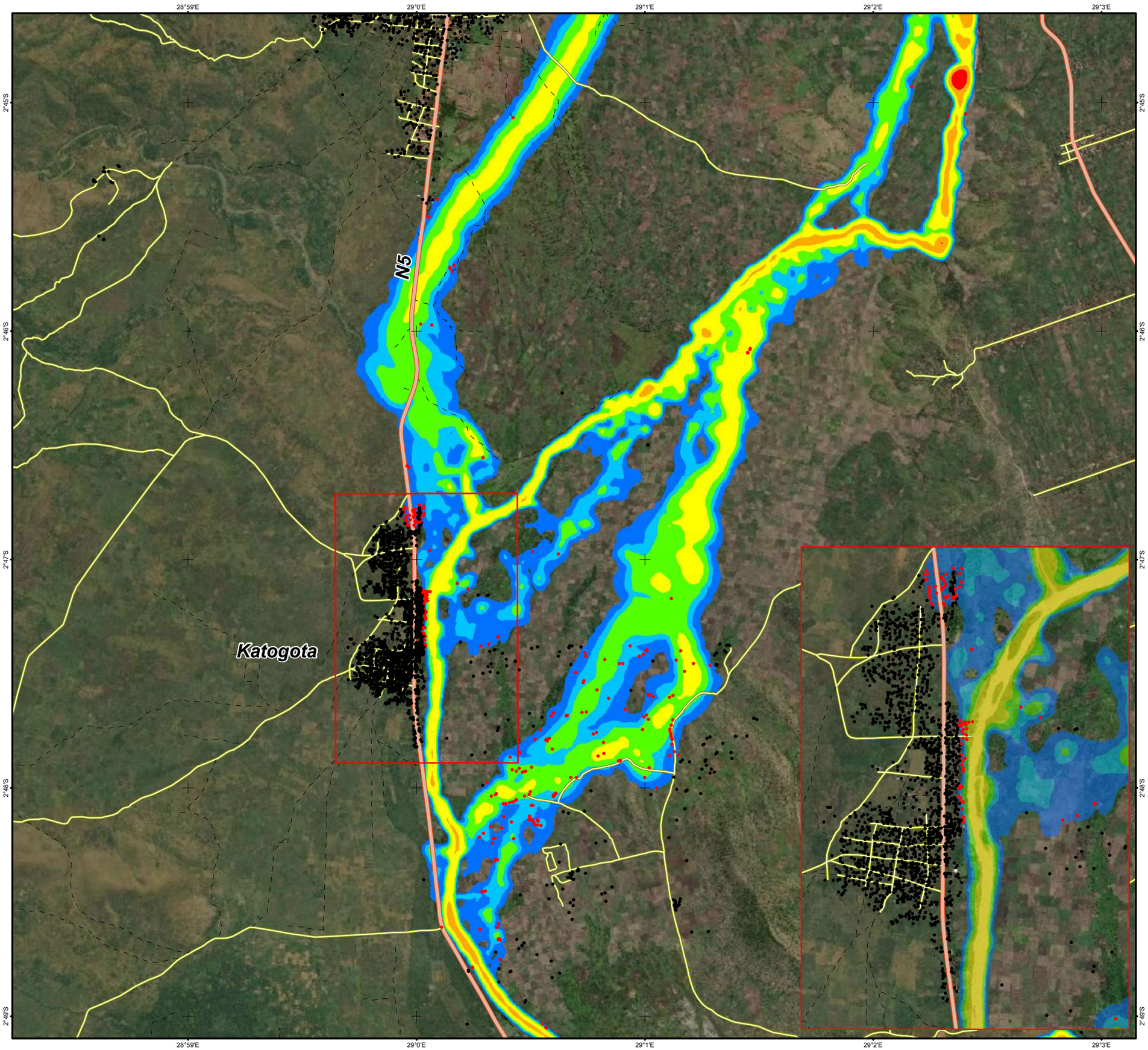

Legend

Ruzizi III dam site	*Barrage de Ruzizi III*
Main road	*Route principale*
Secondary road	*Route secondaire*
Track	*Piste*
Non-impacted building	*Bâtiment non-impacté*
Impacted building	*Bâtiment impacté*

Maximum height (m)

Hauteur maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

0 0.4 0.8 1.2 1.6 2 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

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REL Ruzizi III Energy Limited

REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

SUNNY DAY DAM BREAK

Maximum height
Katogota zoom

RUPTURE DU BARRAGE EN CONDITIONS NORMALE
Hauteur maximale
Zoom sur Katogota

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28°59'E 29°0'E 29°1'E 29°2'E 29°3'E

2°45'S 2°46'S 2°47'S 2°48'S 2°49'S

N5

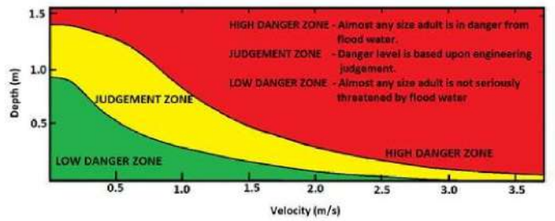
Katogota

Legend / *Légende*

Ruzizi III dam site	*Barrage de Ruzizi III*
Main road	*Route principale*
Secondary road	*Route secondaire*
Track	*Piste*
Non-impacted building	*Bâtiment non-impacté*
Impacted building	*Bâtiment impacté*

Danger areas

Low danger	*Danger faible*
Medium danger	*Danger modéré*
High danger	*Danger fort*



0 0.4 0.8 1.2 1.6 2 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

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DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

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Danger areas — *Zones de danger*
Katogota zoom — *Zoom sur Katogota*

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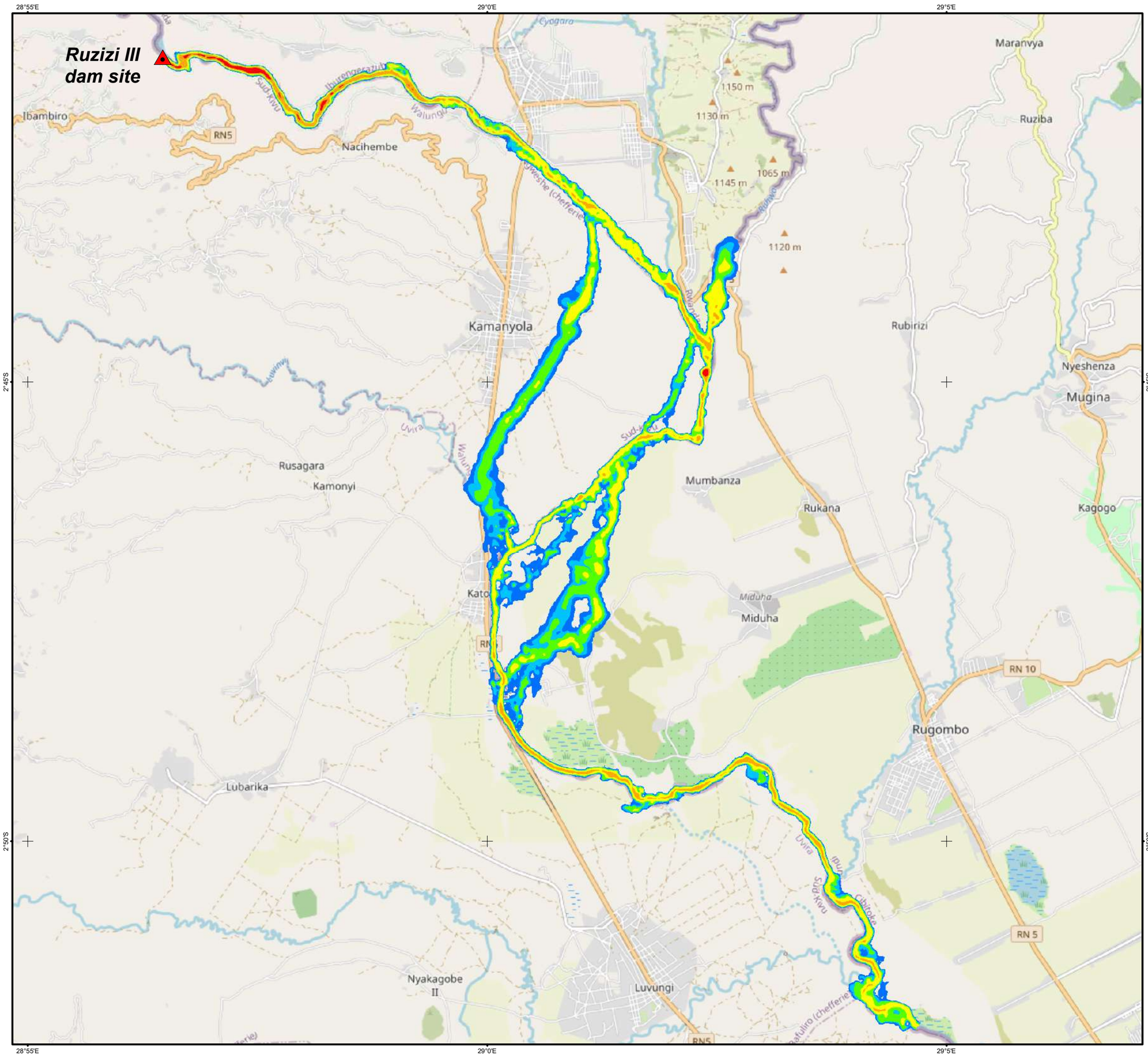


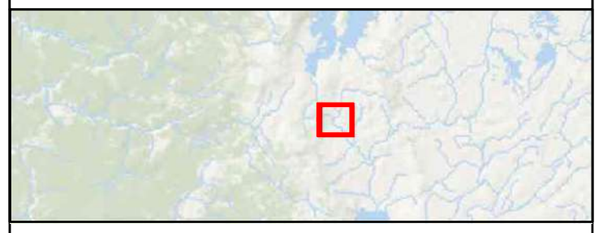
Legend

Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Maximum height (m)

Hauteur maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

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Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

FLOOD INDUCED DAM BREAK
Maximum height

RUPTURE DU BARRAGE EN CONDITIONS DE CRUE
Hauteur maximale

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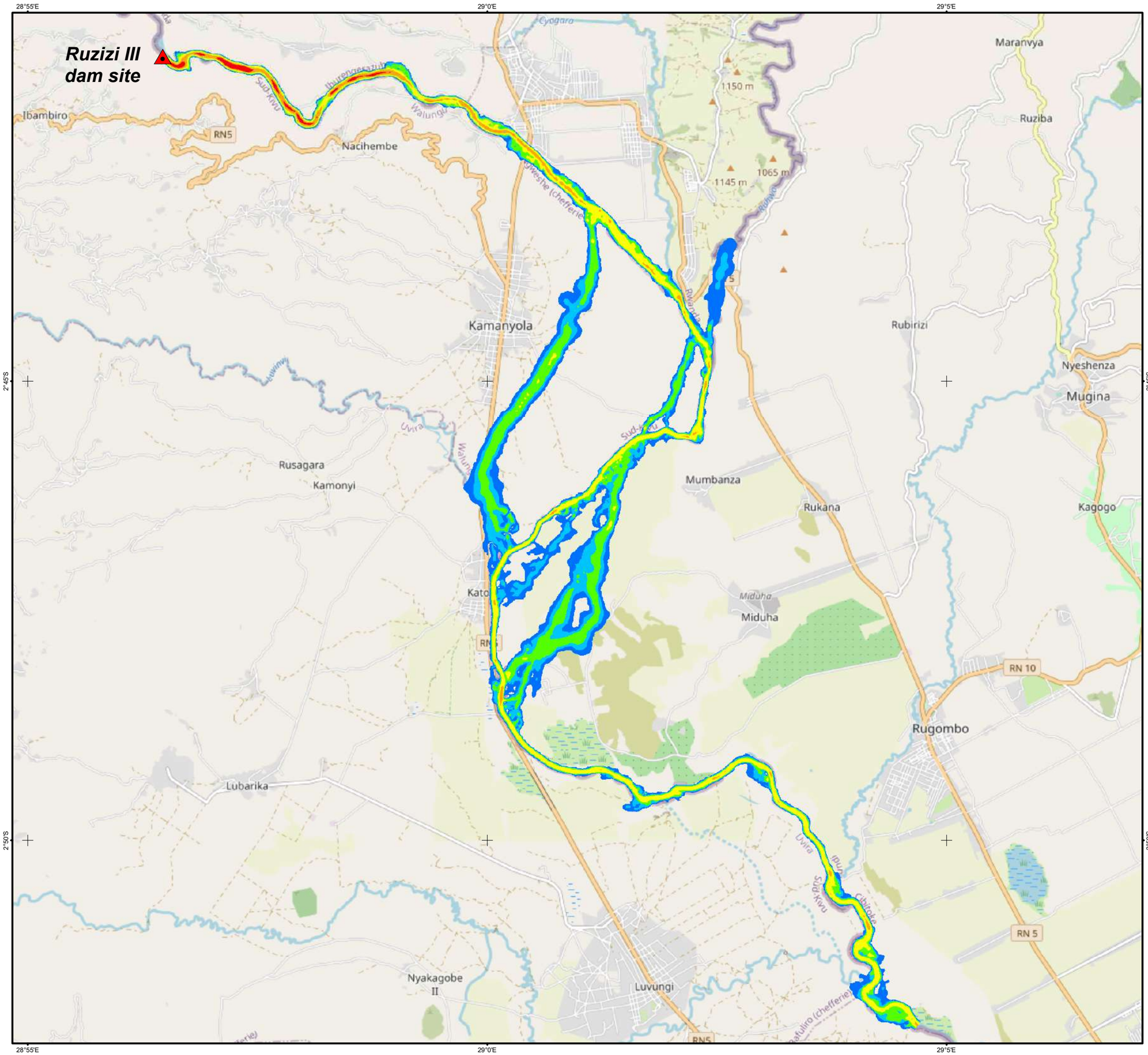


Legend

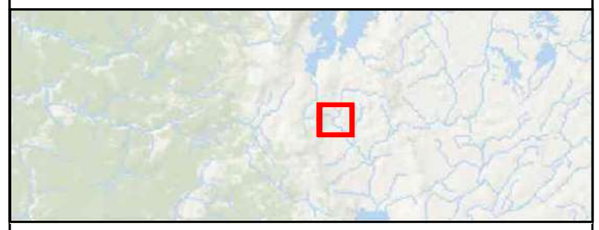
Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Maximum velocity (m)

Vitesse maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

Légende



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

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Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

FLOOD INDUCED DAM BREAK
Maximum velocity

RUPTURE DU BARRAGE EN CONDITIONS DE CRUE
Vitesse maximale

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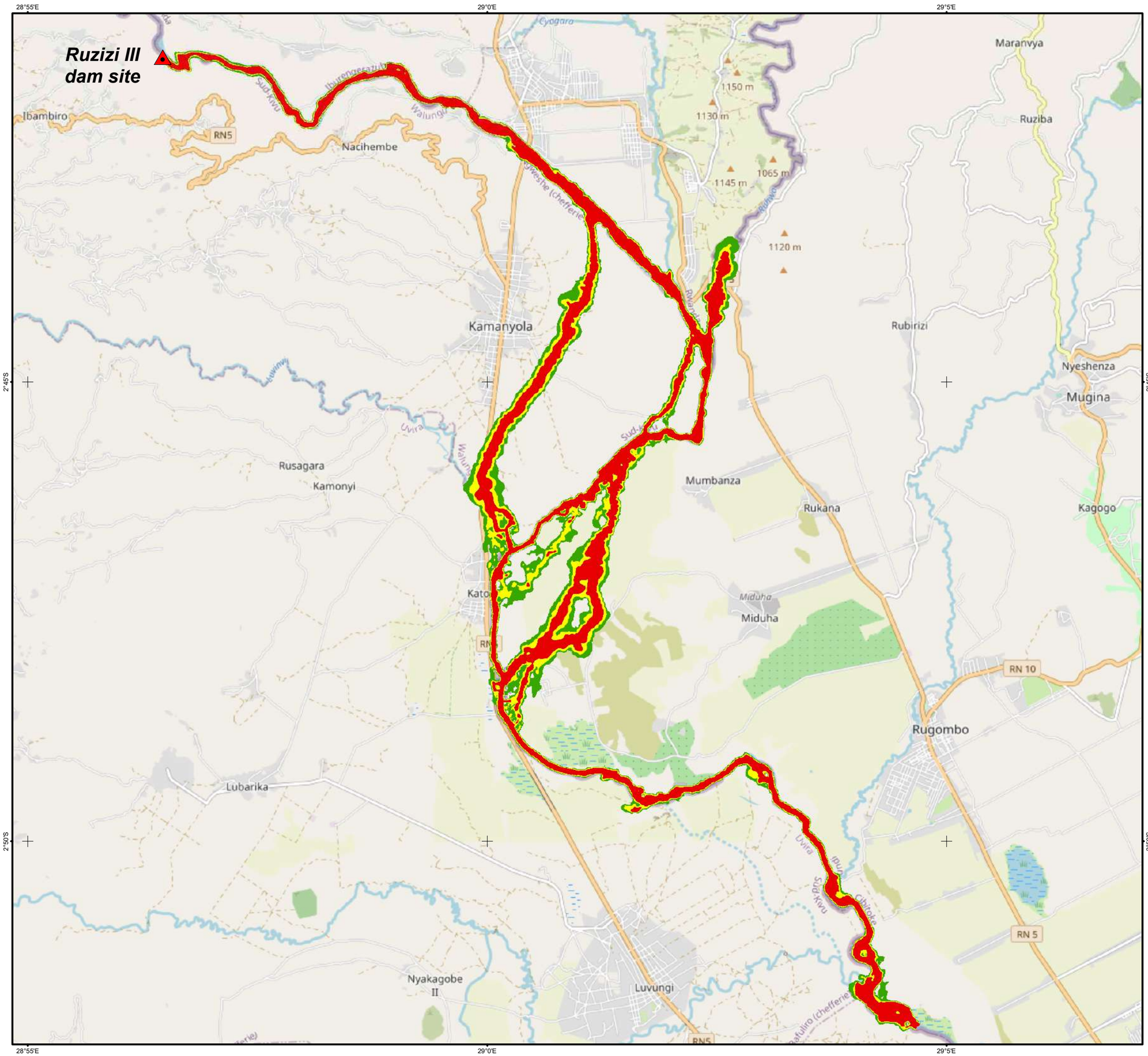


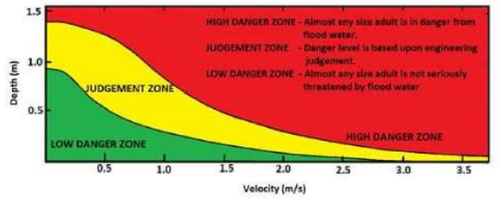
Legend

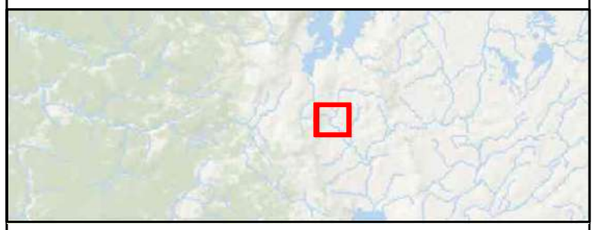
Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Danger areas

Low danger	*Danger faible*
Medium danger	*Danger modéré*
High danger	*Danger fort*

Légende





0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

N

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Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

FLOOD INDUCED DAM BREAK

Danger areas

RUPTURE DU BARRAGE EN CONDITIONS DE CRUE

Zones de danger

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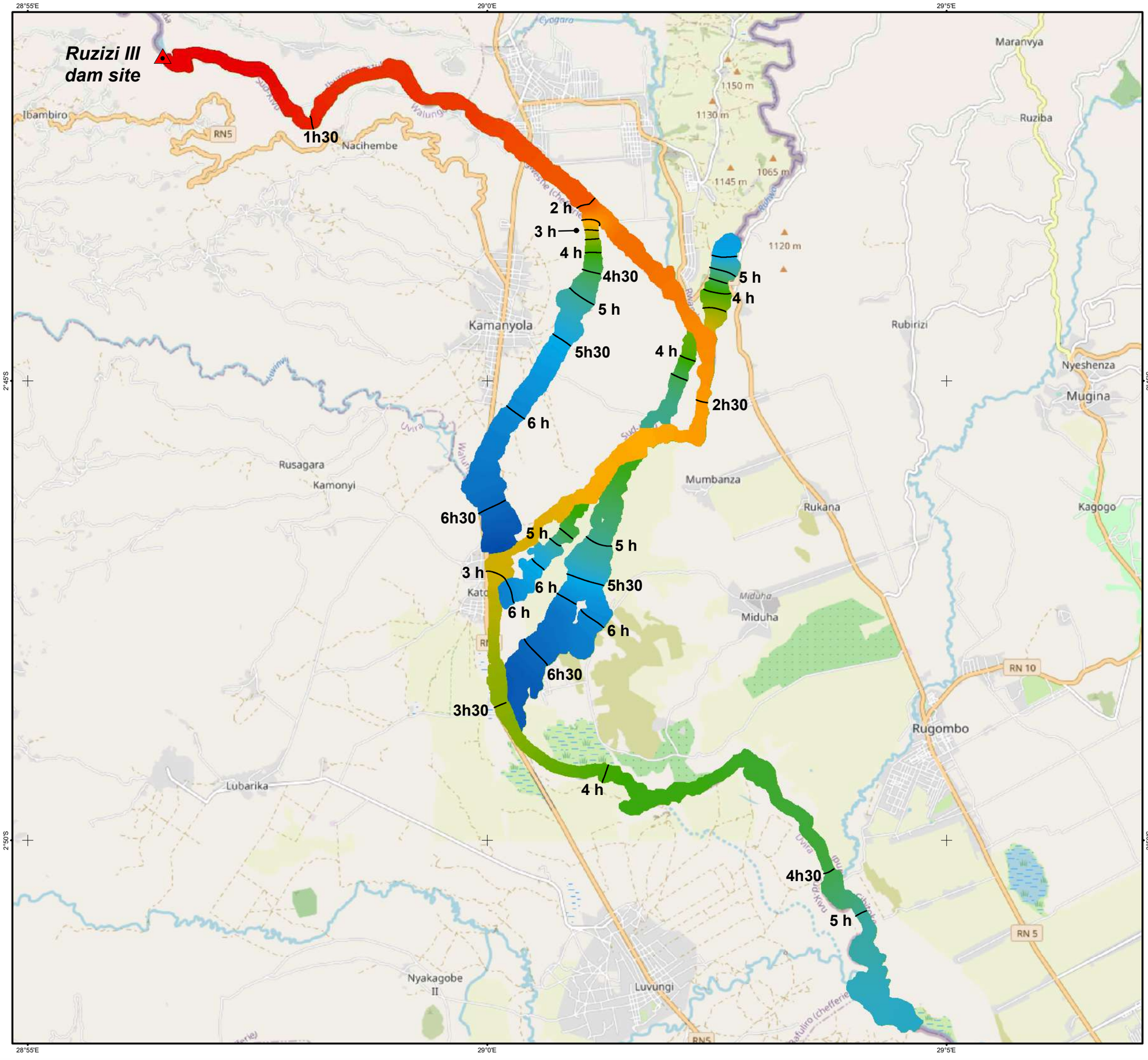


Legend

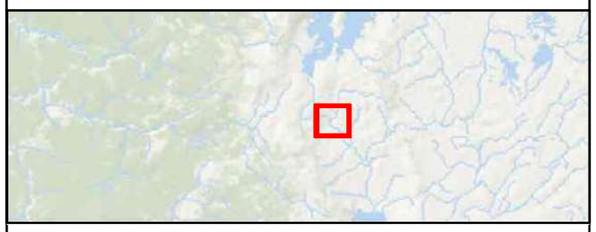
Ruzizi III dam site	Barrage de Ruzizi III
Main road	Route principale
Secondary road	Route secondaire
Other road	Autre route

Propagation time (hour)

Temps de propagation (heure)

6
3
0

Légende



0 1 2 3 4 5 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

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Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

FLOOD INDUCED DAM BREAK
Propagation time

RUPTURE DU BARRAGE EN CONDITIONS DE CRUE
Temps de propagation

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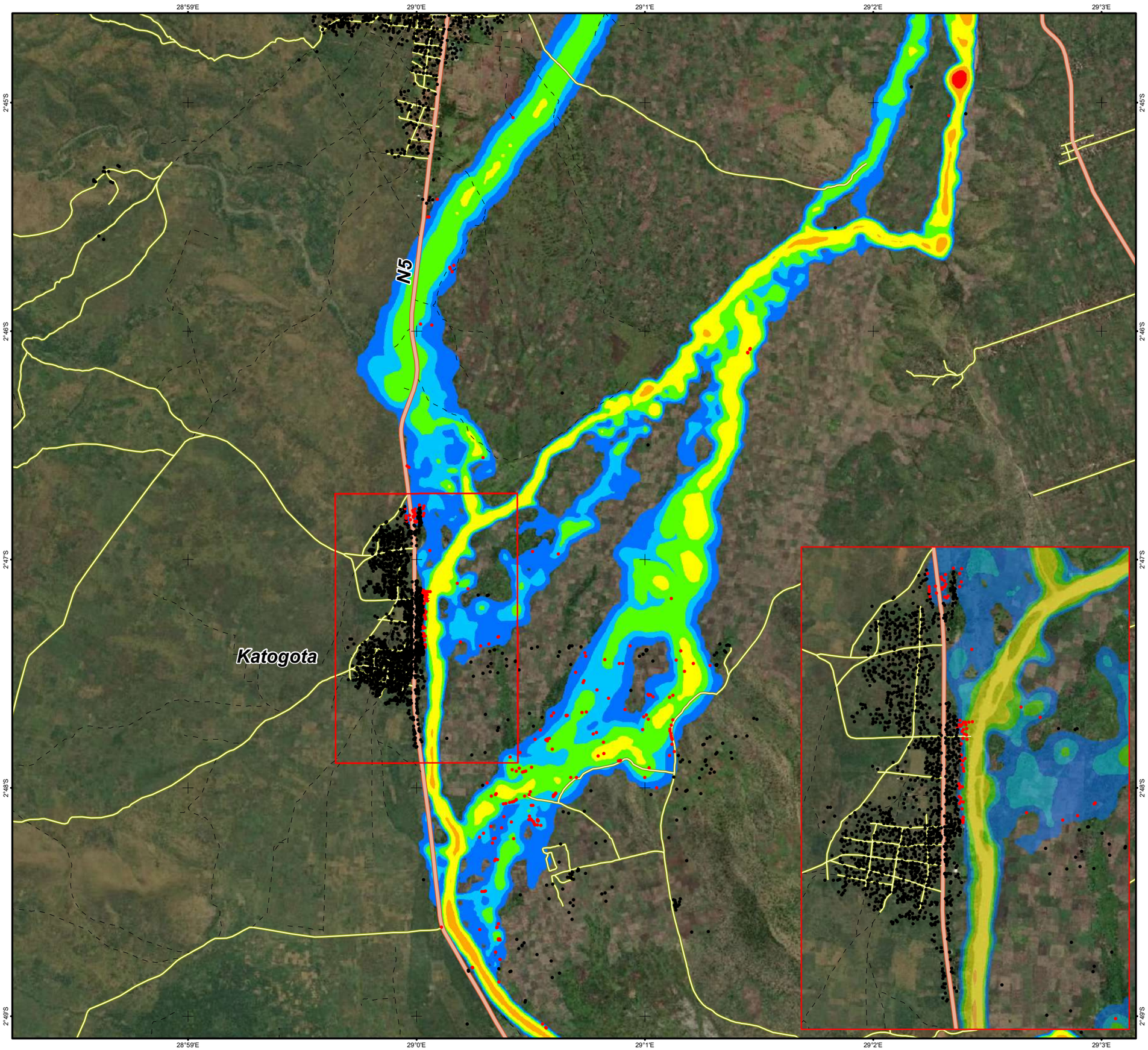

Legend

Ruzizi III dam site	*Barrage de Ruzizi III*
Main road	*Route principale*
Secondary road	*Route secondaire*
Track	*Piste*
Non-impacted building	*Bâtiment non-impacté*
Impacted building	*Bâtiment impacté*

Maximum height (m)

Hauteur maximale (m)

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

0 0.4 0.8 1.2 1.6 2 km

Coodinate system : WGS 1984
Projection : WGS_1984_UTM_Zone_35S
Unit : Meter

Sources : Open Street Map, 2020

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REPUBLIC OF RWANDA

RUZIZI ENERGY LIMITED

Projet

RUZIZI III HEPP

DAM BREAK STUDY — *ONDE DE RUPTURE*

Sujet

FLOOD INDUCED DAM BREAK
Maximum height
Katogota zoom

RUPTURE DU BARRAGE EN CONDITIONS DE CRUE
Hauteur maximale
Zoom sur Katogota

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J. Climate Risk and Vulnerability Assessment

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Application of the Hydropower Sector Climate Resilience Guide to Ruzizi III HEP

Owner's Engineer Services for the Ruzizi III HEPP Project

Ruzizi III Energy Limited

RWANDA - DEMOCRATIC REPUBLIC OF THE CONGO - BURUNDI

CONFIDENTIAL

August 7, 2020

REPORT

RUZ-AVP-TEF-GEN-HYD-RAP-003

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Ruzizi III Energy Limited

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REPORT

Our ref. : **RUZ-AVP-TEF-GEN-HYD-RAP-003**
Entity : Unit Africa
Imputation : P.014690

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Client : Ruzizi III Energy Limited
Project : Ruzizi III
Country/State: Rwanda - Democratic Republic of the Congo - Burundi

Title : Application of the Hydropower Sector Climate Resilience Guide to Ruzizi III HEP
Subtitle : Owner's Engineer Services for the Ruzizi III HEPP Project
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Application of the Hydropower Sector Climate Resilience Guide to Ruzizi III HEP

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Application of the Hydropower Sector Climate Resilience Guide to Ruzizi III HEP

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LIST OF ABBREVIATIONS AND ACRONYMS

ABAKIR	Autorité de Bassin du Lac Kivu et de la Rivière Rusizi
CCGT	Combined Cycle Gas Turbine
CEPGL	Communauté Economique des Pays des Grands Lacs
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CMIP5	Coupled Model Intercomparison Project Phase 5
CRU	Climate Research Unit
CT	Combustion Turbine
DRC	Democratic Republic of Congo
EGL	Énergie des Grands Lacs
ESIA	Environmental and Social Impact Assessment
ETP	Evapotranspiration
GCM	Global Circulation Model
IDF	Intensity-Duration-Frequency
IHA	International Hydropower Association
KNMI	Koninklijk Nederlands Meteorologisch Instituut
masl	Meters above sea level
MER	Monitoring, evaluation and reporting
NPV	Net Present Value
NRCS	Natural Resources Conservation Service
O&M	Operation and Maintenance
PMF	Probable Maximum Flood
PPA	Power-Purchase Agreement
PPP	Public-Private Partnership
RCP	Representative Concentration Pathway

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REL	Ruzizi III Energy Limited
SINELAC	Société Internationale d'Electricité des Grands Lacs
SNEL	Société Nationale d'Electricité (RDC)
SSP	Shared Socioeconomic Pathways
USD	United States Dollar
USGS	United States Geological Survey
WCRP	World Climate Research Program

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1. INTRODUCTION

Climate change is a major challenge for existing and future water resources infrastructure. An increase in temperature could lead to an increase in evaporation, intensify extreme rainfall events and modify temporal and spatial distribution of precipitation in the future. In response, new approaches, such as the Climate Resilience Guide from the International Hydropower Association (IHA, 2019) have recently been proposed to provide decision making support for implementing a climate risk management plan. The goal of such a plan is to identify measures, whether structural or functional, to build resilience into the system so that it can address potential future climate changes.

This report provides the Climate Risk Assessment of the Ruzizi III hydropower project. The Assessment follows the Climate Resilience Guide, herein referred to as the IHA Guidelines. The process consists of 5 phases, which are illustrated in Figure 1-1.

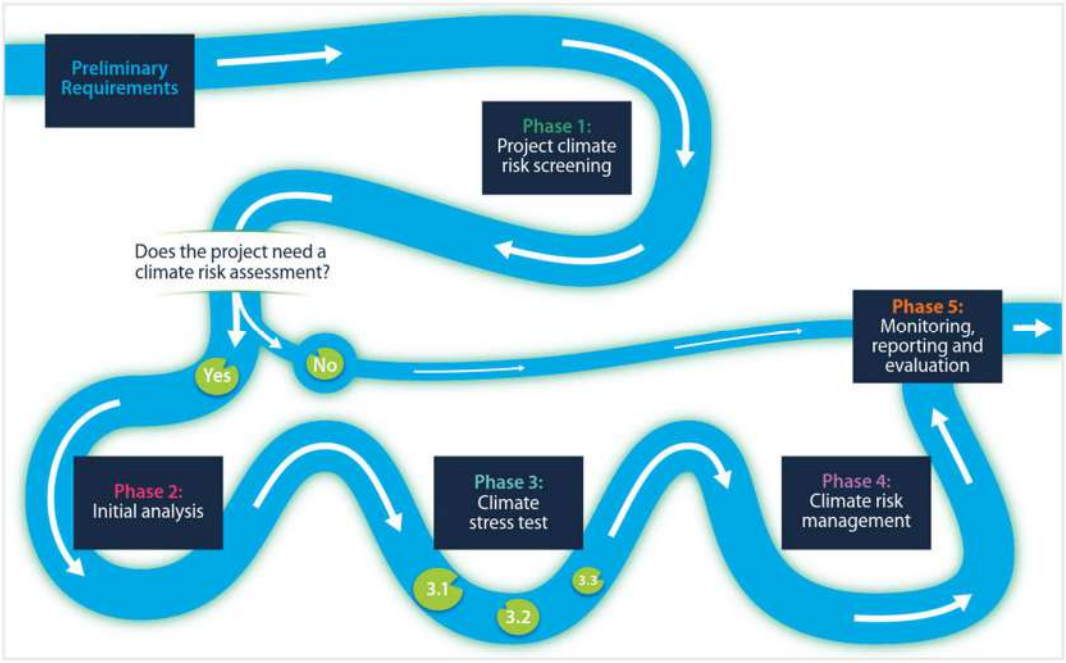

Figure 1-1: Phases of the IHA Guidelines (International Hydropower Association, 2019)

Phase 1 (*Project screening*) aims to qualitatively determine the project's vulnerability to climate change by considering characteristics such as project location, mode of operation, technical design, and socio-environmental components. In Phase 2 (*Initial analysis*), the current and projected climate data are analyzed. Depending on the quality and quantity of data, a methodology to quantitatively assess the project's resilience to climate change is developed in Phase 3 (*Climate stress test*) following requirements provided in the Guidelines. If the project is deemed vulnerable, a Climate Risk Management Plan is proposed in Phase 4 (*Climate risk management*) through the testing of adaptation measures. The goal is to ensure project resilience as well as cost-effectiveness and economic feasibility. Finally, a monitoring, evaluating and reporting (MER) plan is provided in Phase 5 (*Monitoring reporting and evaluation*).

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Stakeholders engagement is a key element of the IHA Guidelines. Virtual stakeholder workshops are encouraged throughout the process to verify analysis assumptions made during Phases 1, 2 and 3, including on the economic, social and environmental impacts of the project. Moreover, stakeholder contributions to the climate adaptation plan developed in Phase 4 are expected to improve the ease and likelihood of implementation. Finally, the future MER plan developed in Phase 5 may require the stakeholders' engagement long after the Climate Risk Assessment is complete. Therefore, lack of stakeholder participation at this phase would greatly hinder the ability to put into action the developed Plan. Overall, stakeholder engagement throughout the process ensures an improved and more realistic final product.

Section 2 presents the Phase 1 (*Project screening*) results, including the identified metrics and criteria and an initial Risk and Opportunity Register. The Phase 2 (*Initial analysis*) results concerning the projected climate changes and downscaling method are provided in section 3. The methodology for the climate sensitivity analyses and stress tests is described in section 4 (Phase 3: *Climate stress test*), and adaptation measures for the Climate Risk Management Plan are proposed in section 5 (Phase 4: *Climate risk management*) accordingly. Section 6 outlines the necessary elements for monitoring, reporting and evaluating performance and hydro-meteorological changes in the system (Phase 5: *Monitoring reporting and evaluation*). Finally, information on the engagement of the stakeholders will be provided in section 7.

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2. PHASE 1: SCREENING OF THE PROJECT CLIMATE RISKS

Phase 1 aims at constituting a first qualitative assessment of the Ruzizi III hydropower project. The objective is to determine the vulnerability of the project considering its geographic, regulatory, technical and socioeconomic conditions.

A review of the project's characteristics and context is performed, and results are presented in the following sections.

2.1. Hydropower project characteristics and context

The Ruzizi III hydropower project is located on the Ruzizi River, which marks the border between Rwanda and the Democratic Republic of Congo (DRC). It is part of the Ruzizi Cascade, already comprised of Ruzizi I (built in 1959, 3 km downstream from Lake Kivu) and Ruzizi II (built in 1989, 18 km from Ruzizi I), and it is planned to be constructed approximately 13 km downstream from Ruzizi II.

At this study stage, two alternative projects (and three designs) are considered: the original site (Fichtner's design) and the alternative upstream site with two potential designs (450 m upstream from the original site). Characteristics of both sites are available in Table 2-1.

Table 2-1: Characteristics of the Ruzizi III project designs

	Original site	Alternative site	
Dam type	Asphalt core rockfill dam	Rockfill dam with a central clay core	
Height (m)	28	< 46	
Crest Length (m)	120	250	
Reservoir capacity (hm^3)	1.84 (FSL: 1,107 masl)	2.67 (FSL: 1,130 masl)	7.20 (FSL: 1,145 masl)
Dead storage (hm^3)	0.90	1.14	2.67
Powerhouse	3 Francis turbines with an installed capacity of 50 m^3/s each		
Maximum power capacity (MW)	148	183	203
Average annual energy production (GWh)	861	1,067	1,183

2.1.1. Key stakeholders

The Ruzizi III project is the first regional power project in East Africa to be established as a Public-Private Partnership (PPP). The Great Lakes Energy Organization (EGL), a sub-regional body which coordinates energy development in East Africa, oversees the implementation of the project with the financial help of NEPAD-IPFF, a multi-donor Special Fund hosted by the African Development Bank to make regional or cross-border

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infrastructure projects investment ready. The Project Agreement was signed on July 2019 in Kinshasa between the three states and the private partner, a Consortium constituted of Industrial Promotion Services (IPS) (Aga Khan Fund for Economic Development, Kenya) and SN Power (Norway). The Project Company is named Ruzizi III Energy Limited (REL).

The stakeholders involved in the management of Lake Kivu and the dams on the Ruzizi River include:

- The ABAKIR, the Lake Kivu and Ruzizi River basin organization, which represents the three countries' interests and guarantees an integrated water resources management in the basin. They do not have any authority for deciding short-term water releases from the dams. Their objective is more about ensuring a long-term integrated management of Lake Kivu and the Ruzizi River that comply with international regulation, and about sharing the benefits obtained from the operation of dams.
- The owners and managers of the individual dams, in charge of operating them on a short-term basis, are:
  - Ruzizi I: SNEL, the DRC national electricity company
  - Ruzizi II: SINELAC (in which DRC, Rwanda and Burundi are equal shareholders)
  - Ruzizi III: REL
- The national operators of the electricity networks of the three countries, who ensure that the supply meets the demand.

It must be stressed that a Centre of Coordination had also been suggested to the member states of the CEPGL to purchase water rights, optimize the production of electricity and serve as a unique interface between the country stakeholders (SOFRECO, 2011).

2.1.2. Watershed and climate conditions

Lake Kivu, with an area of 2,416 km^2 and a catchment area of 7,528 km^2, is located at an elevation of 1,460 m. Ruzizi III upstream site is at an elevation of approximately 1,110 m and the intermediate catchment between this site and Lake Kivu's outlet drains an area of 325.4 km^2 (see Figure 2-1).

The Lake Kivu and intermediate catchment soils are quite impervious, due to the large presence of quartzite and clay, and characterized with an agricultural land use. Massive deforestation and bush fires are also assumed to have occurred in DRC (Balagizi, et al., 2013), starting in the 1980s (Bagalwa, et al., 2016) and still continuing in the 2010s (Molinario, Hansen, & Potapov, 2015), and in Rwanda starting with the conflicts of 1994[1]. Such characteristics and processes contribute to an increase in the magnitude of floods in the basin.

Climate over the Lake and Ruzizi III catchments is typical for an equatorial region: a strong seasonality and high inter-annual variability. There are two rainy seasons during the year: from March to May (long rains) and from mid-September to December (short rains); and a significantly dry season from June to August (see Figure 2-2). Average yearly rainfall over 1901-2018 is estimated at 1,519 mm/year using CRU satellite data (with an average increase of 0.93 mm/year, i.e. +6.1% over 100 years). Over the same

[1] https://www.kivu-methane-extraction.com/fr/ki_3b_energetique.htm

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period, evapotranspiration is estimated at 931 mm/year suing CRU satellite data (with an average increase of 0.79 mm/year, i.e. +8.5% over 100 years). Such evolutions may partly be caused by temperature changes. An average increase of 0.54°C per decade has been measured at the Lwiro ground station in DRC, close to the south-western shore of Lake Kivu, over 1967-2004 (Fichtner, 2010); and an increase of 0.29°C per decade in Rwanda from 1985 to 2015 according to the Rwandan meteorological agency (USAID, 2019).

Figure 2-1: Map of the Ruzizi III and Lake Kivu catchments (Google Earth)

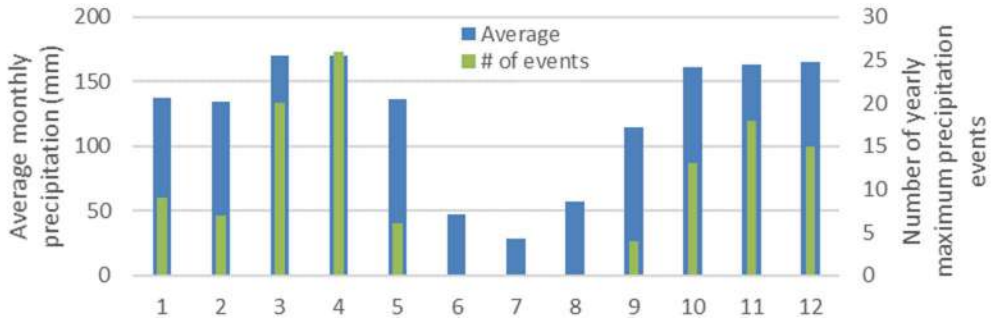

Figure 2-2: Average monthly precipitation and occurrence of yearly maximum precipitation events for each month (CRU data over 1901-2018)

Future projections in Rwanda and the Great Lake Region are presented in Table 2-2.

Table 2-2: Expected climate change in Rwanda and the Great Lakes Region

Variable	Rwanda in 2050 (USAID, 2019)	Great Lakes Region (Government of the Netherlands, 2019)
Temperature	Incremental increase of 1.4-2.3°C	Around +0.4°C per decade, up to +2.5-3°C between 2000 and 2050 and +6°C by 2100. Mostly during Jun-Aug.

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Variable	Rwanda in 2050 (USAID, 2019)	Great Lakes Region (Government of the Netherlands, 2019)
Precipitation	Change between -3% and +9%	Decrease by 2030 (-3 mm/month), but increase by 2090 (+25 mm/month around Lake Tanganyika and in November up to +50 mm/month)
Rainfall pattern	More frequent (+7% to +40%) and more intense (+2% to +11%) rainfall events	Modest decrease for Feb-Aug (long rainy season & long dry season), increase for Nov-Feb (short dry season, up to +25% by 2100), higher intensity of rainfall in heavy rain events
Extreme events	Longer heat waves (+7 to +22 days), longer dry spells (0 to +7 days)	Increased frequency/intensity of floods, increased frequency of hot days/nights, increased frequency of dry spells during rainy season (Rwanda and Burundi) but decreased frequency for DRC
Seasons	-	Increased duration of long dry season (up to May-Sep), including increase in temperature and dryness, decreased duration of rainy seasons

2.1.3. Health, environment and social aspects

DRC and Rwanda are estimated to be the most vulnerable to climate change in the Ruzizi Plain due to the high density in this region (2,000 people per km^2), a large dependency on natural resources and an agricultural productivity considered to be particularly low (Government of the Netherlands, 2019).

The more frequent and intense floods (see section 2.1.2) are expected to impact the yields of widely consumed crops such as maize or beans. Rice cultivation may benefit from the more frequent floods, but its high production cost may not balance the loss of other crops and loss in the fishery sector. Farmers' households may be the most vulnerable population in the Ruzizi Plain, particularly in Burundi and Rwanda where many skilled workers migrate to DRC (Government of the Netherlands, 2019).

Some vulnerability indicators identified for Burundi, DRC and Rwanda are summarized in Figure 2-3.

Variable	Indicator	Year	Vulnerability level		
			Burundi	DRC	Rwanda
Environmental disasters	Drought	2010	high	high	high
		2030	high	high	high
	Floods and landslides	2010	moderate	moderate	moderate
		2030	high	moderate	moderate
	Storms	2010	low	low	low
		2030	low	low	low
	Wildfires	2010	low	moderate	low
		2030	low	moderate	low
Environmental disasters	Agriculture	2010	acute	high	acute
		2030	acute	severe	acute
	Fisheries	2010	high	severe	moderate
		2030	acute	acute	moderate
Health impact	Hunger	2010	severe	acute	high
		2030	severe	acute	high
Total climate (including the factors above + 15 others)		**2010**	**severe**	**severe**	**high**
		2030	**acute**	**acute**	**severe**

Figure 2-3: Vulnerability indicators as they are defined for the Great Lakes Region and Ruzizi Plain (Government of the Netherlands, 2019)

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2.2. Hydro-meteorological data collection

Data have been collected in all previous stages of the Ruzizi III hydroelectricity power plant project: the 2010 Feasibility Study, the Consultant's 2016 Hydrological Update and the Hydrology and Sedimentation Review in the Ruzizi River basin (Tractebel, 2020). Recent operation data at Ruzizi I and II have also been collected during a consultation of the stakeholders in Phase 3 of this Climate Resilience Analysis. A summary of the available data is presented in Table 2-3.

Table 2-3: Available hydro-meteorological data

Data	Metric	Time-period	Source	Comments
Ruzizi II inflows	Flows	1991-2006	(Fichtner, 2010)	-
Lake Kivu water level	Water level	1950-2006	(Fichtner, 2010)	-
		1992-2016	SN Power	Some missing data
		2010-2019	SINELAC	Some missing data
Ruzizi I turbined flows	Flows	1950-2006	(Fichtner, 2010)	-
		2009-2019	SINELAC	Estimated from the energy production
Ruzizi II turbined flows	Flows	2009-2019	SINELAC	Estimated from the energy production
Min and Max Temperatures	Temperature	1990-2016	SN Power	Some missing data
Ground rainfall data	Rainfall	1990-2016	SN Power	Missing data
CRU & CHIRPS precipitation	Rainfall	1901-2018	KNMI	CHIRPS to replace CRU missing data
CRU ETP	Evapotranspiration	1901-2018	KNMI	-
IDF Curves	Rainfall (average)	1971-2014	(Wagesho & Claire, 2016)	3h-rainfall used in NRCS approach
Land use	Land use	2020	Google Earth observations	-
Sedimentation rate at Ruzizi II	Sedimentation	1989-2013	(Studio Pietrangeli, 2013)	Report 410RSP002

The following sections present some general results regarding inflows, floods and sedimentation. More detailed information and figures can be found in the Consultant's Hydrology and Sedimentation Review (Tractebel, 2020).

2.2.1. Inflows analysis

The water balance modelling approach proposed in the Feasibility Study (Fichtner, 2010) has been considered by the Consultant to produce the natural inflow time-series for Lake Kivu. This water balance model is based on precipitation and evapotranspiration only:

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$$Q_{in}^{sim} = (P - E) \cdot A_{Lake} + \varphi \cdot P \cdot (A_{RB} - A_{Lake})$$

with Q_{in} (m^3) the total net inflows to the Lake, P (m) the precipitation, E (m) the evaporation, A_{RB} and A_{Lake} (m^2) the areas of the whole river basin and Lake Kivu, and φ (-) the runoff coefficient. The runoff coefficient φ = 0.26 is found to maximize the Kling-Gupta Efficiency (KGE = 0.66) over the last decade (2010-2018), while maintaining a low Bias (0.0%) and a satisfactory Normalized Root-Mean-Square Error (NRMSE = 17.1%). The period 2010-2018 is used for calibration in this study as probable significant changes in land cover occurred over the last decades (see section 2.1.2). More information on the calibration process is available in the Consultant's 2020 Hydrology Review.

The linear rainfall-runoff relationship from the same water balance model is applied to estimate the inflows coming from the intermediate catchment (i.e. between Ruzizi I and Ruzizi III). The outflows from Ruzizi I, derived from water level-based operation rules of the dam for 2010-2018, are then combined to the intermediate catchment flows to assess the inflows to Ruzizi III.

By simulating inflows using CRU and CHIRPS satellite data over a standard historical period for climate resilience analyses (1976-2005), inflows to Ruzizi III are found to never fall below 63.9 m^3/s and to reach and average of 111.2 m^3/s. Additional results of the statistical analysis conducted on the simulated inflows are given in Table 2-4.

Table 2-4: Characteristics of the baseline scenario's streamflows at Ruzizi III

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average (m^3/s)	115	117	118	123	128	125	112	100	93	94	101	108	111
5th percentile (m^3/s)	97	102	102	106	103	101	87	76	70	71	78	82	93
50th percentile (m^3/s)	114	117	115	120	125	123	112	100	93	91	98	107	111
95th percentile (m^3/s)	138	142	147	154	161	149	134	122	116	115	122	131	132

The increased inflows that are expected in the future (see section 2.1.2) will probably lead to higher flows on average, and thus to an increased hydropower production on average in a year. However, the longer dry spells also expected for the dry season and increased temperature may decrease the lowest flows in June-August.

2.2.2. Flood analysis

Due to the very large storage capacity of Lake Kivu, any flooding upstream of Ruzizi I would be manageable by the dam. An artificial flood generated by a release from Ruzizi I with the four gates open would reach 227 m^3/s.

The NRCS approach (Unit Hydrograph method) has been applied to provide hourly discharge information on the intermediate catchment (between Ruzizi I and Ruzizi III) in the Hydrological and Sedimentation Review (Tractebel, 2020). Floods in this catchment are assumed to be generated by the three main tributaries to the Ruzizi River between the two dams. Based on their geomorphologic characteristics, the time of concentration is of less than 3h for each one of them. The 3h-long rainfall has then been considered in the NRCS method for the three sub-basins. Precipitation Intensity-Duration-

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Frequency (IDF) relationships based on ground data at the Bugarama and Kamembe stations in Rwanda have been used to estimate flood events with a return period of up to 100,000 years – as it is impossible to evaluate a PMF associated to a 3h-rainfall. Results are presented in Table 2-5 in terms of average over 24h (Q24h), average over 3h (Q3h) and peak discharge (Qp).

Table 2-5: Floods generated by a 3h-rainfall over the intermediate catchment

Return period	Q24h (m^3/s)	Q3h (m^3/s)	Qp (m^3/s)
T = 10	35.2	169.1	195.0
T = 100	68.9	332.7	383.8
T = 1,000	99.5	481.1	555.0
T = 10,000	135.9	657.8	758.7
T = 100,000	173.9	842.1	970.9

The more frequent and intense rainfall events that are projected for the future (see section 2.1.2) would likely trigger more intense and frequent floods.

2.2.3. Sedimentation

Based on a bathymetric comparison conducted at the Ruzizi II dam site between 1980 and 2013, a sedimentation rate of 1,123 t/km^2/year has been estimated at Ruzizi II (Studio Pietrangeli, 2013). By extrapolating this value to the Ruzizi III catchment, a sedimentation rate of approximately 203,643 m^3/year is obtained.

Soil erosion is expected to increase with the projected climate change-induced more frequent and intense rainfall events (Government of the Netherlands, 2019). This would intensify reservoir sedimentation and potentially increase the risk of landslide.

2.3. Identification of uncertainties

Table 2-6 presents the project uncertainties, apart from climate change, that could affect the Ruzizi III performance. Identifying them provides perspective into the magnitude of uncertainties introduced by climate change with regards to the already existing economic, environmental, social, regulatory, and technical uncertainties. Throughout the remaining phases, an effort will be made to reduce these uncertainties when possible.

Table 2-6: Project uncertainties beside climate change

Economic	Environmental & Social	Regulatory	Technical
Cost of debt	Requirements for environmental flows	Country and regional constraints on the operation of the project	Hydro-meteorological data uncertainty
Cost of equity	Development limitations identified in the ESIA	Details of the PPA	Geological data uncertainty

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Economic	Environmental & Social	Regulatory	Technical
Electricity pricing	Regulatory changes	Regulatory constraints on power trading imposed by power pools	
Interest rate	Water use changes	Political instability	
Discount rate	Land use changes		

2.4. Risk and Opportunity Register creation

The purpose of the Risk and Opportunity Register is to identify potential climate impacts – either positive or negative – on all aspects of the project and to quantify their likelihood of occurrence. This impact and likelihood information are refined at each phase of the project as the level of analysis and stakeholders' engagement increases.

The Risk and Opportunity Register established for now includes a listing of the following features: (1) climate stressor, (2) threats and opportunities, (3) time scale and (4) rating of potential losses and gains (see Table 2-7). (5) Likelihood and (6) risk/opportunity aspects will be quantified in Phase 2 following the results of the initial analyses, and refined in Phase 3. The register will eventually be used in Phase 4 to propose climate change adaptation decisions.

The listed features can be defined as follows:

- A **climate stressor** is a meteorological variable that could potentially impact the project, such as precipitation, temperature, wind, etc;
- A **threat** is defined as "a circumstance, action, or event that might exploit a vulnerability with the potential to adversely impact an asset or a system" (International Hydropower Association, 2019), while an opportunity represents a circumstance, action, or event that improves the expected performance or provides additional project benefits. For example, changes in precipitation could provide an opportunity to increase (or a threat to decrease) inflows for hydropower generation. Likewise, changes in air temperature could threaten to increase evaporation losses and water temperatures. It must be stressed that the impacts of such threats have yet to be assessed;
- A **time scale** indicates whether a threat will occur gradually over time, such as more frequent droughts or abruptly, such as extreme flood events;
- A **potential loss** (or **gain**) from a threat (or opportunity) is considered through the **impacts** on the project aspects, including the reservoir, dam, electromechanical equipment, transmission lines, powerhouse, access roads, and hydropower generation. For example, increased air temperature could increase equipment failures in the powerhouse, and more frequent and intense flood events could increase the risk of landslides, threatening the dam's safety. The potential **loss or gain rating (from 1 to 3)** measures the impact, positive or negative, of the threat or opportunity:
  - 1: little to no change in energy production
  - 2: temporary change in energy production and/or environmental impacts
  - 3: long-term change in energy production and/or safety;
- A **likelihood** (ranging from 1 to 3) refers to the plausibility that a threat or opportunity happens;

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- A **risk** (or **opportunity**) is the combination of both the potential loss (or gain) and the likelihood for a threat to occur:

Risk (or Opportunity) = Potential loss (or gain) x Likelihood

The Risk and Opportunity Register is adapted to both the original site and the alternative site projects.

Table 2-7: Phase I Risk and Opportunity Register

Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain		
			Project Component	Impact	
				Description	Rating (1-3)
Precipitation and streamflow	+/- inflows	Gradual, long-term	Reservoir and dam	+/- energy generation	3
				Change in environmental flows, ecological impact downstream	2
				Change in flows available for downstream use	1[(2)]
	+/- sediment loads	Gradual, long-term	Reservoir	Loss/gain in reservoir storage, and therefore in the project's lifespan	3
			Dam	Damage to gates	2
			Electromechanical equipment	Damage to turbines	2
	More intense floods	Extreme, sudden	Dam	Increased landslides	3
				Overtopping of the rockfill dam	3
			Powerhouse	Flooding from the river	2
			Access roads	Limited access to plant	2
				Damage to unsurfaced roads	1
	Change in variability	Gradual, long-term	Powerhouse	Change in variability of turbine efficiency	3
			Reservoir and dam	Change in environmental flows, ecological impact downstream	2
			Hydropower generation	Changes in the energy generation schedule, hourly or seasonally, resulting in a change in grid requirements	3
Temperature	Increased air temperature	Gradual, long-term	Powerhouse	Equipment failures due to heat	3
	More evap. losses	Gradual, long-term	Lake Kivu	Reduced water for energy generation	3

[2] Rating based on the currently available information.

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Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain		
			Project Component	Impact	
				Description	Rating (1-3)
	Increased water temperature	Gradual, long-term	Reservoir	Decreased dissolved oxygen and impact on ecosystems	2

One can note that lightning is not included in the Risk and Opportunity Register as, to the best of the Consultant's knowledge, no observed or projected information regarding the lightning risk is available.

2.5. Performance metrics and criteria

Performance metrics and criteria are defined based on the methods from the Hydrology and Sedimentation Review (Tractebel, 2020) – more details are provided when defining the baseline (section 3.1). Four functions are identified: (1) The cascade (i.e. Ruzizi I + Ruzizi II + Ruzizi III) hydropower generation, (2) safety, (3) environmental impacts and (4) economics. Within these functions, specific performance metrics are identified and criteria – or performance thresholds – are defined when possible. The criteria for the original and alternative (two designs at 1,130 masl and 1,145 masl) sites are provided in Table 2-8.

Table 2-8: Performance metrics and criteria

Function	Performance metric	Criteria		
		Original	Alt. 1,130 m	Alt. 1,145 m
Hydropower generation	Mean annual energy of the cascade	1,219 GWh	1,426 GWh	1,542 GWh
	Annual energy guaranteed of the cascade (95%)	993 GWh	1,162 GWh	1,256 GWh
	Sedimentation rate at the Ruzizi III location	203,643 m^3/year		
Flood security	Check flood peak discharge	1,198 m^3/s		
	100-year return period flood peak discharge – protection of powerhouse, switchyard and access routes	384 m^3/s		
Social and environmental	Environmental flows	11.1 m^3/s ([3])		
	Downstream water demand	Is there a demand?		
Economics	Net present value hydro benefits	338.7 MUSD	534.0 MUSD	654.3 MUSD

[3] 10% of the average monthly flows estimated over the historical period 1976-2005

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2.6. Decision: need for a climate risk assessment?

The questions proposed by the IHA Guidelines to determine whether a climate risk assessment is needed are presented in Table 2-9.

Table 2-9: Questions to assess the need for a climate risk assessment

Assessment question	Answer
Could a change in the hydrological regime significantly affect the hydropower project's economic viability?	Yes
Could a change in the hydrological regime affect service continuity/access to electricity in the region it serves?	Yes
Could any of the performance metrics defined in Step 2.5 be unachievable by potential climate change effects?	Yes
Would a breach of the project's main dam or other associated infrastructure have significant adverse consequences on downstream populations, strategic infrastructure or protected ecosystems?	Yes

Following the answers to these questions, climate change is considered to pose a threat to the Ruzizi III HEPP project and, therefore, the Climate Risk Assessment continues with Phase 2.

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3. PHASE 2: INITIAL ANALYSES

The goal of Phase 2 is to determine an appropriate methodology for the climate stress test that will be conducted in Phase 3.

This section starts by defining the baseline scenarios. The Global Circulation Model (GCM) climate projections are then presented and analyzed. Finally, results from the climate projections' analyses are used to update the Risk and Opportunity Register that has been introduced in Table 2-7.

3.1. Baseline definition

First, a **climate baseline scenario** is defined based on historical hydro-climatic data, so that it can be used as a reference situation for the analysis of climate projections. Any difference between the climate baseline scenario and GCM climate projections will indicate a trend on the evolution of climate parameters. The IHA Guidelines recommend considering a 30-year period that is typical of the current hydro-climatic conditions. Then, the period 1976-2005 is chosen for the climate baseline scenario given that (1) historical data have been gathered over these years in the Hydrology and Sedimentation Review (Tractebel, 2020), and (2) these years are part of the historical period that is considered in the **Coupled Model Intercomparison Project Phase 5 (CMIP5)** which gathers GCM projections – more information is provided in section 3.2 below.

A **performance baseline** is also required to establish the performance of the system with the current hydro-climatic conditions. Such information will be useful to identify and measure the vulnerability of the Ruzizi III system to climate change. The performance baseline then refers to the methods and results used to characterize a recent historical period. For the sake of consistency with the climate baseline scenario, the years 1976-2005 are considered. Moreover, these years still characterize the more current 30-year period as the average monthly precipitation is 124.9 mm and 124.4 mm, for 1976-2005 and 1989-2018 respectively; and the standard deviation of monthly precipitation is 65.3 mm and 65.4 mm, for 1976-2005 and 1989-2018 respectively.

Among the data listed in Table 2-3, the following ones have been particularly useful to analyze inflows, sedimentation and floods, and to calibrate the models:

- Remote sensing Climate Research Unit (CRU) precipitation data over 1976-2005;
- Remote sensing CRU evapotranspiration over 1976-2005;
- Lake Kivu daily water level for 2010-2019;
- Ruzizi I monthly turbined flows for 2009-2019;
- Ruzizi II monthly turbined flows for 2009-2019;
- IDF curves at certain locations in Rwanda for 1971-2014 (Wagesho & Claire, 2016);
- Sedimentation rate at Ruzizi II for 1989-2013 (Studio Pietrangeli, 2013).

It must be stressed that, in the CMIP5 long-term group, each GCM output was simulated over the historical period 1850-2005 based on initial conditions extracted from a control run that considers pre-industrial greenhouse gas concentrations[4]. This historical hindcast (simulated data in the past) may thus provide data that differ from the observed

[4] https://portal.enes.org/data/enes-model-data/cmip5/datastructure

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ones. To address this issue, a correction is planned to be applied to the climate change projections for the future in section 3.2.3 to account for the difference between simulated and observed data over the historical period.

3.1.1. Streamflow and hydropower generation

As explained in section 2.2.1, inflows to Ruzizi II and Ruzizi III have been simulated using a water balance model for Lake Kivu, water level-derived outflows from the Lake Kivu-Ruzizi I system, and a linear rainfall-runoff relationship for the intermediate catchment between Ruzizi I and Ruzizi III. The same model is used in this climate resiliency study to simulate monthly inflows and characterize the performance baseline scenario.

It can be reminded that **energy production is calculated on a monthly basis**. Then, energy estimates are different from the ones of the cascade optimization analysis which are calculated on an hourly timestep – the shorter the timestep, the better the results – but the two studies are used to address different needs: **long-term planning for this Climate Resilience Assessment vs. short-term optimization for the Cascade optimization study**.

Because the Ruzizi II and Ruzizi III reservoirs are designed to store water for less than a day and considering that our analysis is conducted at a monthly time step, all inflows to the dam are assumed to be turbined at Full Supply Level (FSL) to generate electricity, up to the installed maximum power capacity and considering that environment flows at the three dams are not turbined, for the baseline and stress test analysis.

3.1.2. Sedimentation

Without any reliable information on sedimentation directly at the Ruzizi III dam site, a sedimentation rate of 203,643 m^3/year has been estimated in the Hydrology and Sedimentation Review, based on a bathymetric analysis conducted at Ruzizi II by Studio Pietrangeli (2013) – see section 2.2.3. This reference value is used to calculate the lifespan of the dam with the current hydrological conditions (performance baseline for sedimentation).

3.1.3. Flood security

Section 2.2.2 presented the NRCS approach that has been used to provide hourly flood hydrographs on the intermediate catchment. Because the time of concentration in the catchment has been estimated to less than 3 hours, 3h IDF relationships have been used in the approach. The same hourly flood hydrographs and associated flows are now considered to characterize the system's performance baseline with regards to flood security.

3.1.4. Environmental flows

Environmental flows have been considered at less than 7 m^3/s at the Ruzizi III dam site in the original Feasibility Study (Fichtner, 2010). In this study – and pending results from the ESIA – the performance baseline for the environmental flows is defined as 10% of the mean annual inflows over 1976-2005. This provides a more conservative estimate of 11.1 m^3/s at the Ruzizi III location. Environmental flows are not turbined at the three dams. They serve as a release constraint in the hydropower generation modelling.

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3.1.5. Economic analysis

The economic performance baseline is established based on the Client's economic model that consists in comparing costs of the Ruzizi III project and of an alternative plan (mix of thermal energies) to produce the same energy. The inputs to this model are (1) the firm power, (2) installed powerhouse capacity and (3) firm plant factor, all three derived from the discharge guaranteed at 95% at the Ruzizi III dam location, and (4) the mean annual energy generated by the project, considering the hydrological conditions of the period 1976-2005.

3.2. Data collection and analysis

In addition to the data already gathered and provided in Table 2-3, future CMIP5 temperature and precipitation projections are collected.

The CMIP5 project has been established as part of the World Climate Research Program (WCRP) with the aim to "provide climate scientists with a database of coupled GCM simulations under standardized boundary conditions"[5]. These simulations are a reference for evaluating the impact of climate change, and research based on the CMIP5 climate scenarios is regularly considered by the Intergovernmental Panel on Climate Change (IPCC)[6].

The climate projections are downloaded using the KNMI Climate Explorer platform[7] for three Representative Concentration Pathways (RCP) that represent different radiative forcing situations for the year 2100:

- RCP 4.5 (for 4.5 W/m^2 in 2100), which characterizes a situation in which gas emissions would peak in 2040. This situation is currently acknowledged as an optimistic situation for the future;
- RCP 6.0. In this situation emissions would peak around 2080 and then decline. This is viewed as a central scenario for the future;
- RCP 8.5, in which emissions would continue to rise throughout the 21st century. This is a pessimistic scenario.

The evolution of radiative forcing as per these three scenarios and RCP 2.6, which is considered as not realistic anymore with the gas emissions that have been observed in the world over the last years, are presented in Figure 3-1.

The CMIP5 experiment consists of an ensemble of simulations from multiple GCMs. An ensemble member refers to time series simulated with one model and a certain initial state. The RCP constraints were then applied to each ensemble member at the end of the historical hindcast (i.e. after 2005) to provide different results depending on potential changes in world gas emissions. In total, **229 scenarios** are collected from the KNMI Climate Explorer platform **for precipitation**, and **234 for temperature**. The repartition

[5] https://pcmdi.llnl.gov/mips/cmip5/history.html

[6] The Intergovernmental Panel on Climate Change is the United Nations body for assessing the science related to climate change. It was created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options (https://www.ipcc.ch/).

[7] http://climexp.knmi.nl/selectfield_cmip5_annual.cgi?id=someone@somewhere

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of all ensemble members in terms of GCM model and RCP is provided in APPENDIX A.

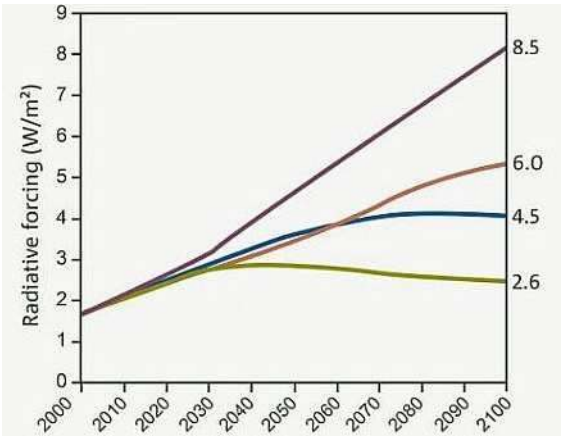

Figure 3-1: Radiative forcing scenarios considered by the CMIP5 (adapted from www.climatechangeinaustralia.gov.au)

Two 30-year time-periods are considered for the analysis of the future in the Ruzizi River basin: 2020-2049 and 2050-2079, for near-term and long-term future hydro-climatic conditions respectively.

3.2.1. Changes in precipitation over the last century

Before starting the analysis of climate change with the CMIP5 scenarios for the future, an evaluation of precipitation variation over the last century is conducted. CRU spatial precipitation data have been gathered for 1901-2018 in the Hydrology and Sedimentation Review (Tractebel, 2020). The average yearly precipitation for this period is 1,485.6 mm/year. The observation of the 10-year moving average reveals a 30- to 40-year precipitation cycle over the 118 years that have been analyzed (Figure 3-2). During the same period, precipitation has increased at an average rate of about 9.3 mm/10 years. This rate is roughly smaller than the change expected for the future in the USAID report (2019) of -3% to +9% up to 2050 (i.e. -15 mm/decade to +45 mm/decade considering the average CRU values), but larger than the one from the Government of the Netherlands (2019) of -36 mm/decade up to 2030 and of more than +56 mm/decade next up to 2090 (see Table 2-2).

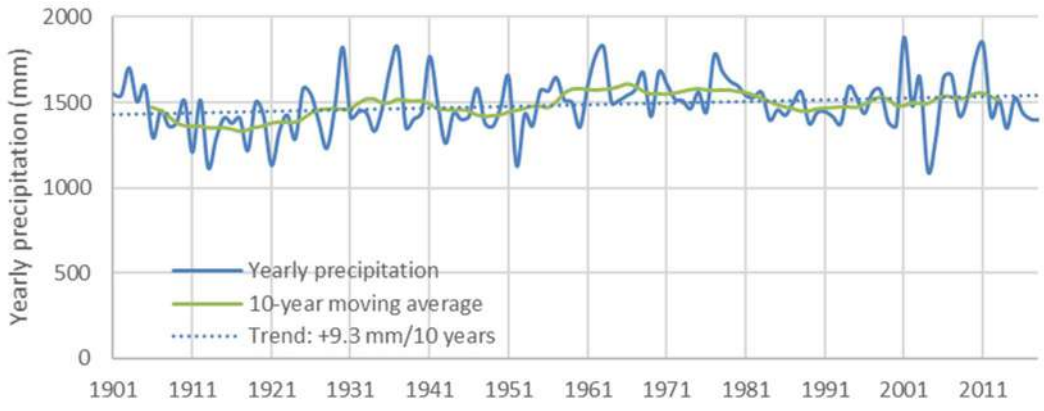

Figure 3-2: CRU yearly precipitation variations over 1901-2018

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The analysis of intra-annual variability also indicates an increase of precipitation for January and March in 1901-2018, but no clear trend can be distinguished for the other months (Figure 3-3).

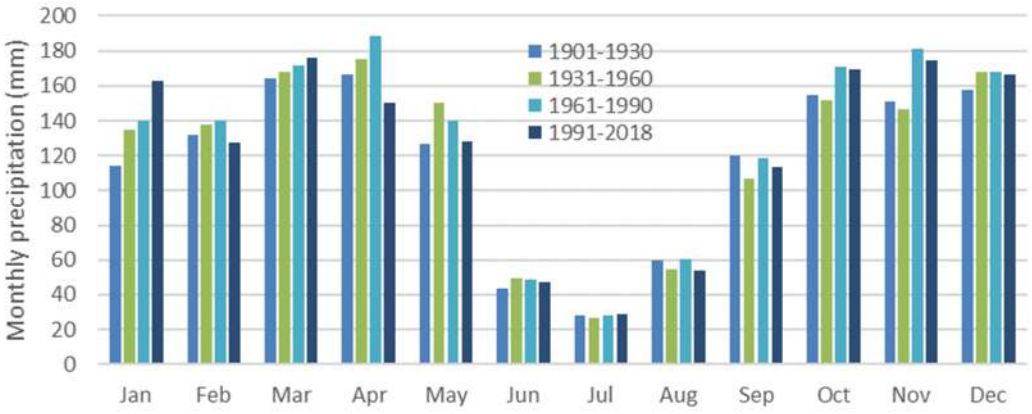

Figure 3-3: CRU monthly precipitation variations over 1901-2018

3.2.2. Assessment of the Global Circulation Models

A comparison of the GCMs' simulated precipitation with the CRU and CHIRPS data over the historical period is conducted in this section. For a given initial state (or more generally: Realization, Initialization, Physics using the RIP-nomenclature), each CMIP5 GCM model produced one simulation for the historical period, to which was applied one or several RCPs. Then, the assessment of the models is carried out for 1976-2005 by considering the average of all members for each model. Results are presented on Figure 3-4 in terms of annual precipitation.

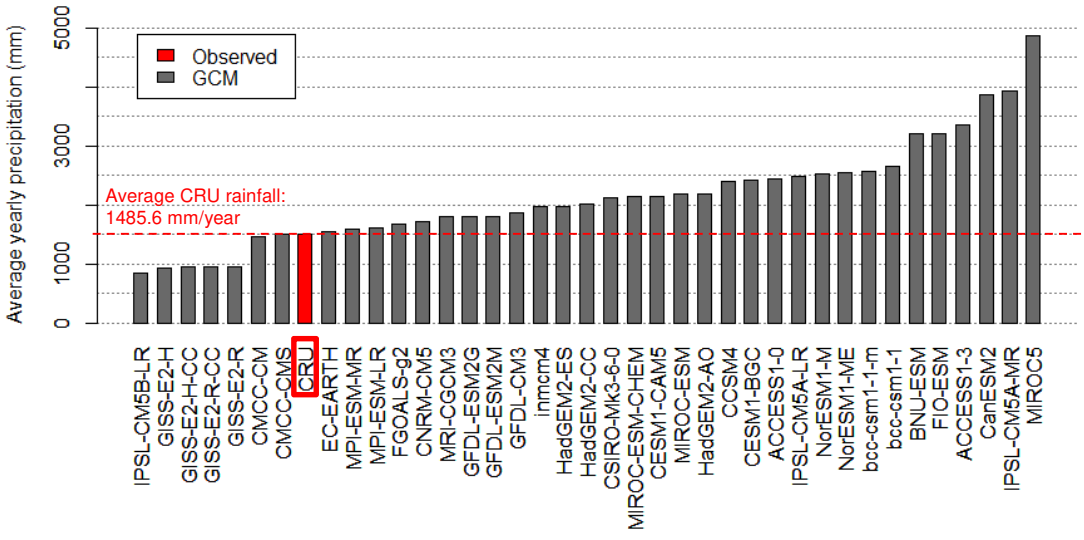

Figure 3-4: Comparison between yearly precipitation simulated by the CMIP5 GCMs and the the climate baseline (1976-2005)

Large annual precipitation differences can be observed between the CRU remote sensed data (climate baseline) and some models. Differences vary from -44% for IPSL-CM5B-LR and +225% for MIROC5. The models falling in the range -10%/+10% are CMCC-CM, CMCC-CMS, EC-EARTH, MPI-ESM-MR and MPI-ESM-LR.

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A comparative analysis of GCMs simulated precipitation and observed CRU rainfall is also conducted at monthly and seasonal scales. The comparison on a monthly basis is carried out after aggregating all GCMs to see if the model can reproduce the average intra-annual variability that has been observed. Figure 3-5 reveals that most of the difference between simulated and observed precipitation is seen during the rainy seasons (March to May and mid-September to December). Simulations for the most humid season October-December overestimate precipitation by 79% on average. The comparison of individual models at a seasonal scale is presented in Figure 3-6.

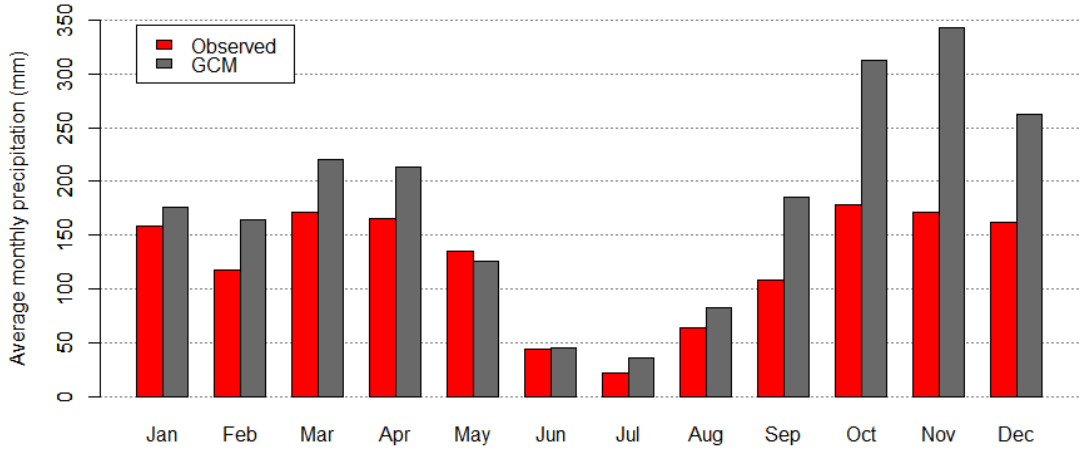

Figure 3-5: Comparison between average monthly precipitation simulated by the CMIP5 GCMs and the climate baseline (1976-2005)

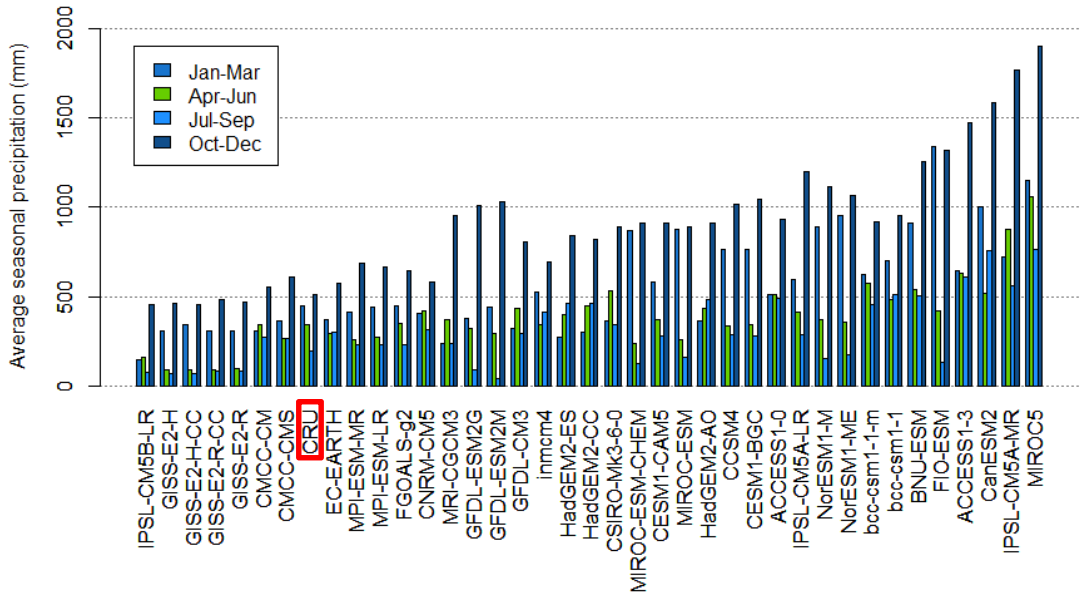

Figure 3-6: Comparison between seasonal precipitation simulated by the CMIP5 GCMs and the climate baseline (1976-2005)

The large discrepancies for most model estimates that are revealed in these three figures can be explained by the coarse spatial resolution of the GCMs compared to the size of the Ruzizi River catchment. The grid cells considered for the simulations vary between 1° and 3° approximately depending on the models, which means that they cover ground areas between 12,500 km^2 and 112,200 km^2, while the Ruzizi III and Lake Kivu catchments have areas of only 2,416 km^2 and 7,528 km^2 respectively. Then, as a solution to bridge the gap between simulated precipitation and remote sensed CRU

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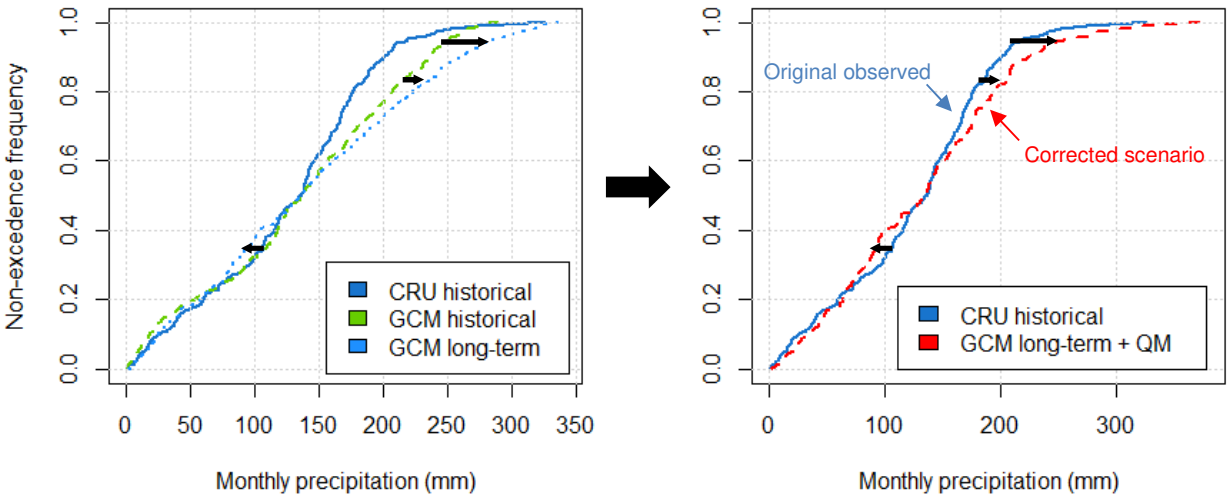
rainfall data, a bias correction method (which would depend on the period of the year or the intensity of rainfall) needs to be implemented before launching the climate stress tests in Phase 3. The goal of such a correction is to statistically downscale the GCMs to the local conditions that have been observed so far in the Ruzizi River basin.

3.2.3. Correction of the GCM precipitation projections

The quantile mapping bias correction method is chosen to correct the large-scale GCM precipitation projections and adapt them to the observed local conditions of the Lake Kivu and Ruzizi River basin system. This statistical downscaling method is particularly recommended for correcting stochastic variables like precipitation or solar radiation. GCM outputs are for instance known to have a “drizzle problem”, i.e. numerous low-intensity rainfall events as compared to observations (Gutowski, et al., 2003), and to not be able to capture realistic inter-annual variability associated to El Niño and La Niña[8]. By considering the full frequential distribution of precipitation values observed on the reference period, and using it to correct projections, quantile mapping enables to more precisely account for the inter-annual variability that is observed on the reference period (see section 3.2.4.2).

Moreover, GCMs face significant difficulties in producing reliable time-series projections, as has been shown in section 3.2.2 with the large differences between the hindcast and the CRU data for the historical period 1976-2005. This issue is particularly problematic when decisions need to be taken for the future based on the projections (Brown, Ghile, Laverty, & Li, 2012). Then, instead of applying a “top-down” approach where future projections would be used directly for the climate stress test of Phase 3, a “bottom-up” approach is preferred by the Consultant: the difference between simulated precipitation over the historical and future periods is added to observed data over the historical period to create bias-corrected scenarios adapted to the local conditions for the stress test.

Figure 3-7 illustrates the quantile mapping bias correction technique applied to a member of the CMIP5 ensemble for the long-term with RCP 8.5. Biases are calculated for each percentile of the cumulative distribution functions for the GCM projections over the historical (1976-2005) and future periods. These biases are then added to the observed data over the same historical period (1976-2005).



[8] http://ccafs-climate.org/bias_correction/

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Figure 3-7: Quantile mapping (QM) statistical downscaling method applied to the member r1i1p1 of the model MPI-ESM-LR (RCP 8.5)

Hereafter, the projections that are used in any analysis are the projections statistically downscaled using the quantile mapping method.

3.2.4. GCM climate change projections for the future

As with the analysis that has been carried out in section 3.2.2, the projections for the future are analyzed for each model by considering the average of all members (see the list in APPENDIX A) to not give more weight to specific models.

In the figures presented in the following sections, boxplots are built on these averages, but all members are represented with circles for visualizing the full range of possibilities. Whiskers extend to the most extreme average values.

3.2.4.1. TEMPERATURE PROJECTIONS

In total, 38 temperature projection average members are analyzed for RCP 4.5, 21 for RCP 6.0 and 35 for RCP 8.5. An analysis is conducted to observe the change in mean annual temperature that is expected for the short-term future (2020-2049) and long-term future (2050-2079). The results, which are presented in Figure 3-8, indicate a change between 0°C and +4°C depending on the model, future period and RCP scenario. For RCP 4.5, the median increase is estimated at +1.2°C in the short-term and +1.8°C in the long-term; and for RCP 8.5, at +1.4°C in the short-term and +2.9°C in the long-term. Most pessimistic models among the CMIP5 project estimate maximum increases of +1.7°C in 2020-2049 and +2.7°C in 2050-2079 with RCP 4.5, and of +1.9°C in 2020-2049 and +3.8°C in 2050-2079 with RCP 8.5.

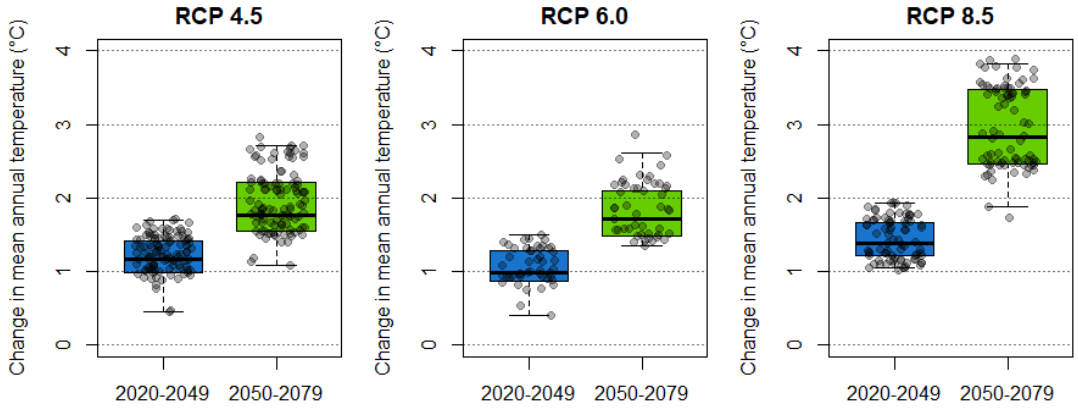

Figure 3-8: Change in mean annual temperature compared to the historical period 1976-2005, for all models and each RCP scenario

3.2.4.2. PRECIPITATION PROJECTIONS

38 precipitation projection average members are analyzed for RCP 4.5, 21 for RCP 6.0 and 34 for RCP 8.5.

Results are presented in this section in terms of (1) change in mean annual precipitation, (2) change in inter-annual variability, and (3) change in intra-annual variability, for both

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2020-2049 and 2050-2079 and compared to the historical climate conditions over 1976-2005 (climate baseline scenario).

The relative changes in mean annual precipitation between future periods and the historical one (1976-2005) are presented in Figure 3-9. Precipitation values are likely to increase between 2020-2049 and 2050-2079: the median change over the ensemble members would increase by +2.3% to +3.4% for RCP 4.5, and by +2.7% to +5.8% for RCP 8.5, for the short- and long-term respectively. Then, as it could be expected, there is also an increase in the median value from the RCP 4.5 to the RCP 8.5 case for both 2020-2049 and 2050-2079.

It can be noted that model estimates are quite more scattered for 2050-2079 than for 2020-2049 with a difference 1st quartile–3rd quartile of 9.0% to be compared to 6.9% (RCP 4.5, long-term vs short-term); and of 13.8% to be compared to 6.7% (RCP 8.5, long-term vs short-term). Such large estimate ranges reflect the difficulty to precisely assess the impact of climate change for a long-term future.

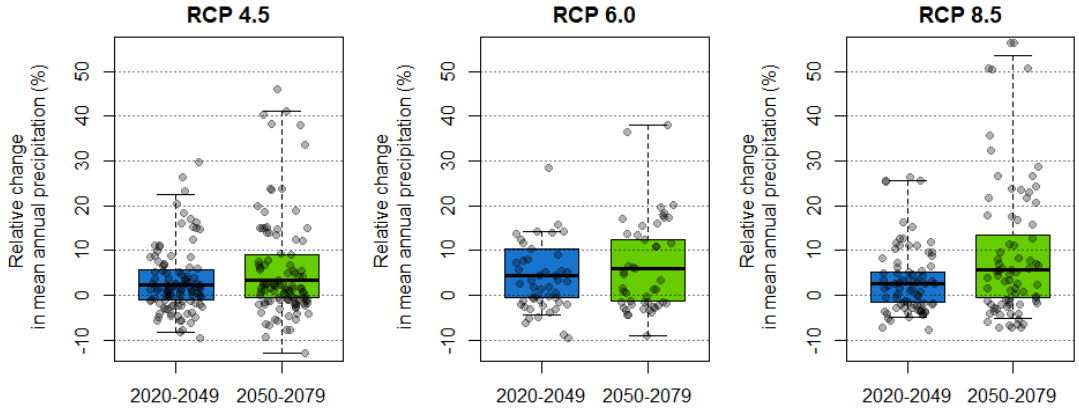

Figure 3-9: Relative change in mean annual precipitation compared to the climate baseline (1976-2005), for all models and each RCP scenario

In this study, inter-annual variability is assimilated to the standard deviation of average annual precipitation over the period that is considered. Relative changes in inter-annual variability between the future periods and the historical one are presented in Figure 3-10. The median relative change over the range of the ensemble members is expected to increase by +7.0% and +10.9%, between 2020-2049 and 2050-2079 respectively, for RCP 4.5; and by +9.8% and +15.0%, respectively, for RCP 8.5.

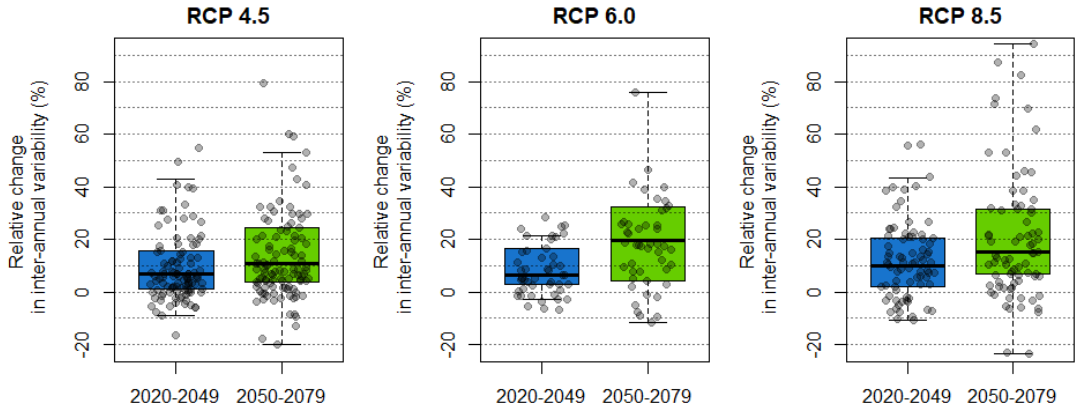

Figure 3-10: Relative change in inter-annual variability compared to the climate baseline (1976-2005), for all models and each RCP scenario

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Intra-annual variability is calculated in this study as the average of the standard deviations determined for each year's monthly values over the considered period. Relative changes in intra-annual variability between the future periods and the historical one are presented in Figure 3-11. The median relative change over the range of the ensemble members is expected to increase between 2020-2049 and 2050-2079 by +4.6% and +6.5%, respectively, for RCP 4.5; and by +6.3% and +11.2%, respectively, for RCP 8.5.

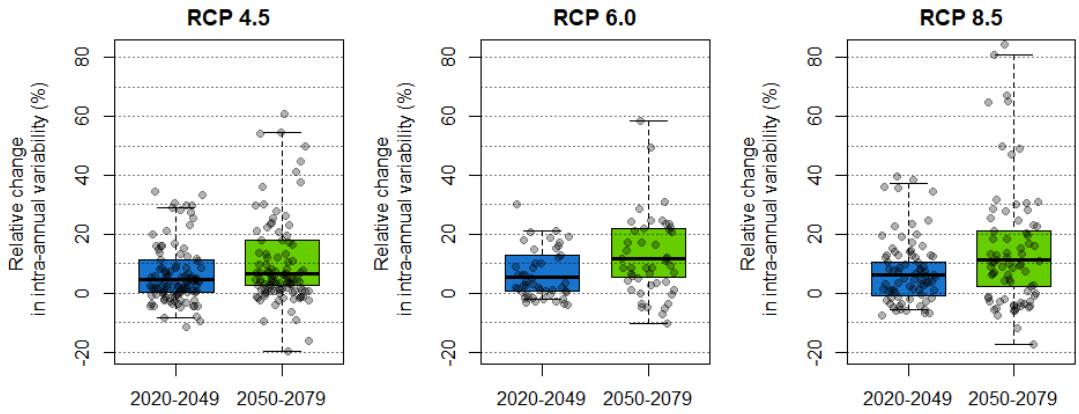

Figure 3-11: Relative change in intra-annual variability compared to the climate baseline (1976-2005), for all models and each RCP scenario

3.2.4.3. EXTREME PRECIPITATION EVENTS

Projections of the annual maximum of daily precipitation are provided in the framework of the CMIP5 project. However, these projections are not used in this climate change analysis for two reasons:

- The uncertainty associated to these projections is very high. Overall, extreme precipitation events are difficult to assess and are strongly characterized by local conditions. Such high scale projections should then be considered with even more caution than projections for average monthly precipitation for example.
- The 3h-long rainfall has been considered in the NRCS method for the three sub-basins (section 3.1.3). It is difficult to estimate changes for this duration based on daily projections.

As an alternative to direct projections, the Clausius-Clapeyron equation can be used to estimate the intensity of precipitation events affected with climate change, based on changes in temperature. This Clausius-Clapeyron approach is also recommended in the IHA Guidelines (International Hydropower Association, 2019). Consequently, the projected changes in mean annual temperature are considered in this study to assess changes in extreme precipitation events. More details are provided in Phase 3.

3.2.4.4. CONCLUSIONS

The CMIP5 GCM precipitation projections have been bias-corrected using a quantile mapping method and CRU remote sensing information gathered for the Lake Kivu and Ruzizi III basins. These corrected precipitation and temperature projections have also been analyzed to assess the direction and magnitude of the expected climate change impacts for the region of interest of this study.

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Results enable to define a range of changes for temperature and precipitation parameters so that a sensitivity analysis framework can be adequately prepared for the Phase 3 stress test. These ranges of changes are summarized in Table 3-1 for each parameter.

Table 3-1: Sensitivity analysis ranges of changes

Parameter	Sensitivity analysis range
Mean annual temperature	From 0°C to +4°C
Mean annual precipitation	From -10% to +50%
Inter-annual precipitation variability	From -20% to +90%
Intra-annual precipitation variability	From -20% to +80%

3.3. Determination of a stress test methodology

The IHA climate resilience Guidelines (International Hydropower Association, 2019) provide criteria for determining which approach is necessary in Phase 3. These criteria are represented in the Figure 3-12 flowchart.

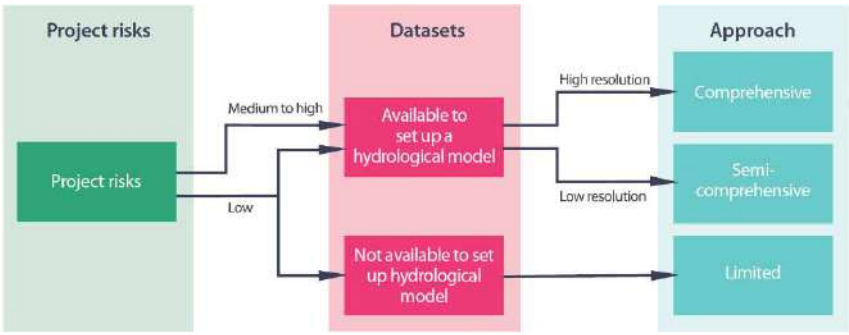

Figure 3-12: Alternative approaches to carry out the Phase 3 climate stress test, subject to level of project risks and datasets availability and quality (International Hydropower Association, 2019)

For the Ruzizi III Climate Resiliency Analysis, most inflows reaching Ruzizi III depend on the controlled outflows of Ruzizi I, which is at the outlet of Lake Kivu. Considering the very large storage capacity of the lake, the risk to see the inflows to Ruzizi III significantly decrease is considered low. Then, because a hydrological model has already been set up in the Hydrology and Sedimentation Review, with monthly datasets, a semi-comprehensive approach is chosen for the Phase 3 climate stress test (Table 3-2).

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Table 3-2: Semi-comprehensive approach for a Phase 3 climate stress test as it is defined in the IHA Guidelines (International Hydropower Association, 2019)

Method – hydrological model	Method – modelling extreme flood events	Future climate scenarios choice	Stress test
Hydrological model with at least monthly time steps; delta change or direct approach	1/ Flood frequency analyses 2/ PMF simulation, as in comprehensive approach, or Clausius-Clapeyron equation approximation	Observed trends and at least three locally credible GCM- or RCM-based climate projections (optimistic, central, pessimistic). The 10th, 50th and 90th percentile values are recommended	Uni- or bivariate sensitivity analyses of precipitation and temperature; for PMF with PMP variations

For the Lake Kivu and Ruzizi River basins, the semi-comprehensive approach consists in the following components:

- A linear rainfall-runoff model has been considered for the hydrological modelling in the original Feasibility Study (Fichtner, 2010) and the Hydrology and Sedimentation Review (Tractebel, 2020). For the sake of clarity and consistency, the same approach is chosen to conduct the climate stress test.
- The NRCS method has been used in the 2020 Review to produce hourly hydrographs, based on the 3h-rainfall that is characteristic of extreme flood events in the Ruzizi I–Ruzizi III intermediate catchment (see section 3.2.4.3). For the stress tests, the method is combined to changes in precipitation deduced from changes in temperature using a Super-Clausius-Clapeyron equation approximation.
- The full set of CMIP5 GCM ensemble members has already been downloaded and analyzed in this Phase 2, exceeding the requirements listed in Table 3-2.
- The stress test is planned to explore both means and extremes – including the changes in variability that have been observed in the analysis of the GCM climate projections – by using the precipitation projections statistically corrected with the quantile mapping method.

To assess the impacts of climate change on the performance metrics previously defined in section 2.5, the stress test will require the simulation of project inflows and outflows, hydropower generation, and extreme flood events. The simulation approaches are presented in detail in Phase 3.

3.4. Risk and Opportunity Register update

The Risk and Opportunity Register from Phase 1 (section 2.4) is updated in this section based on the additional information collected in Phase 2. CMIP5 climate projections are used to evaluate the likelihood that each opportunity/threat identified in Phase 1 occurs. Likelihood assessment range from 1 (unlikely) to 3 (highly likely) based on the consensus between the CMIP5 ensemble members. The following criteria are considered:

- Unlikely (1): lack of CMIP5 scenarios consensus of change, and low magnitude of change;
- Likely (2): lack of CMIP5 consensus in direction of change, but high magnitude of change;
- Highly likely (3): CMIP5 consensus on both direction and magnitude of change.

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The following formula is then applied to calculate the risk/opportunity level:

*Risk (or Opportunity) = Potential Loss (or Gain) * Likelihood*

Figure 3-13 is an illustrative explanation of the risk/opportunity assessment scale scores based on this equation and proposed in the Climate Resilience Guide (International Hydropower Association, 2019). The scores range from 1 to 9, with 1 indicating the lowest risk (or opportunity) and 9 indicating the highest risk (or opportunity).

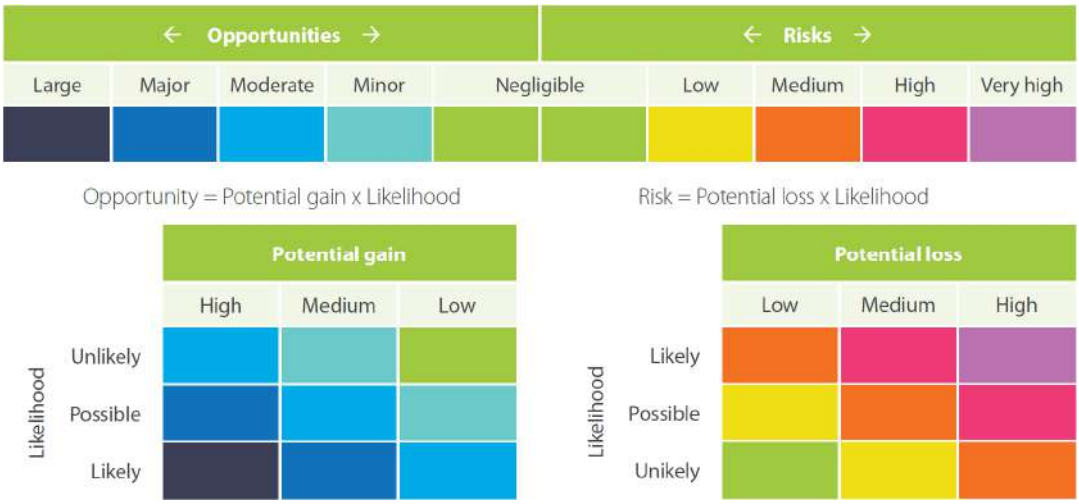

Figure 3-13: Example of risk/opportunity assessment scale scores (International Hydropower Association, 2019)

The updated Risk and Opportunity Register is available in Table 3-3. It must be noted that this register will be updated in the next phase with the results of the climate stress test, and then with any feedbacks from the stakeholders when the opportunity will be given to share and discuss the methodology, criteria and results.

Table 3-3: Phase 2 Risk and Opportunity Register

Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain			Likelihood	Risk/ Opportunity level
			Project Component	Impact			
				Description	Rating (1-3)		
Precipitation and streamflow	Increased inflows	Gradual, long-term	Reservoir and dam	More energy generation	3	3	9
				Change in environmental flows, ecological impact downstream	2	1[9]	2
				Increased flows for downstream users	1	3	3
				Less energy generation	3	1	3

[9] Lake Kivu acts as a buffer storage reservoir to release flows larger than the environmental requirements all year long.

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Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain			Likelihood	Risk/ Oppor-tunity level
			Project Component	Impact			
				Description	Rating (1-3)		
	Decreased inflows	Gradual, long-term	Reservoir and dam	Change in environmental flows, ecological impact downstream	2	1	2
				Decreased flows for downstream users	1	1	1
	Increased sediment loads	Gradual, long-term	Reservoir	Loss in reservoir storage, and therefore in the project's lifespan	3	3	9
			Dam	Damage to gates	2	3	6
			Electro-mechanical equipment	Damage to turbines	2	3	6
	More intense floods	Extreme, sudden	Dam	Increased landslides	3	3 (Original) / 1 (Alternative)	9 (Orig.) 3 (Alt.)
				Overtopping of the rockfill dam	3	3	9
			Powerhouse	Flooding from the river	2	3	6
			Access roads	Limited access to plant	2	3	6
				Damage to unsurfaced roads	1	3	3
	Changes in inter- and intra-annual variability	Gradual, long-term	Powerhouse	Change in variability of turbine efficiency	3	3	9
			Reservoir and dam	Change in environmental flows, ecological impact downstream	2	1	2
			Hydropower generation	Changes in the energy generation schedule, hourly or seasonally, resulting in a change in grid requirements	3	3	9
Temperature	Increased air temperature	Gradual, long-term	Powerhouse	Equipment failures due to heat	3	3	9
	More evap. losses	Gradual, long-term	Lake Kivu	Reduced water for energy generation	3	3	9
	Increased water temperature	Gradual, long-term	Reservoir	Decreased dissolved oxygen and impact on ecosystems	2	1[10]	2

[10] The discharge-refill cycle of Ruzizi III is of less than a day. The water stored in the reservoir will then be renewed frequently.

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4. PHASE 3: THE CLIMATE STRESS TEST

In Phases 1 and 2, information has been extracted from the analysis of hydrology in the Ruzizi River basin, and of the various CMIP5 GCM climate scenarios. This information is used in this Phase 3 to conduct a sensitivity analysis of the Ruzizi III original site and alternative site systems to a range of climate changes, so that the resilience of these systems can be quantified. The goal of Phase 3 is to provide an understanding of whether the identified climate threats are of sufficient concern to warrant resilience measures in Phase 4. At the end of this section, the Risk and Opportunity Register will be updated accordingly.

Impacts of climate change on monthly inflows to the Ruzizi III project and, therefore, to the cascade hydropower generation, sedimentation, safety, environment and economic impacts are assessed through the following steps:

- 1/ Combination of various climate changes (section 4.1)
- 2/ Creation of sensitivity analysis climate scenarios (section 4.2)
- 3/ Definition of plausibility ranges (section 4.3)
- 4/ Sensitivity analysis and climate stress test. Details are provided in separate sections dedicated to each performance sector: cascade energy generation (section 4.4), Ruzizi III reservoir sedimentation (section 4.5), floods (section 4.6), environment (section 4.7) and economics (section 4.8).

4.1. Combination of various climate changes

The CMIP5 ensemble members have been analyzed in Phase 2 to determine a range of potential changes for the following metrics: (1) mean annual temperature, (2) mean annual precipitation, (3) inter-annual variability and (4) intra-annual variability. Analyzing the response of the system regarding energy production, sedimentation, flood security, the environment and economic aspects to changes in these metrics will enable to identify which parameters the Ruzizi III system is more sensitive to. As a first step to reach this objective and to better visualize results of the sensitivity analysis, maps combining the projected changes in the four metrics are presented in a few figures.

But first, it can be reminded that the RCP scenarios represent different potential climate futures. They are consistent with the Shared Socioeconomic Pathways (SSP), which characterize future population growth, development of energy production, food production or land use changes for instance. Because the RCP and SSP scenarios mostly depend on global climate policies, it is delicate to associate them with a probability. Instead, RCP 4.5, 6.0 and 8.5 have been described as optimistic, central and pessimistic in section 3.2. All climate scenarios are presented in the following figures for the three RCPs and two future time-periods. This approach enables the reader to visualize the full range of changes that are considered equally probable. Plausibility ranges are defined in section 4.3 below to adequately interpret the results and not favor any model, socioeconomic future or gas emission scenario.

Figure 4-1 maps the repartition of scenarios for the two future time periods and three RCP scenarios in terms of relative change in mean annual precipitation and change in mean annual precipitation. The range of temperature changes is larger for 2050-2079 than for 2020-2049, mostly due to the RCP 8.5 scenarios. Most changes seem to occur in the ranges [+1°C:+3°C/-10%:+20%] (for changes in [x-axis/y-axis]), but this is analyzed in more details when defining plausibility classifications in section 4.3.2 below.

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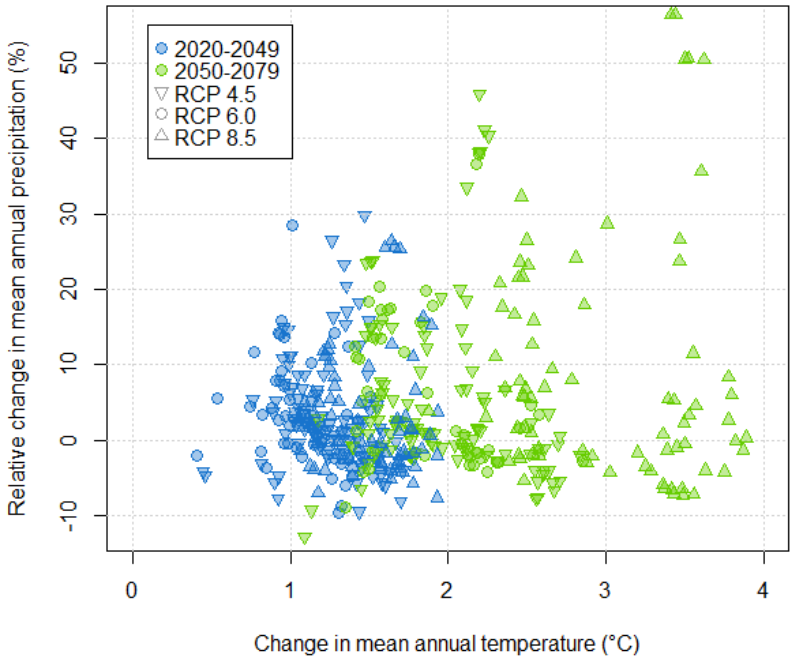

Figure 4-1: Combination of changes in mean annual precipitation and temperature projected by the CMIP5 ensemble members

Figure 4-2 and Figure 4-3 map the repartition of scenarios for the two future time periods and three RCP scenarios in terms of relative changes in inter-annual variability and mean annual precipitation, and in terms of relative changes in intra-annual variability and mean annual precipitation, respectively. In both figures, projected changes cover the full range of changes. However, the three parameters seem to be correlated, and min-max cases are avoided (i.e. upper-left and bottom-right corners in the figures). Such correlation indicates that the increased annual precipitation is mostly caused by precipitation increases during wet seasons and wet years.

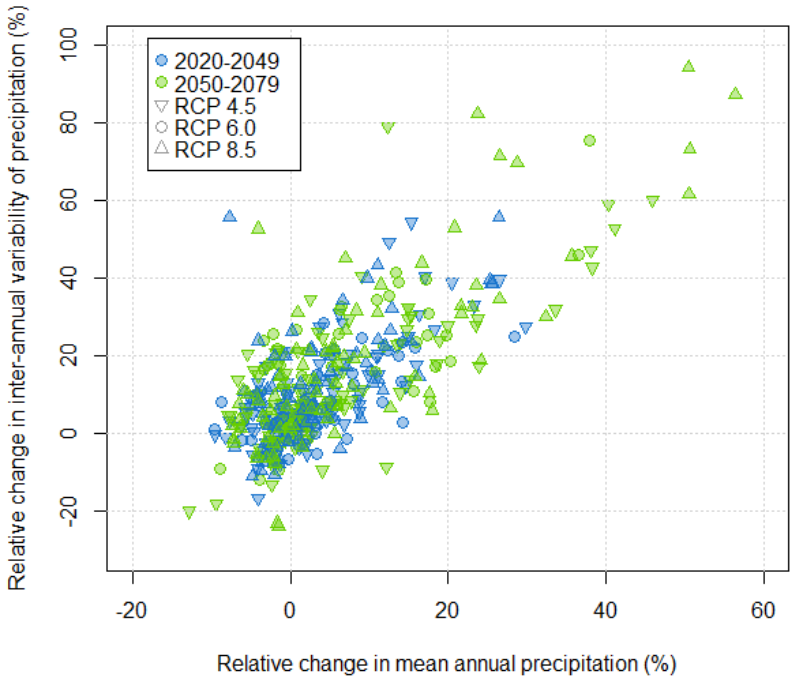

Figure 4-2: Combination of relative changes in inter-annual variability and annual mean of precipitation projected by the CMIP5 ensemble members

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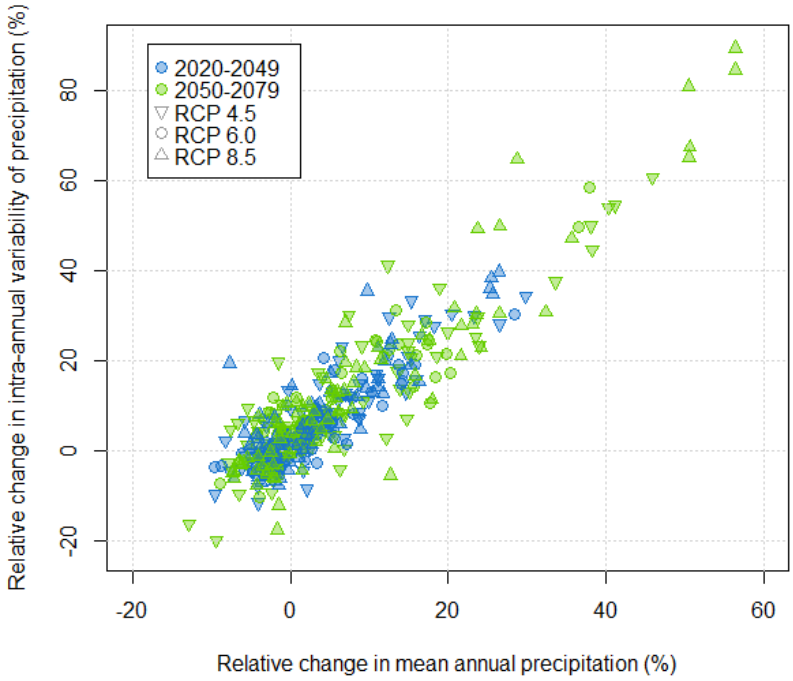

Figure 4-3: Combination of relative changes in intra-annual variability and annual mean of precipitation projected by the CMIP5 ensemble members

Using these figures as a basis, the sensitivity of the system regarding energy production, sedimentation, or economic performance can be visualized by defining artificial scenarios covering the whole range of potential changes in mean temperature, mean precipitation, inter-annual and intra-annual variability.

4.2. Sensitivity analysis climate scenarios

The modelling framework presented in section 2.2.1 to assess inflows to Lake Kivu and from the intermediate catchment between Ruzizi I and Ruzizi III, relies on precipitation, evapotranspiration and operation rules of the Ruzizi I dam. By applying changes to precipitation and evapotranspiration (through temperature), the sensitivity of the system to these changes can be assessed.

The whole ranges of changes in temperature and precipitation (see Table 3-1) are then applied to the 1976-2005 historical temperature and precipitation datasets to create the associated hypothetical climate scenarios and simulate inflows for the sensitivity analysis further below. Detailed methods are presented herein.

4.2.1. Scenarios considering a change in mean annual temperature

In the framework of this study, inflows to Ruzizi III are likely to be impacted by changes in temperature (through a change in evapotranspiration). Ground measurements of minimum and maximum temperature at the Kamembe airport station (in Rwanda, close to the outlet of Lake Kivu) are used to estimate average monthly temperature. Considering the latitude of the Kamembe station, this average temperature can be converted into evapotranspiration with the Oudin method (Oudin, et al., 2005). In this case, changes in evapotranspiration are added to the CRU evapotranspiration time-series for 1976-2005 (baseline) to create evapotranspiration scenarios for the sensitivity

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analysis. As an example, average monthly evapotranspiration resulting from changes in mean annual temperature (in the range 0°C to +4°C; see Table 3-1) are presented in Figure 4-4 and annual averages are provided in Table 4-1.

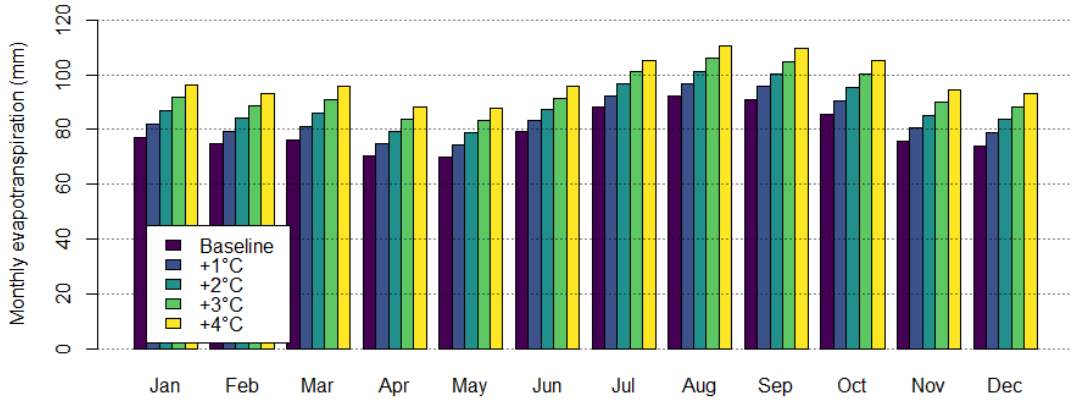

Figure 4-4: Average monthly evapotranspiration of the scenarios derived from the range of projected changes in mean annual temperature

Table 4-1: Average annual evapotranspiration of the scenarios derived from the range of projected changes in mean annual temperature

	Baseline	+1°C	+2°C	+3°C	+4°C
Average annual evapotranspiration (mm)	954.7	1,009.6	1,064.5	1,119.4	1,174.2

4.2.2. Scenarios considering a change in mean annual precipitation

Changes in mean annual precipitation are applied to the monthly CRU and CHIRPS precipitation time-series for 1976-2005 (baseline) to create precipitation scenarios. As an example, annual precipitation resulting from changes in the range -10% to +50% (Table 3-1) is presented in Figure 4-5 and average annual values are provided in Table 4-2.

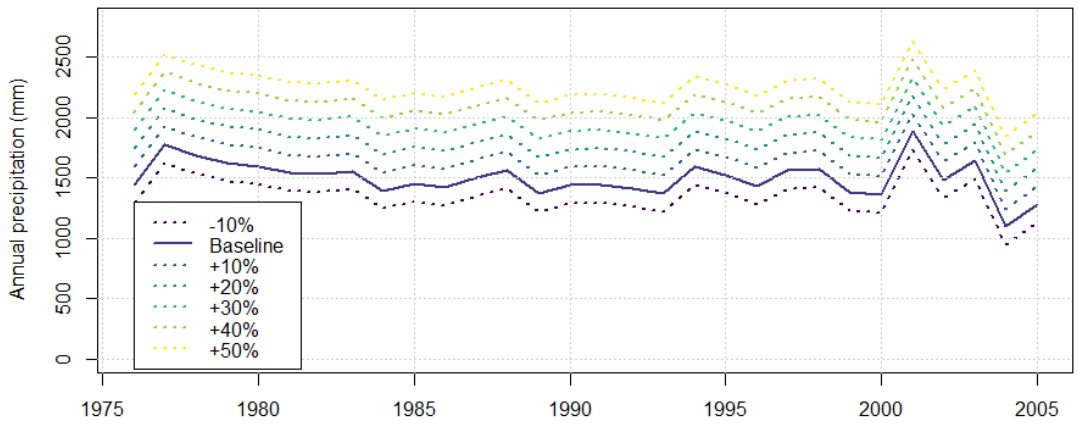

Figure 4-5: Annual precipitation of the scenarios derived from the range of projected changes in mean annual precipitation

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Table 4-2: Average annual precipitation of the scenarios derived from the range of projected changes in mean annual precipitation

	-10%	Baseline	+10%	+20%	+30%	+40%	+50%
Mean annual precipitation (mm)	1,349.3	1,499.2	1,649.1	1,799.1	1,949.0	2,098.9	2,248.8

4.2.3. Scenarios considering a change in inter-annual variability of precipitation

Precipitation scenarios are created in this section by modifying the CRU annual precipitation time-series for 1976-2005 (baseline) to satisfy changes in inter-annual variability – average precipitation remains unchanged over the 30-year period: 1,499.2 mm/year. Annual precipitation resulting from changes in inter-annual variability in the range -20% to +90% (Table 3-1) is provided in Figure 4-6.

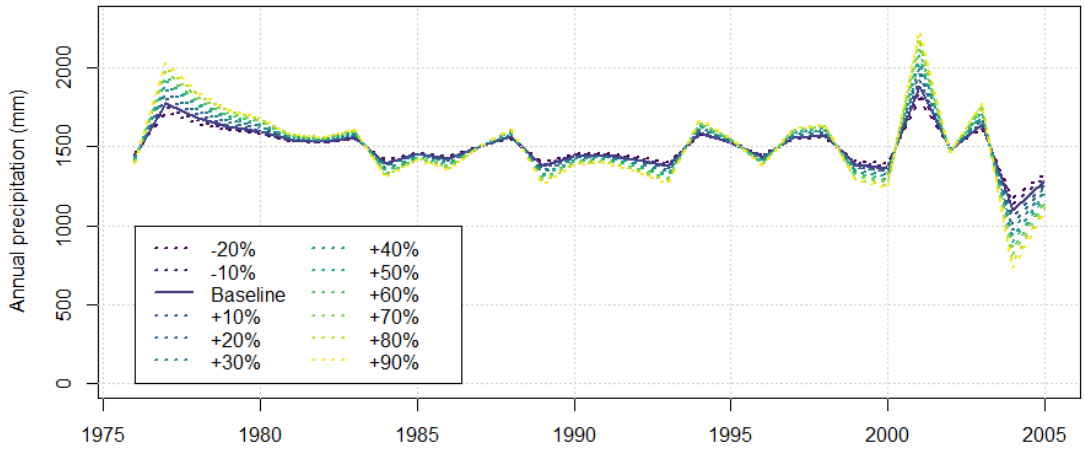

Figure 4-6: Annual precipitation of scenarios derived from the range of projected changes in inter-annual variability of precipitation

The difference to each mean annual value is conserved when calculating the scenarios monthly values, except when it leads to negative precipitation. If this happens, changes are made proportionally to the baseline's monthly precipitation values to maintain positive precipitation values with the same inter-annual variability.

4.2.4. Scenarios considering a change in intra-annual variability of precipitation

The last climate scenarios that will be used in Phase 3 sensitivity analysis considers intra-annual variability. For each year, the baseline's monthly precipitation values are modified according to potential changes in intra-annual variability. Mean annual precipitation remains the same: 1,499.2 mm/year. Figure 4-7 presents the average monthly precipitation values resulting from changes in intra-annual variability in the range -20% to +80% (Table 3-1). Changes in the variation trend for February, June, August and September result from a correction added to maintain the same mean annual precipitation with extreme changes in intra-annual variability.

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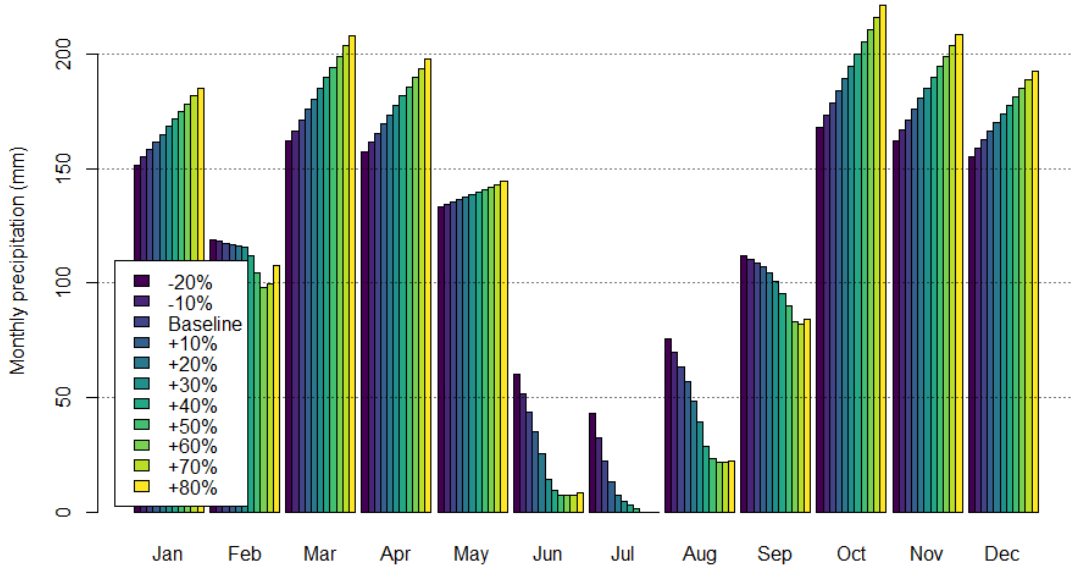

Figure 4-7: Monthly precipitation of scenarios derived from the range of projected changes in intra-annual variability of precipitation

4.3. Plausibility

While plausibility has been qualitatively assessed in terms of magnitude and direction of change in Phase 2, different plausibility ranges based on percentile change values are implemented in this Phase 3:

- The median change among all the projected changes is considered **the *most plausible* change**;
- The changes that separate the 50% of all the projected changes that are the closest to the median change from the others are considered ***plausible***;
- The changes that separate the 90% of all the projected changes that are the closest to the median change from the others are considered ***less plausible***.

For example, considering a range of projected changes in mean precipitation: the *most plausible* change is the median of all changes in mean precipitation; *plausible* changes are the ones at the 25th and 75th percentile of all changes; and *less plausible* changes are the ones at the 5th and 95th percentile of all changes.

Defining plausibility classification enables to interpret climate change projections with such large ranges of potential changes. Indeed, it must be reminded that the uncertainty associated to climate change is often labeled as **deep uncertainty**: no probability can be directly put on a scenario derived from a given climate change projection. Too many socio-economic uncertainties related to global scale political decisions complement climatic modeling uncertainties. In these conditions, defining plausibility thresholds enables to interpret the results from the hundreds of climate change projections by assuming that they have the same likelihood to occur based on current scientific knowledge. It must be stressed, though, that the continuous monitoring of climate parameters and socio-economic pathways leads scientists to regularly refine the climate change projections. This regular update is considered in Phases 4 and 5 to design adaptation options and plan the continuous monitoring and reporting.

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The plausibility thresholds are applied to all models (one average value for all members attached to a model to not put more weight to some models that produced more projections) and by considering the same number of simulations for each RCP to not favor any radiative forcing possibility while still considering all models' projections.

4.3.1. Plausibility classifications for individual parameters

Changes in temperature, precipitation, inter-annual variability and intra-annual variability are classified in terms of their plausibility, following the above-mentioned definitions. Ranges for the individual parameters are given in Table 4-3.

Table 4-3: Parameter plausibility ranges extracted from the analysis of the CMIP5 projections

Parameter	Classification	2020-2049	2050-2079
Temperature	**Most plausible**	+1.2°C	+2.2°C
	Plausible	+0.9°C and +1.7°C	+1.5°C and +3.4°C
	Less plausible	+0.5°C and +1.8 °C	+1.2°C and +3.8°C
Precipitation	**Most plausible**	+2.7%	+5.2%
	Plausible	-2.9% and +11.7%	-2.0% and +19.2%
	Less plausible	-4.8% and +18.3%	-9.0% and +41.1%
Inter-annual variability	**Most plausible**	+7.4%	+14.9%
	Plausible	-2.8% and +21.5%	-0.1% and +31.6%
	Less plausible	-8.8% and +40.2%	-19.8% and +75.7%
Intra-annual variability	**Most plausible**	+5.4%	+8.8%
	Plausible	-2.5% and +17.3%	-1.8% and +28.0%
	Less plausible	-5.7% and +29.1%	-16.1% and +64.7%

These individual parameters' ranges characterize a more precise interpretation (in terms of plausibility) of the results that were introduced in section 3.2.4.

4.3.2. Combinations of various climate changes

To better visualize and interpret plausibility thresholds for climate change projections, plausibility ranges are added to the changes that have been mapped in section 4.1: plausibility thresholds for changes in mean annual precipitation and mean annual temperature are presented in Figure 4-8. The ones for changes in inter-annual variability (and intra-annual variability) and annual mean of precipitation are provided in Figure 4-9 (and Figure 4-10). The apparent correlation between mean annual precipitation, inter-annual variability and intra-annual variability of precipitation already identified in section 4.1 leads us to define more reduced ranges of *plausible* classifications for Figure 4-9 and Figure 4-10.

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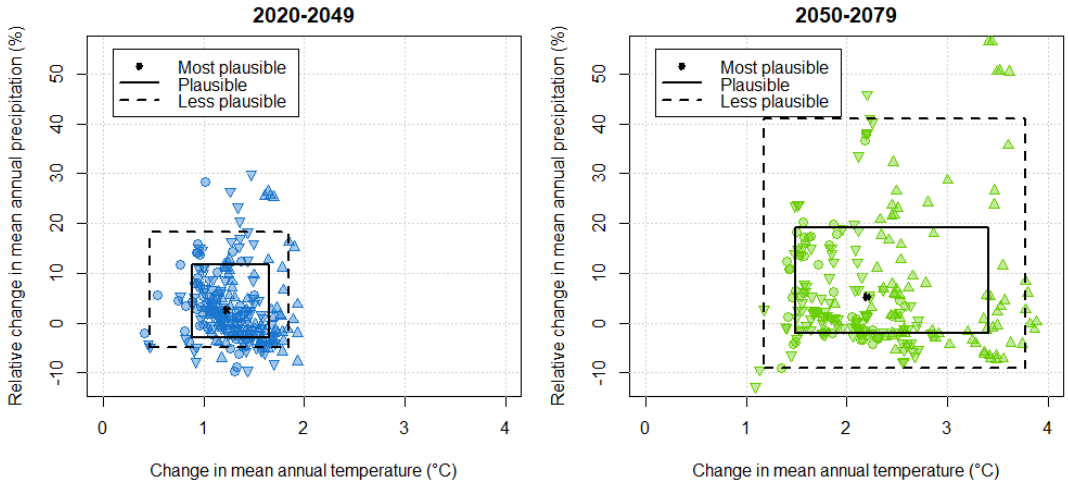

Figure 4-8: Plausibility ranges for the projected changes in mean annual precipitation and temperature

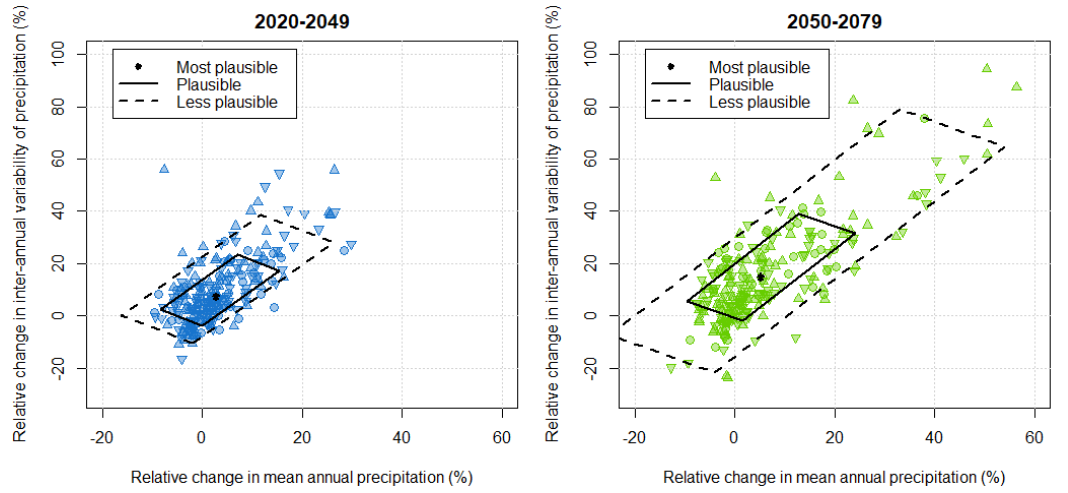

Figure 4-9: Plausibility ranges for the projected relative changes in inter-annual variability and mean annual precipitation

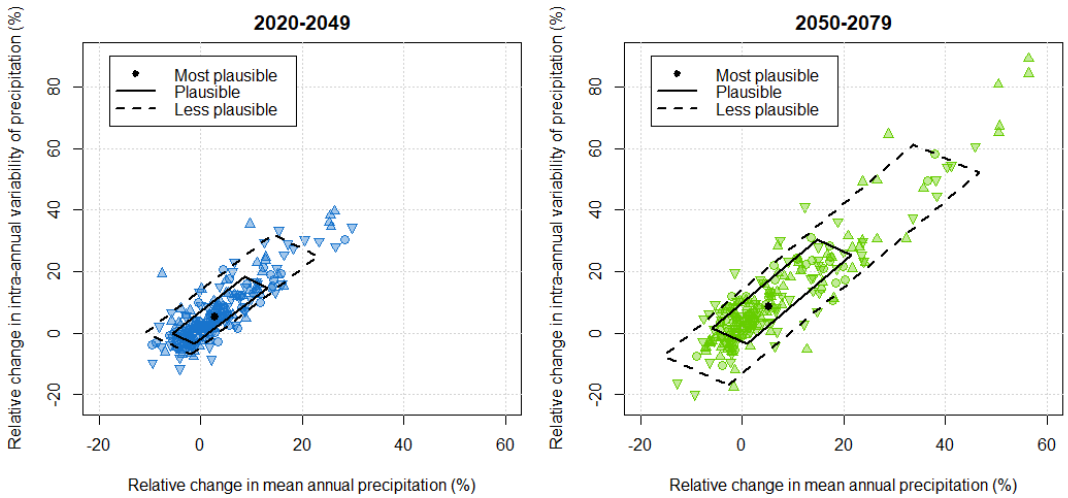

Figure 4-10: Plausibility ranges for the projected relative changes in intra-annual variability and mean annual precipitation

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4.4. Hydropower generation

A sensitivity analysis and stress test for hydropower generation is conducted in this section by analyzing the sensitivity of this parameter to changes in temperature and precipitation. To this end, the hydrological model is directly coupled to the hydropower model (Direct approach in the IHA Guidelines). The hydrological model has been calibrated using measured water level at Lake Kivu and measured flows at Ruzizi I for the more recent period 2010-2018. More information regarding the hydrological and hydropower models (including the difference in the hydropower modeling with the Cascade optimization study) can be found in sections 2.2.1 and 3.1.1, respectively.

The cascade system Ruzizi I-Ruzizi II-Ruzizi III is considered in this hydropower generation section to serve as a basis for the Phase 4 Climate Risk Management Plan. Because the Ruzizi II and Ruzizi III reservoirs are designed to store water for less than a day, and considering that our analysis is conducted at a monthly time step, all inflows to the dams are assumed to be released through the turbines at Full Supply Level (FSL), up to the installed maximum power capacity, and considering environmental flows at Ruzizi I, II and III. The transfer time of a few hours between the dams is neglected on a monthly basis. Energy production is calculated using the following formula:

$$E = \eta \cdot \rho \cdot g \cdot h \cdot min(Q - Q_{env}; Q_{max}) \cdot T$$

with E (Wh) the produced energy, η the efficiency, $\rho = 1000\, kg.m^{-3}$ the density of water, $g = 9.81\, m.s^{-2}$ the gravitational acceleration, h (m) the net head, Q (m^3/s) the discharge, Q_{env} (m^3/s) the environmental flows, Q_{max} (m^3/s) the installed capacity and T (h) the duration of functioning. The values associated to the parameters that depend on the dam are provided in Table 4-4.

Table 4-4: Energy production parameters for the three dams of the cascade and the three designs of Ruzizi III

Parameter	Ruzizi I	Ruzizi II	Ruzizi III		
			Original	Alternative 1,130 masl	Alternative 1,145 masl
Efficiency	0.81	0.85	0.90		
Net head (m)	23.2	28.5	111.3	138	153
Environmental flows (m^3/s)	10.7	10.8	11.1		
Installed capacity (m^3/s)	154	150	150		

The general protocol consists in using evapotranspiration and precipitation scenarios as input in the hydrological model to produce monthly inflows to the dams. These inflows are then used as input in the hydropower generation model. The climate scenarios from section 4.2 are exploited for the climate response maps in the sensitivity analyses, and the quantile mapping-downscaled GCM scenarios from section 3.2.3 are adopted to determine plausibility thresholds.

The performance metrics that have been defined in Table 2-8 for hydropower generation are the mean annual energy and the annual energy guaranteed at 95%. They are analyzed in the next sections for the original site design and the two potential designs of the alternative site: FSL at 1,130 m and FSL at 1,145 m.

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4.4.1. Mean annual energy in the cascade

4.4.1.1. SENSITIVITY ANALYSIS

The sensitivity of mean annual energy production in the cascade to mean annual temperature and precipitation is tested first. Results are presented in Figure 4-11 for the alternative site design with an FSL at 1,145 masl, but relative changes are the same for an FSL at 1,130 masl and for the original site system. The goal of this figure is to provide useful information for identifying the direction of change and the most significant parameters for this study. In this situation, Figure 4-11 reveals that the system is more sensitive to the projected changes in precipitation than to the projected changes in temperature as the mean annual energy varies significantly more along the y-axis than along the x-axis. This difference in the sensitivity of the system makes sense as precipitation has a larger impact on the inflows than evapotranspiration as per the chosen hydrological modelling formulation, and the larger range of changes in precipitation than in temperature. The fact that the production of energy does not change much with changes in precipitation beyond +40% approximately indicates that the current capacity of the alternative site design at 1,145 masl would limit hydroelectricity production if such increase in precipitation were to occur. However, the fact that only a few climate projections (black crosses in the figure) go beyond the 40% increase in precipitation shows that the powerhouse capacity should *a priori* not be a problem in the short-term or the long-term.

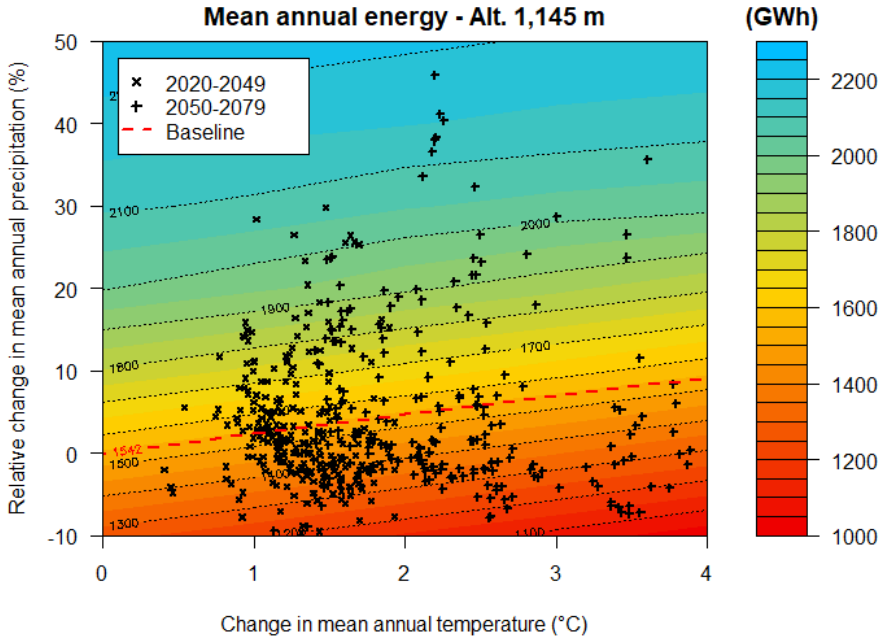

Figure 4-11: Changes in the cascade's mean annual energy consecutive to changes in mean annual precipitation and temperature

The stress test response surface for changes in mean annual precipitation and inter-annual variability is available in Figure 4-12, and the one for changes in mean annual precipitation and intra-annual variability is in Figure 4-13. Both figures characterize the alternative site design with an FSL at 1,145 masl, but relative changes in mean annual energy are the same for an FSL at 1,130 masl and for the original site system. The two surfaces indicate that mean annual energy is very sensitive to mean annual precipitation and almost not to changes in inter-annual and intra-annual variability, which is why the figures are very similar. The difference in the sensitivity can be explained by the fact that most inflows to Ruzizi III come from the outflows of Lake Kivu, which acts a buffer

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storage system for precipitation throughout the year and releases water every month depending on its level – the minimum flow over the historical period has been estimated to reach 63.9 m^3/s. Due to the large size of the lake and its inertia, low flows are not affected by a change in intra-annual variability, but they can be affected by a change in inter-annual variability if the lake does not have enough time to recover from a loss in its total inflows. Moreover, as with the previous figure, it seems that mean annual energy is reaching a maximum beyond a change of +40% in mean annual precipitation, but that the impact on the short-term or the long-term could be limited. This will be investigated in more detail in the Phase 4 Climate Risk Management Plan.

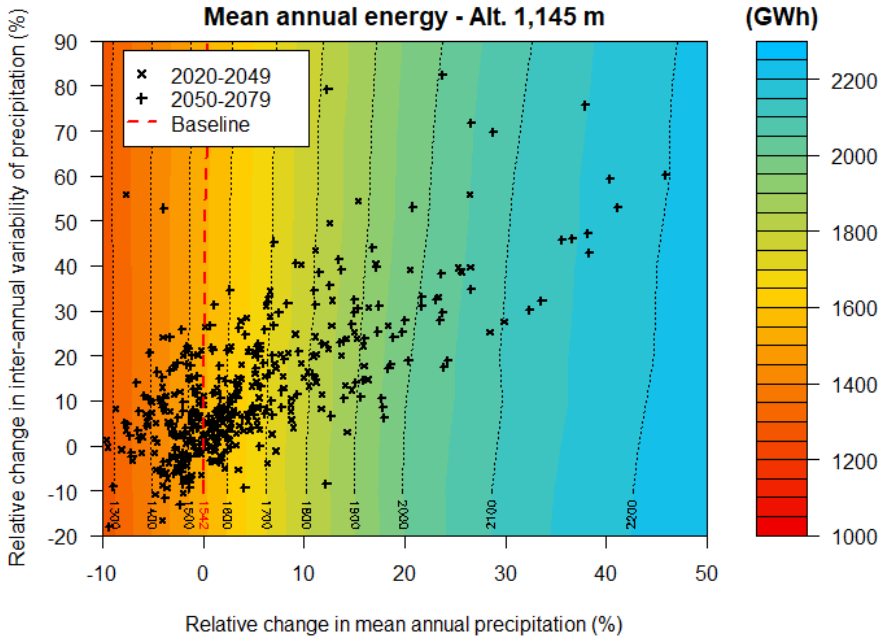

Figure 4-12: Changes in the cascade's mean annual energy consecutive to changes in mean annual precipitation and inter-annual variability

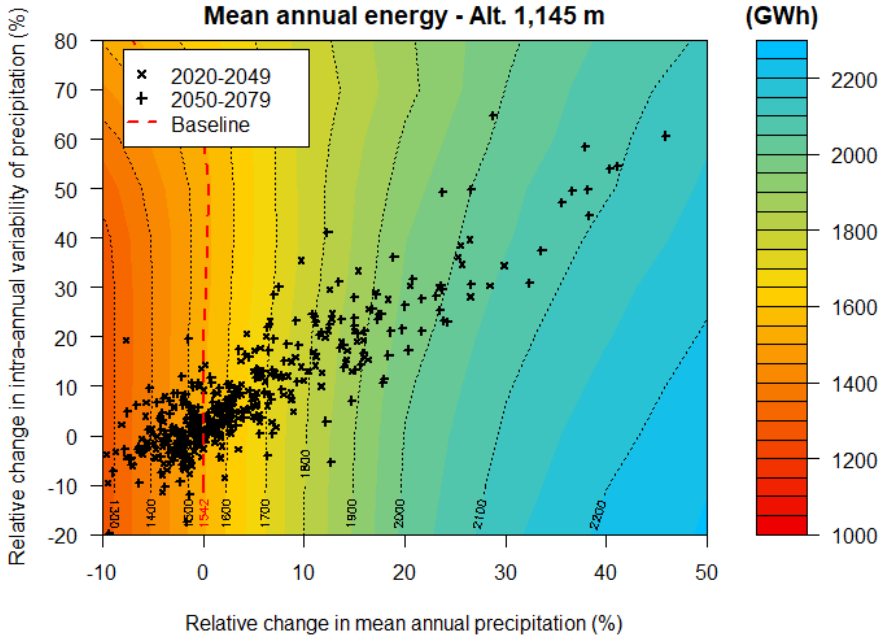

Figure 4-13: Changes in the cascade's mean annual energy consecutive to changes in mean annual precipitation and intra-annual variability

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4.4.1.2. PLAUSIBILITY THRESHOLDS

Plausibility thresholds for mean annual energy production are assessed from the energy values derived from the simulation of all the statistically corrected GCM projections. By doing so, all changes in the mean, extremes and variability of precipitation are considered at the same time and combined with the changes in temperature projected with the same models. The cumulative distribution curve for the alternative site with an FSL at 1,145 masl is provided in Figure 4-14 (distribution curves are similar with other designs). Plausibility classifications are provided in Table 4-5.

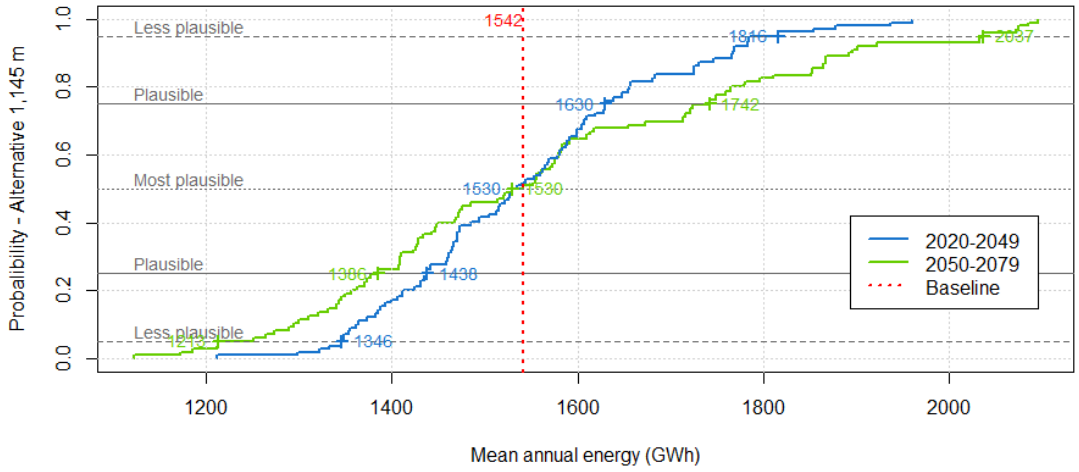

Figure 4-14: Distribution curves for the cascade's mean annual energy (with the alternative site; FSL 1,145 m) with projected changes in precipitation and temperature, for the short-term and long-term

Table 4-5: Plausibility thresholds for the cascade's mean annual energy with projected changes in precipitation and temperature

Classification	2020-2049			2050-2079		
	Original (GWh)	Alt. 1,130m (GWh)	Alt. 1,145m (GWh)	Original (GWh)	Alt. 1,130m (GWh)	Alt. 1,145m (GWh)
Baseline	1,219	1,426	1,542	1,219	1,426	1,542
Most plausible	1,210	1,415	1,530	1,210	1,415	1,530
Plausible	1,137 – 1,289	1,330 – 1,507	1,438 – 1,630	1,096 – 1,378	1,281 – 1,611	1,386 – 1,742
Less plausible	1,064 – 1,437	1,244 – 1,680	1,346 – 1,816	959 – 1,612	1,121 – 1,884	1,213 – 2,037

It is interesting to note that the *most plausible* scenario for the mean annual energy in both the short-term and the long-term is slightly lower than the baseline (1,219 GWh, 1,426 GWh and 1,542 GWh, for the original site and alternative site designs with FSL at 1,130 masl and 1,145 masl respectively). As was seen in Figure 4-11, the increases in precipitation seem to be compensated by the increases in temperature. However, the ranges of the *plausible* and *less plausible* classifications suggest significant changes (increases on average) for up to -13% or +18% in the short term; and up to -21% and +32% in the long-term.

The same protocol is followed in the next analyses.

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4.4.2. Annual energy guaranteed at 95% in the cascade

It can be reminded that the energy guaranteed at 95% is defined in this report as the energy generated with the 5th percentile of **monthly flows** in the Ruzizi Cascade.

4.4.2.1. SENSITIVITY ANALYSIS

The sensitivity of the energy guaranteed at 95% to mean annual temperature and precipitation is tested first in this section. Results are presented in Figure 4-15 for the alternative site with an FSL at 1,145 masl, but relative changes are the same for an FSL at 1,130 masl and for the original site design. This figure reveals that, like the mean annual energy, the annual energy guaranteed at 95% is more sensitive to the projected changes in precipitation than to the projected changes in temperature. As with the mean annual energy analysis, it seems that the energy guaranteed at 95% hardly changes with increases in precipitation larger than 40%, even if the energy guaranteed at 95% is linked to the lowest 5% flow discharges.

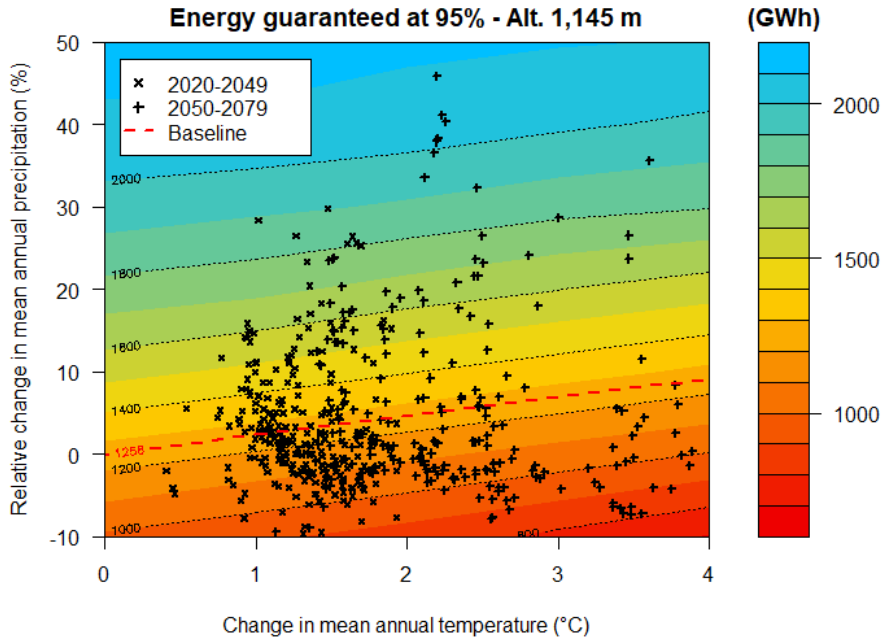

Figure 4-15: Changes in the energy guaranteed at 95% in the cascade consecutive to changes in mean annual precipitation and temperature

The stress test response surface for changes in mean annual precipitation and inter-annual variability is available in Figure 4-16, and the one for changes in mean annual precipitation and intra-annual variability is in Figure 4-17. Both characterize the alternative site design with an FSL at 1,145 masl, but relative changes in the annual energy guaranteed at 95% are the same with an FSL at 1,130 masl and with the original site design. Figure 4-16 reveals that the annual energy guaranteed at 95% is a bit more sensitive than the mean annual energy to the projected changes in inter-annual variability. This may be explained by the fact that an increase in inter-annual variability is expected to lead to a longer dry season and then to smaller flows in this period despite the buffer function of Lake Kivu. Figure 4-17 indicates that, similar to the mean annual energy sensitivity analysis of section 4.4.1.1, the relative change of intra-annual variability does not have a significant impact on the energy guaranteed at 95%.

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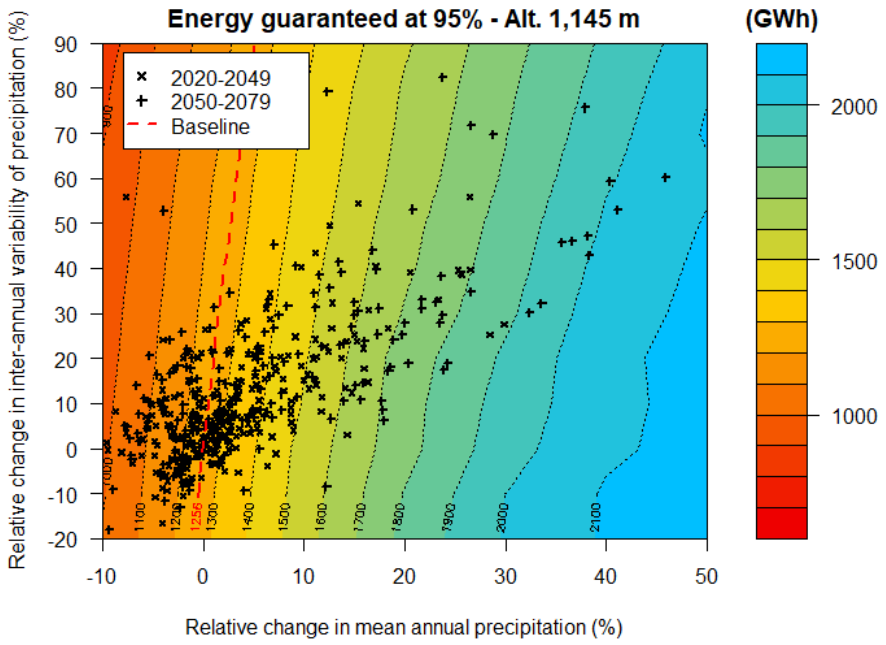

Figure 4-16: Changes in the energy guaranteed at 95% in the cascade consecutive to changes in mean annual precipitation and inter-annual variability

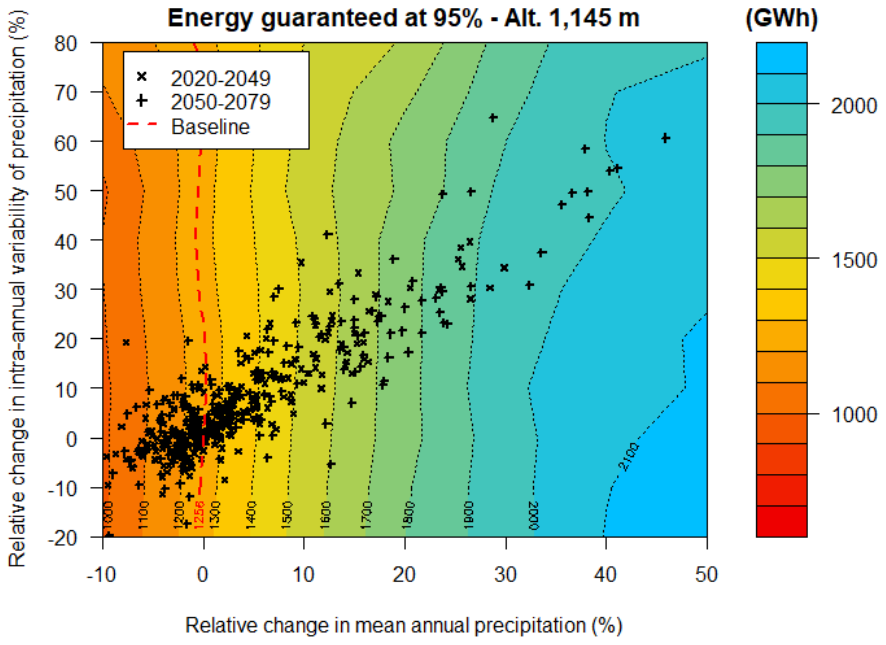

Figure 4-17: Changes in the energy guaranteed at 95% in the cascade consecutive to changes in mean annual precipitation and intra-annual variability

4.4.2.2. PLAUSIBILITY THRESHOLDS

Following the same methodology as the one from the previous section, plausibility thresholds for the production of energy guaranteed at 95% are assessed from the energy values derived from the simulation of all the statistically corrected GCM projections. The distribution curves for the short-term and the long-term are presented

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in Figure 4-18 for the alternative site (FSL at 1,145 masl) and classification ranges are provided in Table 4-6 for the three designs.

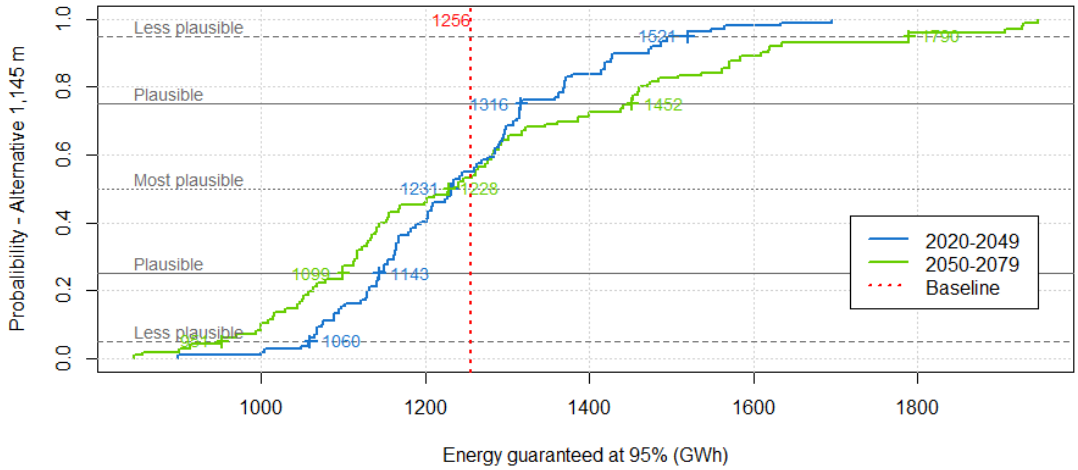

Figure 4-18: Distribution curves for the energy guaranteed at 95% in the cascade (with the alternative site; FSL 1,145 m) with projected changes in precipitation and temperature, for the short-term and long-term

Table 4-6: Plausibility classifications of the energy guaranteed at 95% in the cascade with projected changes in precipitation and temperature

Classification	2020-2049			2050-2079		
	Original (GWh)	Alt. 1,130m (GWh)	Alt. 1,145m (GWh)	Original (GWh)	Alt. 1,130m (GWh)	Alt. 1,145m (GWh)
Baseline	993	1,162	1,256	993	1,162	1,256
Most plausible	973	1,138	1,231	971	1,136	1,228
Plausible	904 – 1,041	1,057 – 1,217	1,143 – 1,316	869 – 1,149	1,016 – 1,343	1,099 – 1,452
Less plausible	838 – 1,203	980 – 1,406	1,060 – 1,521	752 – 1,415	880 – 1,655	951 – 1,790

As in the previous stress test conducted on mean annual energy production relative to projected changes in precipitation and temperature, these results indicate that the *most plausible* scenario for both the short-term and the long-term is that the energy guaranteed at 95% hardly changes. However, the ranges of the *plausible* and *less plausible* classifications suggest potential significant changes, increases on average, for up to -16% or +21% in the short term; and up to -24% and +43% in the long-term.

4.5. Sedimentation

Sedimentation of the Ruzizi III dam site is assumed to only depend on precipitation in the inter-catchment between Ruzizi II and Ruzizi III. The historical value is estimated at 203,643 m^3/year (see section 3.1.2). Changes in mean annual sedimentation are then considered to be directly proportional to changes in mean annual precipitation, as is illustrated in Figure 4-19.

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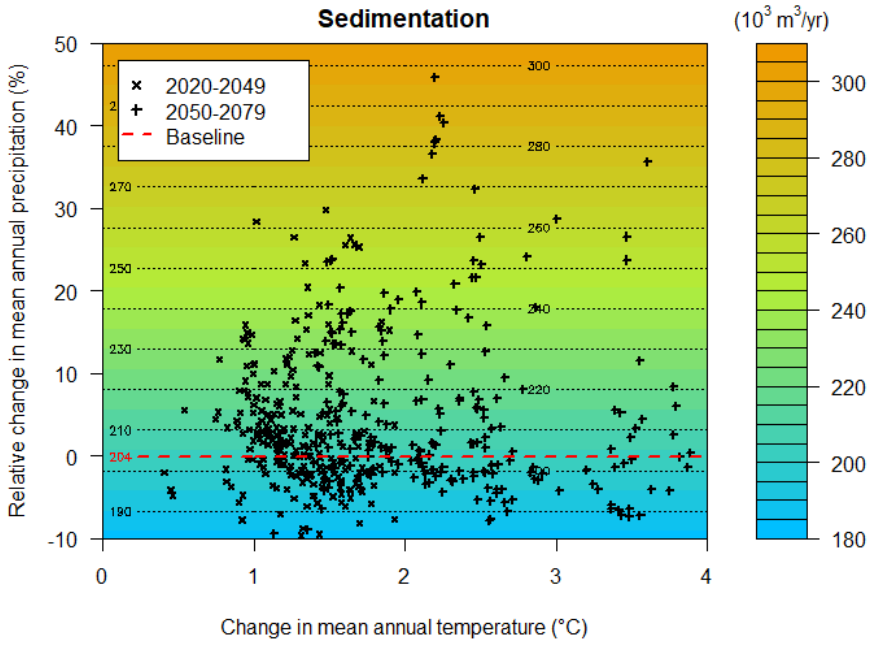

Figure 4-19: Changes in the annual sedimentation rate consecutive to changes in mean annual precipitation and temperature

Distribution curves for the sedimentation rate at the Ruzizi III location are presented in Figure 4-20 and plausibility classification ranges are provided in Table 4-7.

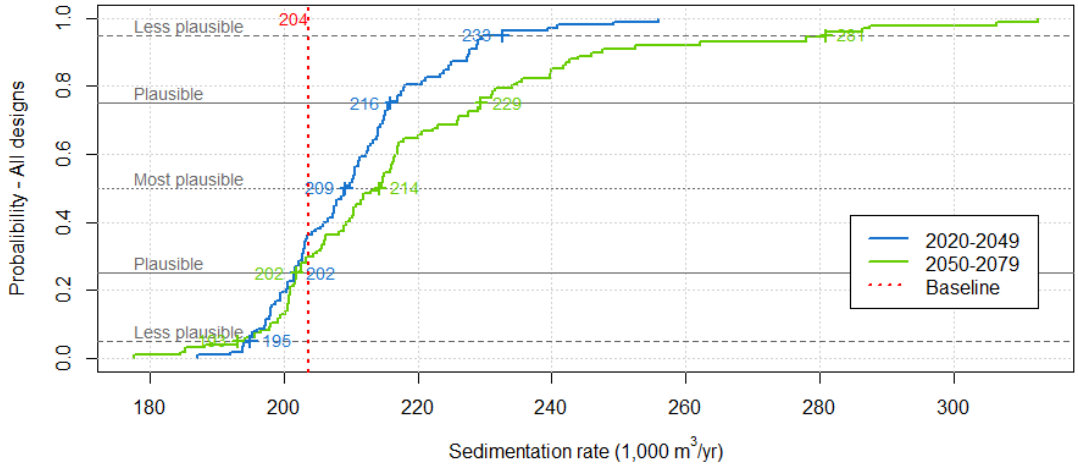

Figure 4-20: Distribution curve for the sedimentation rate at the Ruzizi III location with projected changes in precipitation, for the short-term and long-term

These results indicate, for most of the projections, that the Ruzizi III dam will be filled with sediments more quickly than with the sedimentation performance baseline: a sedimentation rate of 214,000 m³/year (*most plausible* scenario for the long-term) would fill the Ruzizi III dam at the alternative site with design at 1,145 masl in 33.6 years, instead of 35.4 years for the baseline rate; and a rate of 281,000 m³/s would fill the dam in 25.6 years. With the *most plausible* scenarios for the long-term, the designs for the original site and alternative site with FSL at 1,130 masl would also be filled with sediments in 8.6 years (instead of 9.0 years with the baseline), and in 12.5 years (instead of 13.1 years with the baseline), respectively. This means that efforts to block

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or remove sediments would need to be intensified in the future, and even more in the long-term compared to the short-term.

Table 4-7: Plausibility classifications of the sedimentation rate with projected changes in precipitation

Classification	2020-2049 All designs (1,000 m^3/year)	2050-2079 All designs (1,000 m^3/year)
Baseline	204	204
Most plausible	209	214
Plausible	202 – 216	202 – 229
Less plausible	195 – 233	193 – 281

Moreover, the dead storages of the original site and the alternative sites with FSL at 1,130 masl and 1,145 masl are 0.9 hm^3, 1.14 hm^3 and 2.67 hm^3 respectively. A larger dead storage provides more storage for sediments without affecting hydroelectricity production. This means that the alternative site with an FSL at 1,145 masl would offer the best sedimentation management options, well before both the alternative site with an FSL at 1,130 masl and the original site.

It is important to note that this sedimentation analysis is based on results extrapolated from ground surveys conducted at Ruzizi II (Studio Pietrangeli, 2013). A new sedimentation measurement campaign is recommended directly at the Ruzizi III location to get a more recent and adequate assessment of sedimentation.

In addition to increasing sedimentation, more frequent and intense precipitation events are likely to increase soil erosion, which could potentially increase the risk of landslide. The risk at the alternative site would still be quite low, but this could be a larger problem for the original site.

4.6. Flood security

As mentioned in section 2.2.2 and in the Hydrology and Sedimentation Review, the NRCS approach has been applied to estimate floods in the intermediate catchment between Ruzizi I and Ruzizi III. In this catchment, floods are assumed to be generated by the three main tributaries to the Ruzizi River between the two dams. Based on their geomorphologic characteristics, the time of concentration is less than 3 hours for each one of them. The 3h-long rainfall has then been considered in the NRCS method for the three sub-basins.

As an alternative to direct projections, the Clausius-Clapeyron equation is used to estimate the intensity of precipitation events affected with climate change. This equation governs the relationship between the water-holding capacity of the atmosphere and the atmosphere temperature: for a 1°C increase in the air temperature, the air water vapour-holding capacity increases by 7% (Trenberth, Dai, Rasmussen, & Parsons, 2003). Assuming that precipitation is constrained by the water already available in the atmosphere, the Clausius-Clapeyron can be applied to estimate the intensity of extreme rainfall events. For an extreme rainfall duration of less than 24 hours, a Super-Clausius-Clapeyron scaling factor of 1.5 is suggested by Singleton & Toumi (2013). For the Ruzizi

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case, this means that an increase of 1°C would lead to an increase of 10.5% in the 3hr-rainfall intensity.

The extreme precipitation derived with the Super-Clausius-Clapeyron relationship for the projected temperature changes are used as input for the NRCS model calibrated in the Hydrology and Sedimentation Review. The sum of the hydrographs determined with the model for the three tributaries' catchments is calculated to characterize the flood in the intermediate catchment. The check flood is assessed by adding the 227 m^3/s maximum release from Ruzizi I to the 100,000-year return period intermediate catchment flood. Results of the stress test for the range of temperature projections (see Table 3-1) are presented in Figure 4-21. The check flood and 100-year return period flood peak discharge plausibility ranges based on the temperature plausibility ranges (Table 4-3) are provided in Table 4-8.

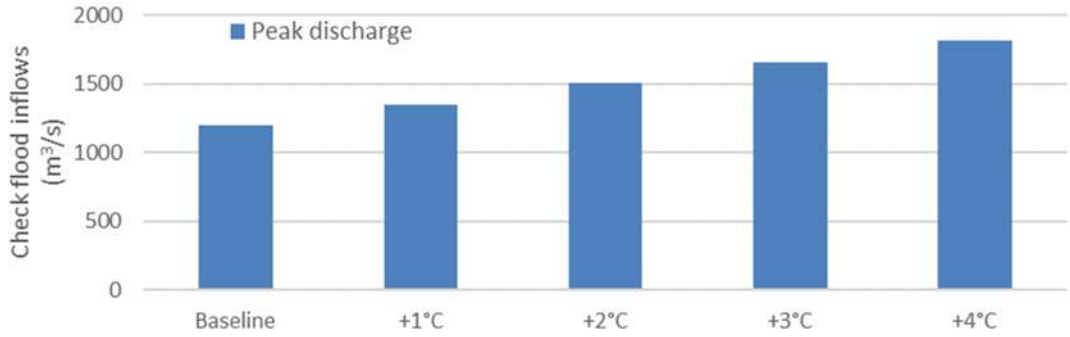

Figure 4-21: Changes in the check flood peak discharge consecutive to changes in mean annual temperature

Table 4-8: Plausibility thresholds for the check flood and 100-year return period flood peak discharges with changes in mean annual temperature

Classification	2020-2049		2050-2079	
	Qp Check flood (m^3/s)	Qp 100-year return period flood (m^3/s)	Qp Check flood (m^3/s)	Qp 100-year return period flood (m^3/s)
Baseline	1,198	384	1,198	384
Most plausible	1,381	473	1,536	551
Plausible	1,335 – 1,458	451 – 512	1,427 – 1,724	496 – 647
Less plausible	1,274 – 1,474	421 – 520	1,381 – 1,787	473 – 679

According to the results provided in Table 4-8, the peak discharge of the check flood is projected to increase by 15% and 28% with the *most plausible* scenario, for the short-term and long-term respectively; and by 23% and 49% with the pessimistic *less plausible* scenarios, for the short-term and long-term respectively, compared to the baseline.

4.7. Environmental flows

Environmental flows are a water release constraint for the dams in the Ruzizi River. They are not turbined at the three dams. Compared to the minimum discharge that is

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estimated for the historical period 1976-2005 (63.9 m^3/s), environmental flows to Ruzizi III (11.1 m^3/s) are very small. Considering that inflows are not projected to change much in the future (*most plausible* scenario), the risk for the environmental flows constraint to not be satisfied can be neglected.

4.8. Economic analysis

The economic assessment constitutes the last step in the modelling cascade that is used for the stress test (Figure 4-22).

The economic model of the Client is used to assess the system's performance. The conclusions of the hydropower generation model are converted into performance indicators for decision making, linking the evolution of power generation and impact of climate change to the evolution of such economic outputs.

The economic assessment is performed through the following steps:

- 1/ Presentation of the methodology
- 2/ Definition of assumptions
- 3/ Analysis of output economic data

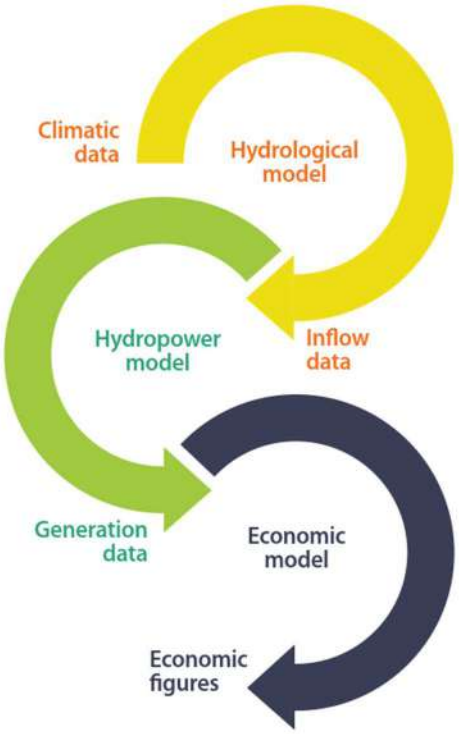

Figure 4-22: Cascade of models considered in the stress tests
(International Hydropower Association, 2019)

4.8.1. Methodology

In Phase 3, the economic model of the Client is used to conduct a first diagnosis of the system's performance in economic terms. The model will also be considered in Phase 4 to evaluate some adaptation measures, when possible, of the Climate Risk Management Plan.

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The economic assessment considered here optimizes the least cost expansion plans with the Ruzizi III project and an alternative plan (thermal mix) without the project. The difference between the two plans gives the costs or benefits of the Ruzizi III project considering plausible climate change projections. By comparing the three design options (original site and alternative site with FSL at 1,130 masl and 1,145 masl), this economic analysis aims at confirming the economic viability and selecting the optimal characteristics (installed capacity, site location and reservoir storage) of the Ruzizi III dam.

The capacity and energy cost values are compared between the hydropower project and an equivalent mix of thermal power plants using diesel fuel. Costs include construction, operation and maintenance and fuel costs. The Net Present Value (NPV) of the hydropower project is selected as a metric for this analysis. Considering that the benefits for both options are identical (the same energy is produced and sold), the NPV is defined as the difference between the present costs of the Ruzizi III hydropower project and the present costs of the alternative plan mixing thermal energies:

$$NPV = \sum_{t=1}^{T} \frac{C_{hydro,t} - C_{thermal,t}}{(1+i)^t}$$

where NPV characterizes the net present value of the hydropower project, $C_{hydro,t}$ are the total hydropower costs for year t, $C_{thermal,t}$ are the total thermal mix costs for year t, i is the discount rate and T is the project operation duration.

The economic model uses as input data (1) the mean annual energy generated by Ruzizi III, (2) the firm power, (3) the installed powerhouse capacity and (4) the firm plant factor. The mean annual energy comes from the same hydropower model used in section 4.4. The other three parameters are derived from the discharge guaranteed at 95% (calculated with the hydrological model) and by optimizing the production of electricity by the cascade Ruzizi II-Ruzizi III over 24h so that it satisfies in priority the demand during nine peak hours that have been identified.

4.8.2. Assumptions

The following assumptions have been made when comparing the hydropower project to the mix of thermal power plants:

Ruzizi III project:

- Project operation duration: 50 years (+ 6 years for the construction of Ruzizi III)
- Discount rate: 10%
- Construction costs: 524 MUSD for the original site, 542 MUSD and 521 MUSD for the alternative site with FSL at 1,145 masl and 1,130 masl respectively, including 40 MUSD for supervision, provision for claims and company costs
- Spread on investment costs on the first 6 years: 7.5% / 9.1% / 17.4% / 23.0% / 24.9% / 18.1%
- O&M costs: 1.5% of the net construction costs
- Plant availability (considering forced and maintenance outages): 94.7%

Thermal mix:

- Two components: a peaking thermal component (combustion turbine, CT) and a baseload thermal component (combined cycle gas turbine, CCGT)

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- Capacity cost: 1,000 $/MW (CT) / 1,600 $/MW (CCGT)
- Capital cost: 122.2 $/kW (CT) / 184.8 $/kW (CCGT)
- Fixed O&M cost: 15 $/kW (CT) / 12 $/kW (CCGT)
- Variable O&M cost: 11.0 $/Wh (CT) / 3.6 $/Wh (CCGT)
- Optimal plant factor: 15% (CT) / 85% (CCGT)
- Availability: 89.5%

4.8.3. Stress test response map and plausibility thresholds

The sensitivity of the net present value of hydropower benefits to changes in mean annual precipitation and mean annual temperature is tested in this section. The stress test response surface for changes in mean annual precipitation and temperature is available in Figure 4-23 for the alternative site design with an FSL at 1,145 masl, but relative changes in NPV are the same with an FSL at 1,130 masl and with the original site design. The changes in this map follow the same direction as the changes in mean annual energy, indicating that mean annual energy is the leading factor in the determination of the NPV hydropower benefits. Plausibility thresholds are provided in Table 4-9 for the three designs.

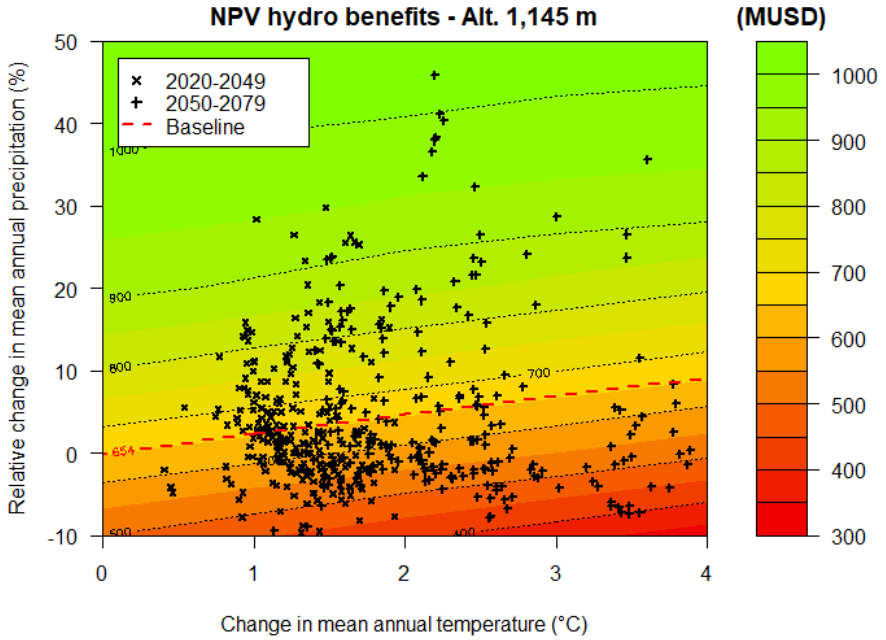

Figure 4-23: Changes in the net present value of hydropower benefits consecutive to changes in mean annual precipitation and temperature

Table 4-9: Plausibility thresholds of the net present value of the Ruzizi III project benefits with changes in mean annual precipitation and temperature

Classification	2020-2049			2050-2079		
	Original (MUSD)	Alt. 1,130m (MUSD)	Alt. 1,145m (MUSD)	Original (MUSD)	Alt. 1,130m (MUSD)	Alt. 1,145m (MUSD)
Baseline	338.7	534.0	654.3	338.7	534.0	654.3

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Classification	2020-2049			2050-2079		
	Original (MUSD)	Alt. 1,130m (MUSD)	Alt. 1,145m (MUSD)	Original (MUSD)	Alt. 1,130m (MUSD)	Alt. 1,145m (MUSD)
Most plausible	331.9	525.5	646.8	329.7	522.9	645.0
Plausible	280.0 – 374.2	476.4 – 577.4	627.2 – 700.7	268.3 – 421.7	447.5 – 635.8	566.6 – 761.3
Less plausible	250.0 – 460.1	425.0 – 683.3	544.0 – 806.8	193.2 – 554.7	355.1 – 798.9	462.1 – 925.6

An interesting conclusion to draw from these results is that, no matter the design, benefits are expected in the future with all climate change projections. However, the NPV of the benefits of the Ruzizi III project is significantly larger with the alternative site designs (and particularly with the higher one with an FSL at 1,145 masl) than with the original site design. The *most plausible* scenario for the long-term indicates benefits of 645.0 MUSD for the alternative site with an FSL at 1,145 masl, i.e. almost two times the benefits of the original site design; and the *less plausible* scenarios indicate that the benefits for choosing the original site design could reach a minimum of 193.2 MUSD in the long-term (pessimistic *less plausible* scenario), while projections for the alternative site design with FSL at 1,145 masl provide NPV estimates that would not go below 462.1 MUSD.

4.9. Risk and Opportunity Register update

The Risk and Opportunity Register is updated based on the results from the climate stress test for each climate variable and sector. Only the columns “Impact – rating” and “risk/opportunity level” are updated. In Phase 1, impacts were assessed based on the review of large scale changes in the regions. In Phase 3, these impacts are updated to take into account the sensitivity of the system to the climate stressors. For example: if all GCMs suggest a large change in precipitation variability, Phase 1 would estimate an impact of 3 (high). However, if the stress test in Phase 3 suggests that the projected changes have little to no impact on the system performance relatively to a certain metric, the impact would be reduced to 1 (low). The updated Risk and Opportunity Register is presented in Table 4-10. Changed values are in red.

Table 4-10: Phase 3 Risk and Opportunity Register

Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain			Likelihood	Risk/ Opportunity level
			Project Component	Impact			
				Description	Rating (1-3)		
Precipitation and streamflow	Increased inflows	Gradual, long-term	Reservoir and dam	More energy generation	3	3	9
				Change in environmental flows, ecological impact downstream	2	1	2
				Increased flows for downstream users	1	3	3
				Less energy generation	3	1	3

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Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain			Likelihood	Risk/ Oppor-tunity level
			Project Component	Impact			
				Description	Rating (1-3)		
	Decreased inflows	Gradual, long-term	Reservoir and dam	Change in environmental flows, ecological impact downstream	2	1	2
				Decreased flows for downstream users	1	1	1
	Increased sediment loads	Gradual, long-term	Reservoir	Loss in reservoir storage, and therefore in the project's lifespan	3	3	9
			Dam	Damage to gates	2	3	6
			Electro-mechanical equipment	Damage to turbines	2	3	6
	More intense floods	Extreme, sudden	Dam	Increased landslides	3	3 (Original) / 1 (Alternative)	9 (Orig.) 3 (Alt.)
				Overtopping of the rockfill dam	3	3	9
			Powerhouse	Flooding from the river	2	3	6
			Access roads	Limited access to plant	2	3	6
				Damage to unsurfaced roads	1	3	3
	Changes in inter- and intra-annual variability	Gradual, long-term	Powerhouse	Change in variability of turbine efficiency	1	3	3
			Reservoir and dam	Change in environmental flows, ecological impact downstream	2	1	2
			Hydropower generation	Changes in the energy generation schedule, hourly or seasonally, resulting in a change in grid requirements	1	3	3
Temperature	Increased air temperature	Gradual, long-term	Powerhouse	Equipment failures due to heat	3	3	9
	More evap. losses	Gradual, long-term	Lake Kivu	Reduced water for energy generation	3	3	9
	Increased water temperature	Gradual, long-term	Reservoir	Decreased dissolved oxygen and impact on ecosystems	2	1	2

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Key elements are as follows:

- Adaptation measures will be discussed in Phase 4 to address the risk of increased sedimentation;
- With regards to floods, the 100,000-year return period flood is projected to increase in the future. This risk is one of the highest for the Ruzizi III project. Adaptation measures will be explored in Phase 4;
- The system's overall energy production is estimated to not be very sensitive to precipitation variability. The threats for the changes in the variability of the turbine efficiency and in the energy generation schedule have then been lowered to 3 (impact lowered to 1).
- The highest risk rating (9) for hydropower generation is associated with temperature increases and the threat they may pose on the hydropower plant. However, a discussion with HEM experts will be done in the further step to find the threshold and, therefore, to define the need for adaptation, if any, that will be explored in greater detail in Phase 4;
- As the increase of inflows is projected to lead to a higher energy production and the temperature increase is projected to lower the energy production at the same time, measures regarding changes in both directions will be discussed in Phase 4.

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5. PHASE 4: CLIMATE RISK MANAGEMENT PLAN

As the Ruzizi III hydropower project is currently at the feasibility stage, a Climate Risk Management Plan is developed in Phase 4 to increase the potential hydropower production and mitigate the risk of floods with regards to the climate change projections.

The purpose of the Climate Risk Management Plan is to propose measures to build climate resilience into the system. Solutions are proposed to address the climate risks equal or greater than 6 in the Phase 3 Risk and Opportunity Register (Table 4-10). Two types of measures are proposed: (1) **design modification measures**, which would require consideration during the design phase; and (2) **adaptation measures**, which could be implemented any time after the completion of the Ruzizi III dam depending on the evolution of climate change. Indeed, contrary to design modification measures, adaptation measures would allow time for further climate monitoring before making decisions. The robustness of each measure is evaluated by comparing the response of the system with and without the measure for the strategic project functions.

Given the deep uncertainty inherent to climate change projections, the Climate Risk Management Plan should be viewed as reassurance that options exist to increase the climate resilience of the Ruzizi III system both during and after the design stage. The Plan ensures that in the event of even the most extreme climate change scenario in the future, options will be available to guarantee project performance. Special attention is then drawn to the most pessimistic bounds of the *less plausible* classification thresholds for the hydroelectricity production function. For the flood security function, though, it must be reminded that the Super-Clausius-Clapeyron equation that has been used in section 4.6 is already an approximation, which is also applied to uncertain projections. Consequently, the *most plausible* threshold in the Climate Risk Management Plan is considered for flood security to limit the number of uncertainties.

As a reminder, the results for the mean annual energy (Table 4-5) and energy guaranteed at 95% (Table 4-6) production indicate almost no change for the *most plausible* classification, and large changes (increases on average) for the *less plausible* classifications. Sedimentation in the Ruzizi III reservoir is projected to increase for the *most plausible* classification and for most scenarios, which will lower the life expectancy of the reservoir if no adaptation solution is implemented (Table 4-7). Large increases in the check flood and 100-year return-period peak flows are projected with all plausibility classifications, for both the short-term and the long-term (Table 4-8).

The Climate Risk Management Plan includes four sections. Section 5.1 introduces design stage options for hydropower and flood security functions and their advantages and disadvantages (in technical and financial terms). In section 5.2, adaptation solutions are proposed to further increase resilience to floods, and quantitative information is provided to support decision making regarding hydropower generation resilience to the whole range of projected changes in precipitation and temperature. In the event where an increased resilience is deemed necessary, some potential design modification and adaptation options would require additional studies, which are presented in section 5.3. Finally, section 5.4 provides the final Risk and Opportunity Register.

5.1. Design stage options

Table 5-1 presents design modification options that could be implemented to improve the resilience of the system with regard to its landslide security, hydropower generation and flood security functions. Each measure to increase the system's resilience relative to a specific function has advantages and disadvantages to take into consideration.

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Table 5-1: Potential design modifications that would increase the resilience of the system relative to landslide security, hydropower production and flood security

Function	Impact	Potential measure to increase the resilience	Implementation	
			Advantages	Disadvantages
Landslide security	Filling the reservoir and damaging the power intake structure	Alternative site instead of original site	Increased benefits	Larger initial investment
Hydropower generation	Equipment failure due to increased temperature	Increase equipment design capacity	Would avoid the likely need to update equipment before the end of its lifespan	Additional costs
	Production decrease due to increased temperature	Release environmental flows through a turbine	Option currently analyzed in the design study	-
	Discharge exceeding the powerhouse capacity due to increased precipitation	Increase the size of the power waterways and leave room for an additional turbine	Project design can be easily adapted	Additional costs
Flood security	Overtopping of rockfill dam	Additional tunnel and gated spillway (Original) / Increase spillway weir width or lowering weir elevation (Alternative)	-	Additional technical studies as well as in-depth economic analysis
	Flooding of the powerhouse	Better protect the powerhouse	-	Additional costs
	Flooding of the plant access roads	Increase the elevation of the access roads	Low implementation costs	-

Details of these potential design modifications are provided in the following sections.

5.1.1. Landslide security

One of the highest risks associated with the Ruzizi III project is linked to the original site design option: the risk of landslide associated with the site's location. To address this risk, the alternative site designs constitute robust design modifications of the original site design to significantly decrease the threat of landslides for Ruzizi III (threat of 3 compared to 9 according to the Phase 3 Risk and Opportunity Register; see Table 4-10).

5.1.2. Hydropower generation

5.1.2.1. INCREASE THE ELECTRICAL EQUIPMENT DESIGN CAPACITY

For this project, the main threat posed by the projected increase in temperature is a threat to the electrical equipment of the powerhouse. It has been given the highest level of threat (9) in the Risk and Opportunity Register (Table 4-10) due to the high confidence in an increase of temperature as per the CMIP5 models' projections (Table 4-3). An increased temperature would likely lead to a greater frequency of failure for electrical

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devices and equipment as well as the following devices that have not yet been defined in the Risk and Opportunity Register: aeration, air conditioning and cooling system, and electrical transformer station. Therefore, it is recommended to update the design standards for project components with long lifespans (i.e. more than 30 years) given that *the most plausible* change in temperature for 2050-2079 is an increase of 2.2°C. For project elements with shorter lifespans, monitoring is deemed sufficient with the intention of updating them at the end of their lifespans. A list of the equipment and whether or not it is recommended to consider a future climate context at the start of the project versus at the end of the equipment lifespan is provided in Table 5-2.

Table 5-2: Estimated additional cost for enhanced electrical equipement to address climate change

Climate stressor	Equipment	Cost	Design based on future climate	Standard changed at the end of lifespan
Temperature	Electrical devices/equipment	N/A		X
	Aeration/air conditioning/cooling system	Negligible	X	
	Electrical transformer station	+5% of initial station cost		X

Given the short lifespan of the electrical devices and equipment and of the electrical transformer station (30-40 years), and considering that they would not experience a significant increase in temperature in the short-term, monitoring is viewed as the most appropriate adaptation solution before replacing them at the beginning of the long-term period considered in this study (2050-2079).

However, with regards to the aeration/air conditioning/air cooling system, the initial design should be updated with more powerful air conditioning, increased tube sizes, larger pumping equipment, etc., to not affect the quality of life of workers inside the plant building. This update would also increase the durability of the electrical equipment inside the plant with increased temperature. Where possible, the adjustments could also be completed incrementally during the adaptation phase (e.g. for the cooling system), but the design should always be considered in the design phase to ensure feasibility in the future.

5.1.2.2. RELEASE THE ENVIRONMENTAL FLOWS THROUGH A TURBINE

In addition to being a threat for the electrical equipment, the projected increase in temperature would lead to a decrease in the inflows reaching Ruzizi III. Producing energy with the environmental flows would help addressing the threat. At this stage, environmental flows at Ruzizi III, which account for 11.1 m^3/s, are not released through any turbine. However, the option exists for the alternative site designs to add a turbine at the foot of the dam for the environmental flows to go through. This possibility is currently analyzed by Tractebel in the Design study. Considering net heads of 30 m and 45 m for the FSL at 1,130 masl and 1,145 masl, respectively, this installation would increase the mean annual production by 25.8 GWh (i.e. +1.8%) and 38.7 GWh (i.e. +2.5%), for FSL at 1,130 masl and 1,145 masl respectively. It can be noted that this option could also be considered as an adaptation measure and implemented after the dam is completed (a comparison with other adaptation measures is conducted in section 5.2.2.4).

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5.1.2.3. PREPARE FOR THE INSTALLATION OF AN ADDITIONAL TURBINE

For the most humid climate change projections (section 4.4), the Phase 3 stress test revealed that the current design would limit the hydropower generation potential. To take advantage of a wetter climate in the future, the powerhouse capacity could be increased at some point in the future. However, as such limitation would only occur with the pessimistic *less plausible* scenarios, it may be better to consider increasing the capacity as an adaptation measure that would depend on the evolution of climate change. In the design stage, though, the size of the power waterways could be increased (to avoid head losses) and room could be left in the plant for another turbine in case the adaptation measure is deemed necessary in the future. Additional information regarding which conditions the additional turbine should be installed in is provided in section 5.2.2.3.

5.1.3. Flood security

5.1.3.1. PROTECTION AGAINST THE CHECK FLOOD

Two design modification options are proposed for the alternative site designs, and one for the original site design, to increase the resilience of the system to a check flood that would be more intense in the future. For the alternative site, the spillway weir width could be increased or the weir elevation could be lowered to avoid the dam to be overtopped. For the original site, an additional tunnel and gated spillway could be built to fulfill the check flood peak discharge evacuation requirements.

For the alternative site designs, the weir elevation could be lowered to be able to release more water. An increase of the spillway weir width could also be achieved by excavating more in the left bank and adding a fourth cell to the labyrinth weir. Indeed, three cells are currently considered to release up to 1,200 m^3/s. A fourth cell would then increase the release capacity up to 1,500 m^3/s approximately. This capacity matches *the most plausible* check flood peak discharge for the long term (see Table 4-8). It can be reminded that, in this Phase 4, the *most plausible* threshold is considered instead of *less plausible* thresholds to increase the resiliency of the system to extreme floods due to the large uncertainties associated with the projections and with the Super-Clausius-Clapeyron approximation. For the original site design, the digging of an additional tunnel and building of a new gated spillway would be required to address the increase of the floods.

5.1.3.2. PROTECTION AGAINST THE 100-YEAR RETURN-PERIOD FLOOD

Concerning protection against the 100-year return-period flood, an increase of the plant's access roads and an additional protection of the powerhouse are measures that could be implemented in the design phase. Some additional analyses would be required but the associated additional costs would be small compared to the threat that is represented by the impossibility to access the plant in case of emergency.

5.2. Adaptation stage options

Proposed adaptation options to increase the resilience of the system to climate change relative to hydropower and flood security are presented in Table 5-3. Contrary to the design stage options, these adaptation options can be implemented whenever it is deemed necessary in the future and depending on the evolution of climate change.

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Adaptation measures include (1) **structural adaptation measures** to update the design of some components of the Ruzizi III project and (2) **functional adaptation measures** to update the operation of some components of the project and particularly of the dams.

Table 5-3: Potential adaptation measures that would increase the resilience of the system relative to landslide security, hydropower production and flood security

Function	Impact	Potential measure to increase the resilience	Implementation	
			Advantages	Disadvantages
Landslide security	Filling the reservoir and damaging the power intake structure	Monitor changes	Little to no implementation costs	-
		Add reservoir bank protections	-	Would require additional studies
Hydropower generation	Equipment failures due to heat	Monitoring	Little to no implementation costs	-
		Design standards based on future climate	Would avoid the likely need to update equipment before the end of its lifespan	Additional costs
		More powerful air conditioning		
	Production decrease due to the increased temperature	Change the operation of Ruzizi I	Little to no implementation costs	-
		Release environmental flows through a turbine	Option currently analyzed in the design study	-
		Use of alternative energy sources	-	Would require additional studies
	Discharge exceeding the powerhouse capacity due to increased precipitation	Install an additional turbine	Project design can be easily adapted	Additional costs
	Lower reservoir lifespan due to increased sedimentation	Monitor sedimentation; dredging the reservoir; watershed management plans to reduce erosion	Little to no implementation costs	On-the-ground measurement campaigns are required
	Damage to gates with increased sediment loads	Monitor damages, consider sediment management systems	-	Would require additional studies and on-the-ground measurement campaigns
	Damage to turbines with increased sediment loads			
Flood security	Overtopping of the rockfill dam	Revegetate the river basin	-	Would require additional studies
	Flooding of the powerhouse			

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5.2.1. Landslide security

In addition to the design stage measure to consider the alternative site instead of the original site for the Ruzizi III project, adaptation measures such as (1) monitoring changes and (2) adding reservoir bank protections could be implemented to protect the Ruzizi III system from the threat of landslides.

Monitoring protocols are discussed in detail in Phase 5. Reservoir bank protections could be added directly around the boundaries of the reservoir or in areas where the risk for rocks to fall is the highest. However, additional studies would be required to adequately implement this kind of adaptation measure.

5.2.2. Hydropower generation

The objective of the resilience analysis for energy criteria is to ensure that hydropower generation reaches the performance baseline for as many climate change projections as possible: 1,542 GWh and 1,256 GWh for the mean annual energy and the energy guaranteed at 95%, respectively, for the alternative site with FSL at 1,145 masl.

In addition to monitoring solutions that will be explained in more detail in Phase 5, and to the measures to avoid the risk of equipment failure due to heat that have already been explained in the design stage section (section 5.1.2), four adaptation solutions are proposed to increase the generation of energy: (1) change the operation of the cascade, (2) release the environmental flows through a turbine – this is also a design stage option currently studied by Tractebel, (3) use alternative energy sources such as solar energy and (4) increase the powerhouse capacity. The first three measures would address a decrease in the inflows to the dam while the last measure could be implemented to address an increase in the inflows. The option to release the environmental flows through a turbine has already been described in section 5.1.2.2. More information regarding the three other adaptation measures is provided in the following sections, as well as a description of potential measures to address increased sedimentation.

5.2.2.1. UPDATE OF THE OPERATION OF RUZIZI I

With the potential increase in the magnitude and variability of the Ruzizi River flows in the future, managing the Ruzizi I dam so that the level of the lake does not exceed the minimum and maximum water levels that have been observed in the past while, at the same time, minimizing the spills to maximize the hydropower generation is of utmost importance. For this reason, an optimization process has been conducted and an update of the Ruzizi I operation rules is proposed to address climate change. The Ruzizi I water release would still depend on the Lake Kivu water level but the release-water level relationship would be different (see Figure 5-1).

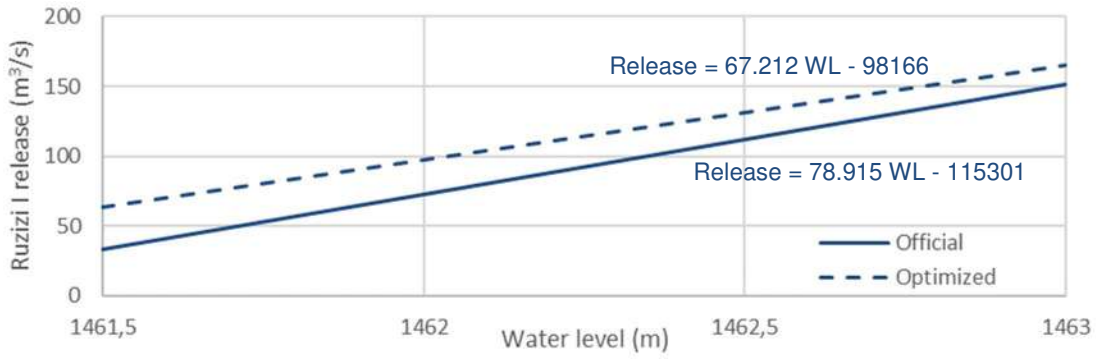

Figure 5-1: Official (current) and optimized operation rules of Ruzizi I

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It must be stressed that the increased release for all water levels with the optimized operation, compared to the current official operation, does not mean that more water would leave the lake on average, but that **more water would be released through the turbines** instead, and that there would be **less spillage**.

The simulation of all climate change projections reveals an increase in the mean annual energy production for all scenarios with the modified operation rules of Ruzizi I compared to current operation. For the alternative site (FSL 1,145 masl), the production would then increase by 21.2 GWh and 29.7 GWh (i.e. 1.3% and 1.7% respectively) on average over all scenarios for the short-term and the long-term respectively. With regards to the energy guaranteed at 95%, the production would decrease with the driest scenarios and increase with the most humid ones, but an average increase of 13.0 GWh and 14.4 GWh (i.e. 0.8% and 0.5% of the baseline production) over all scenarios is projected for the short-term and the long-term respectively. As this measure would not cost anything, it is possible to estimate its impact in economic terms: the update of the operation rule would lead to an increase of the NPV benefits by 10.1 MUSD and 11.6 MUSD, for the short-term and long-term respectively, for the *most plausible* scenario (alternative site with FSL at 1,145 masl).

5.2.2.2. USE OF ALTERNATIVE ENERGY SOURCES

While it is beyond the scope of this study to analyze alternative energy sources, a solar energy option could be considered if additional analyses are deemed necessary. Solar projects are already considered as an attractive option by the SINELAC countries and projects already exist in Rwanda. However, the technology is hampered by the lack of energy storage, which affects the ability to dispatch the capacity. As battery storage would be relatively expensive when compared to reservoir storage from the Ruzizi III project, and Ruzizi III does not enable storage for more than a day, solar expansion would mean a reorganization of the energy distribution throughout the day so that solar energy can be used to meet the daytime demand while hydropower would meet the evening peak demand. Based on 2016 data provided by the Client, an average annual production of 1.30 MWh/m^2 can be expected in the region.

5.2.2.3. INCREASE OF THE INSTALLED POWERHOUSE CAPACITY

The possibility to add another turbine to increase the powerhouse capacity has already been introduced in section 5.1.2 as a design stage measure. Indeed, the option to add a turbine in the future if flows significantly increase will only be economically feasible if the size of the power waterways has already been increased and if room has been left in the plant for a 4th turbine during the design stage. An additional Francis turbine with a capacity of 50 m^3/s could increase the energy generated at Ruzizi III by a maximum of 30% during the months where flows exceed the current powerhouse capacity.

However, this adaptation measure will only be relevant if precipitation significantly increases in the future. The analysis of energy production from Phase 3 has revealed that mean annual energy and energy guaranteed at 95% seemed to hardly change with increases in precipitation larger than 40% approximately. This means that the additional flows created by the increases in precipitation larger than 40% approximately would be spilled and not released through the turbines to generate electricity. An additional analysis is conducted in this section to refine this 40% threshold, i.e. to determine when flows that reach the dam exceed the powerhouse capacity. Energy losses due to water spillage with current design and increased capacity adaptation measure are presented in Figure 5-2 for the alternative site design with FSL at 1,145 masl, but results are similar with the other designs.

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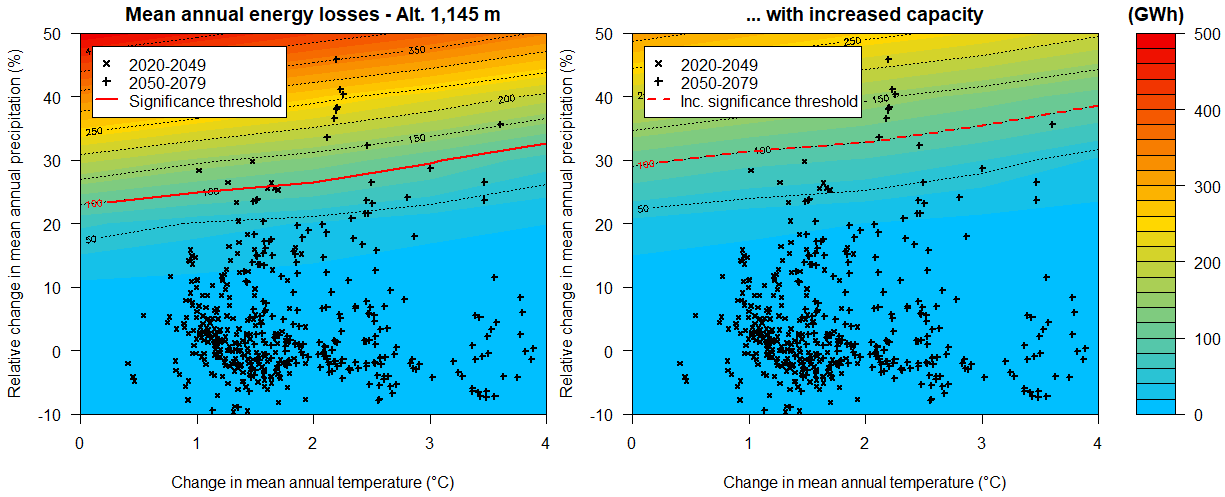

Figure 5-2: Changes in the mean annual energy losses due to water spillage consecutive to changes in mean annual precipitation and temperature, with the standard design (left) and increased capacity adaptation measure (right)

The significance threshold of 100 GWh that is represented in the figures corresponds to 5% of the ~2,000 GWh maximal mean annual energy production across all scenarios. This quantitative assessment is considered more reliable than the above-mentioned approximate of 40% to characterize the changes above which the Ruzizi III system would require an increase in the powerhouse capacity as an adaptation measure. Then, following a decision-scaling approach (Brown, Ghile, Laverty, & Li, 2012), the precipitation-temperature relationship characterizing the 100 GWh significance threshold – i.e. around +28% in precipitation and +2°C in temperature – is proposed to define the **tipping points** for the adaptation measure to be implemented (Figure 5-3). It must be stressed, though, that an additional economic analysis would be required to refine the definition of such a threshold.

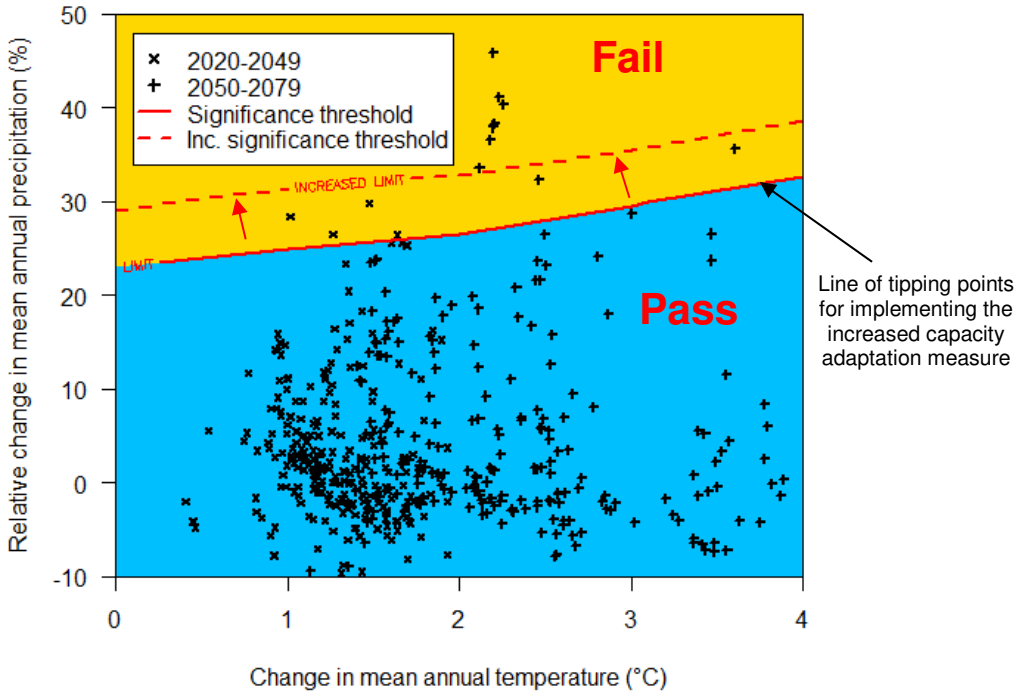

Figure 5-3: Climate response map for satisfying a criteria of energy losses lesser than 5% of the mean annual energy production at Ruzizi III

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5.2.2.4. SYNTHESIS AND COMPARISON OF THE ADAPTATION MEASURES

Results of a detailed analysis of the impact of the three adaptation measures for increasing the energy generated at Ruzizi III (**1: update the operation of Ruzizi I**, **2: release the environmental flows through a turbine** and **3: increase the powerhouse capacity**) with all climate change projections are available in the distribution functions for the mean annual energy and energy guaranteed at 95%, which are presented in Figure 5-4 and Figure 5-5 respectively, for the alternative site design with an FSL at 1,145 masl. Results are similar for the other designs.

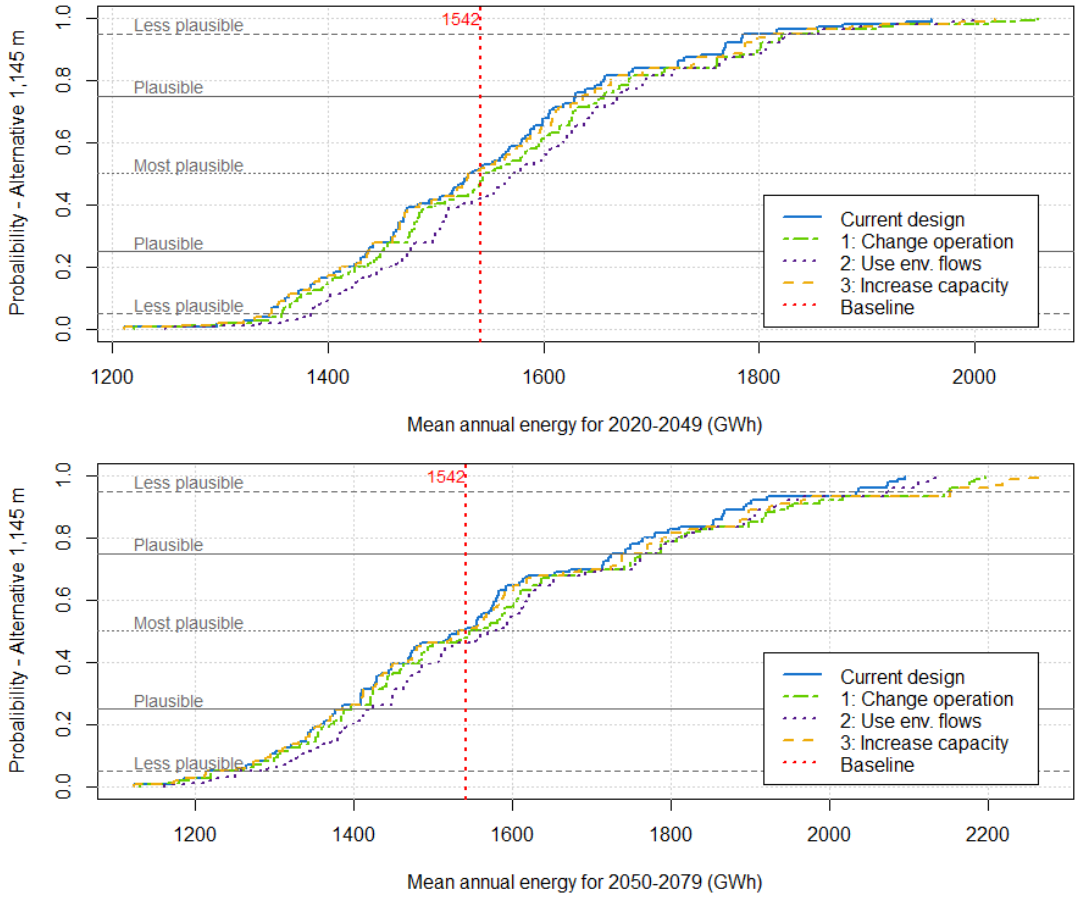

Figure 5-4: Distribution curves for the mean annual energy in the cascade (with the alternative site; FSL 1,145 m) with projected changes in precipitation and temperature, for the current design and with adaptation measures for the short-term and the long-term

Results for the mean annual energy production reveal an increased performance of the system in both the short-term and the long-term with the three adaptation measures. With the update of the Ruzizi I operation and the addition of a turbine at the foot of the dam in particular, as mentioned above, more energy is produced for all of the climate change projections suggested by the CMIP5 GCM models. Concerning the increase of the powerhouse capacity, a significant impact is observed with the 5% most humid scenarios only, for a yearly production that is already above 2,000 GWh with current design. This production value is also in line with the location of the significance threshold in Figure 5-3 – i.e. increases in precipitation and temperature around +28% and +2°C respectively – and the stress test map from Figure 4-11.

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Concerning the energy guaranteed at 95%, the adaptation measure to install a turbine at the foot of the dam would, as for the mean annual energy, increase the benefits for the largest number of projections and provide the best performance of the three measures. Changing the operation of Ruzizi I would decrease the production for the 30% driest climate change scenarios approximately, but would produce the same effects as releasing the environmental flows through a turbine for the 50% most humid scenarios **without any cost for implementing the measure**. Therefore, if increasing the energy guaranteed at 95% is considered more important than increasing the mean annual energy, updating the operation of Ruzizi I should only be implemented if climatic conditions do not reach those from the 30% driest projections – i.e. with changes in precipitation and temperature of about 0% and +2°C respectively. Finally, increasing the powerhouse capacity would have a limited impact on the energy guaranteed at 95%. This last assessment makes sense as the energy guaranteed at 95% performance criteria relates to the lowest flows in a year.

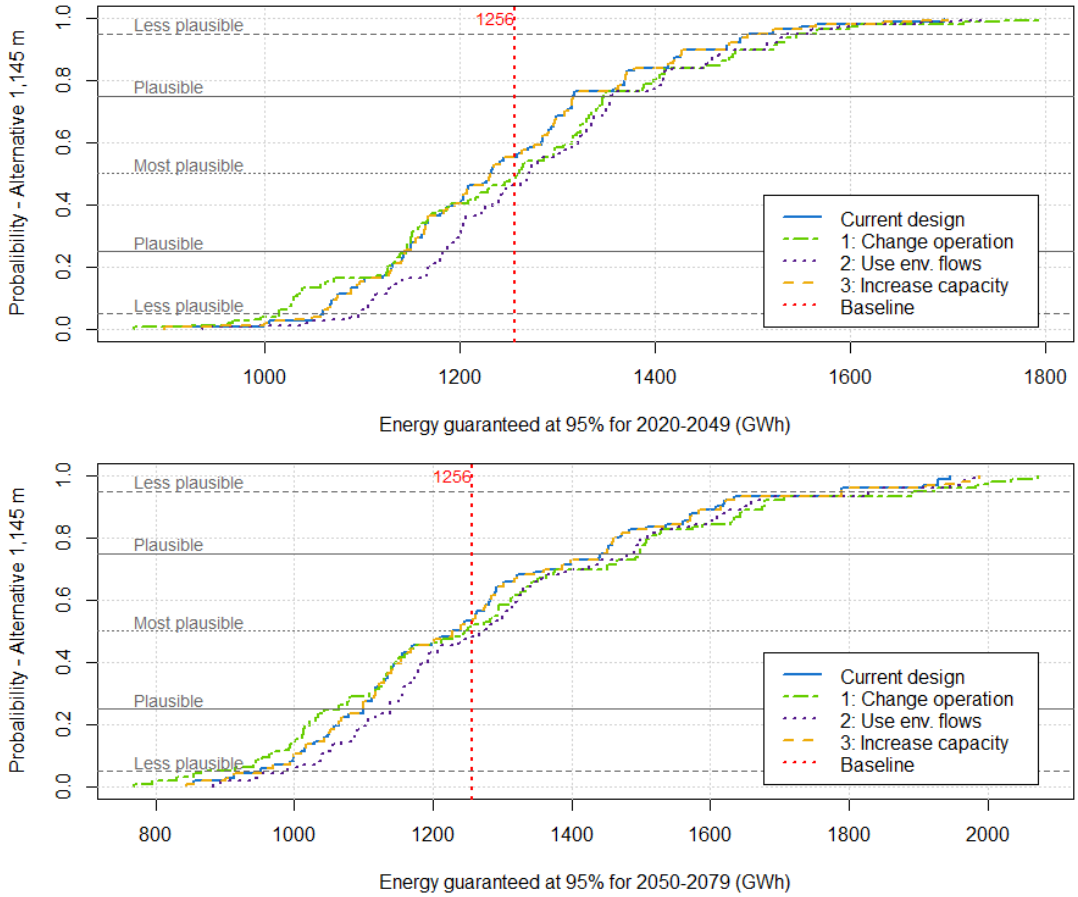

Figure 5-5: Distribution curves for the energy guaranteed at 95% in the cascade (with the alternative site; FSL 1,145 m) with projected changes in precipitation and temperature, for the current design and with adaptation measures for the short-term and the long-term

One can note that the three adaptations measures (change the operation of Ruzizi I, release the environmental flows through a turbine and increase the Ruzizi III powerhouse capacity) being fully independent, combining two or three of them would mean summing the related energy changes for each percentile in Figure 5-4 and Figure 5-5.

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A synthesis of climate change tipping points and ranges where the adaptation measures could be implemented is provided in Figure 5-6. It can be read as follows:

- **1: Update the operation of Ruzizi I**. Considering the *most plausible* change of temperature of +2°C, changing the operation of Ruzizi I would increase the mean annual production for the whole range of changes, but would decrease the mean annual energy if precipitation decreases (see Figure 5-4 and Figure 5-5). Therefore, if the energy guaranteed at 95% is considered more important than the mean annual energy, the adaptation measure should only be implemented if precipitation increases in the future. Otherwise it should be implemented no matter the changes in precipitation and temperature;
- **2: Release the environmental flows through a turbine**. This measure would enable to produce more energy with all the potential changes in temperature and precipitation that are projected by the models. Therefore, it could be implemented any time in the future;
- **3: Increase the powerhouse capacity**. It has been seen that this measure would increase the production of energy by more than 5% only with an increase in precipitation larger than 28% (assuming an increase of temperature of 2°C). Therefore, the adaptation measure should only be implemented in these conditions;
- **4: Use solar energy**. Solar energy is considered as an attractive option by the SINELAC countries. The adaptation measure could be implemented any time in the future, but additional analyses are necessary to analyze it in economic terms.

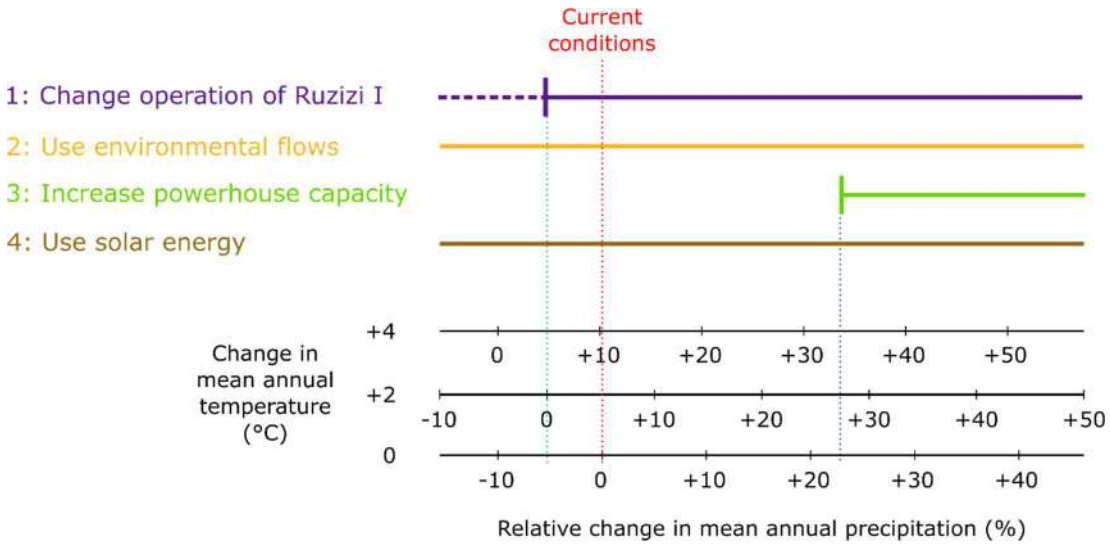

Figure 5-6: Temperature and precipitation change ranges for implementing the adaptation measures

The potential benefits for the four adaptation measures are summarized in Table 5-4.

Table 5-4: Benefits of the adaptation measures to produce more energy (in the range of application of the measures specified in Figure 5-6)

Adaptation measure	Projected benefits (Alt. 1,145 masl)	Comments
Increase the powerhouse capacity	Increase in mean annual production by more than 100 GWh	Additional studies necessary to refine the definition of tipping points

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Adaptation measure	Projected benefits (Alt. 1,145 masl)	Comments
Change the operation of Ruzizi I	Average increase of 21.2 GWh and 29.7 GWh (i.e. 1.3% and 1.7% respectively), for short-term and long-term respectively, over all climate scenarios	Would lead to increases in NPV values of 10.1 MUSD and 11.6 MUSD, for the short-term and long-term respectively
Release the environmental flows through a turbine	Increase of 38.7 GWh (i.e. +2.5%) for all scenarios	Study currently in progress in the design study to refine this estimate
Use of solar energy	-	Expected production of 1.30 MWh/m^2

5.2.2.5. ADAPTATION MEASURES FOR AN INCREASE OF THE SEDIMENTATION RATE

Adaptation measures to address the risk of sedimentation of the Ruzizi III reservoir include dredging the reservoir or implementing reservoir management plans to reduce erosion. However, without on-the-ground measurements of sedimentation in the river at the location of Ruzizi III, it is difficult to provide more detailed adaptation solutions.

A new measuring campaign is recommended to be launched during one whole year to assess the solid flow characteristics (grading, concentration, mineralogy) for all hydrological conditions at the Ruzizi location. Proposed schedule of measurements for the campaign is about 1 measurement per month during the low flow season, and 2 measurements per month during the high flow season. Such campaign should inform about the suspended sediments concentration that could fill the reservoir, and results will allow to define the reservoir sediment management rules (flushing and design).

As for the bed load transport, for which reservoir sediment management rules cannot be used, a structural solution should be designed. It will be the result of concertation between the client, the design team and the sedimentation specialist.

The assessment of suspended and bedload sediments is of utmost importance for defining an appropriate sediment management approach and assess the associated costs. For sake of comparison, Ruzizi II reservoir capacity after 24 years of operation (1989-2013) was reduced to 40% of its capacity. This means that roughly 77,500 m^3 of sediments were retained in the reservoir every year. The expected rate and type of sediments will be estimated in a more precise way from the results of the sediments measurement campaign suggested above.

5.2.3. Flood security

The Ruzizi II and Ruzizi III storage capacities are small compared to the estimated check flood peak flow. Modifying the operation of the Ruzizi cascade would therefore have little impact on flood storage volumes, and would not provide more protection against the check flood.

To increase the resilience of the project to floods in general, revegetating the banks of the Ruzizi River, Ruzizi inter-catchment downstream from Ruzizi I and Lake Kivu basin would help increasing flood security. Such an adaptation measure would be all the more useful as deforestation has been massive in some parts of the basin in the last decades (see section 2.1.2). The measure could be implemented progressively in the whole river basin, starting in the areas where the soils have been the most eroded.

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5.3. Potential additional studies

The Climate Risk Management Plan provides a range of design modifications and adaptation options to enhance flood security and hydropower generation resilience to climate change, if deemed necessary. However, many of the resilience measures, if selected, would require additional studies. These recommended studies are listed in Table 5-5 for the measures presented in this report. Note that the list is not exhaustive and other additional analyses may be required.

Table 5-5: Additional studies recommended for proposed resilience measures

Type	Resilience measure	Additional study
Design modifications	Leave room for an additional turbine	A technical and economic analysis would be required to ensure the feasibility of this modification. An incremental economic analysis would also be necessary to assess the benefits for increasing the powerhouse capacity
	Additional tunnel and dated spillway (original site)	A technical and economic analysis would be required to ensure the feasibility of this modification
	Increase spillway weir width (alternative site)	A technical and economic analysis would be required to ensure the feasibility of this modification
	Increase the elevation of the powerhouse	A technical and economic analysis would be required to implement this modification
	Increase the elevation of the access roads	A hydraulic analysis would be required to implement this modification
Adaptation option	Add reservoir bank protections	A technical and economic analysis would be required to ensure the feasibility of this option
	Change the cascade operation	A more detailed operation analysis would be required to develop operation guidelines adapted to observed climate conditions in the future
	Release the environmental flows through a turbine	An analysis is currently conducted on this option by the Consultant in the conceptual design study
	Use of alternative energy sources	Solar energy has been identified as a potential alternative source of energy in the Ruzizi River basin region. A technical analysis and dedicated ESIA would be required to determine the feasibility of this option and to assess how the operation of the cascade would be modified to increase the performance of the Ruzizi system combined to a solar energy project with climate change
	Monitor sedimentation	Sediment measuring campaigns should be conducted on the ground to precisely quantify sedimentation in the Ruzizi River upstream from Ruzizi III
	Revegetate the river basin	A technical and economic analysis would be required to ensure the feasibility of this option

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5.4. Final Risk and Opportunity Register

The Risk and Opportunity Register is updated based on the accumulation of information leading up to Phase 4, as well as on the proposed resilience measures for each identified risk (Table 5-6). The above-mentioned resilience measures are added for the project elements with a risk level of 6 or more. With regards to the potential losses with a risk level falling below 6, monitoring is proposed as an adaptation measure. Moreover, a key update of this Risk and Opportunity Register is the more detailed description of the threat of temperature increase for the electrical equipment.

Table 5-6: Phase 4 Risk and Opportunity Register

Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain		Risk/ Oppor-tunity level	Potential Resilience Measure	
			Project Component	Description		Design Stage	Adaptation Stage
Precipitation and streamflow	Increased inflows	Gradual, long-term	Reservoir and dam	More energy generation	9	Leave room for additional turbine	Add a turbine if deemed necessary
				Change in environmental flows, ecological impact downstream	2		Monitoring
				Increased flows for downstream users	3		
	Decreased inflows	Gradual, long-term	Reservoir and dam	Less energy generation	3		Monitoring
				Change in environmental flows, ecological impact downstream	2		Monitoring
				Decreased flows for downstream users	1		Monitoring
	Increased sediment loads	Gradual, long-term	Reservoir	Loss in reservoir storage, and therefore in the project's lifespan	9		Monitoring; dredging the reservoir; plans to reduce erosion
			Dam	Damage to gates	6		Monitoring
			Electro-mechanical equipment	Damage to turbines	6		Monitoring
	More intense floods	Extreme, sudden	Dam	Increased landslides	9 (Orig.)	Alternative site	Monitoring; add reservoir bank protection
					3 (Alt.)		Monitoring

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Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain		Risk/ Oppor -tunity level	Potential Resilience Measure	
			Project Component	Description		Design Stage	Adaptation Stage
				Overtopping of the rockfill dam	9	Additional tunnel & gated spillway (Original) / Increase spillway weir width (Alt.)	Revegetate the river basin
			Powerhouse	Flooding from the river	6	Increase the power-house elevation	
			Access roads	Limited access to plant	6	Increase the access roads' elevation	
				Damage to unsurfaced roads	3		Monitoring
	Changes in inter- and intra-annual variability	Gradual, long-term	Powerhouse	Change in variability of turbine efficiency	3		Monitoring
			Reservoir and dam	Change in environmental flows, ecological impact downstream	2		Monitoring
			Hydropower generation	Changes in the energy generation schedule, hourly or seasonally, resulting in a change in grid requirements	3		Monitoring
Temperature	Increased air temperature	Gradual, long-term	Electrical devices / equipment	Equipment failures due to heat	9	Design based on future climate	Monitoring
			Electrical transformer station		9	Design based on future climate	Monitoring
			Aeration / AC / cooling system		9	More powerful AC; increased tube size; larger pumping equipment etc	Monitoring
	More evap. losses	Gradual, long-term	Lake Kivu	Reduced water for energy generation	9		Release the env. flows through a turbine; use solar energy

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Climate Stressor	Threat/ Opportunity	Time Scale	Potential Loss/Gain		Risk/ Oppor -tunity level	Potential Resilience Measure	
			Project Component	Description		Design Stage	Adaptation Stage
	Increased water temperature	Gradual, long-term	Reservoir	Decreased dissolved oxygen and impact on ecosystems	2		Monitoring

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6. PHASE 5: MONITORING, REPORTING AND EVALUATION

A climate resilience monitoring plan is essential to ensuring that adaptation is conducted on a timely basis. This section outlines the objectives of the monitoring plan (section 6.1), the reporting requirements to ensure data is provided in the format required for analysts (section 6.2), the resources necessary to ensure the success of the plan (section 6.3) and recommendations for quality management of the monitoring process (section 6.4). Guidelines for future climate risk assessments are discussed in section 6.5.

6.1. Monitoring objectives

Data monitoring is essential for detecting changes in the Ruzizi III hydropower system. Two types of monitoring are possible, and both are recommended: (1) performance monitoring and (2) driver monitoring.

Performance monitoring consists in the collection and analysis of statistics regarding energy performance. For example: has the annual likelihood of system outages/limited availability increased? Have annual energy production objectives been attained? Performance monitoring is the most direct way to identify a problem. Then, depending on the problem, potential causes can be identified and explored in detail. For example, increased outages or production limitation due to equipment failure are likely caused by either an increase in temperature or the end of the equipment lifespan. Similarly, declining annual energy production without an observed increase in outages is likely caused by changes in inflows and, therefore, precipitation. Depending on the source of the problem, different solutions are required as highlighted in the Climate Risk Management Plan.

Driver monitoring focuses on the drivers of change of the system such as inflows, precipitation and temperature. If a problem is identified regarding energy production, these data will be essential in determining the cause of the problem and, therefore, the appropriate solution. If the monitoring objective is regulatory compliance or developing statistics for engineering design, then discharge may be the most relevant parameter for monitoring. However, if the purpose is to understand runoff processes, to develop water management policies or to calibrate predictive models, then all relevant components of the water cycle should be considered, including stores and fluxes (e.g. temperature, evaporation and precipitation)[11]. For the continued monitoring of Ruzizi III, the latter is of interest to ensure a good understanding of the role of climate change in any future performance failures.

Table 6-1 presents the relevant analysis metrics for hydropower generation flood risk and landslide risk functions. The reporting frequency is discussed in section 6.2.

It must be stressed that the monitoring program should not be limited to the scale of the project. For example, the availability of discharge data from multiple stream gauges in the region provides verification options for future analyses. Likewise, precipitation varies spatially within a watershed; therefore, a regional comparison of precipitation provides a greater level of accuracy in any hydrologic analysis. It is recommended to establish a

[11] https://public.wmo.int/en/bulletin/5-essential-elements-hydrological-monitoring-programme

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monitoring program that will acquire hydroclimatic data at the relevant scale to be able to capture any climate change and understand the evolving context.

Table 6-1: Recommended monitoring metrics per function

Function	Monitoring metric
Hydropower generation: performance monitoring	Power outages and availability limitations: planned and unplanned (days per month)
	Energy produced (GWh)
Hydropower generation: driver monitoring	Precipitation (mm)
	Temperature (°C)
	Inflows (m^3/s)
	Sedimentation rate in the Ruzizi River (m^3/s)
	Sedimentation in the reservoir (hm^3)
Flood security	Precipitation (mm)
	Inflows (m^3/s)
Landslide security	Risk location and volume (frequency and m^3)

6.2. Reporting

The analysis and reporting of data highly depend on the identified objectives. For example, reporting flows to the dam on an hourly basis could be interesting for monitoring and understanding hydropower generation. Modern monitoring systems also exist to provide real-time data to assist in operations and real-time decisions. Moreover, attaining the identified service objectives depends on:

- Staffing (e.g. response time for instrument failure);
- Equipment specifications (i.e. instrument reliability);
- Life-cycle management of equipment (i.e. calibration and control procedures);
- Efficiencies in data production (e.g. automated notifications, auto-corrections, and auto-publication);
- Feedbacks from the data production process (e.g. sufficient metadata to support a continuous improvement process).

For the Ruzizi III hydropower performance, **monthly and annual energy production** statistics are recommended, while **outages and limited availability should be recorded in times per month**. The timing of outages is particularly important given the seasonality that exists in the system and the potential increase of required operations during the wet season in the future. Outages during the dry season will likely have less impact on the overall energy production than during the wet season.

Regarding driver monitoring, **sedimentation in the river should ideally be reported twice a month during the high flow season and once a month during the low flow season**, and every five to ten years in the reservoir; **temperature could be reported**

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daily; and **precipitation and inflow data on an hourly or monthly basis** depending on the function. The **hourly reporting frequency for precipitation and inflows would be required for an updated flood risk analysis** but, depending on the available resources, a less frequent reporting would still be valuable for a hydropower generation analysis.

Table 6-2 summarizes the monitoring frequency recommendations. These recommendations will be reviewed with stakeholders to ensure their feasibility and adjusted as needed.

Table 6-2: Recommended monitoring frequency for hydropower generation and flood security

Function	Monitoring metric	Reporting frequency
Hydropower generation: performance monitoring	Power outages and availability limitations (days per month)	Daily
	Energy produced (GWh)	Monthly and annual
Hydropower generation: driver monitoring	Precipitation (mm)	Monthly
	Temperature (°C)	Daily (but monthly acceptable)
	Inflows (m^3/s)	Monthly
	Sedimentation rate in the river (m^3/s)	Twice and once a month for the high and low flow season respectively
	Sedimentation in the reservoir (hm^3)	Every 5 to 10 years
Flood security	Precipitation (mm)	Hourly
	Inflows (m^3/s)	Hourly
Landslide security	Risk location and volume (frequency and m^3)	Event based

6.3. Resources required

A monitoring and reporting program requires additional costs and resources to the project. In addition to the initial capital cost of installation, operation and maintenance costs consist of, but are not limited to: (1) field calibration and service frequency requirements; (2) unscheduled field visits to repair or replace defective parts; and (3) the labor spent on data corrections and post-processing. There are also risks of data losses due to sensor failure and data degraded by high uncertainty, depending on the quality of the technology used. Money saved in lower quality investments at the beginning of the project can result in increased operations and maintenance costs.

In addition to installation, operation and maintenance costs, training costs also need to be considered. Procedural mistakes are difficult to identify and correct when post-processing data, but they can make the data useless for future analyses. Official trainings reduce the likelihood of mistake occurrence, thus increasing the reliability of the data. Training should be a continuous process to ensure that the monitoring program is up to date with best practices, and that the transfer of knowledge is done when staff changes.

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The responsible parties and budget required to ensure the success of the monitoring and reporting plan will be discussed in the final stakeholder workshop. Standard practices leave the owner/operator responsible for monitoring the asset and local metrics, while stakeholders are responsible for the monitoring of the metrics in general/regional/national context.

6.4. Quality management

Best practices must be taken to ensure the quality of the data being monitored and reported. First, the **data should be properly stored** to avoid any damage and/or loss of data. In addition, **proper monitoring of metadata**, such as the format and units of the reported data, is essential to ensure that the data can be used by future analysts. The data management system must also **document the full history of the data** (e.g. who took the data, when and how?). The most important element to be reported with the monitoring is a change in the method that has been used, such as a modification of the rating curve for converting water depths to flows. Without this information, data become useless, or at best very difficult to use, in future analyses. Finally, **raw data should be preserved** so that analysts can verify any changes indicated in the documentation process.

Quality management standards for hydrometric systems have been provided by the following sources:

- Techniques & Methods Reports published by United States Geological Survey (USGS);
- USGS Techniques of Water-Resources Investigations Reports;
- International Organization for Standardization (ISO) Technical Committees 113 and 147;
- World Meteorological Organization (WMO) publications prepared as part of the Quality Management Framework – Hydrology (No. 49, "Technical Regulations Vol. III Hydrology", 2006 edition; and No. 168 "Guide to Hydrological Practices", 6th edition; and various manuals including the 2nd edition of the Manual on Stream Gauging).

It can be noted that while most monitoring systems have established their own means to verify that quality management standards are maintained, quality management standards can also be certified in the standardized ISO 9000 method if desired[12].

6.5. Evaluation and reassessment of climate risks

The IHA Guidelines recommend updating the Climate Risk Assessment every 10 years as new data and projections become available. However, an updated Climate Risk Assessment does not necessarily require going through all phases of the process. Phase 1 and 2 should always be revisited to collect recent information relevant for the system. For example, Phase 1 should identify new water users, policies and/or energy production objectives. Likewise, system performance should be analyzed and the age of equipment relative to their lifespan considered. For Phase 2, historical data collected during the monitoring and reporting processes, as well as new climate change projections should be analyzed for trends. All this information must be evaluated to

[12] https://public.wmo.int/en/bulletin/5-essential-elements-hydrological-monitoring-programme

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determine whether to conduct a full Climate Risk Assessment, implement a new adaptation stage, or simply continue monitoring.

Figure 6-1 presents the decision process to determine whether a Climate Risk Assessment is required for the hydropower generation function once Phases 1 and 2 are completed.

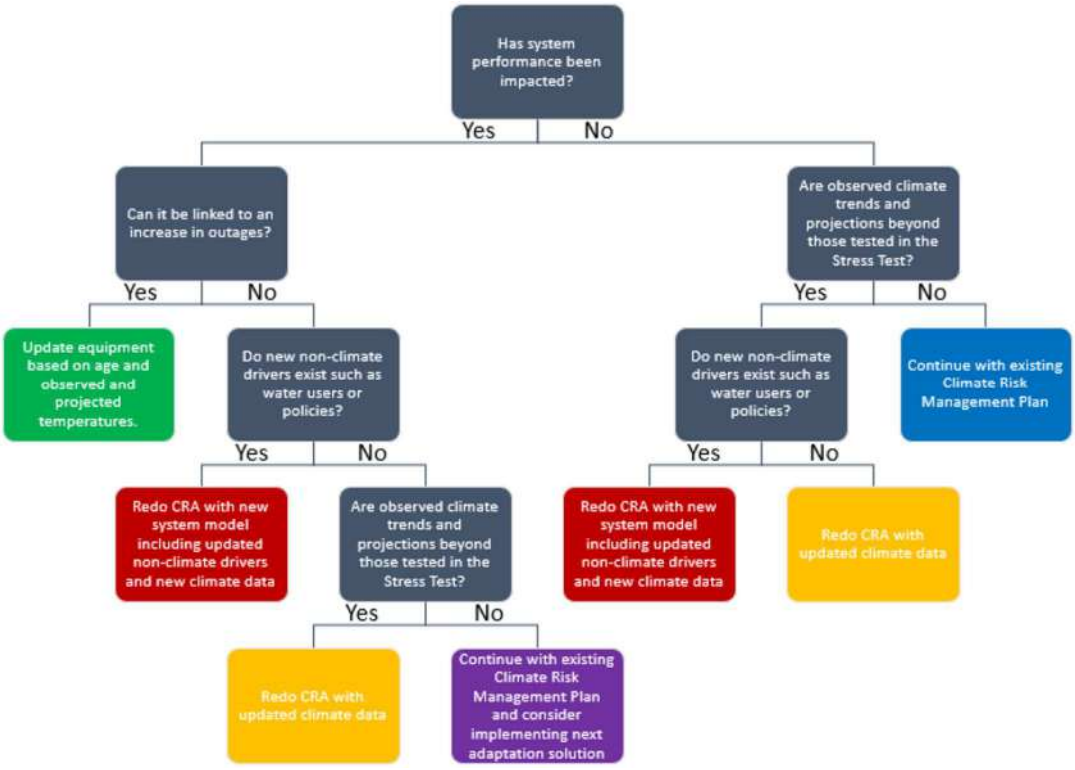

Figure 6-1: Decision flowchart for a Climate Risk Re-assessment

Flood risks also need to be considered in the Climate Risk Re-assessment. Newly available extreme precipitation and flow data should be analyzed to determine if the dam protection levels are beyond acceptable levels. If this is the case, Phase 4 must be implemented again to update the adaptation options and ensure flood security.

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7. STAKEHOLDERS ENGAGEMENT

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APPENDIX A.CMIP5 EXPERIMENTS

Table 8-1: Future precipitation and surface air temperature scenarios collected for the climate resiliency analysis over the Ruzizi River basin. Numbers in brackets refer to temperature scenarios when they differ from precipitation scenarios.

GCM model	Number of members			
	RCP 4.5	RCP 6.0	RCP 8.5	All
ACCESS1-0	1	0	1	2
ACCESS1-3	1	0	1	2
bcc-csm1-1-m	1	1	0	2
bcc-csm1-1	1	1	1	3
BNU-ESM	1	0	1	2
CanESM2	5	0	5	10
CCSM4	6	6	6	18
CESM1-BGC	1	0	1	2
CESM1-CAM5	3	3	3 (*2*)	9 (*8*)
CMCC-CM	1	0	1	2
CMCC-CMS	1	0	1	2
CNRM-CM5	1	0	5	6
CSIRO-Mk3-6-0	10	10	10	30
EC-EARTH	4 (*6*)	0	4 (*7*)	8 (*11*)
FGOALS-g2	1	0	1	2
FIO-ESM	3	3	3	9
GFDL-CM3	1	1	1	3
GFDL-ESM2G	1	1	1	3
GFDL-ESM2M	1	1	1	3
GISS-E2-H-CC	1	0	0	1
GISS-E2-H	15	3	3	21
GISS-E2-R-CC	1	0	0	1
GISS-E2-R	17	3	3	23
HadGEM2-AO	1	1	1	3
HadGEM2-CC	1	0	1	2

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GCM model	Number of members			
	RCP 4.5	RCP 6.0	RCP 8.5	All
HadGEM2-ES	4	3	4	11
inmcm4	1	0	1	2
IPSL-CM5A-LR	4	1	4	9
IPSL-CM5A-MR	1	1	1	3
IPSL-CM5B-LR	1	0	1	2
MIROC-ESM-CHEM	1	1	1	3
MIROC-ESM	1	1	1	3
MIROC5	3	3	3	9
MPI-ESM-LR	3	0	3	6
MPI-ESM-MR	3	0	1	4
MRI-CGCM3	1	1	1	3
NorESM1-M	1	1	1	3
NorESM1-ME	1	1	0 (*1*)	2 (*3*)
Total	**105 (*107*)**	**47**	**77 (*80*)**	**229 (*234*)**

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At the helm of the Energy Transition, Tractebel provides a full range of engineering and consulting services throughout the life cycle of its clients' projects, including design and project management. As one of the world's largest engineering consultancy companies and with more than 150 years of experience, it's our mission to actively shape the world of tomorrow. With about 5,000 experts and offices in 33 countries, we are able to offer our customers multidisciplinary solutions in energy, water and urban.

TRACTEBEL ENGINEERING S.A.

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fax.+33 1 41 85 03 74

PUBLIC DISCLOSURE AUTHORIZED

K. Cumulative Impact Assessment - Focus Group Discussions

PUBLIC DISCLOSURE AUTHORIZED

PUBLIC DISCLOSURE AUTHORIZED

Burundi

PUBLIC DISCLOSURE AUTHORIZED

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

Fiche de présence pour les discussions de groupe	
Nom du village / du district / du pays – **Rugombo / Cibitoke / Burundi**	
Date / heure : **18 / 06 / 2024 – 10h00**	Fiche d'enregistrement # **001**
Participants **(3)**	

A lire à haute voix aux participants : *En signant ce registre, vous acceptez, en tant que participant, de prendre part aux discussions de groupe. Vous avez le droit de ne pas répondre ou même d'interrompre votre participation si vous vous sentez mal à l'aise avec les questions posées. Vos réponses seront rendues anonymes et votre nom ne sera lié à aucune information ou réponse que vous fournirez. Il est possible que votre photo soit prise pendant la réunion et utilisée dans les rapports SLR, mais vous avez le droit de refuser d'être photographié.*

#	NOM DE FAMILLE	Prénom	Homme/Femme	Âge	Profession	N° de tél.	Signature
1	AHISHAKIYE	Médiatrice	F	30	Infirmière	+257 69 13 76 27	
2	NSHIMIRIMANA	Alphonsine	F	38	Elue Collinaire	+257 61 60 43 26	
3	NSENGINYUMVA	Mariam	F	35	Chef de quartier	+257 61 59 12 58	
4							
5							
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8							
9							
10							

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

Fiche d'enregistrement des discussions de groupe

Nom de l'animateur : **Guylaine NTUNAGUZA**	Coordonnées GPS : X **2°53'05.4"S** Y **29°07'22.5"E**
Nom du village / du district / du pays **Rugombo / Cibitoke / Burundi**	
Date / heure : **18 / 06 / 2024 – 10h00**	Fiche d'enregistrement # **001**

Participantes **(3)**

Nom de famille / Prénom	Genre (homme/femme)	Âge	Profession / rôle dans le village
AHISHAKIYE / Médiatrice	F	30	Infirmière
NSHIMIRIMANA / Alphonsine	F	38	Elue Collinaire
NSENGINYUMVA / Mariam	F	35	Chef de quartier

Introduction :

L'enquêteur donnera aux participants un aperçu du Projet à l'aide de cartes et de dessins.

La description montrera l'emplacement du barrage, du réservoir, de la centrale électrique, du tunnel, des routes et d'un campement pour les travailleurs du chantier.

Les activités de construction seront décrites.

Le fonctionnement du réservoir et de la centrale électrique - avec les débits de pointe et hors pointe - sera brièvement décrit.

Questions

[1]. Selon vous, quels changements économiques pourraient survenir dans le village grâce au Projet et pourquoi - et quelle est l'importance de ces changements pour vous ?

- Plus d'électricité pour la population

- Avec plus d'électricité, plus d'opportunités de travail, à cause des coupures fréquentes, il est impossible pour les petits commerçants de travailler correctement

- Plus d'apport en argent, donc économiquement bénéfique

- Pour les femmes, possibilité de créer des entreprises et surtout la possibilité d'avoir des emplois dans le projet.

[2]. Quels changements pourraient survenir dans la vie culturelle et le tissu social du village en raison du Projet, quelle est l'importance de ces changements pour vous ?

- **Les avantages qu'apporteraient le projet : s'il y a création d'emploi, cohésion et entraide parce que les moyens le permettraient**
- **Créer de bonnes collaborations avec les autres pays faisant partie du projet, puisqu'il s'agira de travailler ensemble**
- **Cohésion et rapprochement entre les 3 pays malgré les relations difficiles actuelles**

[3]. Quelles sont vos préoccupations concernant l'embauche de travailleurs extérieurs à la région sur les sites du Projet ? Comment la présence des travailleurs pourrait-elle affecter la vie du village ? Quelle importance accordez-vous à cette question ?

- **Pour le Burundi, il y aura un impact positif parce qu'il y aura des entrées financières, en terme de locations de maison, achat de denrées locales, etc..**

-Côté négatif, avec la diversité des gens extérieurs, crainte que les jeunes filles soient attirés par les hommes, et se retrouvent enceintes et que la communauté se retrouvent avec des problèmes à gérer.

- Nécessité de faire des réunions de sensibilisation dans les collines avant même que le projet ne débute

[4]. Quelles sont les modifications de l'environnement naturel causées par le Projet qui vous préoccupent et pourquoi ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : débit de la rivière, niveau de l'eau, nombre de poissons, animaux sauvages, arbres, fleurs, plantes médicinales, oiseaux, qualité de l'air, niveaux de poussière, niveaux de bruit.

Aucun impact au niveau du Burundi

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[5]. Veuillez énumérer les 6 aspects les plus importants de votre communauté et de votre mode de vie dont nous avons discuté, par ordre de priorité. Veuillez expliquer pour chacun d'entre eux pourquoi il est important.

#	Élément de l'environnement / mode de vie de la communauté	Pourquoi c'est important
1	**Opportunité d'affaires pour les femmes**	En créant des commerces, elles vont créer de l'emploi et pourraient soutenir le système économique
2	**Relations transfrontaliers entre les 3 pays**	Avec la fermeture des frontières, il n'est plus possible de faire la vente de certaines denrées qui étaient génératrices de revenus à la frontière entre les pays
3	**Possibilité d'emploi – Priorité aux femmes**	Pour que les femmes commencent à se prendre en main et qu'elles puissent, elles aussi apporter des revenues dans leur foyer
4	**Engagement communautaire entre les femmes**	Créer des associations d'entraide avec d'autres femmes et créer un système de support
5	**Augmentation de la qualité de vie – de famille et du foyer**	En participant à la vie économique, elles n'auraient plus besoin de constamment demander de l'argent à leur époux, même pour acheter des « tomates ou du pain »
6	**Sensibilisation pour les femmes sur l'importance de l'auto développement**	Faire connaître aux femmes l'important de s'auto-développer et les bienfaits que cela peut apporter au foyer

[6Avez-vous des questions sur le Projet ? Y a-t-il d'autres aspects du projet qui vous inquiètent ou vous préoccupent ?

- **Comment le projet va se faire avec les frontières fermées**

- **Pendant et après la construction, s'il devait y avoir encore des problèmes entre les pays, est-ce qu'il y a risque qu'il y ait coupure de distribution du courant pour le Burundi**

Merci

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

Fiche de présence pour les discussions de groupe	
Nom du village / du district / du pays – **Rugombo / Cibitoke / Burundi**	
Date / heure : **18 / 06 / 2024 – 11h00**	Fiche d'enregistrement # **002**
Participants **(3)**	

A lire à haute voix aux participants : *En signant ce registre, vous acceptez, en tant que participant, de prendre part aux discussions de groupe. Vous avez le droit de ne pas répondre ou même d'interrompre votre participation si vous vous sentez mal à l'aise avec les questions posées. Vos réponses seront rendues anonymes et votre nom ne sera lié à aucune information ou réponse que vous fournirez. Il est possible que votre photo soit prise pendant la réunion et utilisée dans les rapports SLR, mais vous avez le droit de refuser d'être photographié.*

#	NOM DE FAMILLE	Prénom	Homme/Femme	Âge	Profession	N° de tél.	Signature
1	HATEGEKIMANA	Jean Bosco	H	50	Enseignant	+257 68 34 11 89	
2	NDAHABONENYICUTI	Celeste	H	45	Fermier	+257 69 20 87 45	
3	SINDAYIGAYA	Cyrille	H	35	Fonctionnaire	+257 61 39 94 98	
4							
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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

Fiche d'enregistrement des discussions de groupe

Nom de l'animateur : **Guylaine NTUNAGUZA**	Coordonnées GPS : X **2°53'05.4"S** Y **29°07'22.5"E**
Nom du village / du district / du pays **Rugombo / Cibitoke / Burundi**	
Date / heure : **18 / 06 / 2024 – 11h00**	Fiche d'enregistrement # **002**

Participantes **(3)**

Nom de famille / Prénom	Genre (homme/femme)	Âge	Profession / rôle dans le village
HATEGEKIMANA / Jean Bosco	H	50	Enseignant
NDAHABONENYICUTI / Celeste	H	45	Fermier
SINDAYIGAYA / Cyrille	H	35	Fonctionnaire

Introduction :

L'enquêteur donnera aux participants un aperçu du Projet à l'aide de cartes et de dessins.

La description montrera l'emplacement du barrage, du réservoir, de la centrale électrique, du tunnel, des routes et d'un campement pour les travailleurs du chantier.

Les activités de construction seront décrites.

Le fonctionnement du réservoir et de la centrale électrique - avec les débits de pointe et hors pointe - sera brièvement décrit.

Questions

[1]. Selon vous, quels changements économiques pourraient survenir dans le village grâce au Projet et pourquoi - et quelle est l'importance de ces changements pour vous ?

- Il n'y a pas d'électricité et donc plusieurs business qui sont à l'arrêt : ex : il y a des machines qui transforment le riz qui sont à l'arrêt.

- le Gouvernement bénéficierait

- Avec l'électricité, possibilité de mettre en place des industries de transformation, ce qui est impossible aujourd'hui étant donné la conjoncture

- Augmentation du niveau de taxation pour le pays, ce qui augmenterait le niveau de vie du pays

[2]. Quels changements pourraient survenir dans la vie culturelle et le tissu social du village en raison du Projet, quelle est l'importance de ces changements pour vous ?

- **Il y aurait changement pour les gens de la communauté, une meilleure cohésion sociale**
- **En ayant accès à l'électricité, si tout le monde y a accès, moins de jalousie, comme c'est le cas aujourd'hui, ou certains ménages à accès à l'électricité et d'autres non**
- **Changement de mentalité au niveau de la sécurité (moins de vols, etc.)**

[3]. Quelles sont vos préoccupations concernant l'embauche de travailleurs extérieurs à la région sur les sites du Projet ? Comment la présence des travailleurs pourrait-elle affecter la vie du village ? Quelle importance accordez-vous à cette question ?

- Il serait bien d'accueillir des travailleurs extérieurs parce que l'apport économique peut être aussi un changement positif de culture

- Il faut par contre faire attention aux changements possible de mentalités, s'assurer que les responsables locales puissent rester aux aguets pour sensibiliser les gens face aux possible mauvais comportements (alcool, drogues, etc…)

- Risque de grossesses indésirées par des travailleurs extérieures.

[4]. Quelles sont les modifications de l'environnement naturel causées par le Projet qui vous préoccupent et pourquoi ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : débit de la rivière, niveau de l'eau, nombre de poissons, animaux sauvages, arbres, fleurs, plantes médicinales, oiseaux, qualité de l'air, niveaux de poussière, niveaux de bruit.

Aucun impact au niveau du Burundi

[5]. Veuillez énumérer les 6 aspects les plus importants de votre communauté et de votre mode de vie dont nous avons discuté, par ordre de priorité. Veuillez expliquer pour chacun d'entre eux pourquoi il est important.

#	Élément de l'environnement / mode de vie de la communauté	Pourquoi c'est important
1	**Agriculture moderne**	Propice à la vie de communauté parce que c'est la base de tout
2	**Avoir un lieu où vivre**	Avoir accès à un logement pour tous est important, permet de vivre en paix dans la communauté
3	**Avoir des services de soins complet**	Les services actuellement ne sont pas satisfaisant et il est important qu'un service minimum puisse
4	**Niveau de vie qui change**	Une meilleure qualité de vie pour la communauté
5	**Éducation en général**	Lorsque les gens sont éduqués, le niveau de vie de la communauté change en mieux
6	**Relations transfrontaliers entre les 3 pays**	Pour permettre l'échange des denrées et vente inter-échange (commerce, vie ensemble)

[6Avez-vous des questions sur le Projet ? Y a-t-il d'autres aspects du projet qui vous inquiètent ou vous préoccupent ?

- **À quand le début de la construction**
- **Comment va se faire le recrutement**
- **Comment garantir que le Burundi va vraiment bénéficier du projet**

Merci

Cumulative Impact Assessment
Photo of Focus Group Discussions
Cibitoke, Burundi - 18 June 2024

PUBLIC DISCLOSURE AUTHORIZED

DRC

PUBLIC DISCLOSURE AUTHORIZED

F.G Homme Nyangezi

REL
Ruzizi III Energy Limited

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

Fiche d'enregistrement des discussions de groupe

Nom de l'animateur : Stephane BYAMUNGU	Coordonnées GPS : X…… Y……
Nom du village / du district / du pays : Nkarhongwe / Nyangezi	
Date / heure : 13h03 / le 24/05/2024	Fiche d'enregistrement #

Participantes

Nom de famille / Prénom	Genre (homme/femme)	Âge	Profession / rôle dans le village
MASUMBUKO Cihyoka	M	55	Président comité PAP
SAFARI Cosmos	M	60	Cultivateur / PAP.
HERITIER Mulumeodarhora	M	28	Cultivateur
Balufe RUSHIZI	M	61	Cultivateur.
MWAMI ABURHE CINJAHU	M	50	Personne affectée
BALIBUNO MATESO	M	45	Secrétaire / Route

Introduction :

L'enquêteur donnera aux participants un aperçu du Projet à l'aide de cartes et de dessins.

La description montrera l'emplacement du barrage, du réservoir, de la centrale électrique, du tunnel, des routes et d'un campement pour les travailleurs du chantier.

Les activités de construction seront décrites.

Le fonctionnement du réservoir et de la centrale électrique - avec les débits de pointe et hors pointe - sera brièvement décrit.

Questions

[1]. Selon vous, quels changements économiques pourraient survenir dans le village grâce au Projet et pourquoi - et quelle est l'importance de ces changements pour vous ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : valeur de la terre, prix de location de la terre, coût des produits de base.

R/- Nous nous attendons à un développement économique grâce au courant ; on peut installer des moulins, des usines de transformations, on peut quitter dans le noir à travers l'éclairage.
- Il y aura de l'emploi, les populations vont accéder à l'argent, nous pouvons faire le commerce
- Faire éduquer nos enfants
- On peut construire en matériaux durables
- Elever, faire une bonne agriculture etc.

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Ruzizi III Energy Limited

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[2]. Quels changements pourraient survenir dans la vie culturelle et le tissu social du village en raison du Projet, quelle est l'importance de ces changements pour vous ?

R/ Le Paojet va nous permettre de consolider les relations existants entre nous, reduire les conflits familliaux,
- Possibilité de s'entre aider mutuellement car les moyens sont disponible
- Sur le plan culturelle, nous allons développer nos cultures, copier le mod de vie des autres
- Apprendre auprès d'eux.

[3]. Quelles sont vos préoccupations concernant l'embauche de travailleurs extérieurs à la région sur les sites du Projet ? Comment la présence des travailleurs pourrait-elle affecter la vie du village ? Quelle importance accordez-vous à cette question ?

R/ Nous les accueillons chez nous mais nous avons besoins que les embauches soit partagés equitablement.
- Nous avons besoins de ceux là qui sont plus qualifiés & technique que nous.
- Besoins d'eau car nous apprendrons d'eux;
- Avec ça sont des gens qui ne peuvent pas vouloir apprendre de nous nous appeler un plus.
- Soit ils peuvent être des travailleurs mais avec maladie transmissible, bandits, escrocs, etc.
- Impact sur la consommation alimentaire
- non payement de loyer
- Risque de violences sexuelles de nos fille femmes,
- Les travailleurs mal intentionnés tuent sur les autres

[4]. Quelles sont les modifications de l'environnement naturel causées par le Projet qui vous préoccupent et pourquoi ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : débit de la rivière, niveau de l'eau, nombre de poissons, animaux sauvages, arbres, fleurs, plantes médicinales, oiseaux, qualité de l'air, niveaux de poussière, niveaux de bruit.

R/ Les modifications conferre la perte de nos terres productives;
- Déboisement suite à la forte démographie, coupe du bois de chauffe, baise, construction
- Destruction anarchiques des plants soit par les passagers ou soit par les engins du Projet
- Risque que l'eau puisse être insuffisante
- Disparition de nos forêts naturelles.
- Manque de Patturage par les bêts, vols, plus d'accès aux poissons de la rivière Ruzizi
- Les plants medicinales vont disparaître. même chose que les oiseaux
- Pollution des bruits, poussière et air trouble
- Risque des catastrophes naturelles, eboulement, erosion

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[5]. Veuillez énumérer les 6 aspects les plus importants de votre communauté et de votre mode de vie dont nous avons discuté, par ordre de priorité. Veuillez expliquer pour chacun d'entre eux pourquoi il est important.

#	Élément de l'environnement / mode de vie de la communauté	Pourquoi c'est important
1	Eau potable	L'accès est en petite quantité, elle ne nous suffit pas, maladies hydriques ; nos sources sont pareilles.
2	Ecole : Nacerhongwe, E.P Nyungwe, E.P Ngoma, Institut Ngoma, Institut Izambiro, E.P Kashuru Boba	Toute en état de délabrement.
3	Centre de santé Rudahoa : Aménagement + construction de la maternité	Il est nécessaire
4	Route RN5 → réservoir Nacerhongwe → réservoir Rudahoa → "	Pour des raisons d'accessibilité au niveau des réservoirs et dégager le milieu
5	Courant hydro électrique	Pour raisons d'éclairage - Sonerwa - Suivre le tel - usine de transformation - Rudahoa - Age d'insécurité - Charger les téléphones - Pour nous aider à sécuriser car les non affectés ont besoin d'une base ne
6	Activités génératrice des revenues pr les femmes, jeunes, les pers en situation de handicap Accès aux crédits	- Initiation sur l'autonomisation des femmes et jeunes.

[6Avez-vous des questions sur le Projet ? Y a-t-il d'autres aspects du projet qui vous inquiètent ou vous préoccupent ?

a) Avec le début des activités du Projet Ruzizi III ?
b) - Afin de ne pas commencer ~~à~~ comme le Projet a créé l'insécurité des personnes et l'insécurité alimentaire
- Crainte que les PAP ne puissent plus accéder à leurs champs restants.
- Crainte de l'accentuation du vol.
- Crainte de ne pas indemniser les PAP/ont retardé
- Baisse de confiance comme la REL a déjà traîné avec les indemnisations

A Travailler à Domicile

Autorité Nyangezi

REL
Ruzizi III Energy Limited

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - RÉUNION AVEC LES AUTORITÉS EN CHARGE DES AIRES PROTÉGÉES

Fiche d'enregistrement de l'entretien

Nom de l'Enquêteur : Stephane BYAMUNGU	Lieu de la réunion :
Nom de l'Institution :	Groupement de Kamombo (Autorités & leaders locaux).
Date / heure: 24/05/2024	Feuille d'enregistrement#

Participants

NOM DE FAMILLE / Prénom	Poste au sein de l'Organisation
BYAKWELI CANGWA Patient	Chef de section des Eglises 40e CECA
MURHULA KAJABIKA Fabien	Président de la jeunesse
LUGISHO BARHAKOMERWA	Animateur de développement.
MULANGANE BUHENDWA Emmanuel	Représentant Enseignants
KARHIKALEMBU MUBERHWA Dominien	Administrateur Gestionnaire Hôpital SHILO

Introduction:

L'enquêteur donnera aux participants un aperçu du Projet à l'aide de cartes et de dessins.

La description montrera l'emplacement du barrage, du réservoir, de la centrale électrique, du tunnel, des routes et d'un campement pour les travailleurs du chantier.

Les activités de construction seront décrites.

Le fonctionnement du réservoir et de la centrale électrique - avec les débits de pointe et hors pointe - sera brièvement décrit.

Questions

[1]. Quels sont les aspects les plus importants du bassin de la rivière Ruzizi selon vous ?

- C'est une zone fertile, touristique riche en flore. Une zone qui alimente suffisamment le groupement en vivres.
-

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - RÉUNION AVEC LES AUTORITÉS EN CHARGE DES AIRES PROTÉGÉES

[2]. Quels sont les principaux facteurs de perturbation ou défis pour l'environnement naturel et social du bassin de la rivière Ruzizi dans son ensemble ?

- Risque de famine au sein de la communauté (pauvreté).
- le déménagement qui favorisera l'exode rural
- Abandon de l'agriculture et l'élevage
- Destruction de l'écosystème : disparition des plants médicinals, les animaux.
-

[3]. Quels sont les principaux défis environnementaux et sociaux auxquels l'aire protégée est confrontée ? Quelles sont les principales mesures de gestion mises en œuvre ?

- Maladies dues à la pollution (par inallation)..
- Destruction de la bio diversité
- Déforestation. D'où il faut le reboisement
- Usage de masque de protection ⇒ ~~secusil~~ Equipement de protection
- Améliorer la qualité de l'eau.
- Améliorer la qualité de l'air par le reboisement

[4]. Quel type de suivi environnemental menez-vous et quelles sont les tendances actuelles ?

- Sensibilisation de la population sur le feu de brousse et la protection des animaux sauvages (Comme les singes)
Cependant, les animaux protégés comme les singes sont en voie de disparition suite aux activités de l'agriculture qui menacent leur lieu de démeure.
Faible sensibilisation sur la protection de l'environnement.

[5]. Y a-t-il du braconnage dans l'aire protégée ? - Quelles sont les mesures de prévention du braconnage et quelle est leur efficacité ?

- Le braconnage existe mais seuls les singes sont protégés tandis que les autres espèces sont en voie de disparition. Les mesures mises en place est la sensibilisation non efficace par manque des sanctions aux braconniers

[6]. Quelles sont les modifications de l'environnement naturel causées par le Projet qui vous préoccupent et pourquoi ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : débit de la rivière, niveau de l'eau, nombre de poissons, migration des poissons, faune, arbres, flore, plantes médicinales, oiseaux, qualité de l'air, niveaux de poussière, niveaux de bruit.

- La pollution du sol, de l'eau, de l'air et l'atmosphère
- Disparition de certains espèces animale et végétale
- Diminution de la population animale et végétale
- Création d'un lac en face du barrage qui peut avoir des conséquences néfastes à la végétation.

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - RÉUNION AVEC LES AUTORITÉS EN CHARGE DES AIRES PROTÉGÉES

[5]. Veuillez énumérer les 4 aspects les plus importants qui ont été discutés, par ordre de priorité. Veuillez expliquer pour chacun d'entre eux pourquoi il est important.

#	Élément de l'environnement / mode de vie de la communauté	Pourquoi c'est important
1	L'eau potable	Une denrée très importante pour la population surtout qu'elle va lutter contre la réduction des maladies hydrique.
2	Construction des marché	Approvisionnement en produits de première necessité mais aussi le relevement economique
3	Construction ds écoles	Améliorer la qualité de l'éducation des enfants.
4	Construction d'un Centre de santé moderne	Accès aux soins de santé de qualité.

[6]. Avez-vous des questions sur le Projet ? Y a-t-il d'autres aspects du Projet qui vous inquiètent ou vous préoccupent ?

- La main d'oeuvre sera t-elle locale?
- La population bénéficiera t-elle de ce courant comme la senario des projet Ruzizi IV ?
- N'y aura t-il pas d'autre projets à réaliser pour toucher les bénéficiaires indirects du projet ?
- Y aura t-il gestion rationnels des fonds ?

F. G. Femmes Nyangezi

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

Fiche d'enregistrement des discussions de groupe

Nom de l'animateur : Stéphanie Byamungu

Coordonnées GPS : X……
Y……

Nom du village / du district / du pays : Nyangezi / Kabare

Date / heure : Matin / le 24/05/2024

Fiche d'enregistrement #

Participantes

Nom de famille / Prénom	Genre (homme/femme)	Âge	Profession / rôle dans le village
NAOMIE M'MUNYEMA	F	35ans	Cultivatrice
KUSINZA MISEZARI	F	40ans	cultivatrice
BADERHA POLISI	F	45ans	Cultivatrice
MWANGAZA MASUMBUKO	F	30ans	Cultivatrice
BAHALEMBAKA CIHENGA	f	35ans	Cultivatrice.

Introduction :

L'enquêteur donnera aux participants un aperçu du Projet à l'aide de cartes et de dessins.

La description montrera l'emplacement du barrage, du réservoir, de la centrale électrique, du tunnel, des routes et d'un campement pour les travailleurs du chantier.

Les activités de construction seront décrites.

Le fonctionnement du réservoir et de la centrale électrique - avec les débits de pointe et hors pointe - sera brièvement décrit.

Questions

[1]. Selon vous, quels changements économiques pourraient survenir dans le village grâce au Projet et pourquoi - et quelle est l'importance de ces changements pour vous ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : valeur de la terre, prix de location de la terre, coût des produits de base.

- La valeur de la terre pourra s'améliorer suite à une forte demande suite aux terres qui seront cedées en faveur du projet. Les P.A.P. indemnisés en besoin des terres pourront les loger et les acheter à un prix raisonable
- La création de l'emploi permettra aux habitants d'améliorer leur habitat, de créer des AGR et faire des activités commerciales qui donneront une certaine valeur aux produits de première nécessité.

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[2]. Quels changements pourraient survenir dans la vie culturelle et le tissu social du village en raison du Projet, quelle est l'importance de ces changements pour vous ?

Les changements dans la vie culturelle peuvent être positifs ou négatifs
- Positifs : * Les femmes pourront avoir un emploi, apprendre les métiers et surtout avoir le pouvoir d'achat, leur autonomie et le respect.
* L'emploi aux hommes va reduire la charge aux femmes qui font (jour et nuit) travaillent jour et nuit pour leurs suivi et celui de leurs familles

Negatif : Parfois une insoumission chez certaines femmes suite au relevement financier particulièrement pour les foyers à problèmes.

[3]. Quelles sont vos préoccupations concernant l'embauche de travailleurs extérieurs à la région sur les sites du Projet ? Comment la présence des travailleurs pourrait-elle affecter la vie du village ? Quelle importance accordez-vous à cette question ?

L'embauche de travailleurs extérieurs est nécessaire en cas de besoin et cela lorsque leur expertise est absente dans la zone. Cependant, ils vont contribuer au développement dans la zone et surtout la naissance des activités génératrices de revenue.
Le mixage dû à la présence des travailleurs extérieurs n'impactera pas négativement la (population) culture des village car la population elle même est mixte.
Cependant, une mesure de protection des filles mineures pourraient être mises en place par REL pour les protéger contre ces travailleurs

[4]. Quelles sont les modifications de l'environnement naturel causées par le Projet qui vous préoccupent et pourquoi ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : débit de la rivière, niveau de l'eau, nombre de poissons, animaux sauvages, arbres, fleurs, plantes médicinales, oiseaux, qualité de l'air, niveaux de poussière, niveaux de bruit.

- La pollution est l'une des problèmes qui peuvent avoir des conséquences sur la santé de la population.
- Ce projet empechera aux population qui font leur élevage des petits bétails comme les chèvres de ne plus le faire car elles sont gardées dans la zone du projet.
- Les poissons et les animaux sont sauvage sont en régression dans la zone suite à la pêche inappropriée, l'agriculture et le feu de brousse. Neanmoins, le petit nombre des singes qui restent dans la zone risquent de disparaître.

- En barrant l'eau, un grand espace des champs sera immergé. Il en est de même pour les plantes.
- Le lit de la rivière Ruzizi risque d'avoir des perturba-

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[5]. Veuillez énumérer les 6 aspects les plus importants de votre communauté et de votre mode de vie dont nous avons discuté, par ordre de priorité. Veuillez expliquer pour chacun d'entre eux pourquoi il est important.

#	Élément de l'environnement / mode de vie de la communauté	Pourquoi c'est important
1	L'eau potable	Lutter contre les maladies hydriques.
2	Construction des écols (et centre de santé).	Les enfants vont étudier dans de bonnes conditions et la réduction de la charge des parents sur les frais scolaires et sanitaires
3	Route de desserte agricole reliant la Route Nationale n°5 au barrage	*Donner un accès facile au lieu de travail. * Valorisation de nos produits agricoles, car ils seront vendus même aux ~~travailleurs~~
4	Construction d'un centre de santé moderne	Accès aux soins de santé de qualité et surtout réduire au taux de mortalité lors d'accouchement dû à la longue distance pour atteindre l'hôpital
5	Construction du marché	Promouvoir les activités commerciales dans la zone et surtout les échanges commerciaux avec les autres groupements Relevement économique.
6	Centre de formation socio professionnel	Permettre aux femmes d'avoir un accès facile à la formation des métier afin d'avoir un emploi dans le projet.

[6Avez-vous des questions sur le Projet ? Y a-t-il d'autres aspects du projet qui vous inquiètent ou vous préoccupent ?

- Certaines personnes sont des pêcheurs des poissons et les femmes voudraient savoir si celles-ci auront toujours cette permission dans la zone du projet.
- Ce projet sera t-il réalisé étant donné qu'il a beaucoup duré et peine à débuter.
-

F. G Femmes Kamanyola.

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

Fiche d'enregistrement des discussions de groupe

Nom de l'animateur : Stephane BAHAMUREGE	Coordonnées GPS : X…… Y……
Nom du village / du district / du pays KAFUNDA	
Date / heure : 15h00 le 23/05/2024	Fiche d'enregistrement #

Participantes

Nom de famille / Prénom	Genre (homme/femme)	Âge	Profession / rôle dans le village
FRANCINE M'BASHIRI	F	31 ans	V. Coordo - PAP.
NSIMIRE M'KABANGULO	F	42 ans	membre de comité PAP.
MARIE M'GALIRWA	F	35 ans	Cultivatrice
NSIMIRE BUTOTO	F	25 ans	Cultivatrice
MUSAMINI BACHUEBA	F	56 ans	Cultivatrice
M'NYABAHIKO SAVERINE	F	60 ans	
MUHIGIRE NAWEZA	F	42 ans	m. comité PAP.
MACORI MASUMBUKO	F	29 ans	Cultivatrice

Introduction :

L'enquêteur donnera aux participants un aperçu du Projet à l'aide de cartes et de dessins.

La description montrera l'emplacement du barrage, du réservoir, de la centrale électrique, du tunnel, des routes et d'un campement pour les travailleurs du chantier.

Les activités de construction seront décrites.

Le fonctionnement du réservoir et de la centrale électrique - avec les débits de pointe et hors pointe - sera brièvement décrit.

Questions

[1]. Selon vous, quels changements économiques pourraient survenir dans le village grâce au Projet et pourquoi - et quelle est l'importance de ces changements pour vous ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : valeur de la terre, prix de location de la terre, coût des produits de base.

- Accès aux moyens financiers
- Favoriser le développement
- Faciliter l'accès à nos enfants à l'école
- Accès aux soins

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[2]. Quels changements pourraient survenir dans la vie culturelle et le tissu social du village en raison du Projet, quelle est l'importance de ces changements pour vous ?

- Apprentissage auprès des autres (IT, ix autres)
- Impact sur le marché / hausse de prix
- vol des poulets et de biens
- DVPt des milieux
- criminalité grandissante

[3]. Quelles sont vos préoccupations concernant l'embauche de travailleurs extérieurs à la région sur les sites du Projet ? Comment la présence des travailleurs pourrait-elle affecter la vie du village ? Quelle importance accordez-vous à cette question ?

- Ils sont les bienvenus
- Les étrangers doivent vivre avec ceux d'ici
- Nous allons apprendre au près d'eux
- Changement de comportement
- DVPt économique

Désavantages :
- Poids sur le Projet / responsable
- routes qui n'ont pas des bandits passés
- l'influence sur les divisions
- déboisement de la main d'œuvre locale

[4]. Quelles sont les modifications de l'environnement naturel causées par le Projet qui vous préoccupent et pourquoi ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : débit de la rivière, niveau de l'eau, nombre de poissons, animaux sauvages, arbres, fleurs, plantes médicinales, oiseaux, qualité de l'air, niveaux de poussière, niveaux de bruit.

R/ - Barrage construit
- usage du courant
- démonte des bois / déforestation
- baisse de la production
- accès de la consommation / branchement.
- Animaux sauvages : disparition etc

Pour le Papa
- Plus de respect
- les pères deviennent bandits
- les fêtes sont exposés au vols

- Equilibre économique
- mariage légaux
- les fêtes sont discrets

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[5]. Veuillez énumérer les 6 aspects les plus importants de votre communauté et de votre mode de vie dont nous avons discuté, par ordre de priorité. Veuillez expliquer pour chacun d'entre eux pourquoi il est important.

#	Élément de l'environnement / mode de vie de la communauté	Pourquoi c'est important
1	Pont reliant [illegible]	- Relance segue des milieu - échange commerciaux
2	Eau potable	- Consommation - Reduire les risques d'origine hydrique.
3	Ecole : maternelle, primaire.	faire étudier les enfants dans un cadre idéal
4	AGR femmes & jeunes	Reduire le vol à la paroisse
5	Courant.	Pour l'éclairage et la reduction de l'insécurité
6	Centre de santé	Le C.S n'existe pas à Kafumbe.

[6Avez-vous des questions sur le Projet ? Y a-t-il d'autres aspects du projet qui vous inquiètent ou vous préoccupent ?

RAS

F.G Hommes Kamanyola

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

Fiche d'enregistrement des discussions de groupe

Nom de l'animateur : Stephane BYAMUNGU	Coordonnées GPS : X…… Y……
Nom du village / du district / du pays : Kamanyola / Kashenyi	
Date / heure : Le 23/05/2024 à 13h00'	Fiche d'enregistrement #

Participantes

Nom de famille / Prénom	Genre (homme/femme)	Âge	Profession / rôle dans le village
Franco KACANUKA	M	50	Pres CDQ.
PACifique NAMBEKERA	M	54	Sec Com PDP.
~~Francine MIBASHI~~	~~F~~	~~31~~	~~V. Cord. PDP.~~
Bebaba BUTESHERWA	M	38	
Safari MUNOGA	M	49	Pres PDP.
~~USIMARE MIKARAMUKO~~	~~F~~	~~42~~	
Marie RUTUPI	M	28	
RUKUNDU John	M	32	
ASifiwe RAHACHI	M	35	

Introduction :

L'enquêteur donnera aux participants un aperçu du Projet à l'aide de cartes et de dessins.

La description montrera l'emplacement du barrage, du réservoir, de la centrale électrique, du tunnel, des routes et d'un campement pour les travailleurs du chantier.

Les activités de construction seront décrites.

Le fonctionnement du réservoir et de la centrale électrique - avec les débits de pointe et hors pointe - sera brièvement décrit.

Questions

[1]. Selon vous, quels changements économiques pourraient survenir dans le village grâce au Projet et pourquoi - et quelle est l'importance de ces changements pour vous ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : valeur de la terre, prix de location de la terre, coût des produits de base.

R/ - Accès à l'emploi
- Circulat° monétaire
- Comerce
- Ces hotel et des maisons d'accueil seront bâtis
- Dvpt économique, agriculture x élevage
- Ces jeunes seront tjs occupé
- Diversité des activités économiques / commerciales

Terre : Valeur ajouté

	Avant le P.	Pendant & Après Projet
Achat	250 m² = 50.000 (2000 $)	120.000 $ 30.000 $
Location	25 m² = 5 $	20 $

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[2]. Quels changements pourraient survenir dans la vie culturelle et le tissu social du village en raison du Projet, quelle est l'importance de ces changements pour vous ?

R/- Hausse de la demande effective
- Les produits de la 1ère nécessité seront recherchés
- Les besoins seront accrus
- Cas de violences sexuel
-

[3]. Quelles sont vos préoccupations concernant l'embauche de travailleurs extérieurs à la région sur les sites du Projet ? Comment la présence des travailleurs pourrait-elle affecter la vie du village ? Quelle importance accordez-vous à cette question ?

R/- Valeur ajoutée
- Impact
- Apprentissage techn.
- Promot° travail-professionnel
- Métissage
- Renforcement des capacités techniques de la main d'oeuvre local
- formation
-

- Engrossement des filles
- Maladies sexuelles
- Conflits
- Séparation des foyers
- Débauchage de la main d'oeuvre locale

[4]. Quelles sont les modifications de l'environnement naturel causées par le Projet qui vous préoccupent et pourquoi ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : débit de la rivière, niveau de l'eau, nombre de poissons, animaux sauvages, arbres, fleurs, plantes médicinales, oiseaux, qualité de l'air, niveaux de poussière, niveaux de bruit.

R/- Impact négatif sur la biodiversité aquatique
- Déboisement
- Besoins accrus des bois de chauffe, brasi, ect briques ect
- Menace des ressources naturels
- ~~Assainissement~~
- Probl des déchets
- Sachets bio x non dégradable
- Perte des espaces verts x arable

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PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - DISCUSSIONS DE GROUPE

[5]. Veuillez énumérer les 6 aspects les plus importants de votre communauté et de votre mode de vie dont nous avons discuté, par ordre de priorité. Veuillez expliquer pour chacun d'entre eux pourquoi il est important.

#	Élément de l'environnement / mode de vie de la communauté	Pourquoi c'est important
1	Pont reliant la RDC au Burundi	Pour faciliter la communication entre les 2 pays et la pendule économique de Kamanyola.
2	Eau potable	Reduction de maladies d'origine hydrique.
3	AGR.	Developpement économique et social des communautés
4	Rehab de RDA	faciliter l'accès, et l'évacuation des produits champêtres
5	Ecoles / Structures scolaires	Permettre aux élèves d'étudier dans un cadre adéquat
6	PDA et PSH.	dans le but d'appuyer au mécanisme directes des PDA & PSH.

[6Avez-vous des questions sur le Projet ? Y a-t-il d'autres aspects du projet qui vous inquiètent ou vous préoccupent ?

RAS.

PUBLIC DISCLOSURE AUTHORIZED

Rwanda

PUBLIC DISCLOSURE AUTHORIZED

REL Ruzizi III Energy Limited

SLR

RUZIZI III HYDROELECTRIC POWER PROJECT
CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

Focus Group Discuss Attendance Sheet	
Name of Village / District / Country KABEZA / RUSIZI / RWANDA	
Date / time: 17/05/2024 / 9h20 - 10h55	Record Sheet #
Participants	

To be read out to participants: *By signing the register, you as the participant, agree/consent to the participation in the focus group discussion. You have the right not to answer or even to stop your participation whenever you feel uncomfortable with any questions being asked. Your answers will be rendered anonymous, and your name will not be connected to any information or the answers you provide. Your photograph might be taken during the meeting and used in SLR reports, but you have the right to refuse to be photographed.*

#	FAMILY NAME	First Name	Male/Female	Age	Occupation	Tel No.	Signature
1	INGABIRE	Beatha	F	48	Umuhinzi	0783242182	
2	UZAMUSHAKA	Athenie	F	49	Umuhinzi	0723841769	
3	Niminani	petronille	F	44	umuhinzi	0784766644	
4	Nzitabakuze	Gratien	M	45	Umuhinzi	0725395642	
5	Ntabimana	Innocent	M	54	umuhinzi	0795931448	
6	NGwabije	Emoki	M	82	umuhinzi		
7	Masumbuko	George	M	74	umuhinzi	0789514106	
8	NSabimana	Immaculé	M	63	umuhinzi	0790 308372	
9	NDaci mana	bosco	M	42	Uhinzi	0786091444	
10	AYANKAMIYE	Anathalie	F	50	UMUHINZI	0782955564	

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SLR

RUZIZI III HYDROELECTRIC POWER PROJECT
CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

Focus Group Discuss Attendance Sheet	
Name of Village / District / Country NYARAHANGA / RUSIZI / RWANDA	
Date / time: 17/05/2024 - 15h - 16h30	Record Sheet #
Participants	

To be read out to participants: *By signing the register, you as the participant, agree/consent to the participation in the focus group discussion. You have the right not to answer or even to stop your participation whenever you feel uncomfortable with any questions being asked. Your answers will be rendered anonymous, and your name will not be connected to any information or the answers you provide. Your photograph might be taken during the meeting and used in SLR reports, but you have the right to refuse to be photographed.*

#	FAMILY NAME	First Name	Male/Female	Age	Occupation	Tel No.	Signature
1	~~HABYARIMA~~ NIZA	ANICET	M	54	Ubucuruzi	0784417373	
2	BIKORIMANA	J. Pierre	M	45	Mutekano	0781968730	
3	NYIRARENZAHO	NATARIA	F.	65	Gucuruza imbuto		
4	MUKARURANGWA	ALphonsine.	F.	40	Umucuruzi	0798732100	
5	NTAWUHIGANAYO	Drophine.	F.	37	Ubucuruzi	0727808345	
6	TWAGIRAYEZU	innocent	M.	53	Umuhinzi Mworozi	0724398203	
7	UWIMANA.	Ahianne	F.	35	Ubucuruzi	0782693110	
8	UKWITEGETSE	MERIA.	F.	51	Ubucuruzi	0722866926	
9							
10							

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RUZIZI III HYDROELECTRIC POWER PROJECT
CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

Focus Group Discuss Record Sheet	
Facilitator name: NGIRINSHUTI Emile	GPS coordinates : X 2°41'49.0" Y 29°00'30.9"
Name of Village / District / Country KABEZA / RUSIZI / RWANDA	
Date / time: 17/05/2024 / 9h20-10h55	Record Sheet #

Participantes

Family Name / First name	Gender (male/female)	Age	Occupation / role in village
IMGABIRE Beatha	F	48	Umuhinzi
N. mirwanani-petronille	F	44	umuhinzi
Uzamukunda-Sidercyo	F	49	umuhinzi
AYINKAMIYE ANATORIE	F	50	MUNIGUDU

Introduction :

The Facilitator will provide the participants with an overview of the project with the help of maps and drawings.

The description will show the location of the dam, reservoir, powerhouse, tunnel, roads and construction camp.

The construction activities will be described.

The operation of the reservoir and powerhouse – with peak and off peak flows will be briefly described.

Questions

[1]. What economic changes do you think might happen in the village because of the Project and why - and how important is that to you?

Note for facilitator: If needed, the following examples can be suggested: value of land, price for renting land, cost of commodities.

① Job creation might offer higher wages; ② Increased local businesses which lead to the demand of local services such as food, renting prices, cost of commodities.

Importance: ① Reducing poverty; ② Improving livelihoods of vulnerable groups; ③ Diversification of economic activities.

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RUZIZI III HYDROELECTRIC POWER PROJECT

CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

[2]. What changes to the cultural life and social fabric of the village might happen because of the Project, how important is that to you?

① The outside workers can introduce of new cultural practices and tradition ② lifestyle changes ③ Economic empowerment ④ Reduction of our youth migration to the cities ⑤ Social changes and networks lead to the conflicts.

Importance: ① Modernisation and tradions can be balanced ② Inclusive ~~economi~~ social-economic growth.

[3]. What are your concerns regarding the employment of workers from outside the region at the Project worksites? How might the presence of the workers affect the life in the village? How important is that for you.

① Job competition the newcomers will compelete with local especially vulnerable groups.
② Social conflicts; ③ Impact on local businesses and higher cost of renting
Effect ① Inflation: hugher costs of commodities; ② Increased pressure in education

Importance: ① Economic growth; ② Higher quality of life for locals throught employment.

[4]. What changes to the natural environment caused by the Project are you concerned about and why.

Note for facilitator: If needed, the following examples can be suggested: river flow rates, water level, number of fish, wild animals, trees, flowers, medicinal plants, birds, air quality, dust levels, noise levels.

① Noise pollution: heavy trucks which reduce the quality of life.
② Biodiversity losses: loss of fish species; medicinal plants; trees.
③ Air quality and pollution: due to the dust and emissions from machinery.

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CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

[5]. Please list the 6 most important aspects of your community and way of life we discussed, by order of priority. For each one, explain why it is important.

#	Element of environment / community way of life	Why it is important
1	Employment to the local community specially women and youth.	Vulnerable groups will benefit from new jobs creation.
2	Local businesses opportunities for women.	local businesses create a sustainable economy to the women groups.
3	Community engagement	Women will be accountable to the family development.
4	Improved quality of life of the women and their families.	Access to finance through wages will be gained; education quality to their children.
5	Social Cohesion	Conflict resolution among family members, strong community bonds.
6	Environmental conservation.	Environmental protection and ensuring that natural resources are preserved for future generations.

[6]. Do you have any questions about the Project? Is there anything else about the Project that you are worried or concerned about?

① Hiring the outside workers might displace local communities especials women, which will lead to unemployements.

② when will the project pay us the compensation fees?

Thank you

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RUZIZI III HYDROELECTRIC POWER PROJECT
CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

Focus Group Discuss Record Sheet		
Facilitator name: NGIRINSHUTI Emile	GPS coordinates : X..2°.41'.49.0"..... Y..29°.00'.30.9"	
Name of Village / District / Country KABEZA / RUSIZI / RWANDA		
Date / time: 17/05/2024 / 9h20 - 10h55		Record Sheet #

Participantes

Family Name / First name	Gender (male/female)	Age	Occupation / role in village
AZINKAMIYE AMATORIE	F	50	FUDUGUDU
NSabimana Innocent	M	63	umuhinzi
Nzumbuko George	M.	74	umuhinzi
MGWABIJE Enock	M	82	umuhinzi
INGABIRE Beatha	F	48	Umuhinzi
Nyiramoni Petronille	F	44	Umuhinzi
Uwamahoro Sideriya	F	49	Umuhinzi
NZIGAMAKUZE Gratien	M	45	Umuhinzi

Introduction :

The Facilitator will provide the participants with an overview of the project with the help of maps and drawings.

The description will show the location of the dam, reservoir, powerhouse, tunnel, roads and construction camp.

The construction activities will be described.

The operation of the reservoir and powerhouse – with peak and off peak flows will be briefly described.

Questions

[1]. What economic changes do you think might happen in the village because of the Project and why - and how important is that to you?

Note for facilitator: If needed, the following examples can be suggested: value of land, price for renting land, cost of commodities.

Economic changes might happen in the village because of the project are the following: ① Increased local business activity: Construction and operation phases may increase demand for local services such as food and retail; ② Improved roads, utilities and facilities could be part of the project, benefiting the villages overall economy. ③ Job created by the project might offer higher wages than existing local opportunities, improving living standards. ④ workers moving to the area may boost demand for housing. Importance to us: ① Reducing poverty ② Improving livelihoods, ③ The village might be more resilient due to the diversified economic activity.

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RUZIZI III HYDROELECTRIC POWER PROJECT

CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

[2]. What changes to the cultural life and social fabric of the village might happen because of the Project, how important is that to you?

① Influx of workers can lead to the introduction of new cultural practices and traditions. ② lifestyle changes could shift social norms and tradition practices. ③ strengthening social networks; and changes which can lead to the conflicts or tensions between new comers and permanent residents. ④ Economic empowerment (woman and youths through job opportunities ⑤ Reduction of youth migration to urban areas.

Importance to us: ① Balance between tradition and modernisation is important to us; ② Inclusive growth, particularly vulnerable groups from benefiting the project opportunities.

[3]. What are your concerns regarding the employment of workers from outside the region at the Project worksites? How might the presence of the workers affect the life in the village? How important is that for you.

Concerns: ① Jobs competition (outside workers will compete with local residents. ② skills mismatch; ③ social conflicts between local residents and outside workers. ④ Higher costs of local housing and other services; ⑤ Impact on local businesses.

Effect on village life: ① Improved cultural exchange; ② Inflation: Prices for goods, services might rise due to the higher demand; ③ Increased pressure in education and other services such as healthcare which could affect their quality and accessibility.

Importance: ① Economic growth; ② The high quality of life for local residents; ③ Prioritizing employment to the local residents.

[4]. What changes to the natural environment caused by the Project are you concerned about and why.

Note for facilitator: If needed, the following examples can be suggested: river flow rates, water level, number of fish, wild animals, trees, flowers, medicinal plants, birds, air quality, dust levels, noise levels.

1). Biodiversity loss and destruction to the natural habitat: loss of species can disrupt ecological balance and negative impact such as water purification pollination.

2) Air quality and pollution: Poor air quality leads to the negative effects on human health and air pollution due to the dust, emissions from machinery

③ Noise pollution: reduce the quality of life for communities.

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CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

[5]. Please list the 6 most important aspects of your community and way of life we discussed, by order of priority. For each one, explain why it is important.

#	Element of environment / community way of life	Why it is important
1	Employment to the local residents.	Ensure that local communities benefit from new jobs which might lead to the economic empowerment and reducing poverty.
2	local businesses opportunities	local businesses create a sustainable local economy. Fostering entrepreneurship in the village.
3	Maintaing social cohesion	strong community bonds, conflict reduction, conservation of traditions
4	Community Engagement	Accountability; sense of ownership.
5	Quality of life of local Communities.	Access to health services, Education quality and welfare of communities.
6	Environmental conservation and sustainable infrastructure	Environment protection and sustainable infrastructure as crucial for long-term community viability and ensuring that natural resources are conserved for future generations.

[6]. Do you have any questions about the Project? Is there anything else about the Project that you are worried or concerned about?

① How many jobs will be created by the project, and what proportion will be reserved for local communities?.

② When will the project pay us the compensation fees?

③ There is a concern that hiring outside workers might displaced local communites, leading to unemployment among locals.

Thank you

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RUZIZI III HYDROELECTRIC POWER PROJECT
CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

Focus Group Discuss Record Sheet	
Facilitator name: NGIRINSHUTI Emile	GPS coordinates : X 2°40'39.7" Y 28°56'50.3"
Name of Village / District / Country NYAGAHANGA / RUSIZI / RWANDA	
Date / time: 17/05/2024 - 15h - 16h30	Record Sheet #

Participantes

Family Name / First name	Gender (male/female)	Age	Occupation / role in village
Nzirarenzaho Anatalia	F	65	Gucuruza imbuto
Mukarurangwa Alphonsine	F	40	Umucuruzi
Ntawuhiganayo Prophine	F	37	Umucuruzi
Uwimana Éliane	F	35	Ubucuruzi
Kwitegetse Merida	F	51	Ubucuruzi

Introduction :

The Facilitator will provide the participants with an overview of the project with the help of maps and drawings.

The description will show the location of the dam, reservoir, powerhouse, tunnel, roads and construction camp.

The construction activities will be described.

The operation of the reservoir and powerhouse – with peak and off peak flows will be briefly described.

Questions

[1]. What economic changes do you think might happen in the village because of the Project and why - and how important is that to you?

Note for facilitator: if needed, the following examples can be suggested: value of land, price for renting land, cost of commodities.

① Increased small businesses of the women like restaurants, selling fruits and vegetables.

② The value of land will be increased and nowadays the ~~fait~~ for renting land is higher than before and the cost of commodities is higher. Before renting was at 50000 Rwf but now is ranging between 100000 - 150.000 Rwf. But the value of land depends on the location.

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[2]. What changes to the cultural life and social fabric of the village might happen because of the Project, how important is that to you?

① The new cultural practices will be introduced like. Polygamy or polyandry which could lead to the family conflicts.

② lifestyle changes: The local communities will be changed by the behaviors of newcomers on how they do different things.

③ Interacting with other community.

[3]. What are your concerns regarding the employment of workers from outside the region at the Project worksites? How might the presence of the workers affect the life in the village? How important is that for you.

① Job competition between outside workers and local communities.
② Social conflicts among outsiders and local.

Effect ① Increased pressure in basic needs (education, healthcare)
② Higher price of renting houses.
③ High cost of our production (commodities).

Importance ① Economic growth in the project worksites.
② The quality of life will be improved through monetary circulation.

[4]. What changes to the natural environment caused by the Project are you concerned about and why.

Note for facilitator: If needed, the following examples can be suggested: river flow rates, water level, number of fish, wild animals, trees, flowers, medicinal plants, birds, air quality, dust levels, noise levels.

① Noise pollution caused by heavy trucks lead to the disruption of local wildlife
② Biodiversity losses caused by project activities lead to the destruction of natural environment.

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CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

[5]. Please list the 6 most important aspects of your community and way of life we discussed, by order of priority. For each one, explain why it is important.

#	Element of environment / community way of life	Why it is important
1	Employment	Our younger children's will be prioritized to get a job and unemployed in our village will be sensibilized.
2	Strong Community ties	Maintaining cultural identity and social harmony of our community.
3	Community engagement	To empower community to play an active role in development process.
4	Improved small businesses opportunities.	local businesses will be created to sustain local economy in our project area (village).
5		
6		

[6]. Do you have any questions about the Project? Is there anything else about the Project that you are worried or concerned about?

When will the project pay us the compensation fees?

Thank you

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RUZIZI III HYDROELECTRIC POWER PROJECT
CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

Focus Group Discuss Record Sheet

Facilitator name: NGIRINSHUTI Emile	GPS coordinates : X 2°40'39.7" Y 28°56'50.3"
Name of Village / District / Country	NYAGAHANGA / RUSIZI / RWANDA
Date / time: 17/05/2024 - 15h - 16h30	Record Sheet #

Participantes

Family Name / First name	Gender (male/female)	Age	Occupation / role in village
Habyarimana Aniket	M	54	Ubucuruzi
Bikorimana J Pieri	M	45	Mutekano
Nyirarenzaho Anatalia	F	65	Gucuruza imbuto
Mukarurangwa Alphonsine	F	40	Umucuruzi
Ntawuhiganayo Drophine	F	37	Ubucuruzi
Twagirayezu Innocent	M	53	Umuhinzi mworozi
Uwimana Éliane	F	35	Ubucuruzi
Ukwitegetse Merida	F	51	Ubucuruzi

Introduction :

The Facilitator will provide the participants with an overview of the project with the help of maps and drawings.

The description will show the location of the dam, reservoir, powerhouse, tunnel, roads and construction camp.

The construction activities will be described.

The operation of the reservoir and powerhouse – with peak and off peak flows will be briefly described.

Questions

[1]. What economic changes do you think might happen in the village because of the Project and why - and how important is that to you?

Note for facilitator: If needed, the following examples can be suggested: value of land, price for renting land, cost of commodities.

① Job creation might offer higher salaries which will impact positively our livelihoods.
② Increased small businesses in our community. ③ Our houses will be rented and we will gain money through our commodities ④ Access to finance because of our wages will pass through microfinance institutions.
⑤ Even now price of renting land is expensive than before in 2021

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CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

[2]. What changes to the cultural life and social fabric of the village might happen because of the Project, how important is that to you?

① Introduction of new cultural practices from the outside workers.
② lifestyle changes: some things will be expensive. mainly basic daily needs.
③ social changes lead to the conflicts among family members.

Importance: - Inclusive economic growth.
- Balance modernisation and tradition.
- Interaction with other community

[3]. What are your concerns regarding the employment of workers from outside the region at the Project worksites? How might the presence of the workers affect the life in the village? How important is that for you.

① The outside workers will compete with us in getting jobs.
② Social conflicts with the outside workers might arise.

Effect: ① Higher price of renting houses; ② Increased pressure in different services (education, healthcare) ③ Inflation: Higher costs of our commodities.

Importance: Meanwhile the quality of life for locals will be improved through employment; economic growth in the project area (worksites).

[4]. What changes to the natural environment caused by the Project are you concerned about and why.

Note for facilitator: If needed, the following examples can be suggested: river flow rates, water level, number of fish, wild animals, trees, flowers, medicinal plants, birds, air quality, dust levels, noise levels.

① The project might affect water through overuse or pollution
② Destruction of habitat: the project activities could lead to the destruction of natural environment (local wildlife and biodiversity)
③ Noise pollution: project activities might lead to the disruption of local wildlife and quality life of communities.

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CUMULATIVE IMPACT ASSESSMENT – FOCUS GROUP DISCUSSIONS

[5]. Please list the 6 most important aspects of your community and way of life we discussed, by order of priority. For each one, explain why it is important.

#	Element of environment / community way of life	Why it is important
1	Employment to the local Communities.	Project activies will create the new jobs to our younger childrens
2	Improved local Businesses opportunities.	local businesses will sustain local economy in the project area
3	Access to public services and improving quality of life.	To have a better quality of life depends on accessing the basic needs such as healthcare, education and sanitation as fundament to the wellbeing.
4	Community engagement	Community engagement empowers communities to play an active role in Community development process.
5	Environmental stewardship	Environmental protection as a pivot for long term viability of the communities by conserving natural resources.
6	Preservation of traditions and strong Community ties.	To continue maintain social harmony and cultural identity of Community.

[6]. Do you have any questions about the Project? Is there anything else about the Project that you are worried or concerned about?

When will the project pay us the Compensation fees?

Thank you

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Nyagahanga village/Murya cell/Nzahaha sector

Kabeza village/Nyange cell/Bugarama sector

PUBLIC DISCLOSURE AUTHORIZED

Rusizi National Park Authorities

PUBLIC DISCLOSURE AUTHORIZED

Fiche de présence à la réunion des Parties prenantes institutionnelles sur l'évaluation de l'impact sur la communauté	
Nom de l'Institution / Organisation **Parc National de la Rusizi**	
Lieu de la réunion **Installation temporaire à l'extérieur du Parc**	
Date / heure: **18/06/2024 – 14h00**	Fiche d'enregistrement # **003**
Participants **(3)**	

#	NOM DE FAMILLE	Prénom	Homme/Femme	Âge	Poste	N° de tél.	Signature
1	MATESO	Madeleine	F	42	Caissière & guide touristique	+257 61 88 99 11	
2	NDIMUBAKUNZI	Elie	H	43	Garde forestier	-	
3	SINÙOHAGERA	Jean Bosco	H	52	Chef de secteur & guide touristique	+ 257 79 71 07 61	
4							
5							
6							
7							
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9							
10							
11							

PROJET DE CENTRALE HYDROÉLECTRIQUE RUZIZI III
ÉVALUATION DE L'IMPACT CUMULATIF - RÉUNION AVEC LES AUTORITÉS EN CHARGE DES AIRES PROTÉGÉES

Fiche d'enregistrement de l'entretien	
Nom de l'Enquêteur : **Guylaine Ntunaguza**	Lieu de la réunion : **Installation temporaire à l'extérieur du Parc**
Nom de l'Institution : **Parc National de la Rusizi**	
Date / heure: **18/06/2024 – 14h00**	Feuille d'enregistrement# **003**

Participants

NOM DE FAMILLE / Prénom	Poste au sein de l'Organisation
MATESO / Madeleine	Caissière & guide touristique
NDIMUBAKUNZI / Elie	Garde forestier
SINZOHAGERA / Jean Bosco	Chef de secteur & guide touristique

Introduction:

L'enquêteur donnera aux participants un aperçu du Projet à l'aide de cartes et de dessins.

La description montrera l'emplacement du barrage, du réservoir, de la centrale électrique, du tunnel, des routes et d'un campement pour les travailleurs du chantier.

Les activités de construction seront décrites.

Le fonctionnement du réservoir et de la centrale électrique - avec les débits de pointe et hors pointe - sera brièvement décrit.

Questions

[1]. Quels sont les aspects les plus importants du bassin de la rivière Ruzizi selon vous ?

- **L'écosystème**
- **La biodiversité qui font partie de la faune / flore, qui sont les éléments les plus importants**

[2]. Quels sont les principaux facteurs de perturbation ou défis pour l'environnement naturel et social du bassin de la rivière Ruzizi dans son ensemble ?

En tenant compte du contexte actuelle, les inondations. La population en souffre. Au niveau du Parc, ils n'ont plus de lieu de travail, les visites sont réduites considérablement, pas de contrôle d'animaux et souvent les gens ont peur de faire le tour même en bateau, ne sachant pas d'où peuvent survenir les animaux, ex ; les crocodiles. N'ayant pas de visites, il n'y a pas d'entrées de fonds.

[3]. Quels sont les principaux défis environnementaux et sociaux auxquels l'aire protégée est confrontée ? Quelles sont les principales mesures de gestion mises en œuvre ?

L'ecosystem a besoin d'être protégé et il faut donc une sensibilisation de la population, par exemple, pour respecter les limites. Actuellement, il y a des réunions de sensibilisation qui sont effectués par des associations qui travaillent directement avec le staff du Parc.

[4]. Quel type de suivi environnemental menez-vous et quelles sont les tendances actuelles ?

Actuellement, il n'y a pas de suivi qui est fait, c'est impossible. Il y a des oiseaux et animaux qui ont été relocalisés à Rukoko.

À cause du niveau d'eau, les animaux se sont retrouvés sur la rue et le parc à perdu 12 antilopes, mangé par des chiens.

[5]. Y a-t-il du braconnage dans l'aire protégée ? - Quelles sont les mesures de prévention du braconnage et quelle est leur efficacité ?

Oui, il y en a, mais pas en mesure de dire en quel quantité. Ceux qui font le braconnage, lorsque attrapés, il sont envoyés en prison, mais évidemment certains le font en cachette et ne sont pas attrapés.

Il faudrait clôturer sur une plus longue surface pour empêcher un accès relativement facile au Parc. Les patrouilles sont effectués, à pied, et à bateau, mais en ce moment, avec la pénurie de carburant, c'est encore plus difficile d'assurer ces patrouilles

[6]. Quelles sont les modifications de l'environnement naturel causées par le Projet qui vous préoccupent et pourquoi ?

Note pour l'animateur : Si nécessaire, les exemples suivants peuvent être suggérés : débit de la rivière, niveau de l'eau, nombre de poissons, migration des poissons, faune, arbres, flore, plantes médicinales, oiseaux, qualité de l'air, niveaux de poussière, niveaux de bruit.

Pas du côté du Parc National ou du Burundi

[5]. Veuillez énumérer les 4 aspects les plus importants qui ont été discutés, par ordre de priorité. Veuillez expliquer pour chacun d'entre eux pourquoi il est important.

#	Élément de l'environnement / mode de vie de la communauté	Pourquoi c'est important
1	**Construire une digue**	Elle va donner une direction de la Rusizi pour empêcher que la population soit envahie par les inondations
2	**Stopper le braconnage**	Pour garder et préserver l'habitat des animaux vivant dans le Parc
3	**Faciliter le travail des associations de femmes**	Ces femmes aident dans le Parc en faisant le nettoyage des mauvaises herbes, du bois mort, ce qui aide à garder le Parc propre
4	**Avoir un Parc qui est fonctionnelle**	Cela apporte des touristes qui font des apports financiers au Parc, et donc aux employés, - si le Parc ne fonctionne pas, pas de boulot pour eux, pas de salaire, pas d'appui pour les familles. Lorsqu'il y a visite de touristes, cela veut aussi dire entrée des devises dans le pays.

[6]. Avez-vous des questions sur le Projet ? Y a-t-il d'autres aspects du Projet qui vous inquiètent ou vous préoccupent ?

- **À quand le début des travaux**
- **Avec qui le projet va travailler au niveau du Burundi**
- **Est-ce que le staff du Parc National seront nécessaires pendant la réalisation du projet**
- **Est-ce que le respect des normes de protection de l'environnement seront respectés**

Merci