MINISTRY OF ENVIRONMENT
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Document I – Terms of Reference

Assessing flood risk and its potential control and management in Masaka wetland, Rwanda

a. Background

Water for Growth Rwanda is a joint Rwanda - Netherlands programme, implemented by the Government of Rwanda and supported by the Embassy of the Kingdom of the Netherlands (EKN), covering a period of 4 years from May 2015 up to and including April 2019. The overall objective of the programme is to effectively manage water resources to contribute to sustainable socio-economic development and equitably improved livelihoods. The implementation is through a consortium of Mott MacDonald (lead), SHER and SNV.

Masaka is a wetland located in the south-east of Kigali. Recently, the wetland has been subjected to flooding putting at risk major infrastructures in the vicinity. A combination of climatic factors and man-made activities (major agriculture development, industries, roads, etc. all reclaiming wetland areas) have resulted in constant flooding and formation of a permanent lake in the wetland that, when affected by water level increases associated with rainfall events, threaten major infrastructure. None of the previous assessments of flooding in area were done using a proper, in-depth assessment of hydrological changes within the area; nor did they seek to determine what exactly the problem/s is/are and how to best address it/them.

The Government of Rwanda (GoR) would ideally like to protect the wetland environment and, at the same time, protect existing infrastructures in the area.

It is within this context that the Ministry of Environment (MoE) through the Rwanda Water and Forestry Authority/ Water Resources Management Department (RWFA/WRMD), with the support of the Water for Growth Rwanda (W4GR) programme, intends to procure the services of a Consultant to conduct a hydrological and hydraulic study that will allow decisions to be made on how to ensure sustainable flood risk management for infrastructure around, and environmental protection of, the wetland area.

b. Objectives

The purpose of the study is to undertake a hydrological and hydraulic study of the Masaka wetland area with a view to understanding the causes, nature and dynamic of the flooding issues affecting the area in the Masaka wetland where the lake has formed and propose flood risk management structures.

c. Outputs

The major outputs of this study to be carried out by the Consultant will be

- Hydrological and hydraulic models of the area that will allow for modelling of the effectiveness and impacts of possible structural and non-structural flood control measures for the Masaka wetland in future that will resolve flooding issues whilst not adversely impacting the wetland environment;
- Pre-feasibility level design and cost estimates of flood risk management structures

d. Study area

For this study, accurate flood modelling is of prime importance. Through this process, a detailed analysis of the hydrological behavior of the Masaka wetland, under natural and anthropogenic conditions, will be done. To achieve this, a delineation of the flood model domain is very important. In this document a flood model domain is provided, its delineation was done based on the current observations of the flooding issues of the area, the configuration and topography of the Masaka wetland. The flood model domain delineation was done in such a way that, all the inflows and outflows boundary conditions are clearly defined. These boundary conditions constitute water inputs and outputs to the flood model, this regulating the simulation of flood within the model, in addition to a very accurate topographical representation of the flood model domain. Figure 1 provides an illustration of the delineated flood model domain for this study.

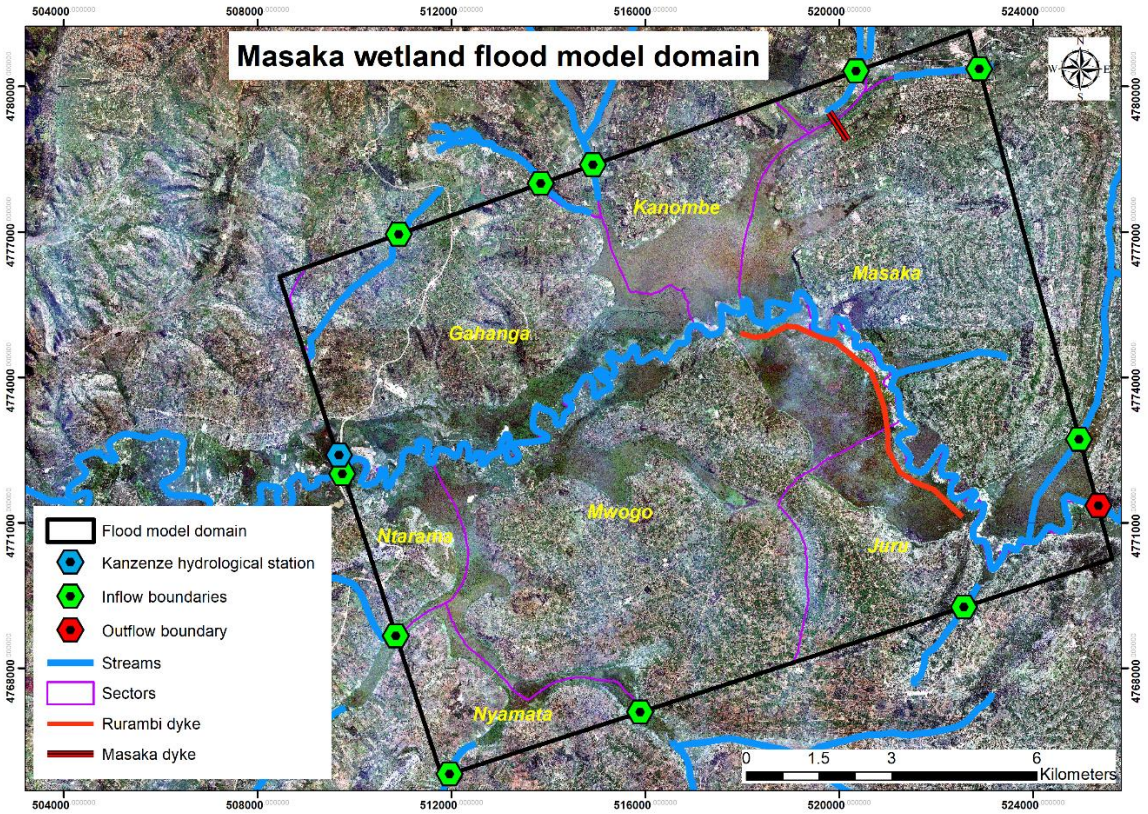

Figure 1: Flood model domain.

The delineated flood model domain has an area of 163.9 square kilometers. The portion of the Masaka wetland comprised between three hillslopes, starting from the existing Kanzenze hydrological station all the way downstream to the Rurambi Dyke, is included in the flood model domain. Twelve boundary conditions were identified for this flood model domain (eleven are inflow boundaries and one is an outflow boundary). The many boundary conditions identified for this flood model domain indicates that the Masaka wetlands has a complex hydrological behavior which requires careful analysis and detailed assessment in order to be able to propose effective flood management measures in the area. Each inflow boundary condition represents a catchment that contributes water in the flood model domain. In this document for convenience, all the catchments providing water into the flood model domain were delineated and are presented in Figure 2. The conceptualisation of the study area, presented in this document, is the basis guiding the proposed scope of work for this study.

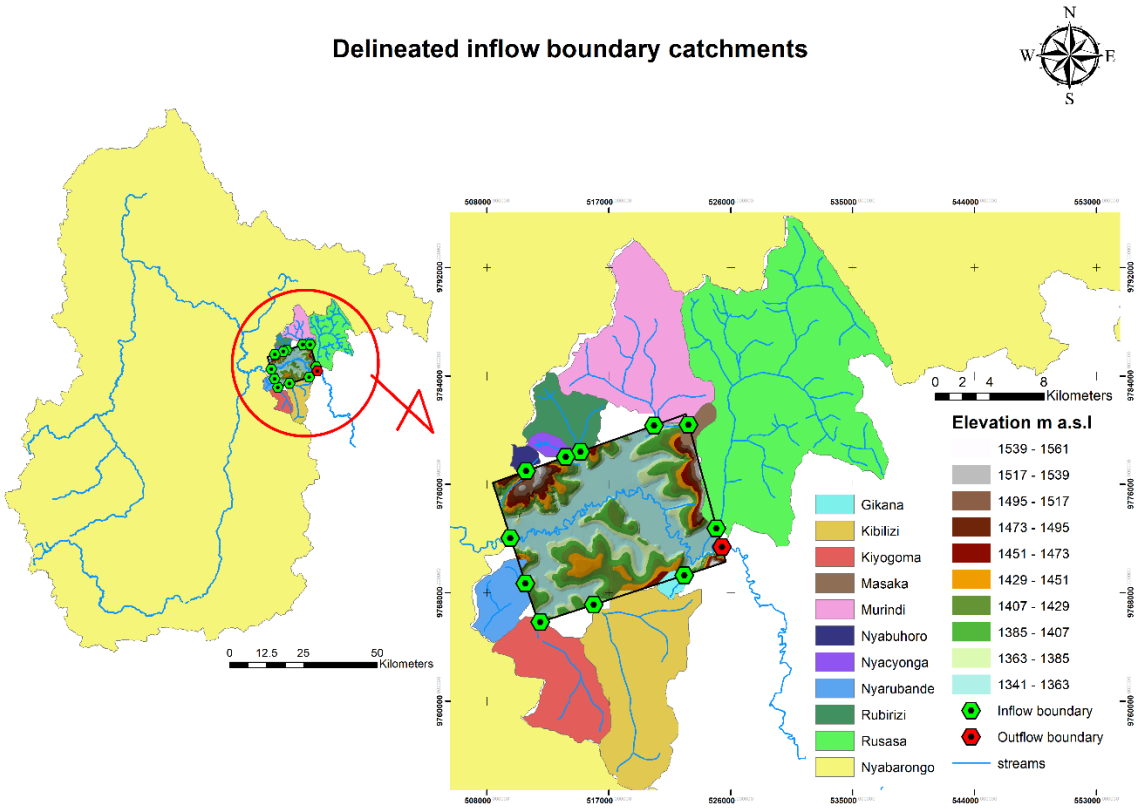

Figure 2: Inflow boundary catchments.

There are eleven catchment inflow boundaries delineated; these are summarised in Table 1.

Table 1: Delineated inflow boundary catchment.

#	Name	Area km^2
1	Masaka	4.42
2	Murindi	79.26
3	Rubirizi	20.16
4	Nyacyonga	4.12
5	Nyabuhoro	3.19
6	Rusasa	214.81
7	Gikana	2.93
8	Nyarubande	17.59
9	Kiyogoma	43.93
10	Kibilizi	82.65
11	Nyabarongo	13,925

e. Scope of work/methodology

The following study will be implemented by the Consultant in a systematic way. The study focus will be to analyze the hydrologic behavior and flood routing of the area. This study will be conducted in three phases. Therefore, the scope of this study is as follows:

Phase 1: Study area appraisal

In this stage, a technical assessment of the existing flooding issues in the area (including preliminary field investigation if required) will be conducted. Existing reports and stakeholders shall be consulted to get an overview of what is their view of the problem perceived and expectations to address the issue.

The Consultant in this stage is expected to closely collaborate with the technical staff in the WRMD in RWFA to develop a concise inception report with a detailed methodology agreed and understood by the concerned parties.

Phase 2: Hydrological analysis

This phase is composed of several steps. The main goal in this stage is for the Consultant to determine estimated peak discharges, at different return periods for each of the inflow boundary conditions. The general descriptions of the steps to be conducted in this stage (methodology to be detailed in the inception report) are as follow:

- Rainfall analysis: In this step, the Consultant is expected to collect existing rainfall data from all the meteorological stations within and near the delineated catchments. From all the stations from which data is collected and based on the length of the available time series, a subset of target stations will be selected for use. Their consistency will be assessed and corrected, if necessary, for effects such as topographical influence and so forth. From the pre-processed rainfall data, for each delineated catchment, an estimation of aerial rainfall time series will be done. The latter will serve as input for the frequency analysis, per each catchment, using commonly used approaches such as the Gumbel distribution method. From the frequency analysis conducted, extreme rainfall

values at different return period (10, 25, 50 and 100 years) per each delineated catchment will be estimated. *Note: in case high temporal scale rainfall data are not available, the Consultant is advised to use what is available and at the end propose, in agreement with the Client, a suitable approach to estimate extreme effective rainfall events from the frequency analysis results.*

- Rainfall pattern: this step is useful to understand the flow pattern of the Masaka wetland. The consultant in this step will only focus at estimating a typical rainfall aerial distribution in the area, during rainy seasons, covered by the delineated catchments. In order to estimate the typical rainfall pattern of the area, satellite rainfall data (to be proposed by the Consultant) will be used. In this stage, no pre-processing of satellite data is expected.
- Unit hydrograph: for each of the delineated catchment, the unit hydrograph will be estimated (this is an empirical approach for extreme peak flow estimation). Except for the catchment of Nyabarongo, all other ungauged catchments' unit hydrograph will be estimated using the geomorphological instantaneous unit hydrograph (GIUH) approach (method based on topographical data, which are available). For the case of the catchment of Nyabarongo, the unit hydrograph will be determined from existing hydrological data at the station of Kanzenze, however the station does not accurately capture peak flows (a correction is needed for peak flows at the station, the consultant shall propose an approach for this correction to be detailed in the inception report).

Phase 3: Flood modelling

a. Flood modelling. A 2D numerical model will be developed by the Consultant for the flood zone in the Masaka wetland, with a preference for a non-proprietary model like HEC-RAS 5.0 (or latest version).
b. An in-depth topographical survey of the selected flood model domain will be conducted (covering the river channels, the floodplain, major infrastructures in the area, etc.), and a spatial resolution of less than 1 m is expected. The Consultant will propose an adequate and feasible methodology for topographic survey and the expected vertical accuracy of the survey of the floodplain should be included in the proposal. It should be noted that the wetland is a large and vegetated and it may not be easy to survey.
c. The limitation of data for the model calibration is acknowledged, therefore to ensure an acceptable degree of accuracy for the model results, the Consultant will have to propose a method by which to calibrate the model which must be accepted by the Client. One such approach would be to use a strict stepwise calibration consisting of adequately parameterising the model and its boundary conditions. This, or the method suggested, should be proposed in the technical proposal and elaborated on in Inception Phase and agreed with the WRMD. The chosen method will be conducted in very close collaboration with the technical team from the RWFA/WRMD and W4GR.
d. Flood mapping. There is limited data, so setting proper values for return periods may be problematic, especially in light of expected climate change (intensification of rainstorms), but also in light of upstream intervention plans (for example the new dam that is planned). This means that upstream scenarios should also be considered (or that the model should be based on the current situation, but with the flexibility to update the analysis to incorporate future developments). For the return periods, it will be useful to include a sensitivity analysis to determine how much the floods change if the design values for discharge and peak rainfall change. The flood maps will be the result of the 2D flood model developed. These maps should

indicate the depths, the velocities and the extents of flood at 10, 25, 50 and 100 years return periods. The number of scenarios proposed and costed should be made clear by the Consultant. The flood maps produced should clearly identify the areas, infrastructure and investments at risk from flooding under each return period. At the outflow point, an analysis must be done of the extent to which downstream flood levels constrain discharge, as constrained discharge will increase flood levels.

e. Financial estimation of potential flood damages. The potential cost of damage to the main infrastructures and investments identified as at risk in 'd.', and for each return period, should be costed.
f. The Consultant should then propose and model the impacts of potential flood risk management structures (options appraisal) designed to reduce the likely impacts of floods on the identified infrastructure etc. but to also maintain the wetland environment.

Phase 4: Pre-Feasibility study

The consultant will provide preliminary designs and cost estimates for the alternatives developed under Phase 3-f.

This will involve:

g. Confirmation of the exact location of each structure – establishment of benchmarks, topo surveys (digital terrain model of the sites, longitudinal profiles and cross sections as necessary).
h. The verification of foundation conditions depending on the size of the structures proposed – investigations will be done as appropriate with hand augers and dynamic penetrometer.
i. Preparation of preliminary level design drawings with main dimensions, elevation of the proposed structures and their preliminary cost estimates.
j. Proposed organisation, planning and costing for the development of feasibility and detailed design studies.

Deliverables

The deliverables of the study to be submitted are as shown in Table 2.

Table 2 Deliverables expected of the consultant

Deliverable	Description
Inception report	This report shall include: a detailed methodology of the study to be carried out (technical choices made, assumptions made, etc.), a work plan with detailed milestones and a proposed table of content of the study report. The report must contain a consistent methodology with a logical sequence of activities to complete adequately the study. This report will constitute the technical agreement that the Consultant must follow during the duration of the study.

Deliverable	Description
Inception Report workshop	Workshop to review and approve the Inception Report
1st Interim report	A technical report addressing Phases 1 and 2: • Study area appraisal • Hydrological study report *This needs to be reviewed and approved by the Client before any hydraulic modelling is carried out.*
1st Interim report workshop	Workshop to review and approve Phase 1 and 2
2nd Interim report	A technical report addressing Phase 3 items a-d inclusive *This needs to be reviewed and approved before any hydraulic modelling is carried out*
2nd Interim report workshop	Workshop to review and approve Phase 3 a-d
Draft final report	Report addressing Phase 3 sections e and f, draft final options appraisal with other technical reports as appendices and Phase 4 – Pre-Feasibility of flood risk management structures proposed in 3-f
Draft Final Report workshop	Workshop to review and approve Draft Final Report
Final report	Final report and model addressing all the comments provided by the stakeholders to the draft final report and previous reports

a. Time of the study

The study is proposed to be conducted over a period of **four months from the Commencement Date to the submission of the Final Report**. A period of 3 weeks shall be used to develop a concise Inception Report during which the Consultant will need to conduct preliminary fieldwork to gain a better understanding of the context of the study. In addition, during that period, a detailed methodology will be developed together with the technical team of RWFA/IWRM and W4GR.

b. Required qualifications and experience

The study will be conducted by a consultancy firm with the following qualifications and experience.

- The consultancy firm must have demonstrated practical experience of at least 10 years in a similar contract.
- The consultancy firm must be able to demonstrate experience of at least 2 pieces of directly comparable and similar of work in the African region with preference given to experience in Rwanda itself

- The consultancy firm must have demonstrated experience of working in a participatory manner and of capacity building of and for Government staff in delivery of their technical work
- The consultancy firm must provide the following team:
  - **A senior hydrologist**, who will be the Team Leader, with at least a Master of Science degree (in either hydrology, water resources engineering or any other related field) and a practical experience of 7 years related to flood management studies and project development. Experience of working in data scarce areas would be an advantage. Must also have practical experience related to rainfall-runoff and numerical modeling in data scarce areas with knowledge of GIS and Earth observation techniques and software
  - **Flood Modeler,** with a at least a Master of Science degree in flood modelling and 5-years' experience in flood modelling and mapping
  - **A Structural Engineer,** with at least a Master of Science degree (in structural and/or civil engineering, hydraulic structure or any other related engineering field) and a practical experience of 5 years related to hydraulic structure design.
  - **An Economist,** with a Master's degree in economics and a practical experience of 5 years related economic assessment of flood management or other related projects.

c. Consultative meetings, training and capacity building and workshops

Four workshops will be organised to discuss the inception phase, the interim report, the draft final report and the final report. These will be organised and delivered by the consultant in conjunction with the RWFA/IWRMD and ISU water for growth.

The Consultant shall prepare and agree with the Client a detailed outline and workshop format before conducting the workshop. PowerPoint presentations will be concise, and the Consultant will ensure that sufficient time is made available for discussion.

The Consultant shall prepare and distribute workshop papers for use by the participants sufficiently in advance of each meeting as agreed with the client during the Inception Phase

At the conclusion of the workshop, the Consultant shall compile and submit the proceedings of the workshop to the Client.

The Consultant is expected to work with staff from the Water Resources Management Department (WRMD) in the execution of their work. A small amount of space can be made available for 1 or 2 people in the offices of the Client. Relevant data and other documents can and will also be provided to the Consultant by the Client team where available.

The majority of the key work, such as site survey, modelling etc. shall be undertaken in Rwanda and in association with staff from the WRMD – work not undertaken in-country should be limited to 'data crunching' and other non-key activities.

d. Supervision arrangements

The Client is the RWFA / WRMD. The Consultant will be directly supervised by WRMD staff. Outputs of the study will be reviewed by a Technical Committee (TC) to be selected by RWFA and the main other partners in this project, like MININFRA, as represented in the W4G Steering Committee. The Technical Committee will include members from national agencies, the Client and the ISU W4G team. If needed,

special expertise will be recruited via ISU W4G. The RWFA/IWRMD will ensure close coordination with other national agencies, to ensure smooth information exchange. The Client will hold discussions with the Consultant at various stages of the consultancy to assess work progress, discuss constraints and possible interventions to ensure quality and meet deadlines.

e. Quality Management Requirements

Ideally, the Consultant will be required to demonstrate in their proposal evidence of adoption of the use of a Quality Assurance System (such as ISO 9001 or equivalent), and/or to describe how quality control will be implemented in the course of the project.