Terms of Reference for International Firm

UPDATING THE NILE HYDROPOWER OPTIMIZATION AND FLOW MANAGEMENT DECISION SUPPORT SYSTEM (NHPFM-DSS)

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1 Introduction

The IPCC's Sixth Assessment Report (2021) predicts that global warming will increase the frequency and intensity of heavy precipitation events in Uganda and the Lake Victoria basin, leading to higher water levels in Lake Victoria and exacerbating flood risks around the lake and along the White Nile. Recent high-water episodes have caused extensive property damage, disrupted transportation, and communication networks, and stressed the Nalubale and Kiira hydropower facilities. Economic activities such as fishing, tourism, and transportation were also affected, incurring significant flood management costs. While higher water levels can enhance hydropower generation, they pose management challenges to prevent shoreline flooding and ensure dam safety.

With funding from the European Union through the Agence Française de Développement (AFD) Digital Facility, Uganda Electricity Generation Company Limited (UEGCL) received a grant to develop an optimization tool for the energy sector along the Nile in Uganda. A water balance and allocation model (MIKE Hydro Basin) was developed to provide both short-term and seasonal forecasts and predictions. Additionally, a flood model (MIKE Hydro River) was employed to simulate the hydrology and hydrodynamic conditions downstream of Lake Victoria's outlet. The models were integrated into an all-in-one DSS using DHI's platform with a DSS web user interface. The web user interface comprises components such as flood and flow forecasting visualization and dissemination modules required for flood forecast reporting among others. The system includes automatic downloading and processing of earth observation and numerical weather prediction data, to provide real-time, forecasts for robust decision-making.

The Ministry of Water and Environment with support from GIZ and the Nile Basin Initiative would like to optimize hydropower production and other lake uses while minimizing the negative effects of extreme water levels and adhering to transboundary obligations. The ministry intends to extend this Optimization Decision Support System to support these activities and provide transboundary flood advisory on the White Nile up to Borr.

1.1 Problem Statement

The management of water resources along the Nile River in Uganda, particularly Lake Victoria, poses significant challenges due to the need to balance hydropower production with flood risk mitigation and the competing demands of various water users. The existing decision support system (DSS) for managing water releases from Lake Victoria does not adequately address the complex and dynamic nature of these competing interests.

The primary issues include suboptimal hydropower production due to inconsistent and Inactionable water release schedule and inadequate flood management plan or mechanism. The current water release policies do not effectively mitigate flood risks, leading to significant damage to communities, infrastructure, agriculture, and the environment around the shores of Lake Victoria, Lake Kyoga, and Lake Albert.

Additionally, conflicting water use demands arise from the diverse needs of multiple stakeholders, including navigation, fisheries, and agriculture, which are not sufficiently considered in the decision-making process, leading to conflicts and suboptimal water resource allocation.

There is a need for a comprehensive Decision Support System to support water release decisions and generate detailed reports on the implications of different water release policies, particularly in terms of impacts on flooding and other sectoral effects.

1.2 Project objectives

The Ministry of Water and Environment of Uganda with support from GIZ and the Nile Basin Initiative has identified the need to update the existing DSS to better understand the hydrology of the upper Nile basin, inflows, and water levels to improve its regulatory and transboundary cooperation function and optimize its operations.

The system will be able to forecast short-term to long-term flows (from two-week forecasts to 9 months forecasts). The system will have capabilities to investigate the impacts of different operation rules for the dam cascades as scenarios and establish the magnitude of the flood downstream selected infrastructure and waterbodies indicated in the following sections. The system will be used to provide flow forecast advisory up to but not including the Sudd.

2 Description of the Proposed Assignment

The upgraded DSS will integrate real-time data from multiple sources and use advanced analytics and machine learning for better water availability and demand. Comprehensive

reporting tools will generate detailed reports on water releases, flood impacts, and benefits for hydropower and other uses. The water release options will seek to minimize flooding around Lake Victoria, Lake Kyoga, and Lake Albert as well as along the Bahr El Jebel or White Nile River in South Sudan up to Bor in South Sudan, considering the hydropower dam cascade.

The system will improve stakeholder communication by incorporating tools for effective information sharing and joint decision-making processes among government agencies, power station operators, and transboundary partners.

The consultant is required to update the system to:

1. make short-, medium--, and long-term river flow forecasts up to Bor in South Sudan. Forecasts should make use of the existing and most recent data from the Nile Basin Hydrological Monitoring System. The system should be able to consume the time-series data automatically and therefore integration mechanisms have to be developed. The system should be able to consume downscaled forecast climate data prepared by ICPAC among other data sources.
2. provide outputs for exploring different lake outflows/release rates and analyze power production and various water uses along the Nile system within Uganda to guide the issues of water release permits.
3. Calibrate and validate the model to for the additional catchments included in the model.
4. Assess the impact of different release regimes on hydropower production, lakeshore flooding on Lake Victoria, Lake Kyoga, and Lake Albert, and the effects along the Nile in Uganda and Bahr El Jebel or White Nile River in South Sudan. This will be achieved by including stage inundation curves/maps for Lake Victoria, Lake Kyoga, and Lake Albert based on the available topographic surveys of the lake shores (survey data collected by MoWE).
5. Extend the model to Bor including the rainfall runoff so that the model can be used to study the implications of river management in South Sudan up to the inflow to the Sudd at Bor. However, **the project does not include modeling of the Sudd.**
6. The system should have a dashboard version and standard report for purposes of the quarterly river forecast reporting including different water level thresholds.
7. In addition, develop the capacity of selected professionals to enable them to undertake future improvements to the system configuration as may be required.

The assignment will involve the application of the updated tool for seasonal river flow forecasting for three seasons, therefore the assignment will be spread out so that the model updates delivery coincides with the periods in which this assessment is undertaken. The delivered updated system will then be used working with the client's staff to prepare the various river flow forecasts as use cases. The capacity of the client's staff should be developed in this process based on an agreed capacity-building needs and plan proposed during the inception phase.

At every end-of-use case, additional requirements will be identified for further improvement of the system by the following reporting period.

3 Detailed tasks

The following table is a detailed description of the deliverables and schedule.

Activities	Tasks	Deliverables	Delivery date
Activity 1: Inception Phase	Task 1.1: Review of the existing model, other tools, data sources, and the requirements of the assignment.	*Deliverable 1.1: Inception Report* *Deliverable 1.2: Inception Workshop* *Deliverable 1.3: Capacity building roadmap prepared*	*End of October 2024*
Activity 2: Model upgrade	Task 2.1: Working with the client's team, extend the model to Bor add lake releases scenario function, and implement system outputs.	*Deliverable 2.1: Updated system with new functionality based on the requirements above.* *Deliverable 2.3: Report on further improvements required for additional updates of the system.* *Deliverable 2.4: Report on first capacity building*	*End of December 2024*
Activity 2: Model upgrade & application use case 1	Task 2.1: Working with the client's team, extend the model to Bor add lake releases scenario function, and implement system outputs.	*Deliverable 2.1: Updated system with new functionality based on the requirements above.* *Deliverable 2.2: Data prepared for a three-month river flow forecast report.* *Deliverable 2.3: Report on further improvements required for additional updates of the system.* *Deliverable 2.4: Report on second capacity building*	*End of February 2025*
Activity 3:	Task 4: Working with	*Deliverable 3.1: Data prepared for a three-*	*End of April 2025*

Activities	Tasks	Deliverables	Delivery date
Model application use case 2 & capacity building	the client's staff, the consultant will develop and apply the tool to a river flow forecasting activity for the one seasonal river flow forecast.	*month river flow forecast report.* *Deliverable 3.2: Report on the updated system and further improvements required for additional updates.* *Deliverable 3.3: Report on third capacity building*	
Activity 4: Model application use case 3 & capacity building	Task 5: Working with the client's staff, the consultant will develop and apply the tool to a river flow forecasting activity for the next seasonal river flow forecast.	*Deliverable 4.1: Data prepared for a three-month river flow forecast report.* *Deliverable 4.2: Report on final updates of the system.* *Deliverable 4.3: Report on the final capacity building undertaken*	*End of August 2025*

3.1 PAYMENT SCHEDULE

The payment to the consultant shall be made against deliverables submitted by the consultant acceptable to the client. The proposed payment schedule shall be finalized during contract negotiations.

3.2 ESTIMATED LEVEL OF EFFORT

The estimated level of effort is 70 man-days spread over 8 calendar months.

4 RESPONSIBILITIES OF THE CLIENT

The Client, the Nile Basin Initiative, has the following responsibilities:

- The client will assign a focal point expert as the manager of the assignment.
- The client will organize for national experts to participate in model development, calibration and validation, data provision, and data quality.
- Sharing all required documentation and preparatory documents regarding the modelling and studies.

- Lead in the organization of the inception workshop, training workshops/implementation workshop (workshops venue, issuing invitations, providing stakeholder lists, and logistics for the participants).

5 Consultant's Qualifications, Experience Requirements, and Consultant's Team Composition

This assignment is targeting a Consulting firm with at least ten years of experience working with Mike Hydro, Mike Workbench, and Mike Operations software. Demonstrated experience of at least three projects undertaking similar assignments in the Nile Basin or transboundary basins with similar complexity. The consultant should be able to acquire the required software licenses to enable smooth updates of the relevant models. The Client is aware of the importance of the various skills and expertise required for this assignment. For this assignment, the Consulting firm shall provide the following key experts to execute the envisaged project tasks:

5.1 Team Leader

The team leader should have the following qualifications:

- Master's Degree in either Hydrology, hydraulics, Water Engineering, Water Resources Management, or another closely related field.
- At least 10-year experience in hydrological modelling of complex basins with different climate conditions. Experience in modelling water infrastructures like dams or natural water storage is an asset.
- Five years' experience working with Mike Hydro, Mike Workbench & Mike Operations software.
- Experience in utilizing real-time hydro-met data for updating hydrological model simulations.
- Demonstrated knowledge of the white Basin hydrology.
- Expertise in integrating climate data into hydrological and hydraulic models and **spatial data analysis**.
- Able to write clean, simple, modular, and maintainable code. Experience in automatizing complex workflows that rely on different external datasets in a very robust and easy-to-maintain manner.
- Demonstrated experience in using the Mike Workbench and Mike Operations software.

- Demonstrable experience in building the capacity of professionals in the development of models, scripting, and building client-server applications using the Mike Workbench and Mike Operations software.

5.2 Hydrological Modelling Expert

The following are the required qualifications for the Hydrological Modelling expert:

- Master's Degree in Hydrology, Water Engineering, Water Resources Management, or other closely related field.
- Experience in hydrological model conceptual design, calibration, and validation for complex hydrological systems with different climate conditions.
- Five years' experience working with Mike Hydro, Mike Workbench, and Mike Operations software.
- Experience in modelling water infrastructures like dams or natural water storage.
- Experience in tailored adaptation of hydrological models that are used by the Client including stream flow correlation approaches for a wide range of applications such as extremes (floods and droughts), reservoir operation, irrigation and environmental flows and **spatial data analysis**.
- Experience in utilizing real-time hydro-met data for updating hydrological model simulations.
- Detailed knowledge of the strengths and weaknesses of satellite-based climate products, their bias correction, and assessing their usefulness for hydrological simulations. Experience in data correction, statistical analysis, and gap-filling of time series. Strong analytical skills to ensure that data is viable and accurate.
- Experience in capacity building of professionals in model development and application.
- Demonstrated utilization of these datasets in the White Nile Basin hydrology.

5.3 Software Engineering Expert

The Software Engineering expert's qualifications include the following:

- Master's degree in computer science, computer engineering or other closely related field. Excellence in software design and development, scripting, software integration and extension as well as server- and client setup.
- Five years of experience in the acquisition and manipulation of Earth Observation data into the Mike Workbench and Mike Operations Software.
- Experience in client-server software development, integration, and testing.

- Experience in database design, administration, and automation.
- Experience working in the Nile Basin or similar developing countries
- Experience in capacity building of professionals in enhancing model applications and accessing internet resources/public domain data using programming languages like Python and Visual Basic.net among others.