Government of The People's Republic of Bangladesh

Ministry of Water Resources

Bangladesh Water Development Board (BWDB)

Bangladesh Sustainable Recovery, Emergency Preparedness and Response Project (B-STRONG) (BWDB Part)

Terms of Reference (ToR)

For

Consultancy services for Expansion of the Flood Forecasting Model and Development of Basin Based Model for FFWC

Package no. BSTRONG/BWDB/S-07

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1. Introduction

Bangladesh is the lower most riparian country of the Ganges, Brahmaputra and Meghna rivers basin area of which is around 1.7 million sq. km. This basin experiences huge rainfall during monsoon months (May-October), produces huge runoff which exceeds the carrying capacity of the rivers, spills over the banks towards plains, and at times takes shape in flood. Moreover, land elevation of southern part of the country is quite low close to seal level. These coastal areas of the country are also quite vulnerable to flood resulting from tidal surges as well as tidal floods which take severe shape during extreme weather conditions in the Bay of Bengal. Nevertheless, floods extend all over the county with severe shape while river flood coming from upstream riparian basins coincides with extreme weather condition prevailing in the Bay of Bengal. Such countrywide severe floods occurred in the country during 1988, 1998 and 2004 caused widespread damage throughout the country. A major portion of flood damage is due to damage or destruction of infrastructure, and infrastructure managers could not efficiently use the forecast information available to plan emergency damage prevention measures in flood-affected areas. Thus, recurrent floods set back the country's efforts to alleviate poverty.

Due to the location of the country in the low-lying deltaic floodplains at the convergence of three Himalayan Rivers, heavy monsoon rainfall concomitant with poor drainage often results in annual flooding. In the Nineteen Sixties, flood protection with structural measures was initiated in the country to increase crop production and reduce food deficit. Later on, it was comprehended that implementation of mass scale structural measures of flood protection will result in severe environmental degradation in the country. Accordingly, flood management with both structural measures and non-structural measures like flood forecasting and early warning are introduced in the country.

2. Background

Flood Forecasting and Warning Centre (FFWC) of Bangladesh Water Development Board (BWDB) was established in 1972 for providing flood information including early warning to the people. Currently FFWC generates 5-days deterministic forecast at 61 stations, 10-days probabilistic medium range forecast at 38 stations and 3-days probabilistic discharge forecast at 3 stations for the riverine flood prone part of the country. Besides there is 3-days deterministic flash flood forecasting model for the Noth-Eastern part of the country during pre-monsoon. The development of FFWC has gone through distinct periods of supports from multiple agencies over the past decades. Following a period of initial support by the United Nations Development Program (UNDP), the flood forecasting and warning services upgraded into mathematical model-based MIKE11 and Flood Watch system during the project "FAP 10: Expansion of Flood Forecasting and Warning Services", financed by Danish International Development Agency (DANIDA) from 1995 to 1997. After the record flood event in 1998, DANIDA took up a new project for strengthening and consolidation of FFWC's activities which ended in December 2006 where Danish Hydraulic Institute (DHI), Denmark and Institute of Water Modelling (IWM),

Bangladesh provided the technical support. The devastating flood of 2007 has made it essential to recalibrate, update and validate the flood forecasting model.

In order to strengthen the existing flood forecasting system and capacity development of FFWC for effective flood management in the country, a research and prediction modelling study was undertaken (June 2011 – June 2014) by FFWC, BWDB under the Comprehensive Disaster Management Program II (CDMP II), project of the Department of Disaster Management (DDM) under the Ministry of Disaster Management and Relief (MoDMR). Under the program, the flood forecasting model was updated, calibrated and validated including increase of forecast lead time from 3 days to 5 days. The extent of the flood forecasting model of FFWC then included around two-third of the country covered northwest, northcentral and northeast region of Bangladesh (i.e. Rangpur, Rajshahi, Dhaka, Mymensingh, Sylhet divisions), whereas the coastal and South-Eastern Hill region of the country (i.e. Khulna, Barishal, Chattogram divisions) were not included.

Under the Haor Infrastructure and Livelihoods Improvement Project (HILIP) by Local Government Engineering Department (LGED, the pre-monsoon flash flood forecasting model was updated and established at FFWC, BWDB for the North-Eastern part of the country during 2015 to 2022. 3-days lead time deterministic hydrodynamic model was developed including the Barak basin and sub-basin based models of the Meghalaya and Tripura river system within the Upper Meghna basin. The model was made operational in 2019 after three years of experimental operation and operational since now. While the model is operational, its performance can be enhanced by integrating more available datasets including upstream rainfall, particularly for flashy catchments.

With days capacity of FFWC has flourished appreciably, and demand was raised to expand flood forecasting covering whole country. The supported system (software & hardware) of flood forecasting model became old, incomputable with available software operating and hardware system available in the market. FFWC professionals faced difficulty in operating the flood forecasting system based on the old hardware and software. Thus, BWDB took a program to upgrade the flood forecasting model under a World Bank funded program titled "Bangladesh Weather and Climate Services Regional Project (BWCSRP, Component-B) during 2016 to 2024. The key upgradations of flood forecasting system done under BWCSRP included: (i) modernize the data collection system, (ii) expansion of flood forecasting model covering whole country, (iii) introduce 1D-2D coupled flood inundation model in coastal region, (iv) upgrade supporting software and hardware of flood forecasting model, (v) update existing Decision Support System (DSS) using DHI MIKE+ 2023 and MIKE Operations, and (vi) capacity building to FFWC professionals through formal and on the job trainings which were done during 2022 to 2024. The updated model was run on test basis during 2024 flood season. It was noted that due to absence of detailed information in transboundary flashy river sub-basin scale, the severe flash floods in Eastern Bangladesh including Feni, Cumilla, Habiganj, Moulvibazar districts could not be estimated accurately from the model.

In between, a DANIDA funded project titled "Capacity Development for Enhanced Flood Forecasting and Warning Services of Bangladesh for Cross-border Flow Prediction and Urban Flood Forecasting" was implemented during 2022 to 2023. A cross-border inflow model was developed for the trans-boundary Ganges and Brahmaputra basins, with the goal of using its output as upstream boundary input for the 5-day deterministic flood forecast model. However, the model could had certain limitations, primarily its inability to produce accurate forecasts in flashy

catchments such as the Teesta, Dharala, and Dudhkumar rivers. Further improvements are possible by incorporating new datasets and recalibrating the model for these dynamic regions.

As the flood in Bangladesh is mostly trans-boundary in nature there needs to be further improvement of the model in basin scale especially considering the trans-boundary flashy river basins. In the last few years it appears that flash floods are hitting frequently during pre-monsoon and monsoon in the river basins located in north, southeast and eastern regions. The flash flood that occurred in 2024 in the southeastern region was quite unprecedented and caused tremendous suffering to the community and damage to infrastructures. The current model is not properly supplemented with substantial basin scale information so there remains uncertainty in transboundary flow estimation specially, for flashy rivers.

Also, flood warning circulated countrywide at present is not enough comprehensive to the communities residing in the river basins in north, southeast and eastern regions to be prepared in advent of flash floods. The flood forecasting super model is a national level model and is not such detail to prepare flood forecast in community level. The current inundation model for riverine parts of the country is available at district scale only. Due to absence of detailed topographical information (e.g. floodplains/lands, roads/railway, significant structures etc.), the inundation cannot be estimated very accurately at local level for riverine and flash flood prone areas. In this regard, separate 2-Dimensional inundation models are essential for those areas which is currently available only for the coastal regions. The Eastern and Northern parts of the country can be addressed primarily on account of recent as well as recurring flood events.

FFWC is now also facing difficulty in operating multiple models with the available single software package procured under BWCSRP, which does not permit to run multiple 1D/2D models of different zones parallelly and thus interfering with time efficiency of operational forecasting. This problem is likely to be more acute with days due to enrichment of flood forecast system in coverage, quality and diversity to meet the upcoming demands of communities. Also it is a necessity to introduce Web Applications module of MIKE Operations in new FFWC DSS featuring advanced observation, monitoring and dissemination facilities, but not implemented in BWCSRP. Therefore, advanced software module availability supporting multiple users' facility is crucial to enhance the flood forecasting system with more diversification of flood forecast products necessary to satisfy the increased demand of the nation.

3. Study Area

The study area comprises three distinct spatial domains. Domain-1: One is Ganges Brahmaputra and Meghna Basin Model which is a transboundary river basin. The basin roughly includes 133 sub-catchments out of which 79 in the Ganges basin, 47 in the Brahmaputra basin and the rest 7 in the Meghna basin. Areas included in the Ganges, Brahmaputra and Meghna basins are approximately 979503 sq. km, 520663 sq. km. and 26567 sq. km, respectively, which are located outside Bangladesh.

Domain-2: South-Eastern Region comprising Cumilla, Noakhali, and Feni districts (around 6056 sq.km) includes Gumti (105.96km), Little Feni(56km) and Feni-Muhuri-Selonia (159 km). This region is characterized by a combination of floodplains, coastal plains, and hill-affected river systems, making it highly dynamic in terms of water flow and sediment behavior.

Domain-3: Brahmaputra River in the northern region of Bangladesh, encompassing parts of Kurigram, Gaibandha, and Jamalpur districts. This region is highly vulnerable to annual monsoon-induced flooding due to its low-lying topography and direct exposure to the dynamic flow regime of the Brahmaputra major transboundary river with high discharge and sediment load.

4. Objectives

The prime objective of the consultancy service is to improve the flood forecasting model at trans-boundary basin scale and enhance capacity of the flood forecasting system computable with community specific demands. The specific objectives of the program are as follows:

- Develop/update river basin wise hydrological models for all major river basins and flashy trans-boundary river sub-basins using multiple hydro-meteorological data
- Develop in-country river basin specific 2D flood inundation model using available detailed topographical information for the flash flood prone parts of the Eastern region (Cumilla, Noakhali and Feni districts); and for the riverine flood prone parts of the Northern region (Kurigram, Gaibandha and Jamalpur districts)
- Enhancement of FFWC DSS based on MIKE+ 2023 and MIKE Operations software system by upgrading to multiple user facility (total 2 users) and incorporating Web Applications module in MIKE Operations
- Associated capacity building of BWDB professionals

5. Scope of Works

The scope of works of the consultancy services are described in the following:

A. Review of literature and data collection

- Collection of previous reports and documents on flood forecasting and review.
- Identification of required data (hydro-meteorological, topographical, and other data required for modelling) for setting up of model, calibration, and validation.
- Secondary data collection includes basin wise rainfall, satellite-based rainfall, evaporation, water level, discharge, river cross-sections, topography, etc. from BWDB, BMD, SoB, and public domain.
- Review of available data and information to find out the adequacy for model development and plan suitable methodology.
- Primary data collection for bathymetry survey of the Gumti River (embankment to embankment) @ of 500m interval for 100 km

B. Develop/update river basin wise hydrological models using multiple hydro-meteorological data

- Review, validate and update existing basin based model of FFWC for the Brahmaputra river, Ganges river and Meghna river by including all transboundary river sub-basins therein separately in MIKE Basin/MIKE+ Rainfall-Runoff and calibrating/validating against observed historical flow records.

- Develop hydrological models for all the major rivers of the Southeast Hill basin in MIKE+ Rainfall-Runoff by calibrating/validating against observed historical flow records and coupled with existing 1D hydrodynamic model.
- Process historical and real time in-situ/satellite-based/global hydro meteorological data available from relevant national organizations (i.e. BWDB, BMD etc.) or different sources in public domain and FFWC (i.e. IMD, MSWEP, ERA5, GSMAP etc.)
- Process satellite-based or global land use, soil moisture, water reservoir and topography data available from relevant national organizations (i.e. SoB) or different sources in public domain and FFWC (i.e. USGS, Copernicus, SMAP etc.)
- Process weather forecast (rainfall forecast) available from different sources in public domain and FFWC (i.e. BMD, ECMWF, NOAA, IMD etc.)
- Use multi-model ensemble-based rainfall predictions and multi-source in-situ/satellite-based/globally available real time rainfall observations in basin models to produce cross-border ensemble flow forecasts at boundary points or stations of interest
- Explore one or two open source hydrological models (e.g. HEC-HMS, SWAT, VIC etc.) to compare against MIKE Basin/MIKE+ Rainfall-Runoff
- In case newer data sources (in-situ/satellite-based/globally processed) become available or new approaches seem feasible (e.g. artificial intelligence, machine learning etc.) or comes into attention during the project period as a suitable means for the task, the consultant will include them in their development.

C. **Development of 2D river basin specific inundation models of selected rivers (Gumti, Little Feni and Feni-Muhuri-Selonia) in Eastern region (Cumilla, Noakhali and Feni districts) and of the Brahmaputra river in Northern region (Kurigram, Gaibandha and Jamalpur districts)**

- Delineate river basin specific domain area considering watershed, flood flow and drainage routes.
- Prepare geometry incorporating significant infrastructure and settlements in each river basins.
- Prepare bathymetry of rivers, floodplains, embankments, lands and roads/railway of the model domain based on data and information available.
- Incorporate significant structures (bridges, culverts, regulators etc.) in the geometry.
- Prepare hydrological boundary input time-series of each model domain.
- Calibration and validation of 2D river basin specific inundation models
- Development of model output library

D. Enhance existing Decision Support System (DSS)

- Procure the latest version of all relevant MIKE+ and MIKE Operations module managers for 1 more user (total 2 users) with 1-year maintenance
- Extend DSS in MIKE OPERATIONS WEB with full utilization of all up to date features that are available before the end of the project period with input of DHI expert. 60% to 70% of the development work on this part must be done at the FFWC office to fulfill operational requirements by taking inputs.
- Incorporate new real time stations in flood forecasting networks based on user needs where there is gap of forecasting and station details validated through field visits

- Incorporate option to simulate flood forecasting model with multi-model ensemble-based weather forecast data and varying forecast lead time.
- Update flood forecasting and warning dissemination materials including outlooks, bulletins, hydrographs, rainfall maps, flood inundation forecast maps, visualization tools, result post-processing and dissemination tools etc.
- Update flood analysis and reporting materials including weekly/monthly bulletins, comparative hydrographs, reporting tools, data import/export tools, forecast evaluation tools etc.
- Update forecast materials with area specific forecast lead time and ensemble water level forecasts
- Develop/update user manuals and model operation procedures for FFWC professionals
- The application would not only help new model but also existing National model. It can help in automatic update of website for forecast. This will require some amount of scripting, designing and constant feedback. As and when more models are made available and functional, they can be easily added through MIKE web progressively.

E. Enrich Capacity of BWDB Professionals

- Capacity building training to FFWC/BWDB professionals (3 Nos. comprising 10 Nos. of professionals) prioritizing the FFWC professionals on developed models, weather model dynamics, ensemble-based forecasting, DSS, and software.
- Hands-on training on development, operation and maintenance of MIKE OPERATIONS WEB DSS to FFWC and relevant professionals by DHI expert (1 No., 3 persons, 1 week).

6. Expected Outputs and Outcomes

Outputs:

The expected outputs of the program are as follows:

- Hydrological models of the Brahmaputra, Ganges, Meghna and Southeast Hill basins in sub-basin scale with facility to estimate ensemble based multiple sets of flow prediction.
- 2-Dimensional river basin specific inundation models of Gumti river, Little Feni river, Feni-Muhuri-Selonia river and Brahmaputra river (Kurigram, Gaibandha and Jamalpur part).
- Maintenance of MIKE Software package for one year with procurement of the latest version of Module Managers for 1 more user (total 2 users).
- Existing DSS enhanced and extended in MIKE OPERATIONS WEB with advanced real time observation, monitoring and dissemination facilities
- Trained BWDB professionals on enhanced flood forecasting system and DSS.

Outcome:

- Enhanced flood forecasting system using ensemble-based hydrological models increasing accuracy of trans-boundary flow prediction and 2D inundation mapping for flash flood prone parts of the Eastern region (Cumilla, Noakhali and Feni districts); and for the riverine flood prone parts of the Northern region (Kurigram, Gaibandha and Jamalpur districts).

7. Duration of the service and Key deliverables with timeframe

The duration of the study is 3 years or project completion period whichever is earlier.

Key deliverables with timeframe are as follows:

Sl. No	Deliverable	Deadline
1	Data Compilation and Modelling Framework	At the end of 4th month
2	Basin wise hydrological model	At the end of 16th month
3	Training-1 on Basin wise hydrological model	At the end of 16th month
4	2D river basin inundation models of Feni-Noakhali-Cumilla	At the end of 20th month
5	Training-2 on 2D river basin inundation models of Feni-Noakhali-Cumilla	At the end of 20th month
6	National Workshop-1	At the end of 26th month
7	2D river basin inundation models of Kurigram-Gaibandha-Jamalpur	At the end of 28th month
8	Training-3 on 2D river basin inundation models of Kurigram-Gaibandha-Jamalpur	At the end of 30th month
9	Updated MIKE+ Software with one more user license	At the end of 30th month
10	Enhanced Decision Support System (DSS) with Mike Web with DHI Profcssional input	First Draft (Mike web installation and Data base Preparation) by 12th month, Refined version (Mike web Customization for FFWC) by 24th Month Final (Mike web Interface full Preparation and Operationalization) by 30th month
11	Hands on training on Decision Support System (DSS) with Mike Web with DHI Professional input	At the end of 32nd month
12	National Workshop-2	At the end of 33rd month

N.B.
A technical committee formed by BWDB will review the progress, provide technical suggestion and receive and accept all the deliverables mentioned above. The committee will do meeting at least once in every three months or whenever necessary. The office of the Executive Engineer, FFWC, BWDB would monitor the service and communicate with other line departments, and all concerned for consultation, sharing of ideas and to discuss the findings as well as disputes on behalf of PMU.

8. Reporting

The schedules of submission of Reports are as follows:

Sl. No	Report	Deadline
1	Inception Report	At the end of 2nd month
2	Quarterly Progress Report	At the end of each quarter
3	Interim Report	At the end of each year
4	Basin wise hydrological model Report	At the end of 18th month

5	2D river basin inundation models of Feni-Noakhali-Cumilla Report	At the end of 24th month
6	2D river basin inundation models of Kurigram-Gaibandha-Jamalpur	At the end of 30th month
7	Training Report	At the end of 32nd month
8	Draft Final Report	At the end of 34th month
9	Final Report	At the mid of 36th month

N.B. Hard and Soft copies (along with USB) of all the reports, presentations, data, cross-sections, long profiles, documents, scripts, source codes etc. have to be submitted and must be handed over to BWDB. All the developed models described under scope of works should be made fully operational and installed on BWDB server along with necessary backup copy provided. Review meetings with the participation of concerned Planning, Design and Field level officials of BWDB would be held on Inception, Interim and Draft Final and Final Reports.

Draft and Final deliverables (reports, data sets, model schematizations, maps, brochures) shall be submitted to the Client. All deliverables must be written in English. All report deliverables shall be submitted in MS Office and Adobe PDF. Final report deliverables should also be submitted in hard-copy. All reports should have an easy-to-read layout, should be well-structured and well written, should include a summary and helpful illustrations, graphics, charts and maps. Data sets and models shall also be delivered in a structured manner including sufficient metadata for each data set/model to ensure efficient use for future purposes.

The Consultant shall carry out quality control and quality assurance prior to submitting draft deliverables (reports, models, data sets). Upon request, the Consultant shall provide insight into quality control carried out for all deliverables. These can include, but are not limited to, internal draft versions of reports, internal quality control sheets of model set-up, calibration and validation and internal check lists on data sets. The Client will carry out its own review process. Written comments from the Client will be provided to the Consultant in a structured manner. The Consultant shall provide a response to all review comments when handing in the final reports and/or models so that these can be checked on adequacy before final approval of deliverables.

As part of its proposal, the Consultant shall provide a detailed insight into how the Quality Control/Quality Assurance process will take place for this specific project. That description shall be tailored to the specific assignment. It shall also define the inputs from experts who specifically take care of this quality control process.

9. Seminar/Workshop/Training

- Two (02) national level workshops would be arranged under this project with input from national professionals on basin scale hydrological, 2D hydrodynamic modelling and DSS in terms of ensemble based forecasting including weather model dynamics.
- Three in house trainings each of one week (5 working days each) at BWDB with flood forecasting, hydrology, water resources planning and design relevant professionals.
- One hands-on training (one week) at FFWC, BWDB to relevant professionals with input from a DHI professional on MIKE Operations and MIKE Operations Web covering details of DSS and software.

10. Key Personnel

It is estimated that **13 Key Professional** of **71 Man-Months** will be required for the study as shown in the following Table.

SL	Professionals	No. of Persons	Total Indicative Quantity (Man-Month)
1	Team Leader	1	3
2	Senior Flood Forecasting Specialist	1	4
3	Hydrological Modeler	1	4
4	1D Hydrodynamic Modeler	1	3
5	2D Hydrodynamic Modeler	2	12
6	ICT & Database Specialist	1	7
7	GIS Specialist	1	5
8	Data Analyst	2	9
9	Field Engineer	3	24
	Sub-total (A)	**13**	**71**

Qualifications, Experience and Task of the Key Personnel

Sl. No.	Position	Qualification/Experience	Responsibility
1	Team Leader/ Flood Management Specialist	Master's degree in Civil Engineering/ Water Resources Engineering with 20 years' professional experiences in development of hydrological model, 1D hydrodynamic model, Flood Forecasting System and DSS. He/She should have working experience as Team Leader in at least one project with Flood Forecasting model and DSS development using MIKE + and MIKE OPERATIONS. Experience in development calibration and validation of Flood Forecasting Model of FFWC, BWDB will be an added advantage. Proven working experience in at least one operational flood forecasting system development as well as 2D hydraulic model development for rivers and floodplains is essential.	• Review of past studies, available flood forecasting systems in other countries, flood forecasting system at FFWC. • Develop approach and methodology of the study. • Formulate strategy and action plan for the study, • Guide and supervise the project activities and team members. • Maintain liaison with BWDB and related agencies and coordinate all the stakeholders. • Hold all the meetings with the Client and World Bank. • Prepare reports and deliver as schedule. • Responsible for delivery of all the outputs, reports and maintaining the progress of the project as per the schedule. • Lead in presentations and workshops and organizing the training.

2	Senior Flood Forecasting Specialist	Master's in Civil Engineering/ Water Resource Engineering/equivalent with 12 years of professional experience including 08 years' working experience in hydrological data analysis, hydrological modelling and flood forecasting. Previous experience in flood forecasting model of FFWC and modelling using MIKE + software including knowledge of quasi 2D and 2D model development will be preferred.	• Developing baseline condition of hydrological features of the study area • Understand hydrological characteristics of river basin system using historical data, field visits and discussion with stakeholders. • Review different sources of satellite-based rainfall and find out potentiality of ensemble forecast. • Guide the modeler to improve the existing hydrological model by incorporating available satellite-based rainfall and publicly available Indian rainfall. • Guide the modeler in incorporating various weather forecasts for rainfall to produce ensemble forecasting. • Guide the ICT specialist to develop system to produce local level forecasting and early warning for dissemination using 2D model outputs. • Attend meetings as and when required. • Assist Team Leader as and when required.
3	Hydrological Modeler	Master's in Civil Engineering/ Water resource Engineering with 12 years' professional experience in hydrological analysis in flood management modelling. Should have experience of rainfall run-off modelling using MIKE+ Rainfall-Runoff in operational flood forecasting system.	• Review meteorological data. • Check data quality and filling gap for hydrological modelling. • Review and update of hydrological model of FFWC. • Improvement of existing hydrological model by incorporating available satellite-based rainfall and publicly available Indian rainfall. • Incorporate different weather forecast rainfall to produce ensemble forecasting. • Incorporate updated information of hydrological model in MIKE OPERATIONS (DSS). • Attend meetings as and when required • Assist Team Leader as and when required. • Provide training to FFWC professionals.
4	1D Hydrodynamic Modeler	Master's in Civil Engineering/ Water resource Engineering/equivalent with 12 years' experience in hydrologic analysis in flood modelling. Should have experience with 1D hydrodynamic modelling using 'MIKE+ River' and Data Assimilation and DSS. Should have extensive knowledge of hydrodynamic modelling in flood forecasting. Preference to be given to those with experience on FFWC flood forecasting model.	• Review of hydrological, river cross-section and land terrain data. • Review and update hydrodynamic model of FFWC. • Review forecast stations, evaluate performance and propose new stations as discussion with FFWC. • Update river and floodplain topography with available data and information. • Update boundary information based on available data. • Check calibration and validation of FFWC flood forecasting model.

			• Incorporate updated information of hydrodynamic model in MIKE OPERATIONS (DSS). • Attend meetings as and when required • Assist Team Leader as and when required. • Provide training to FFWC professionals.
5	2D Hydrodynamic Modeler (2 Nos.)	Master's degree in Civil Engineering/ Water Resources Engineering with at least 8 years' professional experiences in development of hydrological model, 1D hydrodynamic model, Flood Forecasting System. He/She should have working experience of development 2D model used in flood forecasting in at least one project. He/She should have proven experience in working with MIKE+ 2D modelling. Should have knowledge on flood forecasting system and DSS using MIKE + and MIKE OPERATIONS. Experience in 2D hydraulic model development for rivers and floodplains in at least one operational flood forecasting system is essential.	• Review of hydrological, topographical, land terrain, infrastructures data. • Review and understand hydrological and 1D hydrological model setup, availability of model results, and define 2D hydrological model domain. • Process land terrain data, river bathymetry data, external and internal time-series boundary inflow/outflow/stage data. • Prepare geometry for 2D model domain considering river system and infrastructures. • Prepare terrain data of land, rivers, embankments, roads, homesteads. • Prepare time-series boundary inflow/outflow/stage setup. • Setup two-dimensional hydrodynamic model, calibrate and validate the models for river hydraulics and flood inundation. • Prepare flood inundation forecast and incorporate dissemination website. • Prepare reports on 2D model developments, make presentation to the client. • Attend meetings as and when required • Assist Team Leader as and when required. • Prepare reports on 2D model works and make available to Team Leader for reporting. • Provide training to FFWC professionals.
6	GIS Expert	Master's in Geography/Urban and Regional Planning/equivalent with 08 years of professional experience including at least 05 years' experience in water resources management projects.	• Assist the modelers in preparation of spatial dataset. • Preparation of different maps showing topography, river networks, catchment delineations etc. • Preparation of maps for websites and reports. • Attend meetings as and when required • Assist Team Leader as and when required. • Prepare reports on GIS works and make available to Team Leader for reporting. • Provide training to FFWC professionals.

7	ICT & Database Specialist	Minimum of bachelor's degree in Computer Science/ Computer Science and Engineering/Civil Engineering/Water Resources Engineering having 3 years' experience in programming using PHP, Java Script, C#, Python, Post GRE SQL, SQL Server, and experience of data base development. Working experience in flood forecasting data base and flood forecasting system will be preferred.	• Write computer programs necessary to process data for model development. • Write computer program to download necessary data in public domain. • Automation of forecasting system from data collection to forecast dissemination. • Write scripts for exchange of data between various formats and models. • Attend meetings as and when required • Assist Team Leader as and when required. • Develop scripts to disseminate forecast output in the existing websites of FFWC. • Prepare reports on ICT works and make available to Team Leader for reporting. • Provide training to FFWC professionals.
8	Data Analyst (2 Nos.)	He/she should have minimum Bachelor's Degree in Civil Engineering or Water Resources Engineering having 5 years of working experience in processing of hydrological, meteorological, topographic and other data. He/She should have experience in mathematical modeling as well as flood forecasting. Previous experience in similar working environment will be preferred.	• Digitize different spatial data including rivers, roads, embankments and homesteads from satellite images in Google Earth. • Prepare shape files of digitized layer data and provide modelers. • Assist different members of the study team by analyzing and processing necessary data and information. • Take part in preparation of different reports as required for the proposed study. • Miscellaneous task as and when required.
9	Field Engineer (3 Nos.)	Minimum of Bachelor's degree in Civil/ Water Resources Engineering. S/he should have at least 3 years of professional experience and should have knowledge of collection and analysis of data of topography, bathymetry, hydro-metric, including experience in stakeholders' consultation, organization of workshop.	• Field visit as and when required by the Team Leader and any other professionals of the team. • Data collection and consistency checking. • Assist the Data Analyst in analyzing different data. • Assist FFWC professionals during monsoon flood season and provide support in real time flood forecasting. • Assist team leader as and when required.

11. Support Staff: 1 Office Manager/ Coordinator, Computer Operator, Peon Cleaner shall be required for the study. Their cost will be covered from the reimbursable.

12. Duties and Responsibilities

A. BWDB's Responsibilities

The Consultant shall work under the direct supervision of the Executive Engineer, FFWC, BWDB, Dhaka. The FFWC wing of BWDB shall assist the project team as required, particularly with regard to the hydrological modelling aspects of the study.

The Executive Engineer, FFWC, BWDB, Dhaka will ensure that the objective of the study as detailed in the ToR would be achieved within all agreed time schedule and that the contents of the report are acceptable to GoB. He will direct the planning process and work program and supervise the Study and monitor progress according to the objectives set in ToR.

The Executive Engineer, FFWC, BWDB, Dhaka will arrange regular meetings between the consultant and BWDB professionals to discuss technical and project management issues. Any unresolved issue either technical or otherwise shall be taken up with BWDB's senior engineers or other GoB agencies as required. BWDB shall provide or make available the following data, services and facilities to the consultants, as per existing rules of BWDB:

- Available information of the study area regarding the history and necessary information from the technical evaluation study team.
- The study-related available reports and documentation can be provided to the consultant by FFWC on return basis.
- Any other services, available with BWDB, to help the consultants to carry out the study objectives as per ToR.
- Necessary guidance on study activities when required.
- Any clarification required about this document for clear understanding of the process of conducting the study.
- Any unresolved issues which could not be settled down in the Board level, might be brought to Steering Committee by forming representatives from BWDB and MoWR

B. Consultant's Responsibilities

The consultant should carry out the services as detailed in "Objectives, Scope of Works and Expected outputs" in the best interest of the government with reasonable care, skill and diligence with sound engineering, administrative and financial practices. The consultants should be responsible to the client (BWDB) for discharge of responsibilities. It will be the responsibility of the consultant to collect all related information and data required for conducting the study. The consultant shall maintain full and continuous liaison with the BWDB. Throughout the consultancy period, the consultant's activities will be reviewed time to time by BWDB conforming to the schedule of time. The consultant will strictly follow the objectives, scope of works, and outputs of the study. All the collected raw and processed data and reports are to be handed over to BWDB in GIS and any other format whatsoever used in the study in soft copies. In response to that, the consultant should -

- Make available all the primary and secondary data (entire set of information involving audio-visual recordings) to BWDB or other agencies concerned as and when required. Data and information would be submitted to the client both in hard and soft copies.
- Make necessary arrangements for site investigation, environmental and social survey & data collection as needed for performance of the assigned task and evaluation thereby.
- Actively join the workshops with regard to the purpose of the study in presence of the BWDB officials and other stakeholders both at the project area.
- All types of technical support (like preparation of maps on necessity of the client and any other information related to the task the consultant is assigned with) to be provided to the client.

- All the training materials and manuals would be provided for future documentation. Necessary logistics for the training programs would be provided.
- All scripts and source code of any application, software, websites etc. developed under the project would be provided in a hard-drive with proper documentation.
- The consultant has to set up their office space, computers, printers, logistics, consumables, etc. for the services.

All the stakeholder consultation sessions would be recorded for future documentation. Video recording would be done and the clips should be handed over to the client. Discussants would be introduced with necessary introductory information and mobile phone number duly incorporated in the reports. Discussion points should be focused properly and addressed accordingly.

13. Procurement/Hiring Method

The Consultant will be procured following Quality and Cost Based Selection (QCBS) method as set forth in the World Bank Procurement Regulations for IPF Borrowers, February 2025.

14. Needs and Justification

In the last several years it appears that flash floods are hitting frequently during pre-monsoon and monsoon in the river basins located in North, Southeast and Eastern regions. The flash flood that occurred in 2024 in the southeastern region was quite unprecedented and caused tremendous suffering to the community and damage to infrastructures. The national level flood forecasting and warning dissemination circulated countrywide at present is not enough comprehensive to the communities residing in the river basins in north, southeast and eastern regions to be prepared in advent of flash floods. The flood forecasting super model is a national level model, and is not such detail to prepared flood forecast in community level. Also as the current model is not properly supplemented with substantial basin scale information there remains uncertainty in trans-boundary flow estimation. Therefore, a properly calibrated trans-boundary basin model at sub-basin scale for four major river basins developed with available best information is a great necessity. This should be coupled with existing 1-Dimensional model and in turn coupled again with localized and detail river basin based 2-Dimensional inundation models for the rivers in north, southeast and eastern region. This will enable to reduce forecast uncertainty and meet the demand of community level flood forecast and warning dissemination. The river basin based flood inundation forecast model may be developed for several flashy rivers including the Teesta-Dharala-Dudkumar river, Jinjiram river, Bhugai-Kangsha river, Surma-Kushiyara river, Juri-Sonai-Bardal river, Manu-Dhalai river, Khowai river, Gumti river, Feni-Muhuri-Selonia river, Sangu river and Matamuhuri river etc. In the first stage, the Gumti river, the Little Feni river and the Feni-Muhuri-Selonia rivers can be taken under development of 2-Dimensional river basin-based flood inundation models.

Also as the Northern part of the Bangladesh is frequently flood affected there is also necessity to incorporate 2-Dimensional model therein along the Brahmaputra river. The Kurigram, Gaibandha and Jamalpur districts cover vast floodplain of the Brahmaputra river and inundated almost every year during monsoon. Activity is ongoing and at the final stage to develop a Lidar based high resolution Digital Elevation Model (DEM) for the area under Provati Project-DDM part. The DEM needs to be incorporated and calibrated to incorporate in 2-Dimensional model coupled with the existing 1-Dimensional model to be used for more local level flood warning generation in the

Brahmaputra basin. This may enrich the warning coverage in the flood prone Northern Bangladesh.

Besides this, the existing MIKE+ license procured under BWCSRP is single and not enables to run multiple flood simulations, specially, inundation scenarios for multiple regions at once. To ensure proper sustainability of the newly procured system it should be atleast a double user license and one more license needs to be procured for relevant Mike+ 1D/2D, MIKE+ Basin, MIKE+ Rainfall/-Runoff and MIKE Operations. This will also come with a one year maintenance contract complementarily with DHI software for one year so that full functionalities including full utilization of numerous CPU cores and GPU can be achieved to enhance computation capacity. However to continue with the full functionality maintenance service needs to be renewed in future.

Lastly, the existing DSS is not integrated with Mike Operation Web Application module which is the latest available DSS in Mike Operations. The Mike Operation Web facility would increase forecast comprehensiveness and forecast interpretation from multiple sources and would be faster for viewing. The ensemble based forecasting needs to be integrated here for better decision making and faster warning generation specially, in terms of flash flood. In this regard, direct input from associated DHI expert would be most efficient in terms of new MIKE Operation Web module implementation as this is the latest addition in DSS from DHI. Also as this is a new prospect, the FFWC and BWDB professionals should be trained on MIKE Basin, Mike Operation Web and associated enhanced DSS in terms of ensemble based forecasting for increased operational capacity. Hands-on training on DSS and MIKE Operations Web for relevant professionals are highly recommended by DHI expert to gain better operational forecasting capacity.

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