

## **TERMS OF REFERENCE (TOR)**

Consultancy Services for “Management Support  
to the Mathematical Modelling Centre (MMC) under Water Resources Department,  
Government of Bihar”



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## BACKGROUND

1. Bihar faces significant challenges due to both floods and droughts, which have severe repercussions for agriculture, water resources, and the livelihoods of its people. Bihar is affected by either floods or droughts on a regular basis, sometimes by both within one year.
2. While Bihar is the most flood-affected state in India, recurring floods and resultant erosion are mostly confined to North Bihar. Flooding in Bihar is associated with long inundation periods and very high sediment load in river water, which destroy crops and infrastructure and threaten dwellings as well as livelihoods of the population. Rising water levels in the rivers during floods may cause physical damage to irrigation infrastructure. Further, flooded rivers carry heavy sediment load that is deposited in rivers and irrigation canals and reduces conveyance capacities. The Water Resources Department (WRD) has built embankments to protect affected area. However, unprotected areas remain, while floods continue to damage existing sections, requiring regular repairs and strengthening to ensure effectiveness and longevity of the infrastructure.
3. Usually, the south and southwest regions of Bihar face regular drought conditions, on average once in every two years. North Bihar is less drought prone but can experience long dry spells as well during the monsoon season. Droughts impact reservoir storage, groundwater levels, and crop yields (monsoon crops, especially rice). While weak or delayed monsoons are largely to blame, a macro-level climate analysis suggests further shifts in Bihar's rainfall and temperature patterns over coming decades. The Fourth Agriculture Roadmap has several schemes that are dealing with measures to combat drought.

## MATHEMATICAL MODELLING CENTRE (MMC)

4. The Government of Bihar (GoB) has initiated action to provide world class services in the field of Water Modelling, using the state-of-art technologies for better flood management, river basin management, river erosion, sediment management, climate change, water resources planning for new project, instrumentation and software. As part of this, Mathematical Modelling Centre (MMC) has been established at Patna, under Water Resources Department (WRD), to institutionalize mathematical modelling technologies, for enhancing its expertise in hydrological, hydraulic, sediment transport and morphological modelling, computational hydraulics, flood risk management, river engineering, and related scientific disciplines. The MMC is a strategic initiative aimed at supporting Integrated Water Resources Planning and Management (IWRM) across the state by providing high-quality analytical services of international standard. These services are crucial for enabling informed decision-making through structural and non-structural measures and nature-based solution (NBS) in areas such as water resource management, flood control, erosion risk management and drought mitigation.
5. The MMC will however require at least a few years to be self-sustainable and intensive on the job training to be able to produce reliable outputs. Thus, a managing consultant is required not only to manage the MMC and help in its operational and functional activities, but also to take over the responsibilities of the immediate modelling tasks assigned to the Centre. The WRD has engaged a Managing Consultant to oversee the operational and functional activities of the MMC. Currently, consultancy services for management support to MMC are being implemented under the World Bank-funded Bihar Kosi Basin Development Project (BKBDP), with the ongoing contract set to expire on March 31, 2025. Therefore, this vital support of the World Bank will continue under the Bihar Water Security and Irrigation Modernization Project (BWSIMP), being prepared.
6. Currently, the MMC primarily focuses on flood forecasting and modelling activities across various river basins. In terms of flood forecasting (FF), 3-day lead forecasts and 5-day advisory forecasts are provided for all major rivers in North Bihar. Compared to flood forecasting, drought forecasting is further behind as it has not yet taken up to provide early warnings in Bihar by MMC. However, there is a growing need to broaden its scope to include real-time drought forecasting, alongside improving MMC's on-going initiatives in flood forecasting, flood and erosion risk management.

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## BIHAR WATER SECURITY AND IRRIGATION MODERNIZATION PROJECT (BWSIMP)

7. The Bihar Water Security and Irrigation Modernization Project (BWSIMP) is currently being prepared for World Bank funding has five project components viz., i) Climate resilient irrigation; ii) Flood risk reduction; iv) Water governance; iv) Project Management; and v) Contingency Emergency Response Component (CERC). The current mandate of MMC is directly relevant for component ii of BWSIMP.

8. The Subcomponent 2.3 of BWSIMP - Strengthening of the FMISC and the MMC provides for hiring Management Consultancy for MMC. The Project will support strengthening of the FMISC to address current shortcomings in flood management through (i) operationalizing a state-of-the-art flood monitoring using a Real-Time Data Acquisition System (RTDAS); and (ii) procurement of topography and bathymetric survey data of the project area for better planning and execution of flood management interventions. Strengthening of the MMC will include investments in technology, personnel, and infrastructure, such as institutionalizing the use of high-performance computing equipment, high-end analytical tools, and advanced communication systems. Embankment Asset Management<sup>1</sup> and River Morphology Studies will also be part of this subcomponent.

9. The use of advanced Flood Forecasting and Early Warning System (FF-EWS) tools developed as part of BKBDP is being used for flood forecasting of all important river basins of North Bihar which is affected by flood in monsoon period. It requires to maintenance and upgradation every year before flood season. Two Performance Based Condition (PBC), expected as a result of the implementation of Sub-component 2.3 of BWSIMP are: i) A composite platform for FF-EWS developed and field tested, for each of the five river basins in North Bihar; and ii) Lead flood forecast for 3–5 days operationalized, and early warnings issued, in each of the five river basins in North Bihar.

10. In addition, the Subcomponent 1.4 of the BWSIMP - Hydrologic Agricultural Information Support Centre (HAISC), a dedicated institution for irrigation and drought management established to be and operational. One of the three PBCs or activities, that the project will finance under the subcomponent is - Advanced Tools for Drought Forecasting and Early Warning System (DF-EWS) developed and institutionalized. MMC can play a major role in implementing this activity, in partnership with the HAISC.

### MMC UNDER BWSIMP

11. The WRD envisions the MMC evolving into a self-sustaining centre of excellence, providing cutting-edge technical expertise in both flood, erosion and drought modelling. An equally important goal is to build the capacity of local teams through continuous formal and on-the-job training and skill development programs. Despite this long-term vision, there is an immediate need for the MMC to update and maintain existing FF model, deliver actionable outputs, particularly in the area of drought forecasting and other on-going mathematical modelling studies, to support ongoing efforts in sustainable water resource management.

12. The purpose of the proposed Consultancy Services is to run successfully and perform operational functions of MMC and support FMISC of the WRD, GoB to their requirement. The Consultant will develop capacity in the MMC, WRD to independently carry out mathematical modelling for various facets of water resource development including flood, drought, groundwater, sediment and erosion management of Ganga basin and other rivers of Bihar. There is a need to maintain and upgrade the present models and develop a real-time drought forecasting system that provides early warnings to mitigate the adverse impacts of droughts on needful basis. Upgrading the current model is necessary to improve computational capacity, enhance data processing speeds, and integrate modern software tools that are essential for effective water resource planning.

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## OBJECTIVES

13. The Managing Consultant will be required to manage the MMC and help in its operational and functional activities and will be fully responsible for the immediate modelling tasks and its deliverables assigned to the Centre for a period of 24 months. The key objectives of the management consultancy for MMC under BWSIMP are:

- The management consultant will work hand in hand with WRD and share accountability to make the project successful, including: i) creating an enabling environment for knowledge base development and learning at the start of the project; ii) review and modification of existing rules and procedures that impede development of skills and expertise for highly specialized mathematical modelling; iii) developing and implementing systems of accreditation within the WRD for assessing the level of expertise attained and linking it with the appointments in MMC; iv) identification and application of change agents that can accelerate the realization of objective and vision of MMC; and v) developing process documentation and monitoring tools.
- Effective support in the operation and maintenance of the established MMC in accordance with latest practices to keep the Centre's infrastructure in optimal working condition, including: i) deploy the experts to support in setup of organization processes, responsible for determining the compliances that are to be met i.e. IT guidelines, audit compliances and to introduce sound management practices in keeping with the future plans for running of the MMC as Centre of Excellence (COE); ii) existing models are based on MIKE software, so consultant should possess MIKE software to support and update existing models. Beside that consultant should also possess essential software's/ hardware & other equipment required to support existing models and proposed modelling task in this consultancy work; iii) improve quality of working environment and outputs; iv) identify the gaps in human resources capacity and provide training as per requirement to create human resource to run MMC efficiently; and v) assist in the planning of new projects related to flood protection, anti-erosion, river interlinking, flood and sediment management, navigation, dredging, river and flow restoration and similar initiatives under the purview of WRD.
- Continue development of MMC with capacity of utilization of the contemporary, state-of the art water resources management modelling tools using industry standard mathematical modelling technology; and updating and calibration of the flood forecasting and other existing models at the centre with the latest available data, incorporating cross-section, topography, LiDAR, and other structural information. Subsequently, ensure validation of the models (including if re-calibration needed) up to the most recent monsoon hydrology with proper documentation; and Identify sources of relevant (morphological, hydrological, hydrogeological, topographical, water quality, groundwater, etc) data and enhance database strength of MMC.
- Develop SOP protocols and a roadmap for the maintenance, operation, and upgrade of flood forecasting and other existing models; suitable formats (using standard nomenclature practices) contents, and dissemination protocols for Flood Alert disseminations; and a flood warning system on the basis of forecast for probable bank erosion and channel migration, with proper documentation consisting of detailed protocol for maintenance of all types like preventive, perfective (accuracy), enhancements etc.; evaluation of existing flood forecasting models, and other operational models developed in this centre and making it operational for upcoming monsoon seasons; and expansion and/or transformation of the domain of flood forecasting and other existing models as per the requirement of the WRD, incorporating latest technology.
- Develop mathematical models for real-time drought forecasting and early warning system (DF-EWS) in specified region/study area; establish real-time DF-EWS capabilities at the MMC to enable proactive decision-making and timely interventions, utilizing advanced hydrological models and real-time data analysis; shift from post-seasonal to preventive drought management by providing actionable forecasts

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and early warnings, supporting timely implementation of drought mitigation in specified region/study area.

- Irrigation engineering modelling, including irrigation water management (current/future water availability and demand) and automation of irrigation water allocation mechanism.
- Add several new water resources modelling technology at MMC including: groundwater modelling, water quality modelling, water supply and distribution modelling, urban drainage modelling and morphology modelling, etc in specified region/study area.
- Conduct hands-on training, hand holding, capacity building and training material for WRD officials, collaborating closely with modelling experts to develop internal trainers and essential training toolkits. This is aimed at preparing new modellers who will be assigned or recruited into the MMC.

## SCOPE OF WORK

14. Six key work areas identified for fulfilling the objectives of the management consultancy for MMC under BWSIMP are:

- i) Review of best practices and technologies for hydrological, hydraulic, sediment transport and morphological modelling, flood and drought forecasting, integrated water resources management (IWRM), hydrographic surveys and other allied disciplines related to water resources development
- ii) Update, improve and upgrade FF-EWS and other existing models within MMC hydrological, hydraulic (1D, 1D/2D linked) and 1D and 2D sediment transport and morphology models including calibration and validation of all models with latest topographic and hydrometeorological data and floodplain mapping, using Artificial Intelligence (AI) and Machine Learning (ML) technology based hydrological modelling.
- iii) Develop drought forecasting and early warning system including data collection and conceptual design of drought forecasting and early warning system (DF-EWS), and dissemination of forecasting.
- iv) Introduce several new modelling technologies required for WRD, including flood, ground water modelling, morphology modelling etc.
- v) Technology transfer, training and capacity building.
- vi) Support to WRD in project planning and implementation.

15. Key tasks of the management consultancy for MMC under BWSIMP, in the first work area - **review of best practices and technologies**, are:

- Provide an overview of global experience and current national approaches to flood forecasting, forecasting of channel planform change of river, drought forecasting, early warning systems and inundation mapping.
  - Develop Standard Operational Procedure (SOP) for routine operations of MMC, including guidelines for model updates, data management, and emergency response procedures.
  - Collection and compilation of relevant data including present status of existing river training works (RTW) and other flood control structures and conduct desk analysis to understand the historical trend, prevailing characteristics so that probable hydraulic phenomena can be projected and thereby platform and basis is developed to authenticate the model generated outputs.
  - To undertake and formulate process for review of relevant literatures to enhance the understating of mechanism and documentation of lessons learnt.
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16. Key tasks of the management consultancy for MMC under BWSIMP, in the second work area - **update, improve and upgrade FF-EWS and other existing models within MMC** are as described below:

- Review and evaluate existing flood forecast and inundation mapping, channel incidence mapping, identification and mapping of critical reaches prone to bank erosion through analysing satellite images, changes in hydrological parameters in the river basin, and identify possible improvements to forecast parameters, accuracy and lead-time implementing statistical correlation, soft computing techniques like fuzzy logic, Support Vector Machine (SVM) and Artificial Neural Network (ANN), stochastic models, and conceptual hydrological/hydraulic models based on current and likely available topographic, hydrologic and hydraulic data in the basin.
- Propose protocols and road map for model maintenance, operation and upgradation to expand the domain of existing flood forecast model as per requirement of Department.
- Identify possible upgradation in scale (domain areas) and in process and dimensions to the Flood Forecasting and other existing models for improvement in forecast with regard to output parameters, lead-time and accuracy. Advantages /disadvantages and strengths / weaknesses of each option shall be elaborated.
- Create a tool for accessing the optimal forecast among various forecast products produced by different international agencies, tailored for use within this MMC and in Bihar.
- Review the existing other models already developed and is in operation for last monsoon and other existing task-based models – hydrology, hydraulics (1D, 2D, 1D-2D linked), 1D and 2D sediment budgeting and morphology, river erosion management and training, canal interlinking model etc., and suggest further improvements.
- Update and calibrate all Flood Forecasting and other existing models established at centre with latest available data such as cross-section, topography, LiDAR, sediment data and other structural data, and then validate the model till latest monsoon hydrology. For this they should possess MIKE software.
- Adapt to the 1D and 2D modelling software (MIKE 11 and MIKE21C) required for hydrodynamic modelling, sediment transport, flood modelling, morphological analysis and modelling, erosion modelling and other facets of water resources development for the activities.
- Floodplain zoning – this involves flood frequency analysis for determining discharge/WL of different return periods at different control stations, application of hydrological, 1D/2D coupled modelling and flood plain mapping without and with embankment condition.
- Organize regular meetings and consultations with stakeholders to align modelling efforts with on-the-ground needs.
- Suggest necessary upgradation of Hardware/Software of MMC for future development.
- Develop a hydrological model using AI/ML for Specified Study area/River Basin.

17. Key tasks of the management consultancy for MMC under BWSIMP, in the third work area - Development of drought indices and drought model, **developing drought forecasting and early warning system** in specified region/study area. This can be characterized by their spatial and temporal statistical properties (e.g. likelihood of droughts of a certain severity in the form of their return periods at a particular location). Exposure describes the absolute amount of assets (e.g., plantations) and economic activity that may experience harm due to the effects of these events. Vulnerability (or sensitivity) captures the degree to which assets and productive activities are susceptible to experience negative impacts of hydro-met hazards, are described below:

- Data collection and compilation and conceptual design of drought forecasting.
- Development of drought indices and drought model – temporary or permanent changes in hazard patterns (e.g., climate change), (ii) changes in the exposure (e.g., agricultural expansion and intensification), and (iii) changes in the vulnerability profiles (e.g., farming practices). That is, risk can be most effectively reduced by managing the exposure and reducing the vulnerability (increasing the resilience) of land.
- The drought indices and model shall make use a combination of rainfall and temperature; soil moisture, total runoffs and evapotranspiration including river flows.

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- Development of drought outlook for advisories be developed in conjunction with Dept of Agriculture inputs by utilizing the variable infiltration capacity and alike models that computes water and energy budget for each grid. Use of remote sensing data for developing the operational spatial drought model of higher resolutions grids are the pre-requisites.
- Development of drought forecasting model of a selected river basin area.
- Design and implement a real-time Drought Forecasting and Early Warning System (EWS) within the MMC, focused on delivering early warnings before low rainfall events.
- Develop an emergency flood warning system for downstream areas of the dam, incorporating real-time monitoring, predictive modeling, and multi-channel communication for timely dissemination of alerts.
- Establish a hydro-meteorological network for inflow forecasting systems of dams in Bihar, integrating real-time data collection, weather forecast, and hydrological model.

18. Key tasks of the management consultancy for MMC under BWSIMP, in the fourth work area - **new modelling technologies**, are described below:

- Develop mathematical model for the rivers other than Flood forecasting and other existing models in the centre incorporating reservoirs and structures, including inundation mapping tool. And also conduct water balance studies for the same. With outputs of the river model, assess hydro-morphological condition for base and climate change condition. On the basis of results, scenario for option including structural measures should be formulated and incorporated in the model to assess performance and effectiveness of the suggested measures.
- Catchment sediment Budget modelling: To understand the sediment generation phenomenon, sediment transport mechanism, morphological characteristics of the rivers, sediment deposition mechanism with respect of identified river, identify critical and other vulnerable locations in the catchment/ reaches in the river, suggest suitable catchment treatment/ river training works for restoration of critical locations/ reaches depending on site conditions.
- Develop a tool for identification of Critical reaches for erosion and sedimentation with major causative physiographic parameters of the catchment and bed like erosion area, LULC and its change, soil type, erosion length of the river, flow velocity, change in riverbed gradient etc. along with identification of the most suitable sedimentation/ morphological modelling under the Indian conditions of topography, geology, meteorology and data availability
- Flood Risk Vulnerability assessment in Bihar for river basin depending on availability of required topographic data using MIKE+ (Modelling of Integrated Knowledge for the Environment), HEC-RAS (Hydrologic Engineering Center - River Analysis System) model or any latest tool/software.
- Create a appropriate flood mapping tool that identifies critical flood-prone areas, ensuring self-sufficiency for MMC officials and staff through technology transfer and in-house customization.
- To establish a system for providing timely advisories and interventions with inter department and other relevant agencies co-ordination
- Develop a database and Decision Support System (DSS) by creating a unified interface enabling access to all information and data pertaining to MMC. If needed, adopt industry-standard DSS like Delft FEWS/MIKE OPERATION or similar through discussion with the client, including modules for data storage and provisions for efficient data downloading and dissemination
- Digitization of embankments, riverbanks, canals, their command areas, structures, and administrative boundaries, ensuring accurate geospatial representation and integration into the Decision Support System (DSS) for improved management and planning
- To run, operate and maintain the established MMC supported by latest practices, for keeping the infrastructure of the Centre in full working order throughout
- Recommend appropriate format and content and dissemination protocols for the Flood and Drought Alert
- Development and continuous updating of web-enabled Windows application on server-client architecture. It shall integrate the knowledge base of hydrologic/hydraulic/topographic data, and after configuration should run automatically. Based on a dynamic front-end module, it shall be possible to modify model inputs, recalibrate and validate online models (Flood/Drought forecast) and offline models (flood risk, erosion, interlink, dredging etc.) when improved data becomes available and disseminate model results

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- Develop a tool for automated satellite image analysis that would provide erosion/sedimentation information for main rivers of Bihar. The tool should be able to identify critical reaches for erosion and sedimentation. Provide a technology transfer training on the tool
  - Based on requirements, develop proper two-dimensional morphological models to support MMC regarding anti-erosion, dredging, infrastructure/bridge scour, char dynamics related activities
  - Breach scenario analysis for events in flood period which include preparation of inundation map report based on that
  - Identification of vulnerable river locations through studies and modelling, using hydrological, hydraulic, and geospatial analyses for proactive flood risk assessment and management before the flood season
  - Assessment of the sediment budget of interstate rivers and rivers originating from Nepal
  - Conduct modelling studies to assess the construction and impact of bridges, embankment raising, and other river training structures on river behaviour, sediment transport, and flood dynamics, ensuring informed decision-making for sustainable flood management and infrastructure planning
  - Development of a hydrological model of selected area/river basin using Artificial Neural Network (ANN)/ fuzzy logic/ Support Vector Machine (SVM).
  - Development of a groundwater model of Bagmati river basin (or Specified Study area/selected area otherwise).
  - Determine the lateral and vertical extent, thickness and continuity of the aquifers and characterize the properties of aquifer sediments based on secondary data in study area.
  - Develop a 3D-groundwater model using MIKE SHE (or other latest software available) for Study area to assess groundwater resources availability.
  - Coupling of surface water and groundwater model to develop surface water-groundwater interaction model to get a complete natural hydrological scenario for assessment, analysis and prediction of groundwater resources for study area.
  - Assess the present groundwater availability using the developed model and examine the impact of climate change and extreme drought conditions on future water availability in the study area
  - Determine and fix the safe yield level of aquifer of the study area based on water resources availability, use, demand, and recharge potential in study area.
  - Identify the Water Stress Area (WSA) considering present and future water uses in the study area, including technical constraints on water access in study area.

19. Key tasks of the management consultancy for MMC under BWSIMP, in the fifth work area - **technology transfer, training and capacity building**, are described below:

- Hand holding in direct work from modelling experts and developing internal trainers and necessary training tool kits (Manual/video tutorials/ presentation etc.) for training new modellers/officers who would be posted/recruited in MMC.
- Provide training on morphological modelling using different tools like MIKE 21C, MIKE 21 FM, MIKE 3, Delft-3D, Hec-RAS) to compare different models.
- Provide training on groundwater modelling using MIKE SHE/MODFLOW.
- Provide training on water quality using MIKE+ ECOLAB.
- Provide training on river and topographic survey techniques using single-beam and multi-beam echosounders, RTK-GNSS, electronic total stations, and photogrammetric/terrestrial/aerial LiDAR systems, including planning, data acquisition, editing, and processing.
- Training on statistical hydrological model using ANN/ fuzzy logic/SVM.

20. Key tasks of the management consultancy for MMC under BWSIMP, in the sixth work area - **support WRD in project planning and implementation**, are described below:

- Work with and assist the WRD in: i) River Basin Management; ii) Flood Forecasting, Flood Management and Drought forecasting; iii) River Erosion/ Sediment Management; iii) Groundwater assessment and management; iv) Water Resources/Irrigation/Drought Management; v) investigating

and determining solutions, both structural and non-structural to particular problems that arise and assist the Department in designing river/basin infrastructure and projects; vi) policy formulation, strategies and action plans, based on the most advanced available knowledge, data and analysis; vii) dissemination, explaining and discussions of knowledge at the levels of the public, the government and private sectors, NGOs, academic institutions and civil society; and viii) becoming (in the longer term) a self-sustaining institution by imparting on job training to the WRD officials and specialists.

- The Consultant should possess MIKE software to support existing model and they should also possess software/hardware required for various task in this consultancy work.
- Provide support for planning of new projects for flood protection works & anti-erosion, and river interlinking works, flood and sediment management, bank erosion/channel shifting/avulsion, irrigation and drought engineering under WRD, Bihar.
- Support WRD for possible immediate works at: i) Sikrahata-Majarhi along Kosi western embankment, iii) Along eastern embankment 60km downstream of Kosi Mahasetu, iv) Flood control structures in Bagmati and other modelling work provided by department time to time.
- Formulating mitigation plan, though modelling options, for efficient channelization of flow and sediment load through desilting, flow restoration, channel linking, structural interventions and natural adaptation etc.
- Formulating survey specifications for any project and model related to MMC and WRD, assisting in surveys carried out by the department, reviewing and monitoring surveys carried out by third party for WRD and MMC.
- Enhancing resilience to droughts by improving water resource management, irrigation planning, and community preparedness.
- Facilitate coordination between the WRD and other relevant government departments, such as the Department of Agriculture, Disaster Management Authority, and Meteorological Department, and others to ensure that the models developed are integrated into broader state-level water management strategies.

## DURATION

21. The duration of the consultancy in a Time-based contract will be for 24 months duration. Deployment of experts will be managed with discussion and approval of the client. The duration of consultancy work can be extended as per the work interest and requirement of the client. Also, this work may be terminated and closed by client at any time. The decision of client will be final and acceptable to all.

## DELIVERABLES

22. The Management Consultant has to deliver the reports, as listed in the table below.

S. No	Submission timeline	Report
1	Within first 45 days from agreement	Inception Report
2	Within 15 Days of the end of reporting quarter.	QPR 1 onwards
3	Within 15 days of completion of the first year.	Interim report (including QPR-4)
4	45 days before the completion of Consultancy.	Draft Final Report
5	15 days after approval of Draft Final Report.	Final Report

23. The reports should be compiled as per the content listed below.

- Inception Report:
  - ✓ An assessment of the available Flood forecasting and other existing models at the MMC.
  - ✓ Assessment Report on the current drought indices, models and management systems in India and abroad that are most suited for Bihar conditions

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- ✓ Data Assessment Report – an examination and quality evaluation of the data utilized in the model, including acquired information and future action recommendations,
  - ✓ An assessment of the immediate modelling needs of FMISC/WRD and accordingly time frame plan to be provide.
  - ✓ A work plan for in-house training of FMISC/MMC, WRD officials.
  - ✓ A work plan for execution of activity mentioned in scope of work.
  - ✓ A work plan for deployment of experts accordingly.
- Quarterly Progress reports (QPR):
    - ✓ Details of activity mentioned in work plan including the recommendations for improving performance with reference to the previous report.
    - ✓ Progress and status of training of FMISC/MMC, WRD officials including training tool kit, methodology, manuals and log files.
    - ✓ Progress and status of new projects assigned by water resources department.
  - Interim Report:
    - ✓ Demonstration of the activities carried out in all six work areas.
    - ✓ Report of the work done in last 12 months including QPR-4.
    - ✓ Recommendations including a management plan and institutional structure for the future MMC.
    - ✓ Early Warning Dissemination Plan, including the development of communication tools.
    - ✓ Recommendations on future suggestive measures for betterment of MMC.
    - ✓ Report on enhancement of model performance for the Flood Forecasting and other models/ existing models and state of development of require models and tools as identified in work plan.
  - Draft Final Report:
    - ✓ This report will include the complete Reports of all assignments mentioned in the Scope of Work.
    - ✓ The report will contain the, management framework for carrying out the day-to-day activities of MMC/FMISC and making it self-sustaining institution.
    - ✓ Outcome of implementation of the recommendation made in Interim Report
    - ✓ Reports of DSS/EWS framework for help in making suitable decisions.
    - ✓ Fully functional DSS/EWS software with necessary source code and licences, training, maintenance and operational manual.
    - ✓ This report will also include QPR-8.
    - ✓ Reports on performance of models, development of tools and policies.
  - Final Report:
    - ✓ This report will include the complete Reports for all assignments mentioned in the Scope of Work.
    - ✓ The report will contain the, management framework for carrying out the day-to-day activities of MMC/FMISC and making it self-sustaining institutions.
    - ✓ Outcome of implementation of the recommendation made in Interim Report.
    - ✓ Reports of DSS/EWS framework for help in making suitable decisions.
    - ✓ Fully functional DSS/EWS software with necessary source code and licences, training, maintenance and operational manual.
    - ✓ Reports on performance of models, development of tools and policies.
  - Compliance of any other recommendations and suggestions by WRD.

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24. The reports shall be submitted in three hard copies and a soft copy (Word & PDF) to the MMC. Five hard copies of the finally approved report by the Standing Review Committee/ Team constituted for this assignment shall also be submitted for the record.

25. **Approval Committees and Review Procedure:** The Inception Report, Quarterly Progress reports, Interim Reports, Draft Final Report and Final Report will be reviewed, accepted and approved by the Standing Review Committee (SRC)/Team constituted for this assignment by Water Resources Department, Government of Bihar. The Consultants will be required to incorporate the suggestions/Observations advised by the SRC/Team for modification of the reports/ and other activities associated with MMC.

26. **Payment Schedule:** Payments to the consultants will be based on the (08) Eight invoices each raised corresponding to quarterly submission of reports, Interim report (Including QPR-4) Final report. The time-based remuneration costs of consultant staff will be invoiced on the basis of the individual time sheets based on deployment of staff duly approved by the client. The payment for the quarter will be released after approval of corresponding reports by SRC.

27. **The consultant shall submit to the client itemized statements at time interval of every quarter.**

## OBLIGATIONS

28. Obligations of the Management Consultant are as listed below.

- The consultant shall follow the tasks and work areas defined in the Terms of Reference and also adhere to the concept outline for the MMC.
- The consultant shall undertake to deliver the outputs described in the scope of work. The assignments and schedules of deliverables resulting from the scope of work shall be specified in the Inception Report.
- The consultant shall undertake in collaboration with MMC, the preparation of the tasks to be included in the work plan following up on the completion of the immediate objectives.
- The consultant would also conduct extensive dialogues with stakeholders for preparing recommendations for the longer-term institutional plan for MMC – including its relationship with its parent body Water Resources Department.
- Consultant shall ensure synchronization of the two viz. Mathematical Modeling Center and Physical Modelling Centre (PMC) for joint research and other projects.
- The consultant shall ensure the successful run of flood forecasting models daily, generate and disseminate alerts and result based on the outputs of these models, on the FMISC/MMC systems during the monsoon period.
- The consultant shall prepare performance evaluation of the model on daily basis for the whole monsoon period or as if required.
- The consultant shall run/modify and run the models on scenario based like for inundation/travel time/discharge etc. of flood in the basin as per requirement of the department.
- The consultant shall also ensure deployment of experts throughout monsoon period.
- The consultant shall ensure non-disclosure of Data /Product/etc. of MMC.
- The consultancy work done in MMC will be copyright of MMC.
- Consultant has to provide source code of all software/models/etc. developed under this consultancy work.
- Consultant shall offer training and provide training material to MMC/WRD officers for the task executed under this consultancy work by nominated Key Personnels/experts as a part of that deliverable.
- Consultant has to provide required inhouse training, 2 numbers of national training at location inside India and 2 numbers of international training to the personnels selected by WRD. For training Program, consultant has to give proposal It will be reimbursable.
- The consultant shall possess the necessary hardware, software, and other required equipment as a minimum requirement for this consultancy. This includes the MIKE software to support and update the existing models, as well as to enhance the MMC's modeling capabilities for both existing and proposed modeling tasks.

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29. Obligations of the Client are as listed below.

- The Client will facilitate in collecting the data.
- The FMISC would participate in all committees that are set up for discussing and monitoring the progress and processes for the work Programme of MMC.
- WRD/FMISC and the Management Consultant will jointly decide the course correction every quarter based upon process documentation and monitoring.
- Office space as per client discretion will be provided to consultant.

#### SUGGESTED KEY STAFF AND EQUIPMENT

30. The consultant will engage the key experts with minimum required qualifications and experience as detailed out in the table below, for given man months. Consultant shall quote payment schedule accordingly.

S. No	Position	Qualifications	Experience	Man months	Roles and responsibilities
1.	Team Leader	Master's degree in hydrology/Water Resources Engg./Civil Engg.	At least 15 years' experience in flood and Water Resources management projects and at least 10 years' experience in flood modelling, sediment transport and morphological modelling, Flood control and river training works. Desirable experience in Technology Transfer and institutional reform.	18	He/she will be responsible for setting up (as well as accepting transfers of Flood Forecasting and other existing models) and quality control of all hydrological and hydrodynamic models; Training and Advising Modellers and at all levels; Managing the entire team of consultants and ensuring timely outputs - communicating with the Head of MMC/ FMISC.
2.	Deputy Team Leader cum Stochastic modelling Expert.	Master's degree in Hydrology/Water Resources/Civil Engg.	At least 10 years' experience in river flood modelling, statistical correlation, soft computing techniques like fuzzy logic, SVM, ANN, stochastic models work. Experience of modelling in a relevant field is essential. Desirable experience in Technology Transfer and institutional reform.	18	He/she will be responsible for setting up and develop hydrological model using statistical technology; Training and Advising Modelers and at all levels; In the absence of the Team Leader managing the entire team of consultants and communicating with the Head of MMC, Head of FMISC. He/she shall assist Team Leader in review of all the survey and other data.
3.	River morphologist cum morphological modeller.	Master's degree in Hydrology/Water Resources/Civil Engg.	At least 12 years' experience in hydraulics of heavily sediment laden rivers, and erosion control with computational hydraulics including 2-D river modelling and morphology, analysing various kind of river training works (RTW). Working experience with software like MIKE 21C/Delft 3D or similar tools is essential.	15	He/she will be responsible for setting up (as well as accepting transfers of Flood Forecasting and other existing models) and quality control of all sediment transport and morphological models - as well as schematizing the related hydrodynamic models; Training and Advising Modellers at all levels; Supervising sediment sampling and analysis. He/she shall assist Team Leader in technical studies of the expected outputs of assignment.

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S. No	Position	Qualifications	Experience	Man months	Roles and responsibilities
4.	Hydrologist Cum Flood Modeller	Master's degree in Hydrology/ Hydraulic / Water Resources/Civil engineering	12 years working experience in hydrologic analysis, hydrological modelling, 1D/2D hydraulic modelling, flood forecasting, flood inundation modelling. 5 years' Experience in designing hydrologic network and HIS. Desirable experience in application Software/Interface Development / design in Flood Forecasting System. Working experience with software like MIKE 11, MIKE Flood, MIKE +, HEC RAS, or similar tools is essential.	15	He/she will be responsible for setting up (as well as accepting transfers of Flood Forecasting and other existing models) and quality control of all hydrological, hydrodynamic flood forecasting and flood inundation models - as well as schematizing the related hydrodynamic models; Training and Advising Modellers at all levels. He/she shall assist Team leader in finding the gaps of available hydrological data and support in collection of missing data required for Flood Forecasting Model updating/development etc.He/she shall assist Team Leader in technical studies of the expected outputs of assignment.
5.	Drought Modeling Specialist cum Hydrometeorologist	Master's degree in Meteorology/ Climate Science/ Environmental Science/Water Resource Engg/Hydrology, or related field.	At least 10 years' experience of developing or implementing drought forecasting models. This includes hands-on experience with predictive modeling tools, historical drought analysis, and integrating climate data for forecasting purposes. Experience with software like SWAT, HEC-HMS, or similar tools is advantageous.	16	Drought Modeling Specialist develops and refines drought forecasting models using advanced predictive tools and climate data. He/She will be responsible to analyze historical and real-time data, collaborate with experts, and provide actionable insights to stakeholders. His/her work involves continuous improvement of models, communication of findings, and capacity building.
6.	DSS Expert/ Software Engineer/ IT Expert	Master's degree in Computer Sciences/Information technology/Software Development.	5 years of Experience in development of DSS systems for applied water resources / hydrology / hydrologic science. NB- DSS Expert/ Software Engineer/ IT Expert multiple (maximum- 3) individual CV may be submitted but overall time input will be 24-man months. In case of multiple CVs Marking will be done on average basis.	24	He/she will be responsible for setting up Decision Support Systems, Data Acquisition Systems, and links with other databases and asset management systems; Writing the necessary software and liaising with the modelling expert's teams on getting the correct conditioning of model results suitable for DSS applications and real time DSS.

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S. No	Position	Qualifications	Experience	Man months	Roles and responsibilities
7.	Groundwater Management Specialist	He/she must have a Master's degree, in Civil Engineering/Water Resources Engineering/Water Resources Management/Geology	He/she must have minimum 15 years of working experience in water resources planning and management having background in mathematical modelling in water resources sector.  He/she must have 15 years of working/ similar practical experience in projects on groundwater resources management, groundwater modelling and assessment.	10	He/she will be responsible for setting up a groundwater modelling unit; review and examine information related to groundwater availability and current and future sectoral demands; Identify gaps that need to be addressed to complete the groundwater assessment; Assist the Team Leader in preparing the details groundwater assessment report.
8.	Senior Groundwater Modeller	He/she must have a Master's degree, in Civil Engineering/Water Resources Engineering/Geology	He/she must have minimum 15 years of working experience in developing groundwater flow models, integrated surface and groundwater models.	12	He/she will be responsible for setting up conceptual model; guide and supervise in collection, processing and analysis of all types of hydrogeological data; guide and supervise to develop and calibrate groundwater model; carry out analysis of the groundwater recharge using groundwater models.
9.	Groundwater Modeller	He/she must have a Master's degree, in Civil Engineering/Water Resources Engineering/Geology	He/she must have minimum 12 years of working experience in developing groundwater flow models, integrated surface and groundwater models.	12	He/she will be responsible for processing and analysis of all types of groundwater related data; development and calibrate of groundwater model; carry out analysis of the groundwater recharge using groundwater models.
10.	Institutional & Management Expert	Master's degree in Civil Engg/Water Resources or related fields.	15 years professional experience in water resource management projects. Should have experience in planning of institutional setup responsible for water resource management and planning. Experience in leading of a water resource management institute is preferable.	8	His/her main responsibility will be to assist and analyse management strategies and other operation techniques for the MMC. At the end of the project he/she will be responsible for creating a report of recommendations for the next Phase.
11.	Mid-level flood forecasting/ Warning Dissemination Expert	Master's degree in Water Resources or related fields.	10 years professional experience in river flood modelling/sediment transport /flood forecasting/ Water Resources/Hydrological Modelling. Experience of modelling in relevant field is essential.	18	His/her main responsibility will be to assist the flood modeller and River morphologist to analyze the hydrological modelling, and other modelling related tasks assigned by team leader and other operation for the MMC.

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S. No	Position	Qualifications	Experience	Man months	Roles and responsibilities
12.	Survey Expert (River Survey)	Master's degree in Water Resources Engg/Civil Engg/ geodesic/ surveying sciences/.	A minimum of 15 years of relevant professional experience in survey works. At least 10 years of proven experience in river surveys (Topographic, hydrographic and hydrometric surveys), including data acquisition, editing, and processing using RTK GPS, Total stations, ADCP, single-beam and multi-beam echosounders. Familiarity with International Hydrographic Organization (IHO) standards is required.	6	His/her main responsibility to train MMC professionals on survey planning, data acquisition, editing, and processing of topographic, hydrographic and hydrometric data and systematic documentation of all survey results.
13.	Survey Expert (Topography and Aerial Survey)	Bachelor's degree in Water Resources Engg/Civil Engg.	A minimum of 10 years of relevant professional experience in survey works. At least 5 years of proven experience in topographic survey using RTK-GNSS, Total station, Aerial survey using UAV (LiDAR & Photogrammetric), including data acquisition, editing, and processing.	4	His/her main responsibility to train MMC professionals on topographic survey planning and data acquisition, editing, and processing of survey data. Deliver training on advanced topographic survey techniques using LiDAR both aerial/terrestrial and systematic documentation of all survey results.
14.	Remote Sensing/ GIS Expert	At least a Master's degree in Geography/Remote Sensing/ Water Resources/Environment or related fields.	5 years' experience in GIS and proficiency in GIS software, image data processing etc.	24	Perform GIS database development, qualitative/quantitative analysis, mapping, collect and handle data, provide mapping services, perform technical research and analysis. Others tasks decided by the team leader and as per requirement for operation of MMC.
15.	Junior Modeller (3 Nos.)	Bachelor's Degree in Civil Engg./Water Resources Engg. / Research Management	2 years professional experience in hydrological/hydraulic/ morphological modelling	10	His/her main responsibility will be to assist the senior/mid-level modelers to analyze the hydrological, image data processing, database management and other operation for the MMC.
16.	AI/ML Expert	Bachelor's Degree in Computer Sciences/Information technology/Software Development/ Water Resources Engg./Civil Engg.	3 years of Experience in developing of AI/ML model in hydrology or related fields.	12	He/she will be responsible for developing models based on AI/ML and assist Team Leader in other relevant work.

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07.02.2025

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