

Analytical Work and Technical Assistance to Support
Strategic Basin Planning for the Ganga River Basin in India

1. Background – the Ganga River Basin in India

The Ganges is the most populated river basin in the world and is home to half the population of India including two-thirds of the nation's poor people. The basin provides over one-third of the available surface water in India and is the focus of over half the national water use – 90 percent of this being in irrigation. Water management is largely undertaken at the state level, and there has been no basin-wide effort for volumetric water planning and allocation. With increasing demand for water in multiple sectors a more strategic approach is now warranted.

The ecological health of the Ganga River and some of its tributaries has deteriorated significantly as a result of high pollution loads (from point and non-point sources), high levels of water abstraction for consumptive use (mostly for irrigation but also for municipal and industrial uses), and other flow regime and river modifications caused by water resources infrastructure (dams and barrages for diverting and regulating the river and generating hydropower).

The Government of India has committed to an ambitious goal of rejuvenating the Ganga and is committing significant funds to address the problem. A strong evidence base is required to ensure that these funds are invested effectively and efficiently. The scale and complexity of the problem requires detailed analysis. While significant analytical effort has been undertaken in the last two years that provides a valuable starting point, there remain many unknowns and uncertainties that require detailed investigation. In particular, as yet there is no robust modelling framework that can assess the consequences of alternative interventions (or suites of interventions) for the environment (including water quality and ecological health of the river) and for different water use sectors. Interventions may include, for example, new sewage treatment facilities, treatment of industrial effluent, environmental flows, increased water use efficiency, improved land management, additional water storages and changed operation of existing water resources infrastructure.

In addition to the technical complexity and scale, Ganga rejuvenation must be recognized as an inherently “wicked problem” given the wide diversity of stakeholder values and perspectives and the political and institutional dimensions that come from distributed responsibilities across multiple jurisdictions and institutions. The technical work must therefore be coupled with a well-structured stakeholder engagement and consultation process, and appropriate governance arrangements to guide both the technical and consultation work. The technical analyses, engagement processes and governance arrangements are the critical pillars of strategic basin planning.

The World Bank, in March 2015, approached the Ministry showing its keenness to support the Ministry in the complex long term task of strategic Basin Planning for the Ganga Basin. World Bank informed that by using their ‘Trust Fund Resources’ they would like to engage consultants for the above mentioned work and requested support of the Ministry for the Consultancy on ‘Strategic Basin Planning for Ganga River Basin in India’. They further informed that they have already received EOI for this work and there would not be financial liability on the Ministry except the institutional support. The support of the Ministry and its organizations was requested for collaborative efforts and approach for modelling, capacity building, facilitating access to data etc.

The Ministry conveyed its support for the consultancy work on 28.12.2015 specifying therein the key objectives, deliverables, Role of World Bank and Role of the Ministry. Simultaneously a Committee headed by the Secretary, MOWR, RD &GR was constituted for monitoring the progress of the above mentioned consultancy. The target date of completion of the project is December, 2017.

2. Objectives

The high-level objectives of the project are:

- (i) To significantly strengthen the capability of relevant central and state government agencies to undertake comprehensive evidence-based strategic basin planning for the Ganga River basin,
- (ii) To develop, document and disseminate (through detailed analytical work and stakeholder engagement) a set of plausible scenarios that balance significantly improving the health of the river and maintaining an acceptable level of economic productivity, and
- (iii) To build stronger and more accessible information and knowledge base to guide ongoing dialogue around and management of the Ganga River basin

These will be achieved by:

- (i) Developing a detailed and robust water resources planning model for the entire Ganga River basin in India and training central and state government engineers and planners in its use
- (ii) Characterizing and analyzing surface-groundwater interactions across the basin using this information to refine the river modelling
- (iii) Undertaking a multi-scale environmental flow assessment across the basin and using these assessments to inform the scenario modelling
- (iv) Developing, modelling and disseminating a series of plausible scenarios that explore alternative options for improving water management including improving river health
- (v) Establishing and facilitating a participatory process across technical and other interested stakeholders (inside and outside of government) to guide and share the work above
- (vi) Ensuring wide access to the models and analyses and quality documentation of these.

3. Study Area

The project will encompass the entire Ganga River basin in India including all tributaries upstream of Farakka Barrage on the Ganga River. Rainfall-runoff modelling in India downstream of Farakka Barrage is not required; river modelling of the Damodar Valley and the distributary channels in West Bengal is not anticipated. The modelling will need to ensure robust assessment of the flows that enter the Ganga via the Nepalese tributaries.

While hydrologic modelling will be required across the full area described above and a development full basin-wide pollutant inventory is required, modelling of water quality, environmental health and surface-groundwater interactions, are expected to be focused in key reaches of the main-stem or tributaries.

4. Detailed Scope of Work

Task 1: River Basin Model Development

This task involves developing a comprehensive rainfall-runoff and river system model for the entire basin within India, calibrated to available stream flow and irrigation diversion data, and using remotely sensed data sets as required, including for evapotranspiration to estimate or to constrain irrigation water use in cases of sparse observations. The model will include a node-link representation of the river system and key water resources infrastructure including hydropower stations and irrigation infrastructure. The flow model will use a time step dependent on the available flow data – ideally daily.

The model will include representation of key surface-groundwater interactions (informed by Task 2 below) and a mass balance of major pollutants of interest from urban and rural sources, both point and non-point. To support the water quality modelling a GIS will be developed of all point and non-point sources assembled all available pollutant data and gap filling with estimates to provide a comprehensive spatial picture of areal and point loadings.

While modelling of flood dynamics is outside the scope of the project, simple modelling of the extent and frequency of inundation of floodplain wetlands is required as a part of the environmental assessments. This can rely on remotely sensed data for flood inundation and for the character and extent of floodplain vegetation coupled with simple models relating inundation extent to river flow level. Digital elevation models may also provide useful for these analyses.

The model will be developed using modern public domain (free) river basin modelling software that has comprehensive documentation, training and other support available, a user friendly graphical interface, and the ability to represent complex operating rules for water resources infrastructure. The modelling will adopt best practice principles including for model conceptualization and set-up, calibration and validation, sensitivity/uncertainty analysis, and version control.

The model development will be undertaken in collaboration with key technical government partners including the Central Water Commission, the Central Groundwater Board, the National Mission Clean Ganga, the Central Pollution Control Board and the National Institute of Hydrology, and relevant state government department. The work will also collaborate with any other organizations undertaking related work for the central government, for example the consortium of Indian Institutes of Technology. This task will undertake and link to concurrent efforts in training and capacity building in hydrologic and river system modelling to establish competent modelers in central and state government agencies.

Task 2 Surface-Groundwater Interaction Analyses

Irrigation in the Ganges basin is the biggest use of water and the majority is dependent on groundwater. Although the alluvial groundwater system is closely connected with the river and canal systems, the two are treated as separate resources.

This task is to improve the understanding of surface-groundwater interactions across the Ganga River basin and will inform the river modelling. It will undertake analytical work to better understand the groundwater systems of the Ganga Basin – in particular the surface-groundwater interactions – building on recent hydrogeological studies. The implications for water planning and management will be described and explored in dialogue with the Central Ground Water Board.

The task will require existing data and information on the hydrogeology, groundwater resources and groundwater use in the Ganga Basin to be compiled into a GIS-based information system. Three-dimensional groundwater management units will be defined across the basin, and these will be prioritized in a risk framework based on the relative level of water use, likely future demand, connectivity to surface water, and water quality threats. A modelling/analytical framework will be

developed that considers all connected ground water sources, but focuses most effort and more detailed analysis on high priority groundwater management units.

This task will either link to, or provide appropriate data from, the groundwater modelling/analysis to the river modelling (Task 1) in order to assess the implications of changed surface water management on groundwater use and vice versa during the scenario analyses (Task 4). The consultants will engage closely with key government agencies and local technical organizations on aspects of this task to ensure acceptance and ownership of the analysis, and will undertake and link to other training and capacity building work on groundwater modelling and analysis to ensure ongoing use of technical assessments of surface-groundwater connections in water planning and management.

Task 3: Environmental Flow Assessments

Environmental flow assessments are a critical and a contested area of river basin planning and management for which there is growing awareness in India but limited experience and capacity. This task will undertake multi-scale environmental flow assessment using a highly consultative process based on sound scientific analyses. The task will build on and extend, to the extent feasible, earlier and ongoing environmental flows work and partnerships for the Ganga. The task will ensure environmental flow regimes, as one key determinant of river health, are represented in the river modeling (Task 1), and will facilitate training of technical professionals through “learning by doing” to build the capacity for ongoing environmental flow assessments as a part of an adaptive approach to basin planning and management.

The task will undertake a basin-wide analysis of flow regime change from natural (using a range of ecologically relevant flow variables and statistics) to provide a broad-scale perspective on likely critical reaches for environmental flows. The task will then identify an agreed list of river sites and reaches for more detailed environmental flow assessments, and set environmental and river health objectives for these sites and reaches. An ecological and socioeconomic baseline will be developed for the sites and reaches, identifying and mapping the key environmental and socioeconomic values and assets of the basin based on existing data, field work, field surveys and broad consultation.

The task will use the river model developed in Task 1 to simulate flow regimes across the river basin under a number of plausible scenarios of changed water use and/or water management, as interventions for pollution reduction. Using appropriate tools and approaches, the implications of these flow regimes will be assessed for hydraulic habitat, river geomorphology, water quality, river ecology, and socioeconomic, cultural and spiritual values. An ecosystem services framework will be one of the tools used in this assessment. These assessments will be compared to defined river health objectives.

As a part of the environmental flow assessments, this task will train government professionals in environmental flow concepts and methods in order to build the capacity for assessing and implementing environmental flows as a part of integrated water resources management.

The task will also develop an adaptive management framework to guide the implementation of environmental flow regimes across the Ganga River basin. This should include specific actions and operating rules for water resources infrastructure, a practical and time bound monitoring program for environmental and socioeconomic outcomes, and include the flexibility to adjust environmental flow regimes to achieve the desired environmental objectives.

In addition to the various water agencies listed earlier, it will be important in this task to engage with the environmental agencies.

Task 4: Scenario Modelling

This task focuses on the use of the river basin model for scenario assessment. The scenario assessments will both inform and be informed by the stakeholder consultant work of Task 5 (below); it is thus a central task for the overall project. Whether any of the scenarios explored lead to the agreement on a basin plan for the Ganga is a matter for the collective governments (central and state) managing the water and related resources of the basin. At a minimum the scenarios will enable a fuller and more evidence exploration of options for river development and rejuvenation, increase the collective understanding of the river basin and reduce the likelihood of wasted investments in river clean-up.

The scope and detail of the scenarios to be assessed will be determined during the course of the project, informed by the analysis as it proceeds and by the consultation processes. Nonetheless, the scenarios will need to consider at least the following issues: (i) options for reducing point source pollution, (ii) options for reducing non-point source pollution, and (iii) options for alternative environmental flow regimes (including through increased irrigation water use efficiency). Other scenarios that may be explored include new hydropower dams, the environmental implications of developing parts of the river for inland waterway transport and the potential impacts of future climate across the water management scenarios.

A key part of the task (and linking to Tasks 5 and 6) will be the sharing of the scenario assessments and their implications with partners and stakeholders, including through reports rich with graphics, through computer visualizations shared online and during consultation workshops. It is expected the process of scenario definition and assessment will be iterative through the process of consultation.

Task 5: Consultation and Engagement

This is a cross-cutting task that will support the technically focused Tasks 1–4.

A critical part of the project will be establishing and facilitating a process of consultation and engagement with key technical partners and stakeholders to ensure understanding and acceptance of the modelling, and to obtain input to model conceptualization and scenario definition. Key partners and stakeholders include the Central Water Commission, Central Groundwater Board, National Mission Clean Ganga, the National Institute of Hydrology, the Central Pollution Control Board, the Ministry of Environment and Forest, state water departments, relevant Indian Institute of Technology and other technical and conservation focused non-government organizations with an interest in understanding and contributing the rejuvenation effort for the Ganga. The project will link to and support the Ganges Basin Modelling Community of Practice that has been established by the World Bank and through this will connect to broader basin dialogue processes.

In addition to ongoing bilateral dialogue with the key organizations, a minimum of three major workshops will be held during the project for (i) model conceptualization, (ii) initial scenario scoping and (iii) dissemination of modelling results and implications. The transparent availability, quality assurance and dissemination of modelling results will be a key component to having engagement and empowerment of communities in the Ganga basin. A range of tools will be developed to explain data and modelling results including web-based dashboards and scorecards that facilitate understanding by less technical groups.

Task 6: Information Systems and Documentation

This task supports the technical Tasks 1–4 to ensure all this work is and well-documented in both technical and less technical forms, and links to Task 5 in supporting the consultation process with stakeholders.

In the support of the modelling Task 6 will create a comprehensive online data portal for the Ganga River basin containing all publically available data used in the modelling and analysis, relevant spatial data including the mapping of groundwater management units from Task 2 and the mapping of ecosystem assets from Task 3. The portal will provide visualizations of modelling results using the concepts of scorecards and dashboards to summarize and communicate complex results. It is anticipated that this would be established in collaboration with the yet to formalized Ganga Knowledge Centre.

High quality reports will be prepared and published describing (i) the river basin model – its conceptualization, set-up and calibration, (ii) the surface-groundwater analyses undertaken and the classification of groundwater management units, (iii) the environmental flow assessments, the ecosystem services and assets, and the social and cultural values of the river, (iv) the definition of the main scenarios modelled and summary descriptions and evaluations of these scenarios against objectives, (v) the design of the supporting information portal, and (vi) the stakeholder engagement processes.