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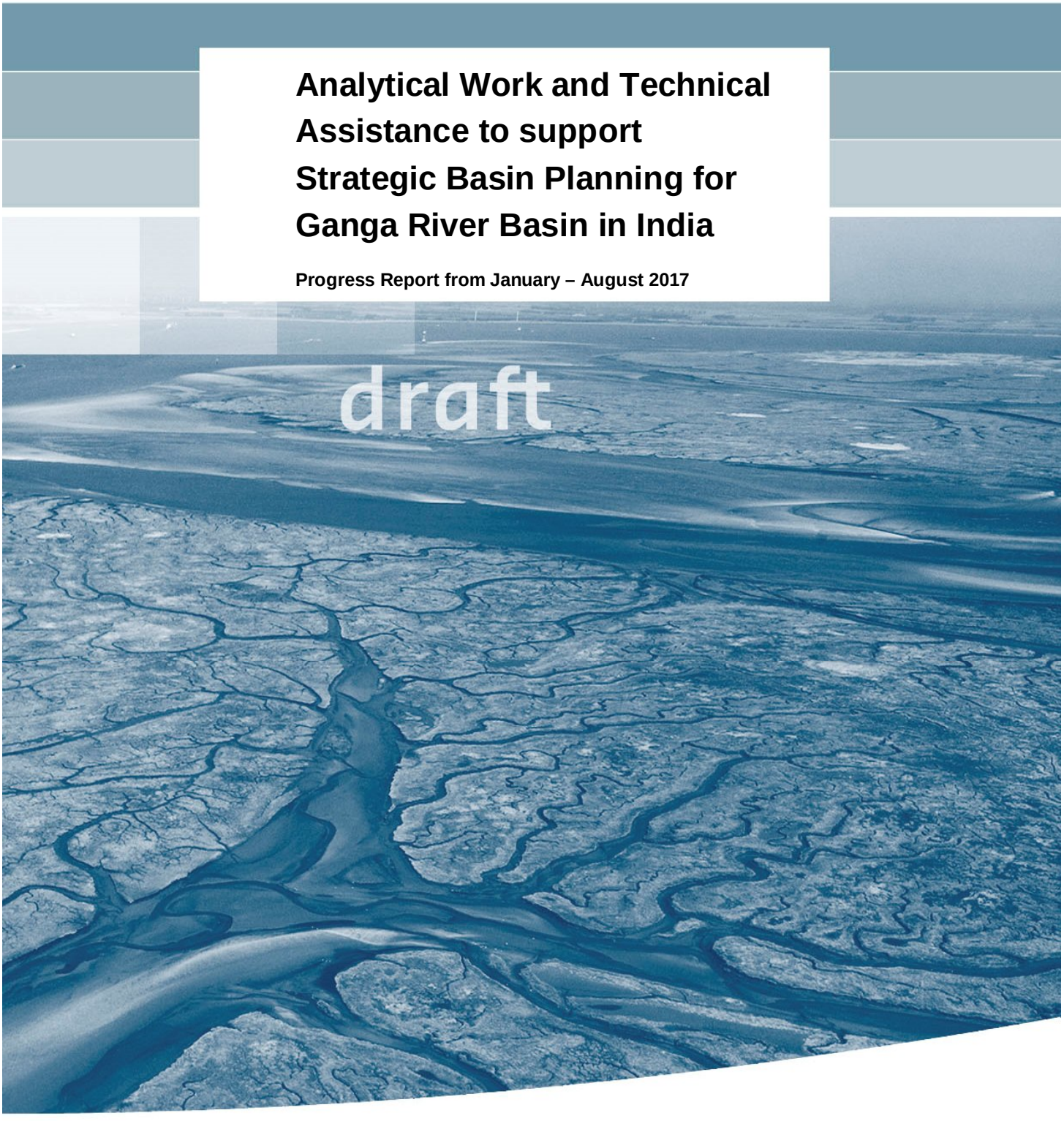
Analytical Work and Technical Assistance to support Strategic Basin Planning for Ganga River Basin in India

Progress Report from January – August 2017



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

Progress Report from January – August 2017
Draft incomplete version

Kees Bons (editor) with contributions from all team members

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India, Ganga River, water quality, ecology, water resources, hydrology, geohydrology, information system, GIS, water demand, irrigation, environmental flows, collaborative modelling

Summary
This report describes the progress of the project "Analytical Work and Technical Assistance to Support Strategic Basin Planning for Ganga River Basin in India" from January – August 2017. The Collaborative modeling phase, as described in the Inception report, was the completed and the Scenario building phase commenced. This is Deliverable 5a of the Project Work plan: "Progress report providing evidence of satisfactory progress on all project tasks", and together with other reports contributes to Milestone 5 of the project.

The project activities are grouped into six tasks:

1. River Basin Model Development
2. Surface-GW Interaction Analyses
3. Environmental Flow Assessments
4. Scenario Modelling
5. Consultation and Engagement
6. Information Systems and Documentation

Progress is evaluated, challenges are identified and actions for the coming period are described.

Overall, the project is progressing but slower than planned:

- Participation of stakeholders was deepened by the scenario building workshops that focused on strategies and solutions for the basin from the perspective of the individual states. A sense of ownership developed within the states.
- Model development progressed well and several capacity building sessions for states, central organizations and a specially formed on-the-job training group were implemented.
- Progress on the environmental flows and surface water – ground water interaction was slower than expected and required additional efforts to bring them forward.

Challenges that the project has to cope with:

- Continuous changing participation in (state level) workshops and training, making it difficult to build on previous sessions.
- Stakeholders' unfamiliarity with strategic planning induces more discussions on model detail level rather than on strategic choices and priorities for the basin.
- Although many organizations are involved it remains difficult to identify the institutions that will carry the strategic planning concept further after finalization of the project.
- Ecological data remains difficult to obtain.

State
Draft

Contents

Abbreviations

AFPRO	Action for Food Production
BIH	Bihar
CWC	Central Water Commission
CPCB	Central pollution control board
CGWB	Central Ground Water Board
CHH	Chhattisgarh
DEL	Delhi
DEM	Digital Elevation Model
E FLOW	Environmental flow
EC	Electrical Conductivity
FAO	Food and Agricultural Organization
GANGAWIS	Ganga Water information system
GW	Ground Water
HC	High Court
HP	Himachal Pradesh
HAR	Haryana
IIT	Indian Institute of Technology
IBRD	International Bank for Reconstruction and Development
IPH	Irrigation and Public Health Department
I & FC	Irrigation and Flood Control Department
IMD	India Meteorological Department
IEWP	India-EU Water Partnership
JHAR	Jharkhand
NIH	National Institute of Hydrology
NMCG	National Mission for Clean Ganga
NGRBA	National Ganga River Board Authority
NGT	National Green Tribunal
NRSC	National Remote Sensing Center
MOU	Memorandum of Understanding
MP	Madhya Pradesh
MoWR,RD&GR	Ministry of Water Resources, River Development and Ganga Rejuvenation
PC	Personal Computer

RAJ	Rajasthan
RIBASIM	River Basin Simulation Model
SPMG	States Level Program Management Group
SWaRA	State Water Resources Agency
SGRCA	State Ganga River Conservation Agency
SYL	Sutlej Yamuna Link canal
SRTM	Shuttle Radar Topography Mission
SPCB	State Pollution Control Board
SW	Surface Water
TDS	Total Dissolved Solids
UPPCB	Uttar Pradesh Pollution Control Board
UD	Urban Development
UK	Uttarakhand
UP	Uttar Pradesh
WALMI	Water and Land Management Institute
WRD	Water Resources Department
WWF	World Wildlife Fund
WRIS	Water Resource Information System
WB	West Bengal
WQ	Water Quality
WIS	Water Information System

1 Introduction

1.1 Ganga River Basin Planning Project

The project ”Analytical Work and Technical Assistance to support Strategic Basin Planning for Ganga River Basin in India”, abbreviated to “Ganga River Basin Planning Project” has the following objectives:

1. Strengthen the capability of relevant central and state government agencies to undertake comprehensive evidence-based strategic basin planning for the Ganga River Basin;
2. Develop, document and disseminate, through detailed analytical work and stakeholder engagement, a set of plausible scenarios that balance improving the health of the river and maintaining an acceptable level of economic productivity;
3. Build a stronger and more accessible information and knowledge base to guide on-going dialogue and management of the Ganga River Basin; and
4. Establish on-going multi-stakeholder engagement processes to support strategic basin planning.

The project is funded by the World Bank; the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR RD&GR) is the key stakeholder and central nodal point for the project. With support from the ministry the project connects to State departments and Central Agencies that play important roles in the planning and management of the water resources within the basin. The project also reaches out and involves academic organizations and non-governmental organizations in order to incorporate the knowledge, ideas and interest of a wide group of stakeholders.

The Inception report was approved in April 2016. The first progress report described the progress to June 2016 and the second the progress of the project to December 2016. This report describes the project progress between January and the end of August 2017.

This is Deliverable 5a of the Project Work plan: “Progress report providing evidence of satisfactory progress on all project tasks”, and together with other reports contributes to Milestone 5 of the project.

The project activities are grouped into six tasks (with their relative size in project activities):

1. River Basin Model Development (20%)
2. Surface-GW Interaction Analyses (15%)
3. Environmental Flow Assessments (15%)
4. Scenario Modelling (15%)
5. Consultation and Engagement (15%)
6. Information Systems and Documentation (20%)

Progress is evaluated, challenges are identified and actions for the coming period are described.

1.2 Context of the Project

As always water issues and river basin management received significant attention in the first half of 2017. The Ganga River Basin Planning Project with its aim to support basin planning in the Ganga Basin interacts with these developments, sometimes reacting, sometimes playing a role in exploring solutions.

In December 2016 Shri Amarjit Singh succeeded Shri Shashi Shekhar as secretary MoWR,RD&GR.

Currently in the Indian Federation, rivers are a state subject and the regulation and development of water of these rivers is a source of interstate differences and disputes. The Ministry of Water Resources, River development and Ganga Rejuvenation (MoWR) has initiated consultations to explore moving water from the State list to the Concurrent list (listing issues where Union Parliament overrules any State decision if different) without taking away the rights of the states.

In an effort to speed up the Cleaning of the Ganga, the National Mission for Clean Ganga (NMCG) has approved projects worth Rs 1,900 crore that will ensure hundred percent sewage treatment facility along four religious cities of Haridwar, Rishikesh, Varanasi and Allahabad. The money will also be spent for ensuring sewage treatment facility in two cities – Vrindavan and Delhi – along Yamuna. With this, NMCG has approved projects worth more than Rs 4,100 crore during the last three months in Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and Delhi.

The National Green Tribunal (NGT) has taken a number of decisions that affect the Ganga water management:

- NGT banned open defecation and dumping of waste on the floodplains of the Yamuna river in Delhi.
- NGT has directed the authorities to take immediate action against industries that operate in residential areas and are a major source of pollution of the river.
- NGT has ordered states to maintain environmental flow of 15-20 percent of the average lean season course in their rivers. Moreover, the states have also been told that if they are unable to adhere to this average percentage, it may approach the environment ministry. The NGT has also agreed to pass an appropriate order in case it is desirable to fix any lower percentage of environment flow than the prescribed one.
- NGT has declared an area of 100 metres from the edge of the Ganga between Haridwar and Unnao as "No-Development Zone". The tribunal has also prohibited dumping of waste within 500 metres of the river and any violations will lead to a fine of Rs 50,000. With many measures taken to clean the stretch between Haridwar and Unnao, the tribunal has now shifted focus to clean the next stretch of the river passing through Allahabad and Varanasi.

A committee constituted in 2016 to prepare guidelines for desiltation of the Ganga river from Uttarakhand to Farakka in West Bengal has recommended measures which include the study of reach-wise sediment transport processes along with establishing annual sediment budgets to guide desilting activities and preparation of annual reports. However, the committee has also pointed out that indiscriminate desilting or sand mining would cause adverse impacts on the river's flow.

For the first time, an across-the-river survey was initiated in the Ganga to ascertain the population of aquatic life including the endangered Gangetic dolphin. The Wildlife Institute of India will conduct the survey and create baseline scientific data for the government to take suitable measures to improve the river water quality.

In the wake of the Ken-Betwa river-linking project hitting a roadblock due to objections from the Madhya Pradesh government, the parliamentary panel in its report has recommended the Centre to form an empowered group of state ministers on interlinking of rivers along the lines of state finance ministers on goods and services tax (GST). The committee has also opined that the Centre should formulate a detailed project for interlinking of rivers that will comprehensively examine environmental, socioeconomic and financial aspects related to the project.

The Patna high court has directed the Bihar government to submit an action plan and time frame to make 4,095 non-functional tube wells in the state operational for irrigation purposes.

In a major relief to the Uttarakhand government, the Supreme Court has stayed the high court order which granted the status of a living human entity to Ganga and Yamuna rivers.

This is the environment in which Strategic Planning for the Ganga River will go forward.

2 Collaborative Modeling and Scenario building Period January - August 2017

The contract between The IBRD and Deltares became effective on June 30th 2015. The inception Report detailed the activities and progress through January 2016. The first progress report described the progress to June 2016 and the second the progress of the project to December 2016. This report describes the project progress between January and the end of August 2017.

2.1 Objectives

The objective of the Collaborative Modeling Phase was to work closely with the Counterpart team and stakeholders to develop models that reflect the relevant water resources interventions and provide output in the form of indicators at meaningful locations.

In this phase we engaged stakeholders from States and Central Organizations in the model setup, bringing different departments together. We discussed issues and explored possible strategies. Relevant indicators for model output evaluation we jointly identified. Relevant data sets were identified with stakeholders and the data collected and analyzed. Based on collected data and the stakeholder suggestions the models are further developed and inter-connected.

The objective of the Scenario Building Phase is to develop, document and disseminate a set of plausible scenarios that balance interests while significantly improving the health of the river and maintaining an acceptable level of economic productivity;

In this phase we use the developed models to assess interventions, strategies and scenarios. We distinguish between developments that are outside the scope of control of government, institutions and organizations managing the Ganga Basin (Scenarios), and those that are within the control of these organizations (Strategies). Climate change and population growth are examples of external scenarios, while reducing pollution sources, conjunctive use of surface and ground water, increased efficiency in agriculture, and new infrastructure are examples of strategies that are assessed in the light of the external scenarios.

2.2 Timeline

During this period several bilateral meetings were held with the Central Groundwater Board (CGWB), Central Water Commission (CWC) to discuss the project approach and the availability of data.

12 January, 2017 *Meeting with Sushri Uma Bharati, Minister, Water Resources, River Development & Ganga Rejuvenation*
On January 12th, the Minister was updated about the project progress by the project team leader in the presence of the secretary, joint secretary, and a number of senior advisors.

13 January, 2017 *Presentation of the project at the 3rd Jal Manthan*
At the third national stakeholder consultation event on water management (Jal Manthan) of the Ministry the team leader presented the project approach in Session-2B : River Basin Management.

Figure 2-1: Presenting the project at Jal Manthan 3 ,and the high level dignitaries.

***21-23 February** Ground water modelling training course*
Frans Roelofsen conducted this training with 9 participants from CGWB and CWC.

***2 March** Basin wide workshop Kolkata*
The 3rd basin wide workshop was held in the Hyatt Regency Hotel in Kolkata at the transition from the Collaborative Modelling Phase to the Scenario Development phase. The objectives of the workshop were:

- to inform the representatives of the Central and State governments about the progress of the project,
- report on the collaborative modeling phase,
- present the models developed, and
- initiate start of the Scenario development phase of the project.

Figure 2-2: Participants at Kolkata basin wide workshop

8-10 March Modelling course
Four International experts presented the approach on Ganga modelling in two parallel sessions. Topics covered: Groundwater modelling with iMOD, mountain hydrology with SPHY, river basin hydrology with Wflow, and water resources with RIBASIM. 21 participants from NIH, CWC, CGWB, and IMD attended.

14 March *Progress meeting with Secretary MoWR, RD&GR*
On 14 March the project team reported and discussed the progress of the project with Dr. Amarjit Singh, Secretary, MoWR, RD&GR, Govt. of India. In this meeting the Secretary

appointed a multi-disciplinary advisory group as well as State wise core groups. Annex A contains the minutes and decisions of the meeting.

31 March *E-flow meeting with central organizations*
Following up on the guidance of the Secretary in previous meeting the e-flow experts of the central organizations discussed the e-flow approach in a meeting at CWC.

3-5 April *Training course on the workflows of the modelling system*
Mark Hegnauer conducted the training with 41 participants from central organizations and states.

19 April *E-flow zonation meeting*
The project team presented the methodology for the e-flow zonation to the experts from the central organizations. After a good discussion the methodology was agreed upon.

25-26 April *Training course on River Basin Simulation modelling*
Marnix van der Vat conducted the training with 25 participants from CGWB, CWC, NMCG, and NIH.

Figure 2-3: Group work during RIBASIM training

27-28 April *Training course on model use for Uttar Pradesh, Uttarakhand and Jharkhand*
Model installation and user training for state level use. 11 participants.

April-June *Scenario Development workshops*
The scenario development workshops at basin and state level were designed to explore realistic strategies and scenarios for the development of the basin. After an update on the model development he possible actions were discussed from the perspective of each state. Using the developed model a number of the discussed interventions were modelled and its results discussed. Finally the institutional setting of basin planning and the role of the states in that process was discussed.

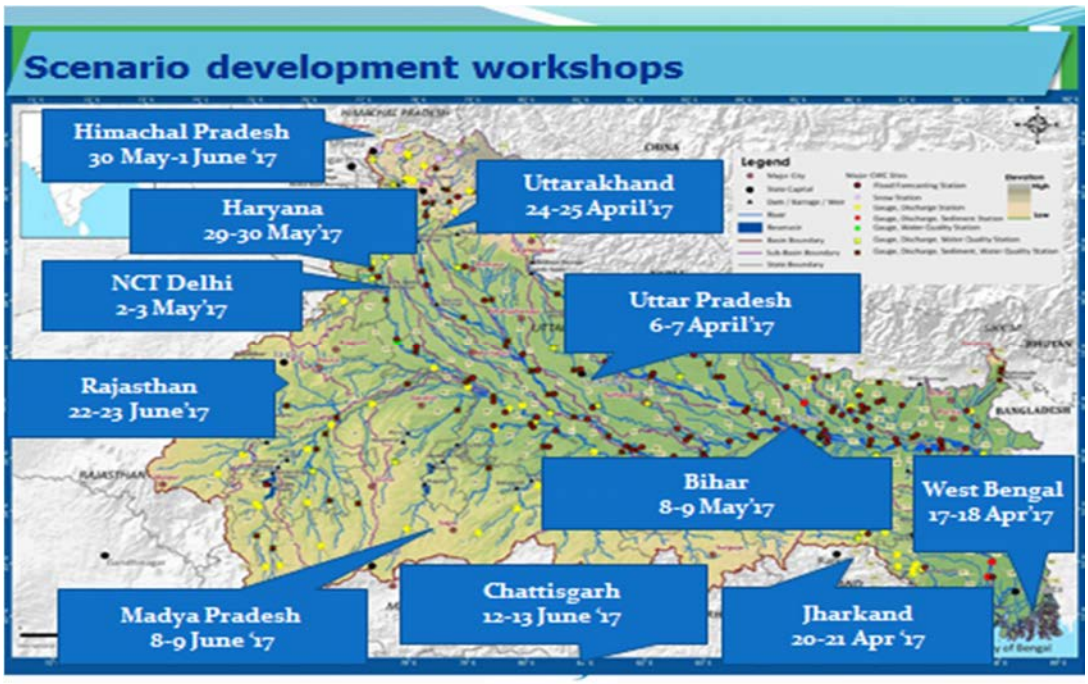


Figure 2-4: Dates of state scenario development workshops

17 May *Expert meeting on e-flow assessment*
On 17 May a brainstorm session was held with experts from ICAR-CIFRI and CWC. After explaining the background and goals of the project the discussion focused on:

- the criteria to select and use target/iconic species in each river zone,
- the best procedures to produce knowledge rules and suitability functions for each

5-6 June *Training course on model use for Delhi, Haryana, Bihar, and Himachal Pradesh*
Model installation and user training for state level use. 11 participants.

22-23 June *Training Ganga River Basin Model – GangaWIS & Wflow*
Mark Hegnauer conducted this training with 24 participants from NIH, CWC, CGWB, and NMCG.

27-30 June *Project review mission William Young TTL, World Bank*
From June 27-30, 2017, a review of project progress was undertaken through a series of meetings with (i) the consultant's project team (including extended one-on-one conversations between the Bank TTL and the Project Director), government representatives of the project's core consultation group (from the NPMU of the National Hydrology Project), and (iii) the Secretary of the Ministry of Water Resources, River Development & Ganga Rejuvenation..

4 July *Progress meeting with Secretary MoWR, RD&GR and Strategic Advisory group*
Project progress was presented and discussed with the Secretary Dr. Amarjit Singh and the members of the Strategic Advisory group. Minutes of the meeting are available as annex B to this report. An important decision was that a dedicated unit shall be set up in CWC to further work on the analytical tool being developed by the project. The on job trainee officers from CWC, CGWB NIH and NMCG are required to be invariably associated in this unit and shall be provided with the vision and guidance by the experts of CWC.

6-7 July *Water Quality modelling training course*
Pascal Boderie conducted this training with 20 participants from CGWB, NIH, NMCG and CWC

Figure 2-5: Participants at Water Quality training course

11-12 July *Ground water modelling training course*
Frans Roelofsen conducted this training with 25 participants from CGWB, NIH, NMCG and CWC

13-14 July *Training course on model use for Madhya Pradesh, West Bengal, Rajastan, and Chhattisgarh*
Model installation and user training for state level use. 11 participants from states and 4 guests from IIT Roorkee.

18 July *Full day discussions on model approach with members of the Multi-disciplinary advisory group*

May-August *Continuous on-the-job training*
9 young experts from NIH, NMCG, CWC and CGWB actively participated in an on-the-job training in all aspects of model development and maintenance.

The following chapters will discuss the developments in the six main tasks of the project in more detail.

3 Task 1 River Basin Model Development

3.1 Introduction

In the previous progress report the main development of the Ganga Model was already described. In the reporting period several improvements and adaptations were implemented, especially regarding the groundwater model and the water quality model.

3.2 Groundwater Model

3.2.1 Training Ganga River Basin Model (Ground water)

On 11 and 12 July 2017 Deltares organized training on the groundwater part of the GRBM. In this 2 day-training in New Delhi 25 people from different institutes participated. They were informed in detail about the latest version of the iMOD model. During several hands on session they got experience in running the iMOD model together with the adjacent models within Fews by using tutorial material. Time was also set apart to have several discussions resulting in an update of the model input.

3.2.2 Update of the Groundwater Model

During the July training model setup was discussed with participants and suggestions for improvement were invited. This resulted in an update of the groundwater model.

Boundaries

The north boundary of the Ganga basin has special characteristics. The boundary was formally modelled as a no flow boundary. But just below the foothills a zone exists called Bhabar. This unit consists of deposits along the foothill characterized by high permeability hydrologically connecting the phreatic zone with the deeper aquifers. Overland flow from the hills is feeding the aquifer in this zone.

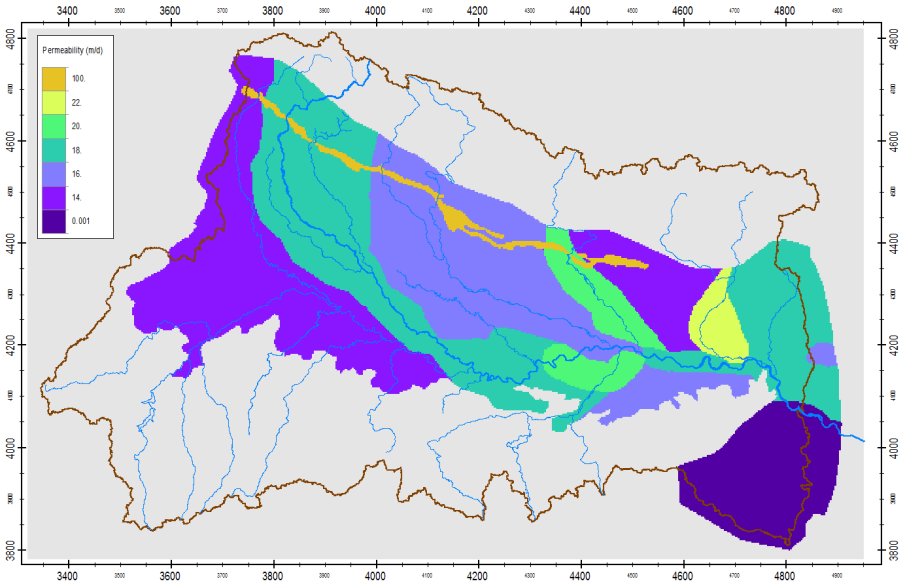


Figure 3-1: Permeability distribution in the basin

From Geological information on the West Bengal part of the model is concluded that the area of alluvial deposits is less extended to the west than originally assumed. The characteristics of the first aquifer in West Bengal also differ from the rest of the model: the first 20 m are clay deposits with low permeability.

3.2.3 Groundwater Model in the GangaWIS

The ground water model iMod exchanges model results with the Wflow and Ribasim model, via the Fews system. The different adapters for preprocessing the Groundwater model, running the model and bringing the result to Fews perform well.

3.2.4 Calibration

In the last progress report we described the availability of monitoring time series. Over 9000 time series were provided by the CGWB. Over 50% of the locations must be skipped for calibration purposes for several reasons: time series cover only a small range of years or time series contain less than an average of 2 measurements a year. The figure below shows the difference of the average calculated value and average measured value..

3.3 Water Quality Model

3.3.1 Addition of Temperature as Parameter

Water temperature is an important temporal and spatially variable forcing function in water quality and ecology processes. Biochemical reaction rates strongly depend on water temperature and the effective removal of e.g. BOD and bacterial pollution depends on the ambient water temperature. Water temperature is also required in the ecological knowledge rules.

We included water temperature to the DWAQ model using a simple approach based an empirical relationship between water- and air temperature (derived from EUWATCH).

Water temperature (wT) is calculated from air temperature (aT) using the following equation:

wT = 5-day average (aT) + constant

The constant value in this relation is derived in the calibration. In Figure 3-2 an example of spatially variable water temperate Ribasim-DELWAQ network is given.

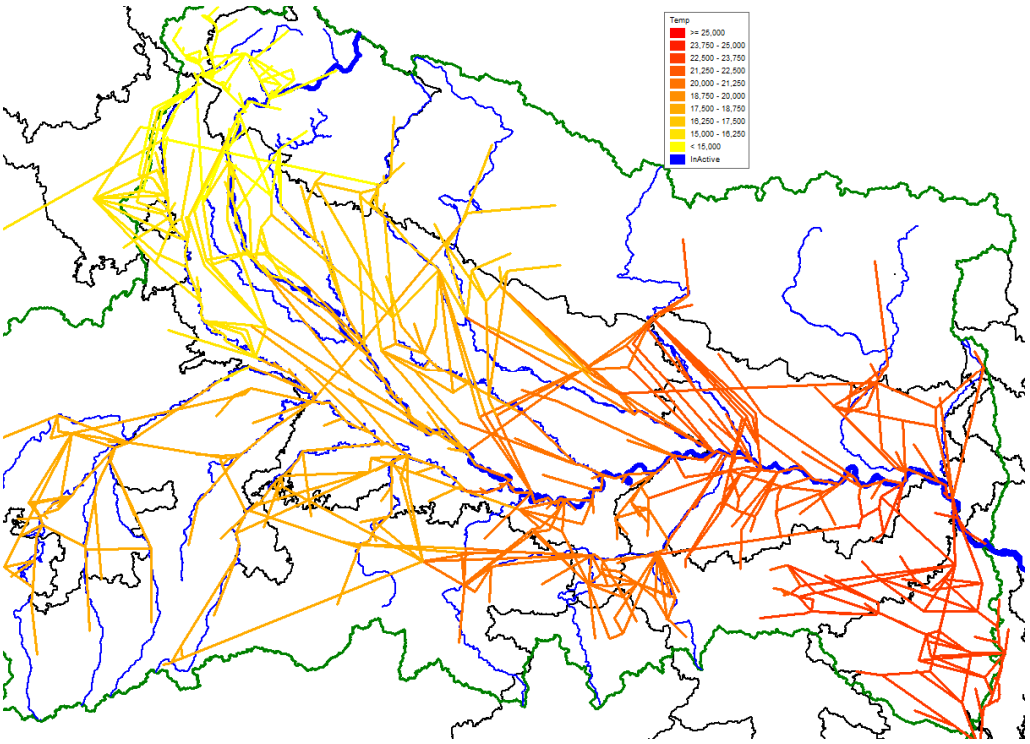


Figure 3-2 Example of spatially variable forcing function for water temperature in the Ribasim-DELWAQ network for February 1999.

3.3.2 Inventory of pollution sources and treatment in the basin

Good progress was made in collecting pollution sources data. The list 764 most polluting industry was geo-referenced and also most existing and planned sewage treatment facilities were identified and geo-referenced. This data was added to the GIS set of all point and non-point sources to provide a comprehensive spatial picture of areal and point loading

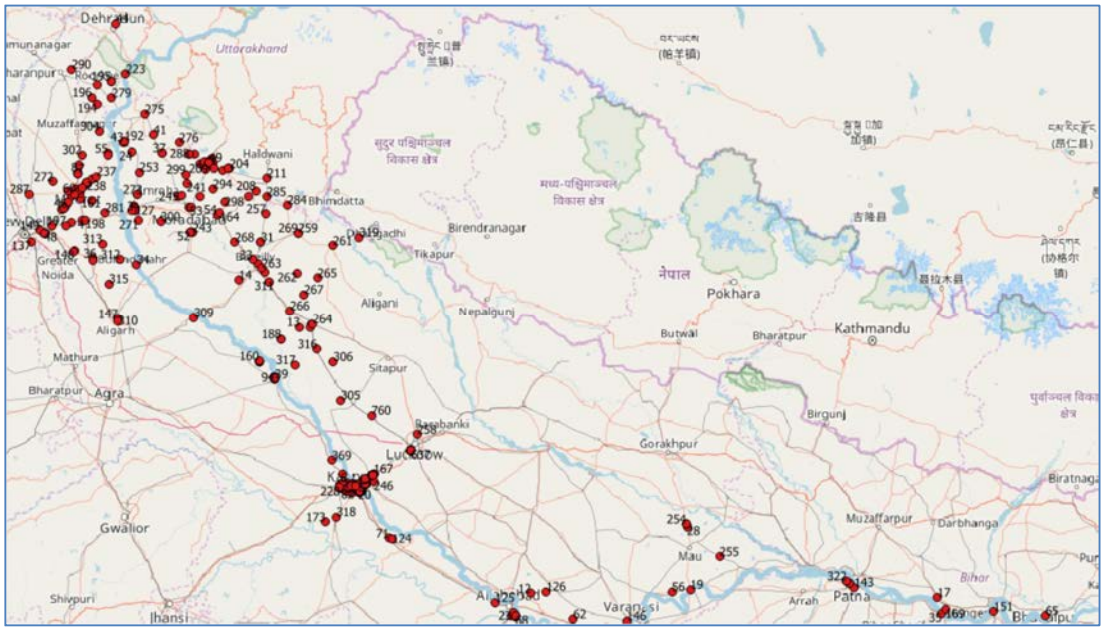


Figure 3-3: Map showing 764 most polluting industries in the basin

3.3.3 Calibration

The calibration is ongoing in a tired approach. All water quality measurement stations on Ganga and Yamuna are used in the first step of the calibration. Based on the results of the first step a selection of stations is used to further calibrate the model. Calibration is done for BOD5, dissolved oxygen, Coliforms (Total and Faecal) and water temperature.

Although there are still uncertainties in the urban emission inventory, emission factors (inhabitants, industries) and unit loads are in principle not part in the calibration.

Evaluation of the water quality model against in situ water quality measurement is still in progress and is done following the following steps:

First step:

- all stations with water quality measurements on Ganga and Yamuna (CWC monthly and CPCB yearly data) are used
- the time series for the calibration period (1999-2009) are aggregated to long term average, 10, and 90 percentile values per station (example graph in Figure 3-4)
- evaluate model performance and calibration by adjusting (diffuse) rural emissions reaching the river.
-

Second step:

- select a number of representative water quality stations
- present the yearly variation in observed and simulated water quality parameters in box-whisker plots (example graph is given in Figure 3-5)
- present the water quality results for lean season and monsoon situations
- model performance evaluation and calibration by adjusting process parameters representing decay and sedimentation

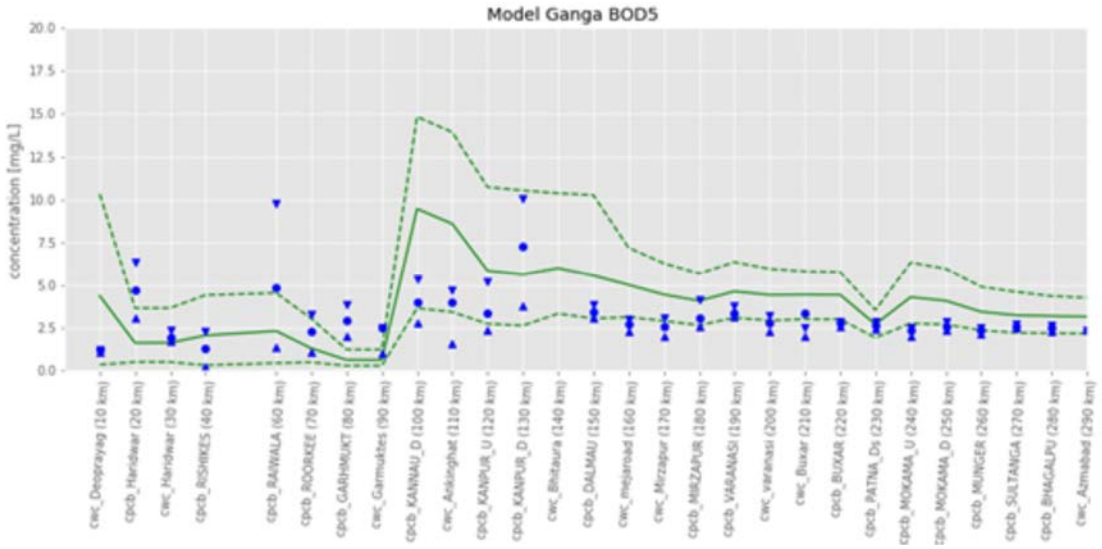


Figure 3-4: Example longitudinal plot of all BOD5 measurements (CWC an CPCB) time aggregated (1999-2009 circle=average, triangle=10 and 90 percentile) compared to model results where solid line shows average and dashed lines show 10 and 90-percentile values.

Criteria and considerations for selecting representative stations are the quality (both data sources show sufficient similarity), the performance of the hydrological model, and the schematisation of the water quality network, notably the locations of the entry points for the (spatially lumped) emissions in relation to the water quality station.

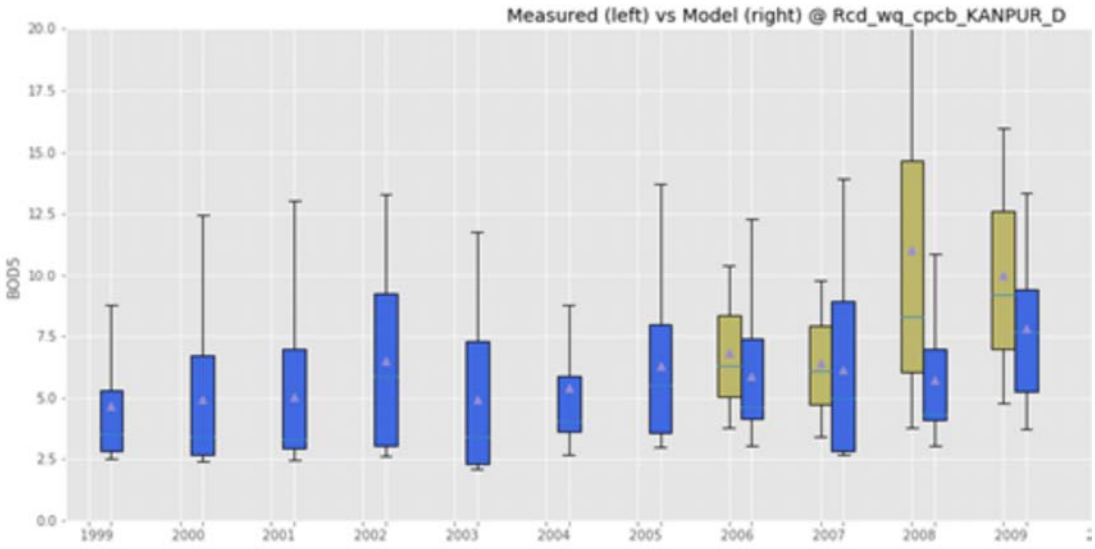


Figure 3-5: Yearly variation of BOD5 measured (brown) and simulated (blue) at Kanpur.

3.4 SPHY Model

The SPHY model was fully developed earlier in the project, but was still operating stand-alone as no adapter to the FEWS system was available originally.

In the reporting period the SPHY model has been incorporated into the Wflow framework, making it one of the modules available there. Following this development the SPHY model

has been included in the GangaWIS and can be run from that environment without problems. SPHY results are now available in the GangaWIS database and are automatically processed as input to the other models.

3.5 Remotely Sensed Data Sets

Remotely sensed data sets are collected to estimate or to constrain irrigation water use. UNESCO-IHE (Wim Bastiaanssen) has gathered seven energy balance models from different sources to calculate the actual evaporation. These sets show varying results. Presently the data from the seven sets are aggregated on a monthly basis for the period 2002 -2013. The special resolution is 250 m x 250 m.

The resulting values will be compared with the present model results for agricultural areas and the where necessary the model can be adapted.

3.6 Inundation Modelling

A simple modelling of the extent and frequency of inundation of floodplain wetlands is prepared.

The Deltares Aqua Monitor (http://aqua-monitor.appspot.com/) was developed as the first global-scale tool that shows, with a 30-meter resolution, where water has been transformed into land and vice-versa between 1985 and 2015. The Aqua Monitor analyses satellite imagery from multiple Landsat missions, and uses Google Earth Engine (Figure 3-6).

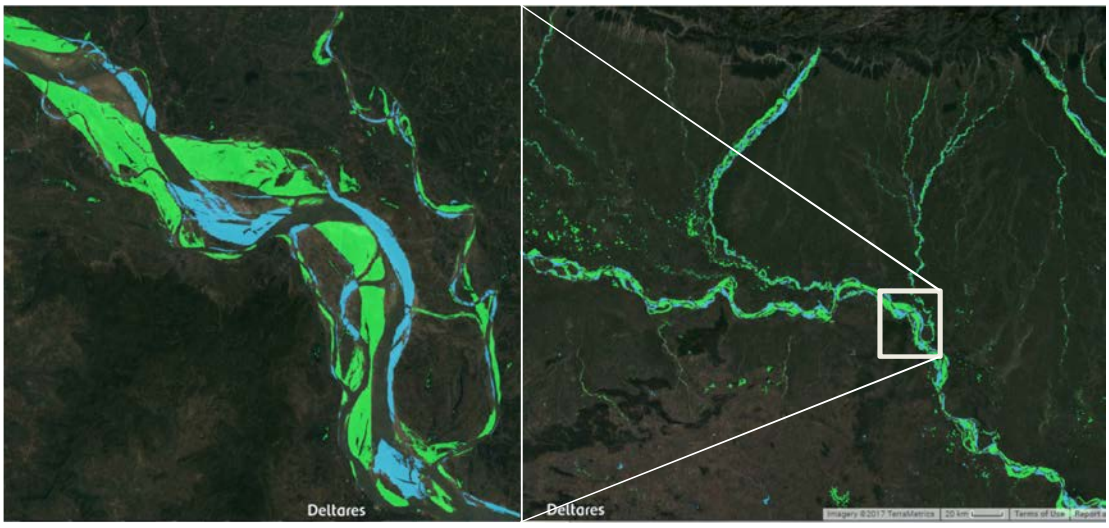


Figure 3-6: Green and blue colors represent areas where surface water changes occured during the last 30 years. Green pixels show where surface water has been turned into land. Blue pixels show where land has been changed into surface water

Apart from changes in river course also flood extend at specific periods in time can be analyzed. The data from the inundation extend and water levels as recorded are presently explored.

The used remote sensing data is obtained with optical sensors. Clouds will obscure the view, resulting in incomplete data in the monsoon, the period when inundations occur. From 2013

onwards additional sensors were used that can penetrate clouds, so these data are explored first to find relations that may be extrapolated for other periods.

The relationship between flood extend and flow levels will be used in the environmental flow analysis.

3.7 Sensitivity/Uncertainty Analysis

Based on the last calibration results a sensitivity/uncertainty analysis of river system modelling will be made. There is a cumulative uncertainty in the model as results from one model are used in subsequent models.

Not all uncertainties can be quantified. It is to be expected that the reliability of comparisons between strategies will be more useful than predictions of actual flows or water quality parameters at a certain location and time.

3.8 Status of the River Basin Model and GangaWIS

By the end of August 2017, All models were connected and the water quality and iMOD models were in the final stage of calibration.

The models are distributed to many stakeholders in all involved states and central organizations. They can already be used to evaluate the impact of interventions and strategies.
The Ganga Water Information System (WIS) is developed enabling users across the basin to:

- Analyze all input data of the modelling system; both static, land use of soil maps and dynamic e.g. time series of temperature and precipitation in graphs and maps. The WIS will provide access/visualize all the various temporal and spatial data, hydrogeology data, WQ, hydraulic infrastructure, ecology, DEM/land use. A local option and a web-based version will available to all users (web-based version will be available when decision is taken on server).
- Import new input data and run one model or more models in sequence (**Error! Reference source not found.**). This option is only available to users that have installed the system on their computer.
- Analyze all model outputs, for individual model runs or comprehensive strategies or scenarios for which all models are run in sequence. A local option and a web-based version are available to all users.
- Present a high-level summary of model results on stakeholder defined indicators, varying by state, on a dashboard. A local option and a web-based version are available to all users.

The system can be installed as a stand-alone system on a PC or laptop. Users have access and control over the data and model runs. The web based version is served from one centrally maintained system. Individual or state users can upload interesting model runs or strategies to this organization so it can be shared with all users in the basin. The management of the ‘mother’ system will be the responsibility of a dedicated unit that shall be set up in CWC to further work on the analytical tool. Distribution of updates to all users will be using Apache Subversion (often abbreviated SVN), a software versioning and revision control system distributed as open source under the Apache License.

4 Task 2 Surface-Groundwater Interaction Analyses

4.1 Introduction

This task is to improve the understanding of surface-groundwater interactions across the Ganga River basin. It involves 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 are described and explored in dialogue with the Central Ground Water Board.

4.2 GIS-Based Information System

Almost all available data has been compiled in GIS maps to be used in the analysis, These maps will be available for users on internet in the GIS map viewer tool. Figure 4-2 give a sample of the files prepared.

4.3 Groundwater Management Units

Meetings have been held with CGWB representatives to define 3-D GW management units across the basin. Figure 4-1 summarizes the framework used during the discussions. The management units based on the discussions will be further elaborated and analyzed. The word 'groundwater management units' proved to be confusing, so we rather speak of areas for which management strategies have to be defined to address one or a combination of issues.

				Demand		SW-GW connectivity		Quality
Category	Sub-category	Issue	Aquifer	Present demand>recharge	Future demand>>recharge	GW status will adversely affect SW	SW status will adversely affect GW	GW quality is threathened
Quality	Geogenic	Inland salinity	deeper					natural
		Arsenic	upper					
		Fluoride	upper					natural
	Antropogenic	Nitrate	upper					
Quantity	Natural	hard rock areas	any					
		drought areas	all					
	Antropogenic	over extraction	upper					
		waterlogging	upper					
				safe	moderate	serious	very serious	other

Figure 4-1: Framework to assess GW management units

4.4 Surface Water Groundwater Analysis

The modelling set-up for exploring surface-groundwater interactions has been developed. As part of the on-the-job training the modelling framework was used to assess the implications of different strategies of conjunctive use for irrigation water availability and groundwater level changes.

4.5 Status of Surface-Groundwater Interaction Analyses

Most of the data collection has been finalized and much of the collected data has already been processed into GIS map layers.

The modelling framework is ready for strategy and scenario runs. In consultation with CGWB the priority units/areas have been identified.

In the coming period a framework will be developed that considers all connected GW resources, and focusses most effort and more detailed analysis on high priority GW management units.

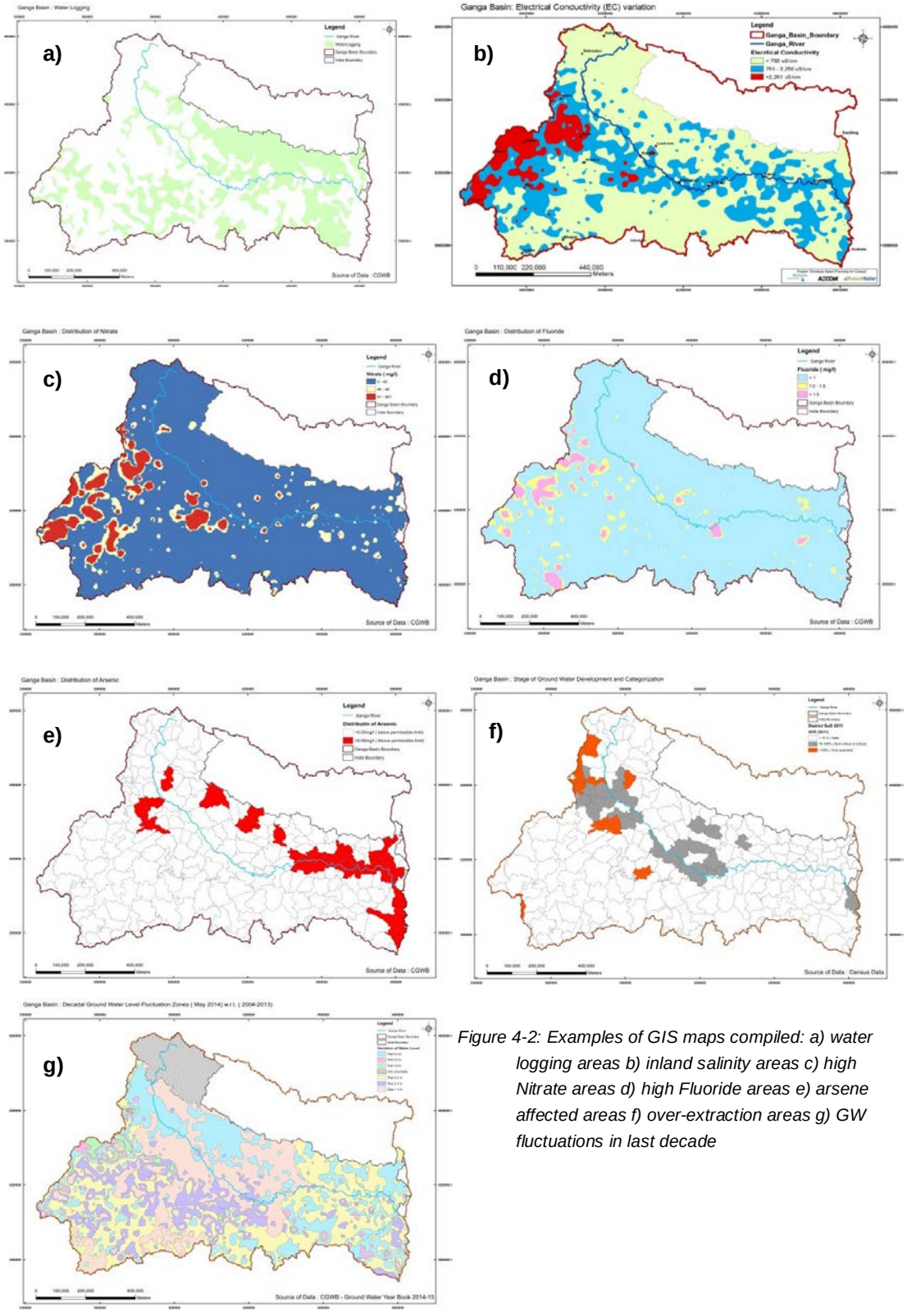


Figure 4-2: Examples of GIS maps compiled: a) water logging areas b) inland salinity areas c) high Nitrate areas d) high Fluoride areas e) arsene affected areas f) over-extraction areas g) GW fluctuations in last decade

5 Task 3 Environmental Flow Assessments

5.1 Introduction

As progress on this task was behind schedule the work plan for the E-flow assessment was adapted. The tasks to be performed are:

1. Zonation of Ganga and relevant tributaries and selection of critical output points
2. Indicators and relations for ecosystem-services
3. Indicators and relations for ecology
4. E-flow assessment
5. Model coupling and dashboard
6. Scenarios and monitoring
7. Training and capacity building

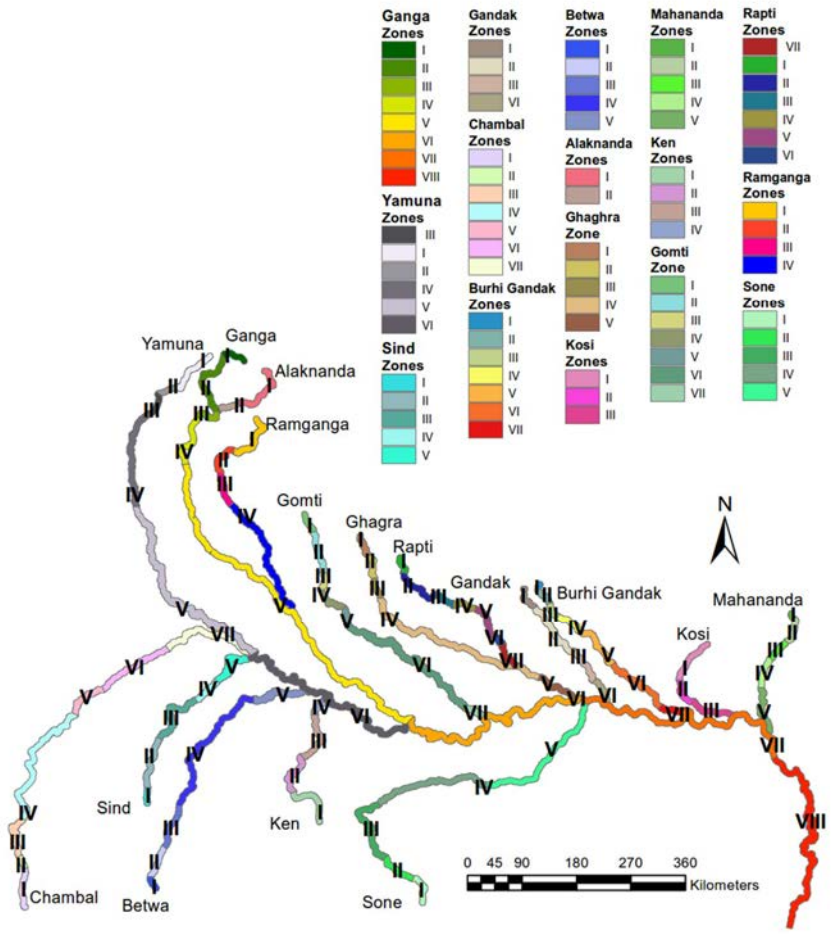


Figure 5-1: Overview of the Ganga zonation and the tributaries that are included in our study.

5.2 Zonation

The zonation of the main stem of the Ganga with its main tributaries was completed (Figure 5-1). The zonation is based on geomorphological and ecological features. The zonation was created in several steps taking into account:

- inflection points where river longitudinal profile shows distinct differences that were identified from Google Earth imagery,
- distinct geomorphological features (river planform, width, confinement and substrate type) identified from Google Earth imagery,
- locations of natural and artificial barriers and large confluences,
- important species habitats and type of riparian vegetation and
- major human pressures (abstraction, obstruction, pollution, siltation).

At least one critical point for each zone will be selected for which the E-flow assessment will be performed. This selection will be based on the available field data combined with available model output nodes.

5.3 Ecosystem-services

A list was created with general river ecosystem services (food, freshwater, fertilizer and biomass, medicine, electricity, building material, health, erosion regulation, security and defense, water burial, removal and neutralization, tourism, spiritual and cultural, aesthetics, education and research). Based on this list, the indicators that are relevant for each zone are documented and depending on the available data and the type of indicator, quantitative relations will be constructed between flow and water quality and ecosystem services. Where necessary, the eco-system services will be coupled to ecological calculations.

5.4 Ecology

A species list including the IUCN-designated globally threatened/near threatened vertebrate species for the Ganga basin was compiled and discussed with Indian experts during a workshop in Delhi on 17 May 207.. This list was supplemented with commercially important fish species (Indian Major Carp species). Based on a literature quick scan, species thresholds for environmental variables for a subset of species were collected. When the information was sufficient, these values were translated in response curves for habitat suitability.

A database in a factsheet-type format was constructed containing the available response curves per species (example in Figure 5-2). A second literature scan will supplement the database with available data for the other species from the complete species list. It is important to note that it is unlikely that we can use all of the listed species in the final E-flow assessment due to limited data on environmental thresholds and/or the lack of input data required for the response curves. In addition to the response curves per species we try to link discharge to inundation extent and derive quantitative relations for fish groups and riparian vegetation.

5.5 Assessment indicators

Per ecological zone, several main ecological and socio-economic indicators are calculated that use processed discharge and water quality data (Figure 5-3). Each indicator is sub-divided in several sub-indicators that are aggregated into the main indicator on the Dashboard. Because the model generates monthly discharge and water quality data, these data are processed with FEWS to generate spatial and/or temporal aggregated values that are needed as input for the sub-indicators. The type of statistic can differ between different sub-indicators.

***Schizothorax richardsonii* (snowtrout)**

Factsheet

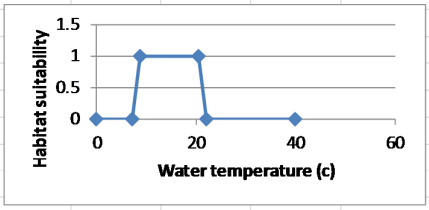
IUCN red list species
Prefers cold headwater streams in Himalaya
Has wide tolerance for environmental conditions
Migrate small distances up tributaries during monsoon
Prefer boulders and cobbles with algea as substrate
gravel spawner

Response curves

Temperature general

Hard lower threshold	7.2	degrees centigrade
Hard upper threhold	22	degrees centigrade
10% boundary for smooth transition	1.48	

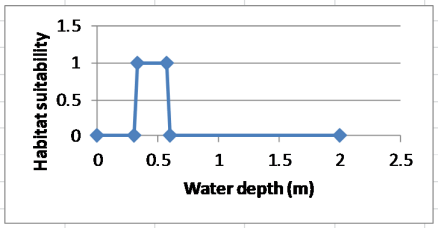
Water temperature	suitability
0	0
7.2	0
8.68	1
20.52	1
22	0
40	0



Spawning (August - October)

Hard lower threshold	0.3	m
Hard upper threhold	0.6	m
10% boundary for smooth transition	0.03	

Water depth (m)	suitability
0	0
0.3	0
0.33	1
0.57	1
0.6	0
2	0



References

http://www.fishbase.org/summary/8705
(Shrestha, 1995).
http://www.fao.org/3/a-y3994e/y3994e0i.htm
http://www.fao.org/3/a-y3994e/y3994e0h.htm#TopOfPage)
(http://nmcg.nic.in/BioFish.aspx

Figure 5-2: Example of a factsheet with response curves in the ecological database

It is important to note that the sub-indicator values represent a deviation from the reference situation. We assume that the reference is the situation without human influence. The indicators will be split into classes that depict percentages of absolute deviation from the reference

5.6 Status of e-flow assessment

The extra efforts to speed up the e-flow task resulted in an improvement in the data collection and development of indicators. The calculation of indicators for hydrological alteration (IHA) will be done when there is a final model run for discharges of the pristine and altered situation. A general IHA assessment will be done with the IHA software and hydrographs for

selected locations will be compared to obtain a more detailed overview. On 15 and 16 November there will be a workshop with Indian experts on ecology and socio-economics to discuss our methodology and validate our indicators and quantitative relations. Based on the results of this workshop, we will refine our results.

When the quantitative relations between ecology, socio-economics and discharges and water quality are ready, ecological and socio-economic implications of different scenarios can be calculated. The quantitative relations will be linked to the river basin model and results of ecological and socio-economic indicators can be shown in the Dashboard.

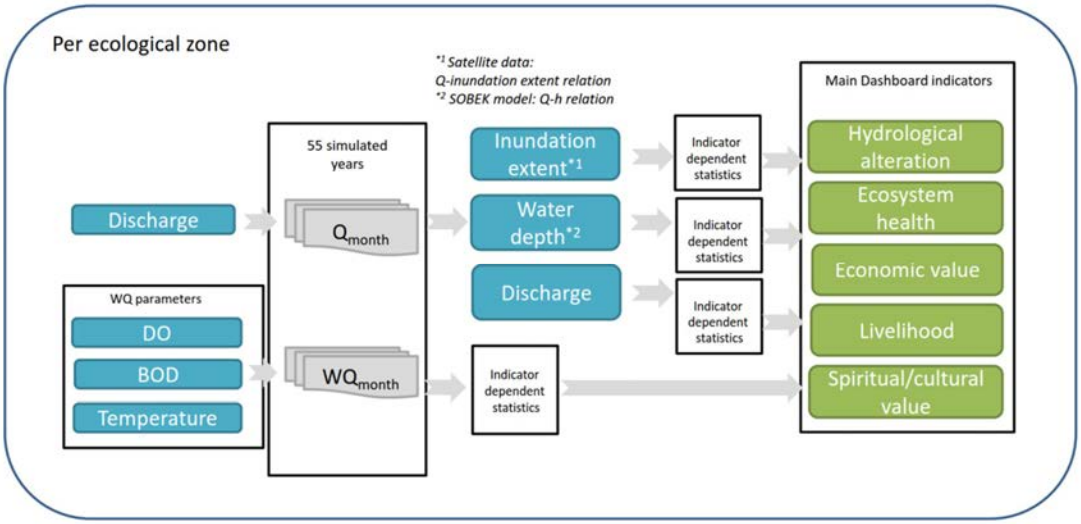


Figure 5-3: Flow diagram for the calculation of environmental flow parameters

6 Task 4 Scenario Modelling

6.1 Introduction

The reporting period was a preparatory period for the actual strategy and scenario runs that will be made using the prepared models.

Scenarios (developments outside the direct influence of the planner) for population development and climate change were prepared and a selection was made the main strategy components (developments the planner can influence) to be evaluated. Data was then collected as needed. Table 6-1 gives and overview of the agreed upon strategies and scenarios, where the present situation and the pristine situation (a basin without any human interference) will serve as reference cases.

Table 6-1: Overview of scenarios and strategies

Scenario→ ↓Strategy	Population growth	Climate change
Do nothing	☑	☑
New infrastructure	☑	☑
Increased agricultural efficiency	☑	☑
Treatment of waste water	☑	☑
Conjunctive use of SW and GW	☑	☑
Reforestation/ catchment measures	☑	☑

Strategies will be detailed and analyzed in collaboration and consultation with the respective stakeholders.

6.2 Reference cases

The present situation and the pristine situation will serve as reference cases. The model of present situation is readily available from the calibration runs. For the pristine situation a new model run had to be prepared.

The main determining factor for the pristine run is the landuse map and the absence of any structures or demands or impacts from domestic or agricultural activities.

The natural vegetation map of India was used to create a landuse map1 the pristine situation (Figure 6-1. For Nepal there is a national land cover database developed by ICIMOD2 that

[1] https://environmentofearth.wordpress.com/2008/03/11/45/

[2] http://www.sciencedirect.com/science/article/pii/S0301479714004009?via%3Dihub

provides insight in the different forest types in the country. The forest types were extrapolated based on the physiographic map (Soil Science Division, NARC) for agricultural areas and fitted with the natural vegetation map of India. The resulting map was gridded and prepared in the correct projection to be used in SPHY and Wflow models.

These model runs allow a basin-wide analysis of flow regime change from natural to provide a broad-scale perspective on likely critical reaches for environmental flows.

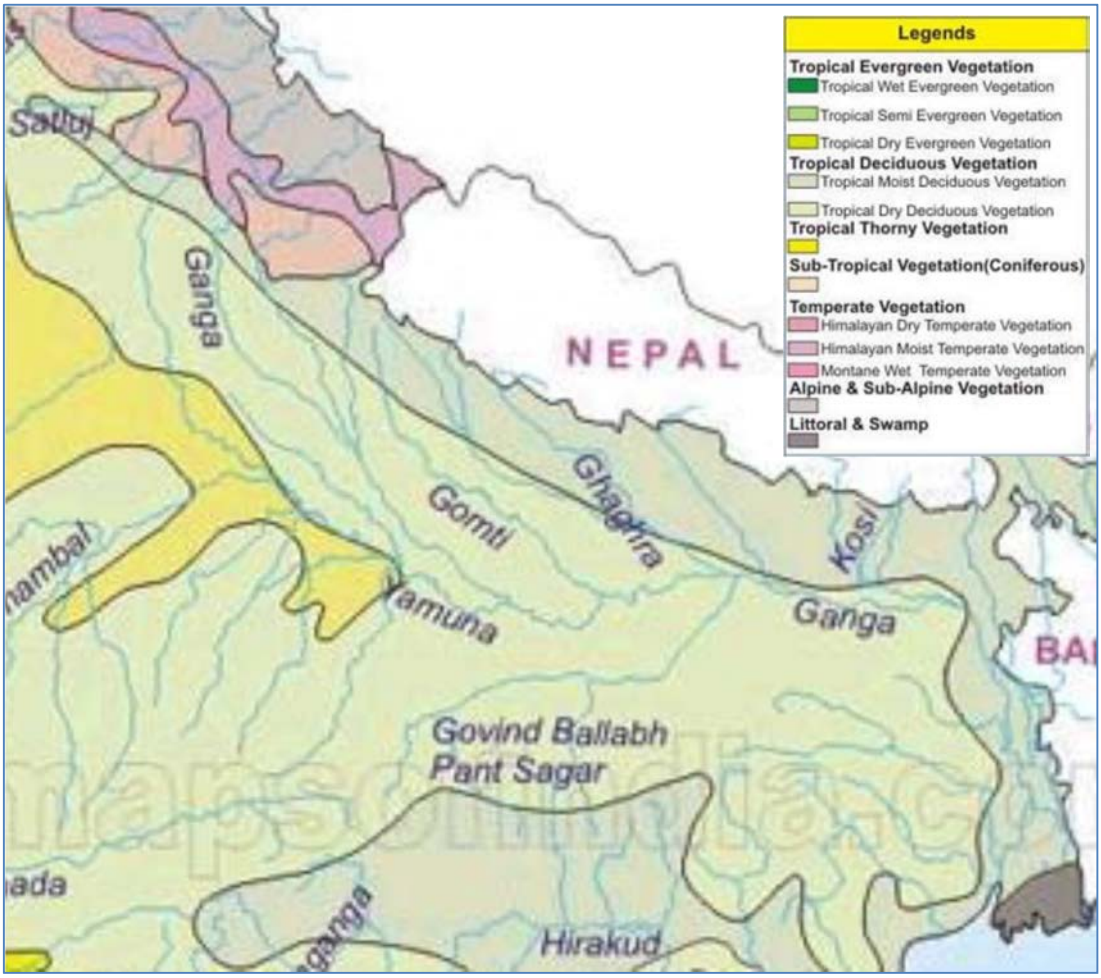


Figure 6-1: Cut-out of natural vegetation map of India (mapsofindia.com)

6.3 Climate change

For the climate change scenarios use can be made of global datasets, which have not been downscaled for the region. However, efforts are made to use downscaled datasets as is preferred by the counterpart organizations. Promising contacts have been established with the Centre for Climate Change Research (CCCR) established at the Indian Institute of Tropical Meteorology (IITM) Pune. CCCR has the mandate of developing an Earth System Model (ESM) and to make the regional climate projections, in addition to work on Paleoclimatology and Greenhouse Gas (GHG) measurements.

6.4 Population projections

Presently the most recent population projection by the government is the report 'Population Projections for India and States 2001-2026' by the Office of the registrar general & census commissioner of May 2006. This projection is based on the census of 2001. Since then data for the census of 2011 are available which can give a correction on the mentioned projection.

After consulting with Niti Aayog, and the Health and Family Welfare, Registrar General and Commissioner of Census of India it was decided to apply a simplified version of the methodology followed in the 2001-2026 projection, only focusing on urban and rural components of the population, using the 2011 census results as the starting point. This projection was made for each district in the basin for 2011 till 2080 in an Excel file that can directly generate the values to be put in the Ribasim Public Water Supply nodes for any selected year. Figure 6-2 presents an example of the population projection for Uttarakhand state.

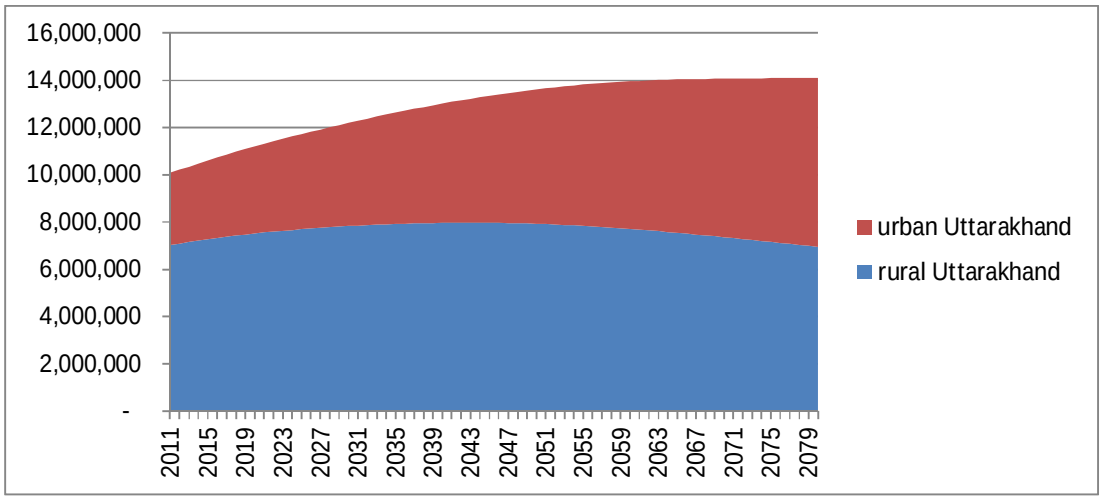


Figure 6-2: Urban and rural population projection for Uttarakhand state

6.5 Status of Scenario Modelling

Preparations for the scenario modeling are well under way. Population projections are finalized and It is expected that climate change data will be available.

Reference runs for the present situation and pristine situation have been prepared.

The model schematization has been prepared in such a way that all presently foreseen strategy components can be evaluated by switching on or off certain infrastructure elements and by adapting input data to nodes.

Discussions with stakeholders and experts are conducted and trial runs are prepared to already experiment with strategy components awaiting the final calibration of the models.

7 Task 5 Consultation and Engagement

7.1 From Collaborative Modelling Phase to Scenario Development Phase

The third basin wide workshop held in Kolkata om March 3, 2017 marked the transition from the collaborative modelling phase to the scenario development phase.The workshop was attended by 56 persons from 17 organizations across the basin. The objectives of the meeting were:

- to inform the representatives of the Central and State governments about the progress of the project,
- report on the collaborative modeling phase,
- present the models developed, and
- initiate start of the Scenario development phase of the project.

As mentioned in chapter 2 the objective of the Scenario Building Phase is to develop, document and disseminate a set of plausible scenarios that balance interests while significantly improving the health of the river and maintaining an acceptable level of economic productivity;

A third round of state level workshops was held between April and June 2017 (Table 7-1). The objectives (expected results) of the third round workshop were:

- Participants familiar with the progress on modelling, GangaWIS and the dashboard,
- Feedback on the process and support for the last phase of the project.
- Participants familiar with how the models and dashboard can be used for strategy and scenario simulation, and evaluation.
- Participants' input for scenarios and strategies.
- Participants' input on approach and methods for stakeholder engagement for the State and Basin planning.

Table 7-1: Summary of participation of stakeholder organizations in the state workshops

Nr.	Date	Venue	State	# participants	# of different departments /organizations present
1	April 6,7	Lucknow	Uttar Pradesh	25	15
2	April 17,18	Kolkata	West Bengal	26	12
3	April 20,21	Ranchi	Jharkhand	38	8
4	April 24,25	Dehradun	Uttarakhand	30	17
5	May 2,3	Delhi	Delhi	29	10
6	May 8,9	Patna	Bihar	36	11
7	May 29,30	Panchkula	Haryana	17	10
8	May 31, June 1	Shimla	Himachal Pradesh	28	14
9	June 8,9	Bhopal	Madya Pradesh	20	10
10	June 12,13	Raipur	Chhattisgarh	18	12
11	June 22,23	Jaipur	Rajashtan	28	14

Figure 7-1 Impression of the workshop in Bihar.

Day 1 started with a presentation and discussion of the project developments till date and subsequently focused on identifying the perceptions regarding promising and realistic strategies. Day 2 started with a presentation of the model runs based on a few of the strategies identified and continued with group discussions on the institutional set-up and stakeholder engagement process needed for the actual basin planning.

On both days the participants were divided into two break-out groups that were each directed by a team of two facilitators, at least one of whom spoke Hindi. The strategy components suggested are summarized in Table 7-2.

Table 7-2: Summary of interventions as part of strategies mentioned in the workshops in the states

	UP	UK	WB	Jharkhand	Rajasthan	HP	Delhi	Chhat.	MP	Bihar	Haryana
Catchment management	■	■	■	■	■	■	■	■	■	■	■
Waste Water treatment, recycling	■	■	■	■	■	■	■	■	■	■	■
Demand management, increase agric efficiency	■	■	■	■	■	■		■	■	■	■
Make new infrastructure	■		■		■	■	■	■	■	■	■
Increase Awareness	■	■		■		■	■	■	■		■
Cropping pattern change, Increase command area	■	■	■	■				■	■		■
Limit GW extraction	■		■	■	■	■	■				■
Financial incentives, Water pricing /metering	■		■		■			■	■		■
E-flow enforced	■		■				■			■	
Artificial recharge of GW	■			■			■	■			
Change in Water distribution rules			■							■	■
Increase flow for navigation			■								

7.2 Status and Use of Stakeholder Engagement

State consultations are finalized. A final basin wide workshop will be held as well as a number of consultations on e-flows and strategies and scenarios.

8 Project Work Plan

Based on the progress of the project, the work plan as presented in the Inception report remains unchanged. However, the schedule for the deliverables has been adapted to include proper time for finalization of draft deliverables. Also in consultation with the client the arrangement of final project reports has been adapted. All deliverable reports are now mentioned both with the timing of the draft as well as the final report in Table 8-1.

Table 8-1: Schedule of milestones and deliverables

Deliverables / Reports	Draft	Final	Milestone
Contract signing		Jul-15	1
Inception report		Apr-16	2
Progress report 1 (up till July 2016)	Aug-16	Dec-16	3
Report describing model conceptualization and setup	Jun-16	Dec-16	
Report with detailed approach for Task 2 and 3	Jun-16	Dec-16	
Report on initial stakeholder engagement and roadmap	Nov-16	June-17 Reviewed Aug 2017	4
Report describing information system design	Nov-16	June-17 Reviewed Aug 2017	
Progress report 2 (up till Dec 2016)	May-17	June-17 Reviewed Aug 2017	
Draft Report on (i) surface groundwater analysis, (ii) Environmental Flow Assessment and (iii) Scenario Modelling	Dec-17	Jan-18	5
Progress report 3 (up till June 2017)	Nov-17	Nov-17	
Draft Report on (i) River Basin Modelling (all aspects) and (ii) documentation of information systems	Dec-17	Jan-17	
Final Report on (i) surface groundwater analysis, (ii) Environmental Flow Assessment and (iii) Scenario Modelling		Mar-18	6
Final Report on (i) River Basin Modelling (all aspects) and (ii) documentation of information systems		Mar-18	
Draft Project Management Report (including Stakeholder engagement processes and executive summary of Technical reports)	Jan-18	Jan-18	
Progress report 4 (up till Dec 2017)	Jan 18	Feb-18	
Delivery of all model software developed and associated data files		Dec-17	7
Final Project Management Report (including Stakeholder engagement processes and executive summary of Technical reports)		Mar-18	

ANNEX A: Minutes of meeting 14 March 2017

BY FAX/EMAIL

No. 21/123/2015-NHP/1810-1891
Government of India
Ministry of Water Resources, RD & GR
National Hydrology Project

Room No. 208
Block-3, CGO Complex
Lodhi Road
New Delhi - 110003

Dated: 17/03/2017

Sub: Summary Record of the decisions taken by Secretary, MOWR, RD & GR during Presentation taken by him on 14.03.2017 regarding World Bank funded Consultancy by Deltares on 'Strategic Basin Planning for Ganga River Basin in India'

Please find attached Summary Record of the decisions taken by Secretary, MOWR, RD & GR during Presentation taken by him on 14.03.2017 regarding World Bank funded Consultancy by Deltares on 'Strategic Basin Planning for Ganga River Basin in India' for your kind perusal and further necessary action please.

Encl : As above

17/3/17
(Rakesh Kashyap)
SJC III, NHP

To:

1. The Member, WP&P, CWC, R.K. Puram, New Delhi
2. The Member (RGI), CGWB, Bhujal Bhawan, CGO Complex, Faridabad
3. The Director, NIH, Roorkee
4. Executive Director (Technical), NMCG, Major Dhyanchand Stadium, New Delhi with the request to kindly nominate Officers of NMCG for State wise core group indicated in Annex I.
5. The Chief Engineer, BPMO, CWC, New Delhi
6. Dr. Nandakumaran, Regional Director, NHP, CGWB, Faridabad
7. The Chief Engineer, UGBO, CWC, Lucknow
8. The Chief Engineer LGBO, CWC, Patna
9. The Chief Engineer YBO, CWC, New Delhi
10. The Chief Engineer IBO, CWC, Chandigarh
11. All the Officers of the State wise Groups indicated in Annex I of the Summary Record of the decisions taken by the Secretary, MOWR, RD & GR.
12. Dr. Kees Bons, Team Leader, M/s Deltares

Copy for kind information to:

1. The PPS to Secretary, MOWR, RD & GR
2. The PPS to the Chairman, CWC, R.K. Puram, New Delhi
3. The PPS to the Director General, NMCG, MOWR, RD & GR, New Delhi
4. The PPS to the Chairman, CGWB, Bhujal Bhawan, CGO Complex, Faridabad
5. PS to JS (A & GW), MOWR, RD & GR
6. Dr. Anju Gaur, Task Team Leader, NHP, World Bank, New Delhi
7. Mr. C. Rajgopal Singh, Co TTL, NHP, World Bank, New Delhi

Decisions taken by Secretary, MOWR RD & GR during discussions held on 14.03.2017 on World Bank funded Consultancy by Deltares on 'Strategic Basin Planning for Ganga River Basin in India'

1. For e - flows assessment which is one of the major task of this consultancy work, Mr. Bhopal Singh, Chief Engineer (HRM), CWC and N.N. Rai, Director, Hydrology (NE), CWC who are having expertise in this domain are to be associated under overall guidance of Member D&R, CWC.

2. All the IITs which have earlier been involved in preparation of Ganga River Basin Environment Management Plan are also to be involved in the consultancy work.

3. A multidisciplinary Advisory Group as detailed below is required to be immediately constituted for providing technical inputs in respect of various issues pertaining to rejuvenation and strategic planning for Ganga Basin and to guide the participating organisations for taking the work forward.

1. Sh. A.B. Pandya, Chairman (Retd.), CWC
2. Sh. A.S. Dhingra, Commissioner CAD (Retd.), MOWR
3. Dr. I.M. Mishra, Professor (Retd.), Chemical Department, IIT, Roorkee
4. Prof. A.K. Gosain, Professor (Retd.), IIT, Delhi
5. Sh. S. Masood. Husain, Member, WP&P, CWC, New Delhi
6. Sh. K.B. Biswas, Chairman, CGWB, Faridabad
7. Dr. N.K. Goel, Department of Hydrology, IIT, Roorkee
8. Dr. S. K. Mishra, Professor, WRDM, IIT, Roorkee
9. Dr. R.D. Singh, Director, NIH, Roorkee
10. Dr. Sharad Jain, NIH, Roorkee
11. Dr. M.K. Goel, NIH, Roorkee
12. Dr. A.K. Lohani, NIH, Roorkee
13. Sh. R.K. Jain, Chief Engineer, Monitoring South, CWC, Bangalore
14. Dr. C.K. Jain, NIH, Roorkee
15. Dr. N.C. Ghosh, NIH, Roorkee

The meeting of the Advisory Group with the Consultant shall be held at least once in two months to provide the various inputs for the identified tasks under the consultancy. The Committee shall continue to provide guidance and assistance to the Central and State Organisations even after consultancy work is over.

4. In order to strengthen the capacity building at Central and State level, there is an urgent need for training of Central and State Govt. Officers in development of various models being used in the consultancy and generation of scenarios. Therefore, these models are required to be installed by the Consultant on the

systems of the trainees by first week of April 2017. Working knowledge of the models is also required to be imparted simultaneously.

5. State wise core group having involvement of Officers from CWC, CGWB, NIH & NMCG along with the officers of State Govt. are required to be constituted for ensuring involvement of Central and State Organisations in the Consultancy work, effective capacity building and knowledge transfer.

State wise constitution of the groups is enclosed as **Annex I.**

6. Since the outcome of this Consultancy work would be having convergence with objectives of NMCG, active involvement of NMCG in this Consultancy Work is required.

List of Participants is enclosed as **Annex II.**

Annex I

State-wise details of core groups of basin states in respect of Consultancy work for Strategic Planning of Ganga River Basin in India

Core Group	State	Organisation	Name & Designation of associated Officers
1	Uttarakhand	CWC, Regional Office	S.E., HOC, Dehradun
		CGWB, Regional Office	Ms. Monalisha Singh, Sc. B, Dehradun
		NIH	Dr.Manohar Arora, Sc-D
		State Irrigation Deptt.	CE (Design) & Director, Irrigation Research Institute, Irrigation Department, Govt. of Uttarakhand, Roorkee
		State Irrigation Deptt.	Two officers to be nominated by CE of Irrigation Research Institute, State Irrigation Department.
2	Himachal Pradesh	CWC, Regional Office	Director, M&A, Shimla
		CGWB, Regional Office	Mr.Upendra Srivastava, Sc-D, Faridabad
		NIH	Dr.Manohar A rora, Sc-D
		State Irrigation Deptt.	SanjivKaul, SE, Irrigation &Public Health Dept, Supply & Sewage Circle, Govt. of HP, Shimla.
		State Irrigation & PHE Deptt.	Two officers to be nominated by CE Irrigation &Public Health Dept, Govt. of HP
3	Haryana	CWC, Regional Office	Director, M&A, Chandigarh
		CGWB Regional Office	Mr. M L Angurala, Sc-D, Chandigarh
		NIH	Dr. L. N Thakural, Sc-C
		State Irrigation Deptt.	Mr. Rajiv Bansal, Chief Engineer, Irrigation Dept, Govt. of Haryana, Panchkula
		State Irrigation Deptt.	Two officers to be nominated by CE of State Irrigation Department.
4	Delhi	CWC, Regional Office	SE, HOC, Noida
		CGWB	Mr.Upendra Srivastava, Sc-D, Faridabad
		NIH	Dr.JyotiPatil, Sc-C
		State I & FC Deptt	Chief Engineer, Irrigation &Flood ControlDept, Govt. of NCT Delhi, Delhi
		State I & FC Deptt.	Two officers to be nominated by CE of

			State Irrigation & Flood Control Department.
5	Uttar Pradesh	CWC, Regional Office	Director, M&A, Lucknow
		CGWB Regional Office	Mr.Anmol Sharma, AHG, Lucknow
		NIH	Dr. Anupama Sharma, Sc-E, Dr. Sanjay Kumar, Sc-E & Dr.Pradeep Kumar, Sc-C
		State Irrigation Deptt. & WR	Mr.Sharad Goel, Chief Engineer, ISO, Irrigation & WR Dept, Govt. of UP, Lucknow
		State Irrigation Deptt. & WR	Two officers to be nominated by CE of State Irrigation& WR Department.
6	Rajasthan	CWC, Regional Office	Director, M&A, Jaipur
		CGWB, Regional Office	Mr.Suresh Pareek, Sc-D, Jaipur
		NIH	Dr. Rahul Jaiswal, Sc-D
		State Irrigation Deptt.	Chief Engineer, WR Dept, Govt. of Rajasthan, Jaipur
		State Irrigation Deptt.	Two officers to be nominated by CE of State WR Department.
7	M P	CWC, Regional Office	Director, Monitoring, Bhopal
		CGWB, Regional Office	Ms.NeetyNagi, Sc-B, Bhopal
		NIH	Dr. Ravi Galkate, Sc-E
		State WR Deptt.	Mr. M.K. Acharya, Chief Engineer, WR Dept., Govt. of MP, Bhopal
		State WR Deptt	Two officers to be nominated by CE of State WR Department.
8	Chattisgarh	CWC, Regional Office	Director, M&A, Raipur
		CGWB, Regional Office	Ms.SuchetanaBiswas, Sc-B, Raipur
		NIH	Dr.T R Nayak, Sc-E
		State WR Deptt.	Mr.Jayant Pawar,Chief Engineer (M&G Basin), WR Dept, Govt. of Chattisgarh, Raipur
		State WR Deptt.	Two officers to be nominated by CE of State WR Department.
9	Bihar	CWC, Regional Office	Director, M&A, Patna
		CGWB, Regional Office	Dr.Indranil Roy, Sc-C, Patna
		NIH	Dr.Pankaj Mani Sc-E& Mr.Sumant Kumar, Sc-C
		State WR Deptt.	Mr.Indu Bhushan Kumar, Chief Engineer, Planning & Monitoring, WR Dept, Govt. of Bihar, Patna

		State WR Deptt.	Two officers to be nominated by CE of State WR Department.
10	Jharkhand	CWC, Regional Office	Director, M&A, Ranchi
		CGWB, Regional Office	Mr. T.B N. Singh, Sc-D, Ranchi
		NIH	Mr J P Patra, Sc-C &Mrs.Sashi P Indwar, Sc-C
		State WR Deptt.	Chief Engineer, Planning & Hydrology, WR Dept, Govt. of Jharkhand, Ranchi
		State WR Deptt.	Two officers to be nominated by CE of State WR Department.
11	West Bengal	CWC, Regional Office	Director , M&A, Kolkatta
		CGWB	Ms.Ankita Bhattacharya, Sc-B, Kolkata
		NIH	Mr. B. Chakroborty, Sc-G
		State Irr. & Waterways Deptt.	Mr.SiddharthaDutta, Chief Engineer West, Dept. of Irrigation & Waterways, Govt. of WB, Kolkata
		State Irr. & Waterways Deptt.	Two officers to be nominated by CE of State Department of Irr.&Waterways.

These state level group shall be provided assistance and guidance by the following officers of CWC, CGWB, NMCG and NIH

CWC

Dr. Naresh Kumar, Chief Engineer, BPMO.
Dr. R.N. Sankhua, Director, Basin Planning,
Mr.Rishi Srivastava, Director, Reservoir Operation
Ms. Isly Issac, AD
Ms Deep Shikha, AD
Mr. Sandeep Bisht, AD
Mr. Pushpendu Majumdar, AD
Mr. Dharamendra Kumar, AD

The state wise Groups shall be managed and coordinated by respective Regional Chief Engineers of CWC.

NIH

Dr.Sharad K Jain, Sc-G
Dr. N. C. Ghosh, Sc-G
Dr. C. K. Jain, Sc-G

Dr. M. K. Goel,Sc-G
Dr. A. K. Lohani, Sc-G
Mrs Suman Gujar, Sc-C (Nodal officer in Delhi)

CGWB
Dr.P.Nandkumaran, RD(HP), New Delhi.
Mr. S.K. Sinha, Sc-D & TS to Chairman
Mr.Upendra Srivastava, Sc-D (Nodal Officer)

NMCG
Mr. D.P Mathuria, Executive Director, Technical
Dr. Babu Nair, Scientist D

Annex II

List of Participants in the presentation taken by the Secretary on 14.03.2017 on Consultancy work of Strategic Planning for Ganga River Basin in India

S. No.	Name &Designation
	MOWR, RD & GR
1	Dr. Amarjit Singh, Secretary
2	Sh. Akhil Kumar, JS(A&GW)
3	Sh. N.K. Manglik , SJC, NHP
4	Sh. Rakesh Kashyap, SJC, NHP
	CWC
5	Sh. S.Masood Husain, Member(WP&P)
6	Dr. Naresh Kumar, CE(BPMO)
7	Dr. R.N. Sankhua, Director (BP)
8	Sh. Rajesh Kumar, Director, RDD
9	Sh. Alok Paul Kalsi, DD, RS Dte.
	CGWB
10	Sh. K.B. Biswas, Chairman
11	Sh. K.C. Naik, Member (RGI)
12	Dr. Nanda Kumaran, Regional Director
13	Dr. S.K Sinha, Scientist 'D'
	NIH
14	Dr. R.D. Singh , Director
15	Dr. M.K. Goel, Scientist 'G'
16	Dr. A.K. Lohani, Scientist 'G'
17	Dr. Anupama, Scientist 'E'
	NMCG
18	Sh. Hitesh Kumar S. Makwana, Executive Director
19	Sh. D.P. Mathuria, Executive Director
20	Dr. Babu Nair, Scientist 'D'
	World Bank
21	Dr. Anju Gaur, Task Team Leader
	Deltares/AECOM
22	Sh. Pijush Kanti Datta

ANNEX B: Minutes of meeting 4 July 2017

Summary Record of Discussions of the first meeting of the Multi-disciplinary Advisory Group for the consultancy work by Deltares on Strategic Basin Planning of Ganga River Basin.

First meeting of the Multi-Disciplinary Advisory Group constituted vide NIH letter no. 14/150/2016-NIH/DII dated 02.06.2017 for the consultancy work by Deltares on Strategic Basin Planning of Ganga River Basin was held under the chairmanship of Secretary (WR, RD & GR) on 4th July, 2017 at 1100 hours at New Delhi. The list of participants is annexed at Annexure – I

A presentation was made by Mr. Kees Bons, Task Team Leader from Deltares on consultancy work being carried out for 'Strategic Basin Planning for Ganga River Basin in India' giving therein overview, deliverables, works carried out so far and development of dash board including indicators and visualisations on the dashboard. The Advisory Group mainly discussed about the adequacy of the model, testing of some of the scenarios, indicators on the dash board, validation of the model and way forward so as to ensure sustainability of the work in the long run after the consultants hand over this model to the Govt. of India.

The summary record of the discussions and the decisions taken in the meetings are as below:

1) Since CWC is setting up River Basin modelling centre shortly, a dedicated unit shall be set up in CWC to further work on the analytical tool being developed by Deltares. The on job trainee officers from CWC, CGWB NIH and NMCG are required to be invariably associated in this unit and shall be provided with the vision and guidance by the experts of CWC. The dedicated unit so formed in CWC will initiate discussions with the Ganga Basin States, experts from research institutions and stakeholders from the basin States for facilitating them to use this tool for developing basin plans considering various strategies. (Action:BPMO, CWC)

2) Experts including Shri A.D. Mohile (ex-Chairman, CWC), Shri A.B. Pandya (ex-Chairman, CWC) and Shri M.E. Haque (ex -Member CWC) will mentor the dedicated unit for basin planning of Ganga River Basin . Officers of the Ganga basin states will also be involved along with the regional officers of MoWR, RD & GR already identified for the work of strategic basin planning being carried out by Deltares. BPMO unit shall coordinate and provide all the support to this group. The group thus formed will work

on the various strategies, which inter alia should include impact of inter linking of rivers, improving irrigation efficiency, ecology, etc. (Action : BPMO, CWC)

3) It was also decided that following experts will use the tool being developed by Deltares to analyse the strategies and scenarios and to validate the results :

   (a) The effect of large dams on river health by Prof. N.K. Goel, I.I.T., Roorkee
   (b) Quality aspects by Prof. Arun Kansal, Dean Research, TERI University.
   (c) Effect of climate change by Shri Rahul Saxena, Scientist 'E', Hydrology Division of IMD
   (d) Conjunctive use of surface and ground water by Dr.N.C. Ghosh, Scientist 'G", NIH, along with Scientists of CGWB.
   (e) Water use efficiency by BPMO, CWC along with other concerned units and experts of CWC)

   (Action : Prof. N.K. Goel, IIT, Roorkee, Prof. Arun Kansal, TERI, Sh. Rahul Saxena, Scientist E, IMD, Dr. N.C. Ghosh, NIH, CGWB & BPMO CWC)

4) NPMU shall coordinate with the consultant for making available the tools being developed by the Deltares to the experts for carrying out work as above. (Action; NPMU, NHP and Deltares)

5) To explain the Modelling work and development of tool by Deltares, a demo shall be arranged soon for the Experts of Multi-disciplinary Group in the Deltares Office. (Action: NPMU, NHP & Deltares)

6) The representative of the World Bank conveyed that they have recently reviewed the progress of the consultancy work. According to them, a "Strategic Advisory Group" of senior Indian experts that could provide a two-way interface between the technical project team and senior government policy officials, in order to;

   (i) better envision how the modelling platform being developed can be deployed in support of water-related policy formulation and long-term planning for the Ganga Basin, and

   (ii) guide the technical project team especially during the forthcoming scenario analysis phase of the project to ensure it can provide appropriate policy and planning support.

The following individuals could add considerable value on an Advisory Group with the above role:

1. Yoginder K Alag, Economist, Former Member of Indian Planning Commission, Former Vice Chancellor of JNU and former Union Minister (https://en.wikipedia.org/wiki/Yoginder_K_Alagh)
2. Leena Shrivastava, Vice Chancellor, TERI University (http://www.teriin.org/profile/Leena-Srivastava)
3. A.D. Mohile, Former Chairman CWC
4. Ajit Pattnaik, (Ex-IFS), Former PCCF, Odisha (https://www.linkedin.com/in/ajit-pattnaik-83273935/?ppe=1)

This Group will focus on a strategic water policy and planning and the linkages with the economic policy. This could be called "Strategic Advisory Group" as distinct from the technical group.

Although, some progress has been made on the analytical tasks (including on analysis of surface-groundwater interactions and environmental flows) but these important aspects of the project – that are not solely modelling tasks – are considerably behind; more effort from the Netherlands-based team over the coming months will be important to deliver on these tasks. From here forwards, the modelling parts of the project needs to shift focus quickly towards the application of the modelling platform for scenario modelling. This will require agreement on the scope of scenarios to be explored during the remaining project time, considerable modelling work to explore, describe and document these possible alterative futures, followed by a broad stakeholder consultation around these scenarios. This focus with provide a strong basis for policy engagement and make the establishment and work of the proposed Advisory Group very helpful**.**

7) NMCG shall immediately make available all the available information related to ecological aspects to the Deltares as requisitioned by them through NPMU, NHP. (Action: ED (Tech) NMCG)

8) The information/reports about the ongoing work on strategic basin planning of Ganga Basin will be uploaded on the websites of the MOWR, RD & GR and CWC immediately. (Action : BPMO, CWC and NPMU, NHP)

The next meeting of the Advisory Group shall be held after two months.

Attendance Sheet

Meeting of the Multi Disciplinary Advisory Group for the Consultancy Work by Deltares on Strategic Basin Planning of Ganga River Basin
Venue : Committee Room, Ministry of Labour & Employment
Date : 04.07.2017, 11.00 hrs
MoWR, RD & GR

S. No.	Name	Designation
1.	Dr. Amarjit Singh	Secretary, MoWR, RD & GR (Chair)
2.	Sh. Akhil Kumar	Joint Secretary (A&GW),
3.	Sh. N.K. Manglik	Director & SJC II (NHP)
4.	Sh. Rakesh Kashyap	SJC – III (NHP)
5.	Sh. Deepak Kumar	SJC –I (NHP)
6.	Dr. K.J. Anandha Kumar	Scientist 'D' (Sr. HG.), NHP
7.	Dr. Raja Ram Purohit	Jr. Hydrogeologist, NHP

CWC

S. No.	Name	Designation
1.	Sh.S. Masood Husain	Member (WP&P)
2.	Dr. Naresh Kumar	Chief Engineer, BPMO
3.	Sh. Bhopal Singh	Chief Engineer,HRM
4.	Sh. R.K. Jain	Chief Engineer, Monitoring (S), Bengaluru
5.	Dr. R. Sankhua	Director, Basin Planning
6.	Sh. N. N. Rai	Director, Hydrology (NE)
7.	Sh. Sunil Kumar	Director, NWA, Pune
8.	Sh. Pushpendu Majumdar	DD,
9.	Sh. Dharmendra Singh	AD

CGWB

S. No.	Name	Designation
1.	Sh. K.B. Biswas	Chairman
2.	Dr. E. Sampath Kumar	Member
3.	Sh. Upendra Srivastava	Scientist 'D'
4.	Ms. Neety Nagi	Scientist 'B', Bhopal
5.	Ms. Ankita Bhattacharya	Scientist 'B', Kolkata
6.	Ms. Akansha Kushwaha	AHG, Faridabad

NIH

S. No.	Name	Designation
1.	Dr. N.C. Ghosh	Scientist 'G'
2.	Dr. A.K. Lohani	Scientist 'G'
3.	Ms. Jyoti P. Patil	Scientist 'C'
4.	Ms. Suman Gurjar	Scientist 'C'

NMCG

S. No.	Name	Designation
1.	Sh. Peeyush Gupta	ARTIS

World Bank

S. No.	Name	Designation
1.	Sh. Halla Qadomi	World Bank

2.	Sh. Anish Kumar	World Bank

Deltares Team

S. No.	Name	Designation
1.	Dr. Kees Bones	Team Leader, Deltres
2.	Sh. Piyush K. Datta	Associate Director, AECOM

Experts (Retired & from Other Organizations)

S. No.	Name	Designation & Organization
1.	Sh. A.D. Mohile	Former Chairman, CWC
2.	Sh.A.B . Pandya	Former Chairman, CWC
3.	Sh.A.S. Dhingra	Former Commissioner, CADWM, MoWR, RD & GR
4.	Prof. N.K. Goel	Professor, IIT, Roorkee
5.	Sh. B.P. Yadav	Scientist 'F', IMD
6.	Sh. Rahul Saxena	Scientist 'E', Hydrology Division, IMD
7.	Sh. Pankaj Tyagi	Director, ASRAW, M/o Agriculture
8.	Er.G.R. Zargaz	Team Leader (Water), M/o DWS, GOI
9.	Prof. Arun Kansal	Dean, Research, TERI University