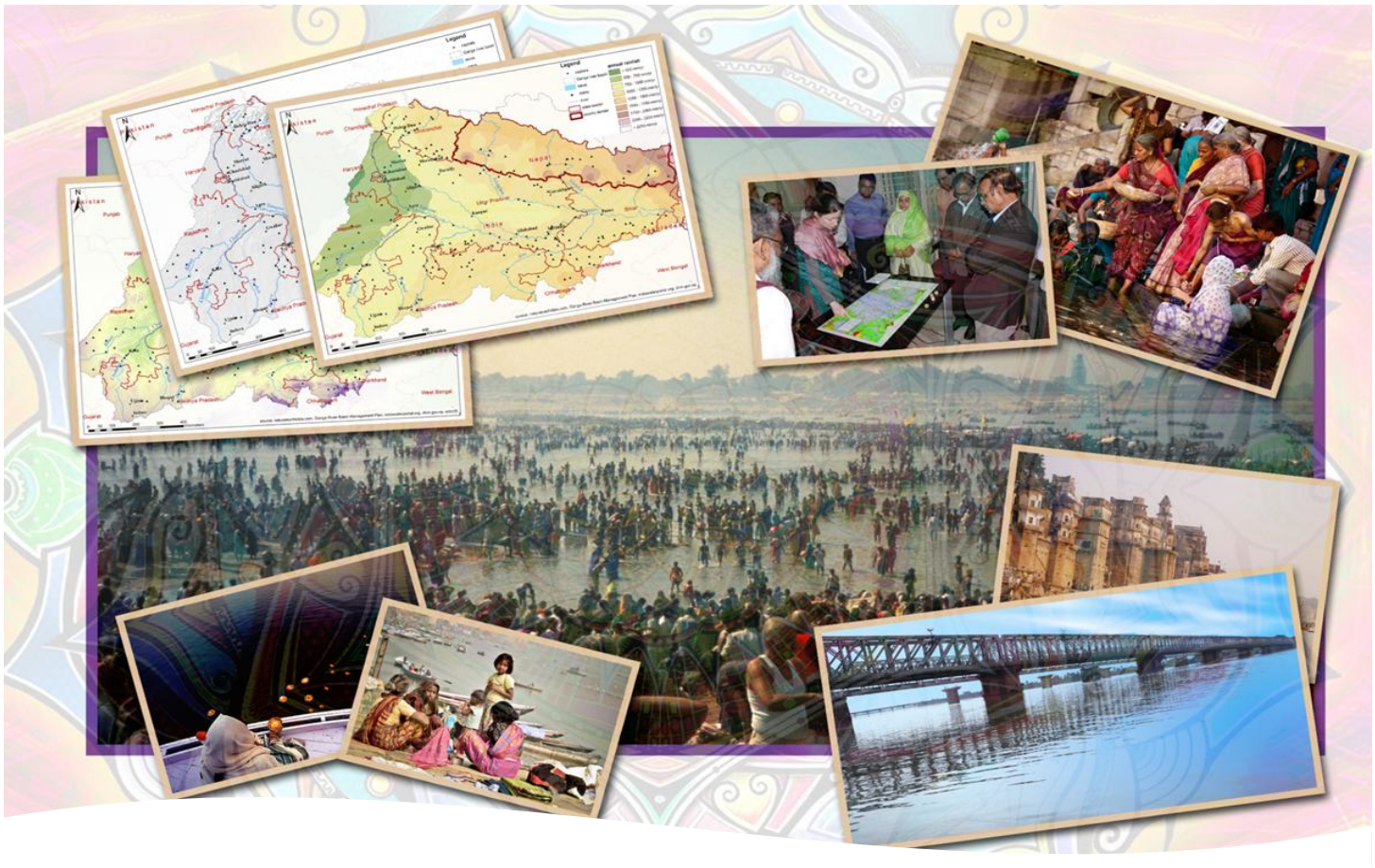
Strategic Basin Planning for Ganga River Basin in India



Progress Report up till December 2017

May 2017

Deltares

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

Progress Report up till December 2016

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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" in the period up till December 2016. This consists of the Collaborative modelling phase of the project as described in the Inception report:

This is Deliverable 4b of the Project Work plan: "Progress report providing evidence of satisfactory progress on all project tasks", and together with other reports contributes to Milestone 4 of the project.

The activities in the conceptualization phase are grouped into three types which are discussed in this report:

1. Stakeholder collaborative modeling
2. Data identification and collection
3. Model development

Finally the progress is evaluated, challenges identified and action for the period ahead described.

Overall project is progressing according to plan:

- Participation of stakeholders is enhanced and deepened by the collaborative modeling workshops that elaborated on the issues raised by the individual states. These workshops also contributed to the sense of ownership at the states.
- Central organizations provide good support and share data. Even the classified data on Ganga flows were made available by the Government.
- Further model development, making use of the information gathered in previous phases of the project and supported by the collaborative modeling workshops progressed well with the first calibration runs made in December 2016.
- Environmental flow assessment has made less progress that planned. However the draft zonation of the Ganga River was prepared as a basis for further assessment.

The main challenges for the project in the coming months can be summed as follows:

- Achieving training and capacity building objectives for the target groups in the relative limited remaining time available.
- Achieving a sense of ownership with the Central and State organizations to whom the modelling system will be transferred in the coming period.
- Developing realistic strategies on a strategic level that will show the synergy possibilities between cross-sectoral plans.

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Contents

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” aims at

1. Significantly 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 significantly improving the health of the river and maintaining an acceptable level of economic productivity;
3. Build stronger and more accessible information and knowledge base to guide on-going dialogue around and management of the Ganga River basin; and
4. Establish on-going multi-stakeholder engagement processes in the basin to support strategic basin planning.

The project is funded by the World Bank, but the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR RD&GR) is the key stakeholder and nodal point for the project at the central level. 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 grasp 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 up till June 2016 and this report discusses the progress of the project up till December 2016.

This is Deliverable 4b of the Project Work plan: “Progress report providing evidence of satisfactory progress on all project tasks”, and together with other reports contributes to Milestone 4 of the project.

The activities in the collaborative modelling phase are grouped into three types which are discussed in this report:

1. Stakeholder engagement
2. Data collection and analysis
3. Model development (including Training)

Finally the progress is evaluated, challenges identified and action for the period ahead described.

1.2 Context of the Project

Water issues and River Basin management in particular received quite some attention in the second half of 2016. 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.

The most important development was that the Central Government, seeking to resolve several inter-state disputes over river water sharing through a model legislation, has come out with a draft National Water Framework Bill, 2016, providing for a mechanism to develop and manage river basin in an integrated manner so that every state gets "equitable" share of a river's water without violating rights of others. It provides an umbrella statement of general principles governing the exercise of legislative or executive (or devolved) powers by the Centre, the states and the local governance institutions. The draft Bill also pitches for establishing River Basin Authority for each inter-state basin to ensure "optimum and sustainable" development of rivers and valleys and devises an integrated approach to conserve water and manage groundwater in a sustainable manner.

Several inter-state disputes evolved in the present period. Between Punjab, Haryana, Rajasthan and Delhi an issue emerged on the sharing of river waters with other states through the SYL canal. The Cauvery river dispute was again brought into the limelight when the Supreme Court directed the release of the Cauvery water into Tamil Nadu. This decision was widely protested by the people of Karnataka, especially farmers. A new dispute has also arisen between Odisha and Chhattisgarh over Mahanadi river water. Internationally the Indus Water Treaty was back in the limelight as an inter-ministerial task force, headed by Prime Minister Narendra Modi, was formed to look into the strategic aspects of the Indus Water Treaty.
The government has decided to constitute a single tribunal for resolving all the inter-state river water disputes while subsuming all the existing ones. Currently, there are eight such tribunals in the country with the need for more tribunals in case a new dispute would arise.

The 2015 Paris Agreement, a landmark global accord to combat climate change, has officially entered into force. The agreement reached the threshold for entry into force in 2016 and was adopted by 195 countries including India.

Regarding the Ganga the Cabinet has approved the River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016. The order delegates financial and administrative powers to National Mission for Clean Ganga (NMCG) to accelerate the process of project implementation for Ganga rejuvenation. The order envisages creation of the National Council for River Ganga (Rejuvenation, Protection and Management) as an Authority under the Prime Minister as Chairperson, replacing the existing NGRBA. It also leads to the setting up of an Empowered Task Force chaired by the Minister of Water Resources along with the other ministries, departments and State governments concerned in the protection of Ganga.

The Ministry of Water Resources and the agricultural ministry have signed a MoU where the latter will develop organic farming in the villages along the Ganga River and will also create awareness about balanced use of chemicals, fertilizers and pesticides.

In the meantime the courts also played their role in directing the management and use of the river: The National Green Tribunal (NGT) has ordered the Madhya Pradesh and the Rajasthan governments to work on maintaining the river's environmental flow (e-flow). The NGT also criticized the approach of the Uttar Pradesh Jal Nigam towards the Centre’s Ganga Action Plan, and in separate decisions directed the National Institute of Hydrology, Roorkee and Central Water Commission to oversee re-identification and demarcation of Yamuna floodplain in Agra, prohibited farming on Yamuna banks citing heavy pollution in the river, and reprimanded the Uttar Pradesh government over the shifting of tanneries located on the banks of the Ganga river in Kanpur.

Uttarakhand State High Court (HC) imposed a ban on construction, felling of, burning of fossil fuel and all plastic bags and other such objects close to the glaciers. Himachal Pradesh HC ordered the state government to file a status report on the shortage of drinking water supply in Shimla after it was reported that contaminated water was supplied in the city.

2 Collaborative modeling period July - December 2016

The contract between The IBRD and Deltares came into effect on June 30th 2015. The inception Report details the activities and progress up till and Including January 2016. The first progress report covered the Conceptualization period from January to July 2016. This report covers the Collaborative modeling period up till December 2016.

2.1 Objectives

Activities in this part of the project / Collaborative modeling phase were aimed at:

Engagement

- Bring different departments together to unravel issues and explore possible strategies
- Engage stakeholders from States and Central Organizations in model setup
- Identify relevant indicators for model output evaluation
- Create stakeholder ownership of the process and methods used

Inventory/Assessment

- Decide on data to be used together with stakeholders
- Collect data and analyze received data
- Assessment for e-flow analysis and surface water – ground water analysis

Develop models

- Based on collected data and the collaborative modeling phase the model are further developed and connected to each other

2.2 Timeline

In the period several bilateral meetings were held with the Central Groundwater Board (CGWB), Central Water Commission (CWC), Indian Meteorological Department (IMD) and Central Pollution Control Board (CPCB) to discuss the project approach and the availability of data.

15 July, 2016 *Collaborative modelling workshop Central Organizations*
On July 15th, just before the basin-wide workshop and the series collaborative modeling workshops in the 11 states, the project organized a 1-day collaborative modeling workshop with 14 specialists from five Central Agencies: CWC, CGWB, CPCB, IMD and NIH Roorkee. On the one hand this workshop was meant to check the results from the visits and questionnaires with the national specialists and on the other hand the workshop also served as a try-out for the basin-wide and the state-level collaborative modeling workshops.

18 July, 2016 *Basin wide workshop*
The second basin-wide workshop was held in Lucknow on 18th July 2016, the participants were relevant stakeholders from all eleven Ganga Basin states, central government agencies, national/ international organizations (participants list attached in Annexure-1). The purpose of this workshop was to initiate the process of collaborative modelling for the Ganga River basin and workout the basin-wide key performance indicators.

Figure 2-1: Participants at 2nd Basin wide workshop in Lucknow

***July-November** Collaborative modeling workshops*
The collaborative modeling workshops at basin and state level were meant to validate and further elaborate the findings for input into the technical modeling process.

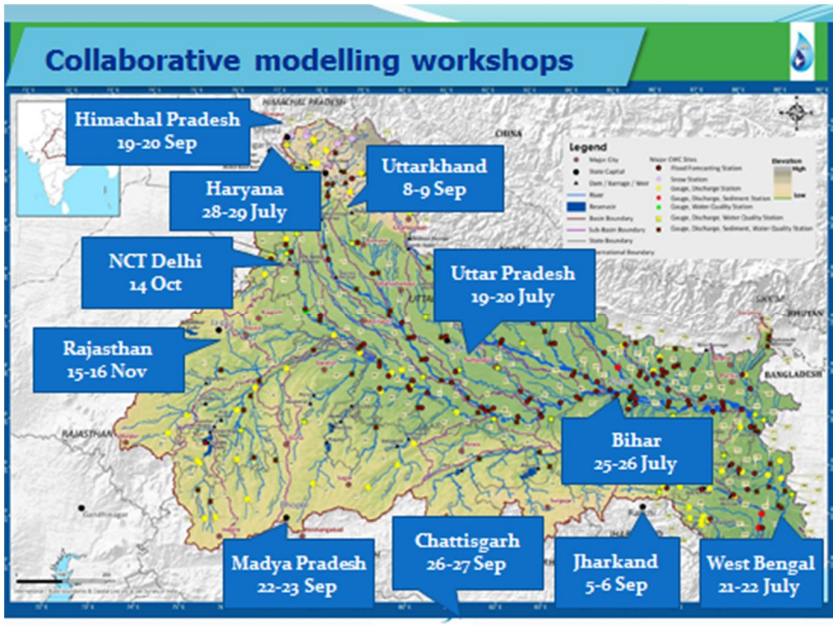

Figure 2-2: Dates of state consultations in the collaborative modelling phase

28 September *Progress meeting with Secretary MoWR, RD&GR*
On 28 September the project team reported and discussed the progress of the project with Shri Shashi Shekher, Secretary, MoWR, RD&GR, Govt. of India.

The following chapters will discuss the three main themes of the collaborative modeling phase in more detail.

3 Stakeholder engagement

3.1 Collaborative modelling phase

The stakeholder engagement in this phase shifted to collaborative modelling where the project team together with the stakeholders identified the issues to be modelled, the data required and the output indicators that would be relevant. The process, participation and results have been reported in the report “Initial stakeholder engagement identification and roadmap” that was published in draft in December 2016 and in final form in May 2017. Here only a summary will be presented.

The objectives of the collaborative modelling workshops were the:

1. Presentation to participants of the purpose, set-up and progress of the project;
2. Validation of the identified issues, causes, and impacts;
3. Identification of causal relationships (Group Model Building) between the different factors;
4. Identification of performance Indicators (for the dashboard);
5. Preliminary identification of possible measures;
6. Geographical translation of causal relationships as preparation for the modeling.

Day 1 focused on identifying the causal loops connecting the different issues, causes and impacts and identifying the main indicators. Day 2 focused on the translation of these factors and other important information on the map, as input for the schematization and other steps of the model development.
On both days the 20+ participants were divided in (mostly) three break-out groups that were each facilitated by a team of two facilitators, at least one of whom spoke Hindi.

Figure 3-1 Causal loop diagram: Yellow boxes are factors (issues, causes and impacts), Orange boxes are suggested indicators, and Pink boxes are possible measures/interventions.

At the end of the workshop the participants filled in an evaluation form. On average, the participants found the workshops (very) useful, they were able to get a good idea of the project, felt that they had good opportunity to provide the project team with relevant information, and found that they gained new insights about the Ganga River.

The issues discussed are summarized in Table 3-2, while the number of participants in each state is summarized in Table 3-1.

Table 3-1: Summary of participation of stakeholder organizations in the different activities

State	H.P.	U.K.	Har	Del	Raj	MP	UP	Jhar	Chh	Bih	WB
# participants per workshop/state	34	26	27	23	25	27	27	32	19	22	22
# of different departments/organizations present	11	12	8	7	8	10	12	10	8	10	9

Table 3-2: Summary of issues mentioned in the questionnaires and/or in the January workshop and/or visits to the states in February – May

Nr.	Issue	Himachal Pradesh	Uttara Khand	Haryan.	NCT Delhi	Raj.	Madya Prad.	Uttar Prad.	Bihar	Jhark.	Chatt.	West Bengal	# of states
	Water quality												
	Effluent and pollution control / Contamination drinking water with pathogens/ *Public health concerns*					1	1				1	1	4
	High concentration of toxic/industrial chemicals in Surface water		1				1				1	1	4
	Agricultural pollution (pesticides etc.)				1			1					2
	River pollution (colliery)/ effect of mining					1				1			2
	waste water contamination in urban areas/pollution from communities (water quality: domestic)		1	1	1						1		4
	groundwater contamination manmade and natural with arsenic, fluoride		1	1		1	1	1	1	1	1	1	9
	Groundwater pollution: High salinity			1		1		1			1	1	5
	Water quantity												
	Limited Availability and rising demand of water			1	1		1	1		1		1	6
	Water distribution								1				1
	natural calamities/Floods (in urban areas)		1	1	1	1		1				1	6
	Flood affected soil Water logging		1	1	1	1			1	1			6
	drought (situation)		1	1		1	1				1		5
	Reduction of river discharge		1						1		1		3
	Groundwater depletion/lowering of groundwater table			1	1	1	1	1	1		1		7
	Groundwater underutilization											1	1
	Interaction surface water - groundwater									1		1	2
	Change monsoon/rainfall (less)										1		1
	Biodiversity												
	Loss of biodiversity (e.g. dolphin)								1			1	2
	Environmental flows	1						1				1	3
	Environmental pollution											1	1
	Ecological protection									1			1
	Sedimentation/siltation												
	Siltation of dams/anicuts	1					1		1			1	4
	Soil and bank erosion	1	1				1		1	1		1	6
	Sea/coast erosion											1	1
	Sand mining			1									1
	Miscellaneous												
	Sand mining			1									1
	Navigation						1	1	1			1	4
	Low agricultural productivity		1										1
	Unplanned development in the whole basin				1								1
	Data acquisition and sharing of (digital) data (with states)				1						1	1	3

3.2 Status and use of stakeholder engagement

The engagement workshops and meetings and the collaborative modeling workshop contribute in various ways to a successful modeling and planning process as described on the next page:

Engagement and ownership creation

In the meetings and workshops special attention was paid to the situation in the state or organization concerned and how an integrated river basin model could be of use in that situation. By emphasizing the usefulness of the models in achieving the priorities and objectives of their own state or organization the specific interests of that state or organization was raised for their own interest and not only for the benefit of the basin. By emphasizing that the inputs of their participants would define the modeling the models became their models and not the model of the consultants. In the process it was also explained that the project would not make a 'plan' or 'advise' but would rather enable the stakeholders to make their own plan and assessment.

Creation of basin understanding

By discussing the position and role of the respective stakeholder organization or state within the basin as a whole an increased understanding of the interrelations between upstream and downstream states and activities increased, both the positive (opportunities for providing storage upstream) or negative (receiving pollution from upstream towns).

Apart from geographic interrelations and dependencies also the awareness of the inter-institutional relationships and dependencies were made visible during the sessions. Many state departments expressed at the end of the workshops that this was the first time the water resources issues were discussed between departments in an integrated way.

Focus on priority issues

By asking the stakeholder to formulate the issues that were relevant to them, the project facilitates that the process of modeling and planning covers all the perceived issues, rather than only the issues typically included by scientifically oriented modelers. By asking the stakeholders to formulate the issues that were relevant to them assures that the process of modeling and planning is indeed focusing on the correct issues and not on perceived issues by the experts. The process of collaborative modeling workshops where the issues were discussed and elaborated helped create a common understanding of cause and effect relations between issues. This will help to focus on addressing key causes and not apparent impacts only.

Collection of relevant data- enhance understanding of the water system

By starting from the perspective of the stakeholder and creating ownership with the stakeholder in the process many stakeholders were willing and proactive is assuring the project would use the correct available data and provided information and data relevant for the modeling and planning process. In turn this enhanced their sense of ownership and commitment as well as interest in the outcomes. In the sessions where the geographic aspects of issues were discussed it was very interesting to see how the stakeholders from different department could complement each other and to their own surprise created a better understanding of the functioning of the water system and how human interventions impacted it.

Identification of relevant indicators for model dashboard

To assure that the models will result in information that is relevant for decision making, the sessions paid special attention on identifying the indicators that decision makers value to base their decision on. These indicators may differ from state to state and also a set of common indicators for the basin as a whole were developed. The dashboard (also called the "one-page summary of the model run outputs") will be based on the indicators that were raised in the process.

Where indicators were mentioned that could not be calculated or simulated with the proposed modeling framework, this process also helped to manage expectations on what can be done with the models and what cannot.

4 Data collection and assessment

4.1 Approach

One of the main purposes of this project is to develop a tool that is useful to the stakeholders and will be used by the stakeholders. The data collection approach focuses on the benefits of the tool and what data the users would need to be present to use the tool for their purpose, rather than on trying to get data as an objective in itself.

We distinguish three types of data:

1. Basin characteristics such as Rainfall, geology, soils, land use, temperature. Without this data the model will not represent the basin, so this data is essential.
2. Calibration and validation data to test if the models actually simulate the surface and groundwater well enough for the purpose of strategic planning. This data on groundwater levels and surface water flows is needed for a limited time period only and the data need not to be stored or shared in the system because after successful calibration they will not be necessary anymore.
3. Data detailing the infrastructure and other human interventions in the system at present and any planned or possible interventions in the future that may be assessed with the models

4.2 Basin characteristics

The Rainfall – Runoff models used in the project, SPHY and Wflow, need static input maps on a 1x1 kilometer grid as well as series of input maps for meteorological forcing. As static input SPHY needs a digital elevation model (DEM) and a local drain direction map and slope map which can be derived from the DEM. Furthermore it needs a land cover map with associated evapotranspiration coefficients assigned to each land cover type, soil map with quantitative soil properties for the topsoil and subsoil, map of glacier outlines and distinction in debris-covered and debris-free glacier surfaces.

Meteorological data has been obtained with the help of CWC from IMD in gridded form. The data for the period 1958 till 2014 has been used and analyzed in comparison with global data sources (WFDEI and EUWATCH). As the data from IMD only covers the territory of India the information for precipitation is merged with the WFDEI data set to obtain coverage for the complete basin to be modelled as shown in Figure 4-1.

When the temperature data was analyzed it was observed that the IMD temperature data for stations high in the mountain showed a marked shift compared with the WFDEI data. Actually the IMD data hardly ever show temperatures below freezing. It has to be concluded that these values cannot be correct and when used would result in unrealistically high snow and glacier melt. In consultation with the MoWR it was decided to use the WFDEI temperature data which show a very good similarity to IMD data for the stations in the lower locations.

The following static data were obtained:

- Elevation from Shuttle Radar Topography Mission (SRTM)
- Land-use based on IIT adapted from NRSC data
- Soil data from FAO soil database

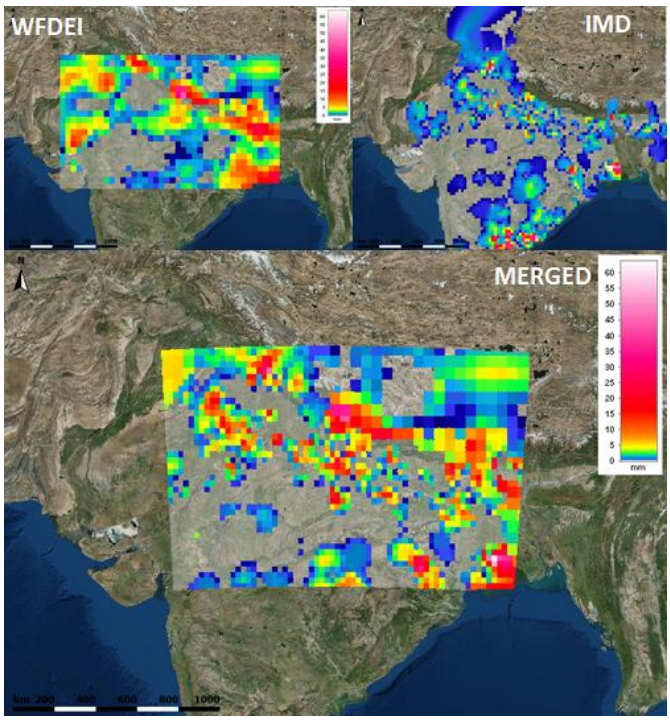

Figure 4-1: Merging of IMD and WFDEI data to obtain coverage for complete basin

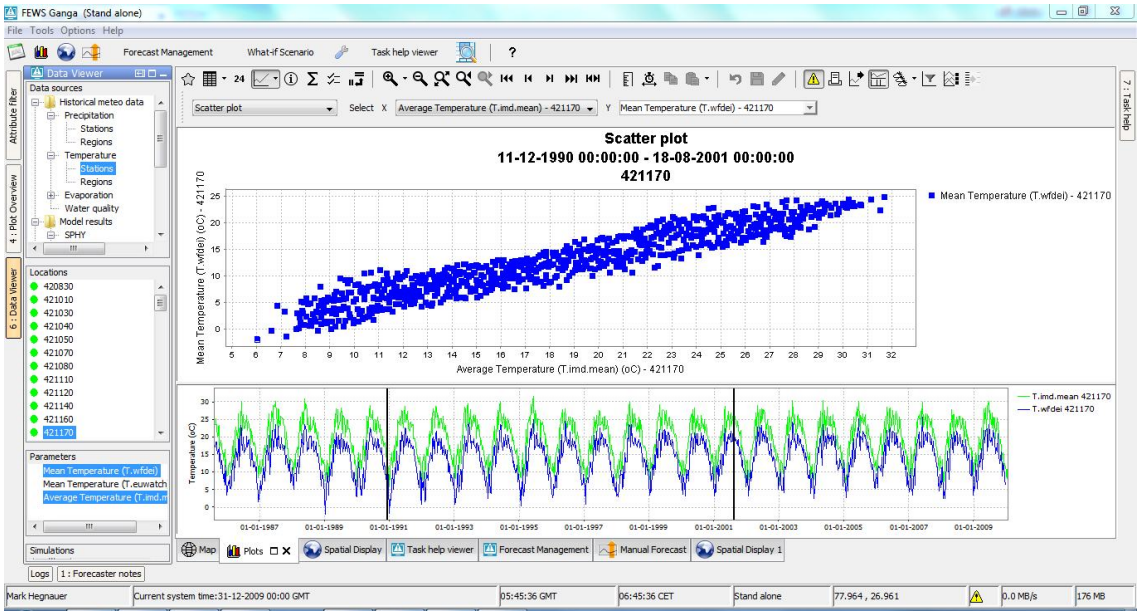

Figure 4-2: FEWS database showing shift in temperature data between IMD and WFDEI for mountain stations

Groundwater data was obtained from CGWB to define the characteristics of the aquifers. Based on the geological map the alluvial sediments were identified that formed the aquifer. Information taken from cross-sections were entered into the model to create a 3d model of the underground (Figure 4-3).

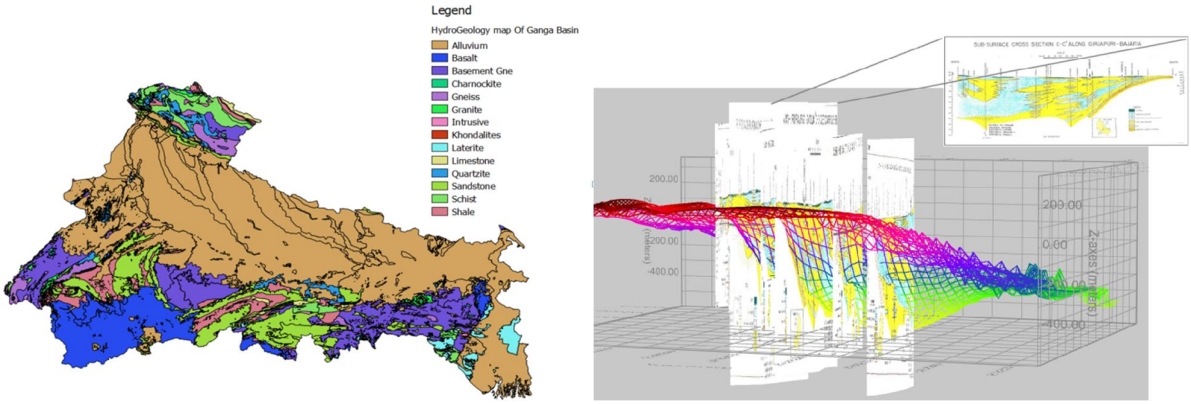

Figure 4-3 (left) Hydrogeology of the Ganga Basin (source: CGWB). The ground water model is made for the alluvium. (right) Information from cross-sections is used to create 3D model of underground

For E-flow assessments the river characteristics were collected and analyzed to obtain representative zones. Zonation is based on the following criteria:

- Slope
- Geomorphology
- Confluences
- Faunal ranges
- Forest Types
- Anthropogenic impacts

This process will continue in the coming months supported by expert sessions.

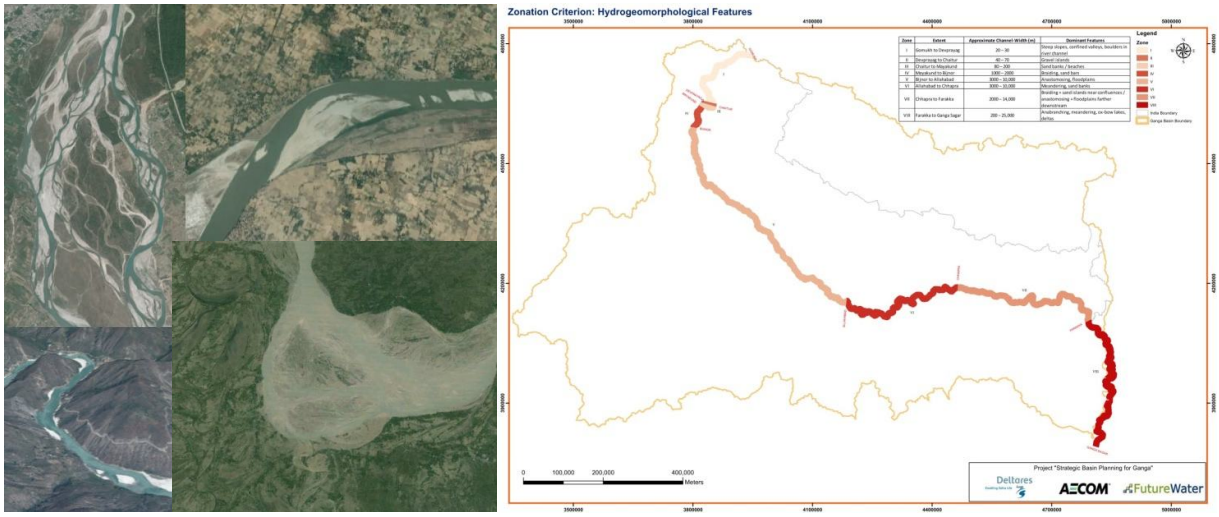

Figure 4-4: examples of geomorphological characteristics used for zonation

4.3 Calibration and Validation data

The Surface water quantity models are calibrated based on observed meteorological and discharge measurements. The overall performance of the model is analyzed based on the monthly average (or total) flow. For a check on the total volume of water, also annual total discharge will be checked.

The comparison of the observed and simulated discharges is done at river locations where the flow is mainly undisturbed. Typically, the Wflow model is calibrated on stations which are located upstream of (large) infrastructural changes in the river.

The data of relevant locations were requested from CWC. Permission to use classified data was obtained as well as a waiver for purchase costs. Although data was requested for the whole basin, including Yamuna, Chambal, Damodar etc., only the data for the Ganga proper was actually delivered (Figure 4-5).

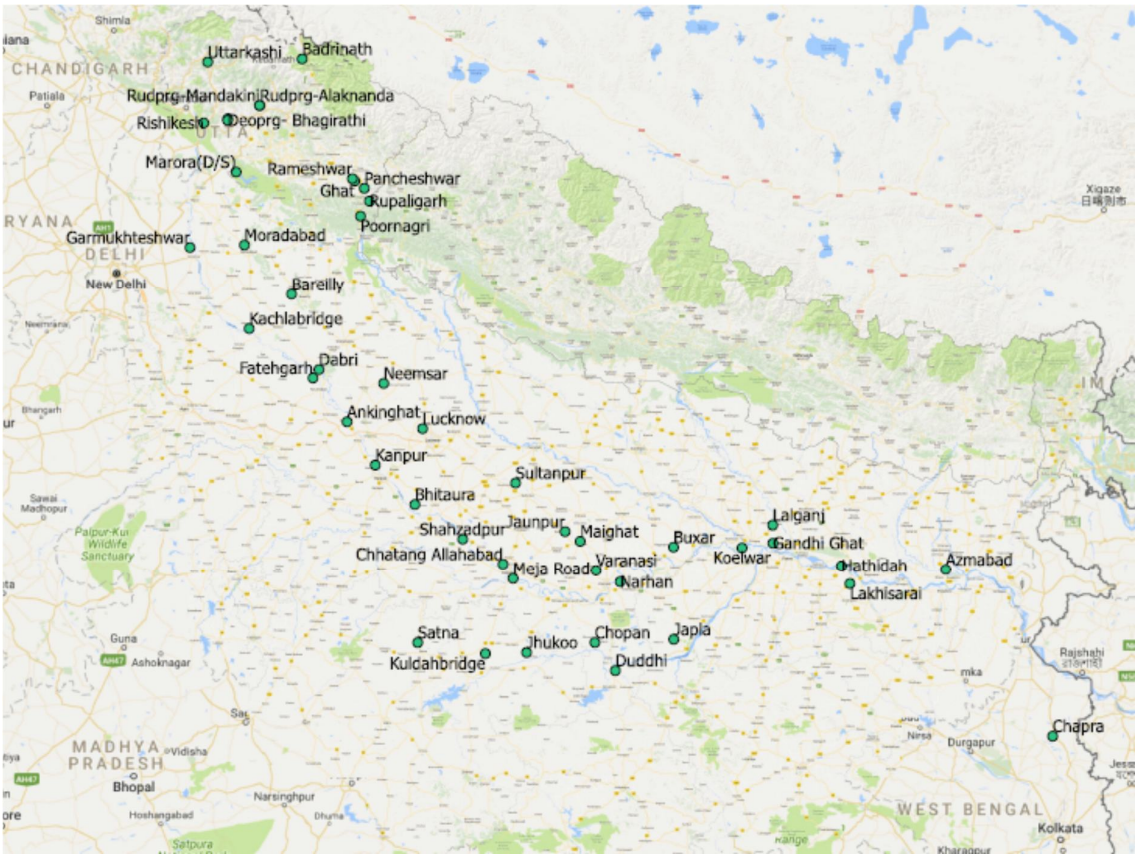

Figure 4-5: CWC monitoring locations for which data was received.

Efforts are still made to obtain the data for the main tributaries as well.

For the calibration of the water quality modeling the following type of data is being collected:

1. Pollution load measurements from Central and State Pollution boards
2. In stream water quality data for calibration and validation of the water quality model. Specific data required for this are:
   a. CWC stations measuring water quality ('Q')
   b. CPCB stations in the Ganga and Yamuna
3. Groundwater quality maps for EC, TDS, Nitrate, Arsenic, Boron and Fluoride from CGWB and states.

Water Quality data from CWC, CGWB, CPCB, and SPCB have been obtained by the project.

4.4 Data detailing the infrastructure and other human interventions

Data on infrastructure, demands and return flow, leakage, recharge and treatment as detailed in the inception report and previous progress report has been collected.
CWC reports on the Ganga basin provided the basic data on river infrastructures. The WRIS site provided additional information on dimensions of structures, reservoirs and canals, although not for all canals all data is available. Data on actual diversion flows is the most notable missing information.

States were most helpful in identifying the agricultural areas at an aggregated level. For example in UP the areas under the responsibility of one Chief Engineer were used as the relevant level. Data for cropping pattern and population were taken from the district level data sets.

For the water quality modeling data to support the Emission Load Estimation procedure was obtained from Pollution boards supplemented with publically available data (e.g. https://data.gov.in and www.censusindia.gov.in). Data on structures is partly already available to the project from reports, websites and earlier projects. Where needed additional information was collected as part of the collaborative modeling workshops in the states and with central organizations.

4.5 Status of data availability

It was known from the start of the project that data collection for such a huge area and for so many different modelling aspects would be a major challenge. The present status of data availability can be considered satisfactory, although it would be beneficial if more data would become available.

The available data is good enough to develop the models and achieve a reasonable to good calibration and validation result.

The most needed missing data are the water level and flow data for the tributaries like Yamuna, Chambal, Damodar etc., to improve the calibration, and data on actual diversion flows at barrages (model diverts water on demand, but actual flows may be more than demands, especially in the monsoon season when actual demand are low). Data on Industry locations and industry types and pollution loads is also scarce.

As it is expected that states and central organizations will be motivated to improve the models once they own them, the transfer of models in the strategy development phase of the project is also aimed at improving the data availability and creating a sense of ownership long before the end of the project.

5 Model development

5.1 General

During the conceptualization phase first versions of the Ground water model, W-flow, SPHY and Ribasim model were prepared, partly to introduce the modeling concept to the team and key interested parties at the central level, but partly as a rough version that can function as a basis for further elaboration in the Collaborative modeling phase.

In the present phase, supported by the inputs of the stakeholders during the collaborative modelling workshops, the actual models were developed. The detailed description of the model development approach is described in the project report "Analytical Work and Technical Assistance to support Strategic Basin Planning for Ganga River Basin in India. Conceptualization of River Basin Model, Surface water Ground water Interaction Analysis, and Environmental Flow Assessment." Published in December 2016. A separate report is prepared on the storage of model input and output in the GangaWIS (Water Information System) and the presentation of results on a dashboard: "Information System Design. GangaWIS. (Draft version December 2016, Final version May 2017). Below a summary is provided.

5.2 Components of the River Basin Model and their interaction

The River Basin Model consists of several components that interact with each other (Figure 5-1). The model deals with:

- The hydrology ;
- The groundwater model;
- The water resources;
- The water quality;

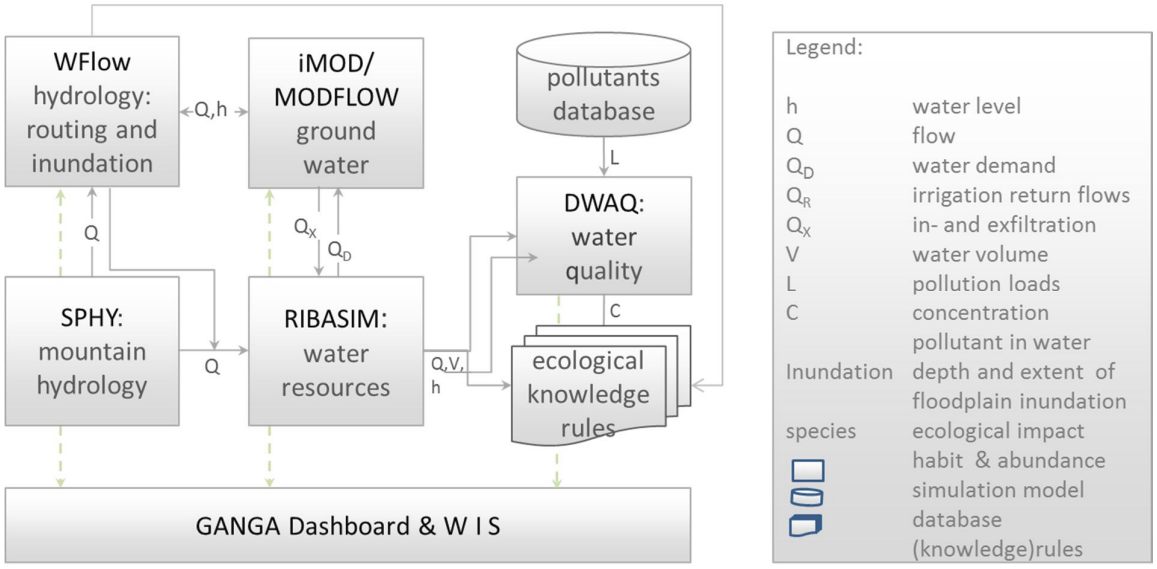

Figure 5-1 Components of the River Basin Model and their interaction

The description of the hydrology and the rainfall-runoff process has been divided over two different models: SPHY and WFlow. They are both fully distributed models working on a grid of square cells. SPHY is used to describe the hydrological process in the mountainous areas in the

Himalaya. This model has been selected, because it is specifically designed for glacier and snow hydrology and because it has been previously applied successfully for the Himalayas.

The rainfall-runoff processes for the non-mountainous part of the Ganga Basin are described by the WFlow model. This is a general purpose hydrological model that also allows calculation of water levels and contains a simplified module to describe flooding in the flood plains of the river. The river discharges calculated by the SPHY model for the Himalayas are used as upstream boundaries for the WFlow model. The information on discharges and water levels calculated by WFlow are used by the groundwater model to describe the interaction between surface and groundwater. This information can be used again as input for a next run of WFlow. In this way an iteration process is created to ensure consistent results from both models.

The water resources model RIBASIM describes the management and use of water. Its hydrological input is derived from the river discharges calculated by WFlow. RIBASIM uses a schematization of links and nodes to describe the flow of water in the rivers, the storage in reservoirs, the diversion into canals and the use and return flow by different functions. Water can be used from rivers and canals or from groundwater. Conjunctive use of surface and groundwater is also possible. Furthermore, return flows can be divided over rivers, canals and groundwater. This an important aspect for the description of the water system in the plains of the Ganga Basin, where extensive leakage from irrigation canals, feeds the groundwater aquifers, that are themselves used for irrigation water supply. Therefore, the RIBASIM model is also linked to the groundwater model by prescribing extraction and infiltration rates.

Water quality can be assessed from the results of the RIBASIM model by tracing the origin of water to different sources of pollution. This allows for a risk assessment of water quality problems. For the most important pollutants for which enough data become available, the RIBASIM results will be combined with a pollutant load estimation to model the water quality with DWAQ.

The impact on the ecology and ecosystem services of the results of the models presented above with respect to discharges, water levels and water quality will be evaluated using knowledge rules. These rules are site specific and will be developed during the project together with the stakeholders and experts.

All model input and all relevant output will be stored in the GangaWIS. The exchange of information between the components of the River Basin Model will also take place through the GangaWIS. The management of different versions of model input and output, to represent different scenarios and strategies, will be included in the GangaWIS. Furthermore, the model results stored in the GangaWIS will provide the input for the presentation of results in the dashboard.

Most of the components of the River Basin Model are open source. This applies to SPHY, WFlow, iMOD, MODFLOW and DWAQ. This means that both the source code and the executable form of the software is publicly available on internet to all interested parties and can be downloaded free of charge. The RIBASIM software is licensed software under transition to become open source. Deltares as the owner of RIBASIM has agreed to make the software available in an executable form free of charge for application with India during and after execution of this project. The GangaWIS uses Delft-FEWS software which is free, and the evaluator for the knowledge rules are built entirely with open source components.

The project area is defined in the terms of reference to “encompass the entire Ganga River basin in India including all tributaries upstream of Farakka Barrage on the Ganga River”. Furthermore it is stated that “the modeling will need to ensure robust assessment of the flows that enter the Ganga via the Nepalese tributaries”. Therefore, the combined application of the hydrological

models SPHY and WFlow will cover the entire Ganga Basin upstream of Farakka Barrage including the parts of the upstream basin located in Nepal and China. This allows for the requested robust assessment of the upstream flows. The application of the other models will be mostly limited to the Indian part of the Ganga Basin upstream of Farakka Barrage, with the possible exception of the major reservoirs on the Nepalese tributaries that might have to be included in RIBASIM to describe consistently their operation. At special request by the State of West Bengal the Hoogly and Damodar river systems have been added to the model area.

The initial set-up of the models SPHY and WFlow (and also iMOD/MODFLOW) is on a cell size of 1x1km. During project execution, the grid size might be enlarged to reduce computation times, but only if this does not compromise unacceptably the accuracy of the results. The models RIBASIM and DWAQ work on a schematization of the river basin as links and nodes. This schematization can be further fine-tuned after the collaborative modeling when the stakeholders will start to use the models themselves.

The models are applied for different periods. For calibration of SPHY, WFlow and RIBASIM (within India) it is foreseen that this period will cover 25 years from 1985 to 2009. For the water quality the period foreseen is 2001 to 2015. The time step of the calculations in SPHY and WFlow will be one day and for IMOD, RIBASIM and DWAQ one month. The reason for this is that the main hydrological processes take place within periods of days and require calibration on this temporal resolution. The main processes regarding water resources and water quality, on the other hand, can be dealt with on the larger time scale of a month.

The aim of the River Basin Model is to support strategic planning on a basin level. Therefore, it is very important to keep the temporal and spatial schematization relatively simple and not to try to include a high level of local detail, because this does not support strategic level planning and might even present results with a false sense of accuracy. This requires trade-offs to be made during the collaborative modeling process between the amount of detail to be included in the models and the strategic purpose for which they will be applied.

5.3 Status of the River Basin Model and GangaWIS

By the end of December 2016 the SPHY, WFlow, IMOD and Ribasim models were filled with all available data and were partly calibrated. The DWaq model was in its final development.

All models were connected and passed a first calibration and validation by the time of the Basin wide workshop in March 2017.

Continued attention will be given to updates as feedback from users comes in and when the missing observations from the tributaries become available.

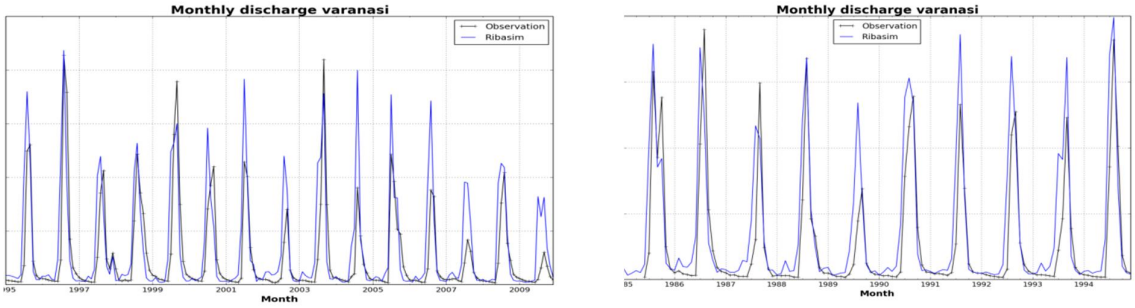

Figure 5-2: Calibration (left) for 1995-2009 and validation (right) for 1985-1995 of combined SPHY-WFlow-Ribasim models at Varanasi.

The models are ready for use by stakeholders in order to familiarize and provide feedback, and the 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 data (temporal and spatial) hydrogeology data, WQ, hydraulic infrastructure, ecology, DEM/land use etc. For this a local option is available to all users as well as a web-based version served by a server computer.
- Import new input data and run one model or more models in sequence (Figure 5.3). 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. For this a local option is available to all users as well as a web-based version served by a server computer.
- Present a high level summary of model results on Stakeholder defined indicators (varying per state) on a dashboard. For this a local option is available to all users as well as a web-based version served by a server computer.

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 on the computers they use. 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 is still topic of discussions with the central organizations of MoWR,RD&GR and the states.

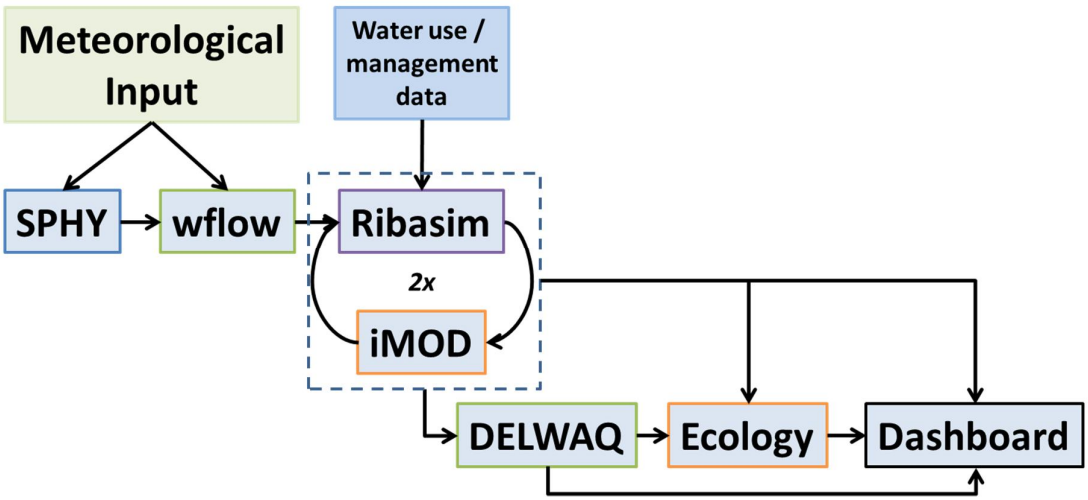

Figure 5.3: Workflow of models

6 Summary and Forward look

6.1 Progress

The project is well under way and progress since July is good, although about two months behind schedule.

Participation of stakeholders is active and engaged. The collaborative modelling workshops proved to an excellent capacity building exercise for the stakeholders while providing valuable inputs for the modellers.

Data collection, although not perfect, resulted in enough data to make the present version of models which is good enough to entice interest of the stakeholders to complete on their own, but also the models can be used to explore interventions, strategies, and scenarios within a couple of months..

Model development succeeded well using available data and models are almost ready to form the basis for strategy and scenario evaluation in the next phase.

Below the progress is summarized per project task.

6.1.1 Task 1 – River Basin Model Development

As described in chapter 5 the W-flow, SPHY IMOD, and Ribasim model were prepared and partly calibrated. The DWAQ model is well underway and is expected to be ready by March 2017.

The data collection described in chapter 4 made good progress. Good links with CWC, CGWB and IMD were useful for detailed data collection and also classified data was obtained (although limited to the Ganga River only).

The modelling system will be ready for the scenario and strategy phase by March 2017.

6.1.2 Task 2 – Surface –Ground water Interaction Analysis

As described in chapter 5 the Ground water model was prepared.

The data collection described in chapter 4 collecting CGWB data as well as reports and information from open sources such as websites and global databases resulted in a valuable amount of data and insights.

The data combined with model runs are now being evaluated and assessed.

6.1.3 Task 3 – Environmental Flow Assessments

The data collection described in chapter 4 produced the information on which the zonation of the main rivers and tributaries was developed, identifying river reaches with distinct characteristics and requirements. The zonation of the Ganga River was concluded and forms the basis for the other tributaries..

6.1.4 Task 4 – Scenario Modeling

Although the actual scenario modeling is planned later in the project, in this phase data collection continued on population and development scenarios as well as on planned and projected interventions in the system (for example interlinking of rivers).

In the stakeholder engagement meetings much attention was given to identify the objectives of the different states and the indicators that were relevant to them is assessing strategies or scenarios. The identified indicators were processed to be included in the dashboard.

6.1.5 Task 5 – Consultation and Engagement

The basin wide workshop held in Lucknow at the end of the conceptualization phase was actively attended by all states and all relevant Central Organizations indicating that the initial engagement activities were successful.

The engagement workshops and meetings and the collaborative modeling workshop contributed to a successful modeling and planning process in several ways:

- Engagement and ownership creation
- Creation of basin understanding
- Focus on priority issues
- Collection of relevant data- enhance understanding of the water system
- Identification of relevant indicators for model dashboard

6.1.6 Task 6 – Information System and Documentation

Based on the information collected in the conceptualization and collaborative modelling phase, both on the model development as well as stakeholder interests a detailed design of the Ganga Water Information System and Dashboard was made and discussed at the Basin wide workshop in Lucknow. This resulted in a report.

The design has been implemented. Both the GangaWIS and Dashboard are functional.

6.2 Issues

Even though the progress in the last half year was good and in agreement with plan (except for some delay). The extension as mentioned in the Inception report and previous progress report is still required even when the project will face no additional delays.

The interest of the Stakeholders sometimes raises hopes or expectations beyond the scope of the project. The project team as well as the counterpart organization needs to continually monitor this and manage unrealistic expectations. Some raised points in this respect are:

- As mentioned before Modeling of floods and sediments is a need expressed by several states, especially Bihar and West Bengal. The modeling of floods and sediments is beyond the scope of the present project as it would require a different type of model (dynamic models), but also much more detailed digital elevation maps that are not available.
- Detail of modelling remains a topic of discussion. It is a persistent perception that a large model can only be made by combining smaller detailed models. The concept of strategic models or macro models is new to many.
- As many stakeholder organizations are mostly involved in short term problem solving and planning they would like to use the present modelling system for that purpose. Quite some time is consumed in explaining the difference between short term operational planning and strategic planning. This is part of the capacity building function of stakeholder workshops.

In order to be really able not only to use the models but also to adapt, improve and create new strategies and scenarios it is required that staff from central organizations and states participate in the on-going modeling work (On the job training). So far it has proven extremely difficult to

make this happen. Although the interest and willingness is there the organization cannot make one or more persons fully available to do this. Without this on the job training the value and sustainability of the project results are significantly reduced. The latest developments at the moment of writing of the report show a positive development that is reflected in the training plan mentioned later in this report.

Lack of data availability for rivers and tributaries other than the Ganga hampers convincing states such as Delhi, Haryana, and Rajasthan regarding calibration of the rivers that are relevant to them. It is also a symptom of the general idea that planning is basically only required for the Ganga proper and not for the basin as a whole.

6.3 Activities of the coming half year

6.3.1 Strategy and scenario development sessions

After completion (although model are never complete) of the model development in the collaborative modelling phase, a basin wide workshop will inform all involved about the progress made and will initiate the phase where interventions will be evaluated and combined into realistic strategies that can be evaluated for the various external scenarios (climate change , population developments tec.). This workshop is planned for March 2017.

Another series of state workshops will be organized in the period March-June 2017 with the following objectives (expected results):

- Participants' understanding of the progress on modelling, GangaWIS and the dashboard,
- Participants' useful feedback on the process and support for the last phase of the project.
- Participants' understanding of how the models and dashboard can be used for strategy and scenario simulation and evaluation.
- Participants' input for initial scenarios and strategies to be assessed.
- Participants' input on how replicable/useful/practical our approach and methods for stakeholder engagement would be when the developed tool will be used for the real planning of the Ganga River Basin management after the project is finished.

In the wake of these workshops, the project team will develop realistic strategies using information from the states and central organizations. The detailed planning for these workshops is as shown in Table 6-1

Table 6-1: Schedule of planned state workshops on strategy and scenario development

DATE	STATE	PLACE
06 & 07 APRIL 2017	UTTAR PRADESH	LUCKNOW
17 & 18 APRIL 2017	WEST BENGAL	KOLKATA
20 & 21 APRIL 2017	JHARKHAND	RANCHI
24 & 25 APRIL 2017	UTTARAKHAND	DEHRADUN
02 & 03 MAY 2017	DELHI	DELHI
08 & 09 MAY 2017	BIHAR	PATNA
29 & 30 MAY 2017	HARYANA	CHANDIGARH
31 MAY & 01 JUNE 2017	HIMACHAL PRADESH	SHIMLA
8-9 JUNE 2017	MADHYA PRADESH	BHOPAL
12-13 JUNE 2017	CHHATTISGARH	RAIPUR
22-23 JUNE 2017	RAJASTHAN	JAIPUR

6.3.2 Model development

Model development focuses on finalization of the DWaq model and calibration as well as the development of e-flow knowledge rules.

The development of knowledge rules for the ecosystem services and/or identified representative key/icon species is based on brainstorm sessions with Indian experts.
The first session is planned for 17 May 2017 and based on the lessons learned from the first session further sessions are planned for mid-June 2017.

6.3.3 Training and capacity building

The capacity building in the coming period covers the main content of the project:

- Strategic Planning, strategy and scenario development
- Environmental Flows
- Surface water – Ground water interaction
- Modelling and model operation and maintenance
- Stakeholder involvement

The three main identified target groups for capacity building are:

A. Core group of officers from CWC, CGWB, NMCG and NIH in on-the-job-training. This group is expected to:
   a) Understand the model setup, data used (detail) and calibration approach
   b) Understand the way models are connected and be able to adapt if needed
   c) Be able to modify the model schematization as well as the input data to the models (recalibrate and run new strategies and/or scenarios)
   d) Analyse model results in the database and on the Dashboard
   e) Instruct new users to install and use the Ganga WIS and included models
   f) (if time allows: create a separate application of SHPY, WFlow, Ribasim, DWaq for a different basin, not interconnected)

B. Wider group of officers from CWC, CGWB, NMCG and NIH. This group is expected to:
   a) Understand strategic planning and modelling (and the difference from operational or detailed planning and modelling)
   b) Understand the model setup, data used (general) and calibration approach
   c) Understand the conceptual approach to environmental flows and what is possible in that respect with the Ganga WIS.
   d) Understand the Surface water – Groundwater interaction
   e) Generate realistic strategies and scenarios for Basin Management of the Ganga

C. Officers from the 11 states in the Ganga basin. This group is expected to:
   a) Understand strategic planning and modelling (and the difference from operational or detailed planning and modelling)
   f) Be able to modify the input data to the models (run new strategies and/or scenarios for the state/basin)
   g) Understand the conceptual approach to environmental flows and what is possible in that respect with the Ganga WIS.
   h) Understand the Surface water – Groundwater interaction

i) Generate realistic strategies and scenarios for Basin Management of the Ganga

The methods used for capacity building in the project are:

- Meetings and discussions
- Workshops
- Classroom training
- On-the-job training

These are supported by reports, PowerPoint presentations and manuals/user guides.

1- - Strategic Planning, strategy and scenario development

From December 2015 onwards a series workshops have been organized both at the basin level as well as on the state level to introduce strategic basin planning and discuss the cause and effect of issues and how strategies could be designed to address these under various scenarios of climate change or population development. The workshops are aimed at representatives from both central and state departments and organizations. In the coming period state workshops are planned as presented in Table 6-1

One final basin workshop is planned for December 2017

Table 6-2: Scheme for on the job training (Group A)

Week	Period	On-the-job training theme	Int.exp
1	4-5 May	General introduction	Bons
2	8-12 May	SHPY-Wflow	
3	15-19 May	E-flows/Ribasim	Magdaleno Mas
4	22-26 May	Ribasim	
5	29 May - 2 June	Water Quality	Boderie
6	5-9 June	Stakeholder consultation	Bons
7	12-16 June	E-flows	Langenberg
8	19-23 June	SHPY-Wflow	Hegnauer
9	26-30 June	(FEWS)WIS+Dashboard	
10	3-7 July	Water Quality/Imod	Boderie
11	10-14 July	Imod-Modflow	Roelofsen
12	17-21 July	strategies / own models	Bons
13	24-28 July	strategies / own models	Bons

Each week will be a mix of instruction, group work and individual work

2 Environmental Flows

In the above mentioned workshops a basic introduction is given to environmental flows. Group A will receive training and work with the approach in the schedule as given in Table 6-2, while Group B will receive a two day training as indicated on Table 6-3. For Group C this is covered in a general way in the two day State modelling course (Table 6-3). Additionally several of the officers from group A and B were/will be present at dedicated meetings such as the meetings on 30 March (general e-flow approach) and 19 April (zonation discussion). Such meetings will be scheduled as needed in the course of the project. The next meeting on ecosystem response with input from experts is scheduled for 17 May.

3 Surface water – Ground water interaction

In the above mentioned workshops a basic introduction is given to surface water – groundwater interaction. Group A will receive training and work with the approach in the schedule as given in Table 6-2, while Group B will receive a two day training as indicated on Table 6-3. For Group C this is covered in a general way in the two day State modelling course (Table 6-3).

Table 6-3: Scheme for wider group (B) and State training (C)

Central Agencies	Period of Training
Training SW-GW/iMod	February 2017 and March 2016
Training workflow	3 and 5 April 2017
Training Ribasim	27-28 April
Training Water Quality	2 days in week of 29 May-2 June
Training e-flows (technical in model)	2 days in week of 12-16 June
Training Rainfall-runoff (Wflow and SHPY)	2 days in week of 19-23 June
Training SW-GW/iMod	2 days in period of 10-12 July
Refresh course Ganga WIS	Middle of Sept TBC
Refresh course Ganga WIS	Beginning of Dec TBC
State trainings	**Period of Training**
1st 4 states (UP, WB, Jharkhand, UK)	27-28 April
2nd 4 states (Delhi, Bihar, Haryana, HP)	5-6 June
last 3 states (Rajastan, Cchattisghar, MP)	29-30 June

4 Modelling and model operation and maintenance

In the above mentioned workshops an introduction is given to the models and their use. Group B will receive training and work with the models in detail in the schedule as given in Table 6-2, while Group B will receive a two day training on each model part as indicated on Table 6-3. For Group C this is covered in a general (only model input no schematization changes) way in the two day State modelling course (Table 6-3).

5 Stakeholder involvement

Participants in Groups A, B, and C are exposed to the stakeholder involvement process and in the third round of state workshops special attention is given to using similar processes in the actual Planning cycle and strategy formulation.

6.4 Project work plan

Based on the progress of the project so far 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 6-4.

Table 6-4: 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	May-17	4
Report describing information system design	Nov-16	May-17	
Progress report 2 (up till Dec 2016)	May-17	May-17	
Draft Report on (i) surface groundwater analysis, (ii) Environmental Flow Assessment and (iii) Scenario Modelling	Aug-17		5
Progress report 3 (up till June 2017)	Aug-17		
Draft Report on (i) River Basin Modelling (all aspects) and (ii) documentation of information systems	Aug-17		
Final Report on (i) surface groundwater analysis, (ii) Environmental Flow Assessment and (iii) Scenario Modelling		Oct-17	6
Final Report on (i) River Basin Modelling (all aspects) and (ii) documentation of information systems		Oct-17	
Draft Project Management Report (incl. Stakeholder engagement processes and exec summary of Technical reports)	Oct-17		
Progress report 4 (up till Sept 2017)	Oct 17	Oct-17	
Delivery of all model software developed and associated data files		Dec-17	7
Final Project Management Report (incl. Stakeholder engagement processes and exec summary of Technical reports)		Dec-17	

ANNEX A: Attendance list basin wide workshop 18 July

S.No.	Name & Designation	Address
1	Mr. Anup	SPMG, Bihar
2	Mr. Arbind Kumar Jha, Asst. Director	Urban Development, Bihar, Patna
3	Mr. Ishwar Chandra Thakur, Professor	WALMI, Patna, WRD, Bihar
4	Dr. Bibhas Chandra Barman	River Research Institution I&W Dte, Govt. of Bihar
5	Mr. Partha Paul, Dy. Director	Central Design Office Irrigation, Govt. of Bihar
6	Mr. D.K. Manavalan, IAS (Rtd.)	AFPRO, Action for Food Production
7	Mr. R.K. Jaiswal, RAS	Commissioner, Nagar Nigam, Bikaner (Rajasthan)
8	Mr. Ravindra Kumar, Advisor	WWF - India
9	Mr. S.K. Dhiwan, Superintending Engineer	IPH Circle, Himachal Pradesh.
10	Mr. Anoop Kumr Srivastava	Basin Planning Expert, SWARA, U.P.
11	Mr. R.K. Jain, Chief Engineer	BPMO, CWC, Sewa Bhawan, New Delhi
12	Dr. R.N. Sankhua, Director	Basin Planning, CWC, New Delhi
13	Ms. Mailina Burkard	G-12, Safdarjung Enclave, New Delhi
14	Mr. Birender Singh, Chief Engineer	3, Shyamnath Marg, Civil Lines, New Delhi
15	Mr. A.N. Gupta	16, Canal Colony, Lucknow
16	Ms Halla Qaddumi	World Bank, Delhi
17	Dr. M.K. Goel, Sci. "G"	N.I.H., Roorkee
18	Dr. D K. Chadha	AECOM
19	Mr. Anmol Shar,	CGWB, NR, Lucknow
20	Ms. Anjani Acharya	CCF (Plan), U.P. Forest
21	Mr. S.K. Sibal, Chief Engineer	CWC
22	Mr. Y.R. Mishra	Special Security, Irrigation & Water Resources, U.P. Govt.
23	Mr. P.P. Pandey, Jt. Secretary	Irrigation & Water Resources, U.P. Govt.
24	Mr. C.K. Verma	Irrigation Department, U.P. Govt.
25	Er. John Anil Malto, Sr. Engineer	Waterways Circle, Jharkhand
26	Mr. Tapan Talukdar, Sci. "D"	CGWB, ER, Kolkata
27	Mr. Sharat Goel, Chief Engineer	ISO, U.P. Irrigation, Lucknow
28	Dr. Indranil Roy, Sci. "C"	CGWB, MER, Patna
29	Mr. Upendra Srivastava, Sci. "D"	CGWB, Faridabad
30	Mr. S.K. Sinha, Sci. "D"	CGWB, Faridabad
31	Mr.Nitin Bassi	IEWP Technical Assistance
32	Mr. V.K. Shrivastava, Chief Engineer	WRD, Bilaspur, Chhattisgarh
33	Mr. U.S. Ram, Executive Engineer	Water Resources, Chhattisgarh
34	Mr. S.P. Rai, Sub Divisional Officer	WRD Chhattisgarh
35	Mr. J.P. Dwivedi, Chief Engineer	Water Resources, Irrigation Department, U.P.
36	Mr. K.C. Naik	CGWB, Faridabad

S.No.	Name & Designation	Address
37	Dr. Nanda Kmar	CGWB, Faridabad
38	Mr. P.K. Sinha, Chief Engineer	U.P. Jal Nigam, Lucknow
39	Mr. Rakesh Kaushal, Chief Engineer & D.G.	Water Resources Deptt., Rajasthan
40	Mr. Arun KumarSidana	S.E. & T.A to C.E. (NCP) Rajasthan
41	Mr. Y.B. Kaushik	Central Ground Water Board, Aliganj, Lucknow
42	Mr. Anand Kumar Anand	Irrigation & Water Resources Departmeent, U.P. Lucknow
43	Mr. Anupam Prasad	CWC, Varanasi
44	Mr. Arun Dobhal	Sr. Water & Sanitation Specialist, W.B.
45	Mr. Walcecl Ahmat	World Bank
46	Mr. P.K. Mishra	Central Pollution Control Board, Zonal Office (N) Lucknow
47	Dr. D.K. Soni	Central Pollution Control Board, Zonal Office (N) Lucknow
48	Dr. Poonam Pandey	Central Pollution Control Board, Zonal Office (N) Lucknow
49	Mr. Vinod K. Tripathi, Sr. Engineer (I.S.O.)	UPWRD
50	Mr. Raj. Singh	World Bank
51	Mr. Nitin Verma	Sustain Asia Consultant 2030 WRG
52	Mr. Shailendra Kr. Singh, Add. Mission Director	S.G.R.C.A., U.P.
53	Mr. K.B. Shrivastav, Director	India Meteorological Deptt., Lucknow
54	Mr. T.U. Khan, Executive Engineer	UPPCB, Lucknow
55	Mr. Amit Satya	Tahal Consulting Engineers Ltd.
56	Mr. Bouke Ottow	Deltares,
57	Mr. L.K. Sharma, Chief Engineer	Uttrakhand Irrigation IRI Roorkee
58	Mr. Raveendra Kumar	I&FC, Govt. of Delhi
59	Mr. Jitendra Kumar	I&FC, Govt. of Delhi
60	Mr. Rajesh Balasubraman	World Bank
61	Mr. Satya	World Bank
62	Mr. Jun....	World Bank
63	Ms. Mumtaz Ahmad	UPSPMG, Lucknow
64	Mr. Prashant Rai, Sci. "D"	CGWB, NR, Lucknow
65	Mr. P.K. Tripathi, Sci. "D"	CGWB/NR, Lucknow