A modelling approach to assess the impact of climate change & anthropogenic activity on the water resources of the Narmada river basin

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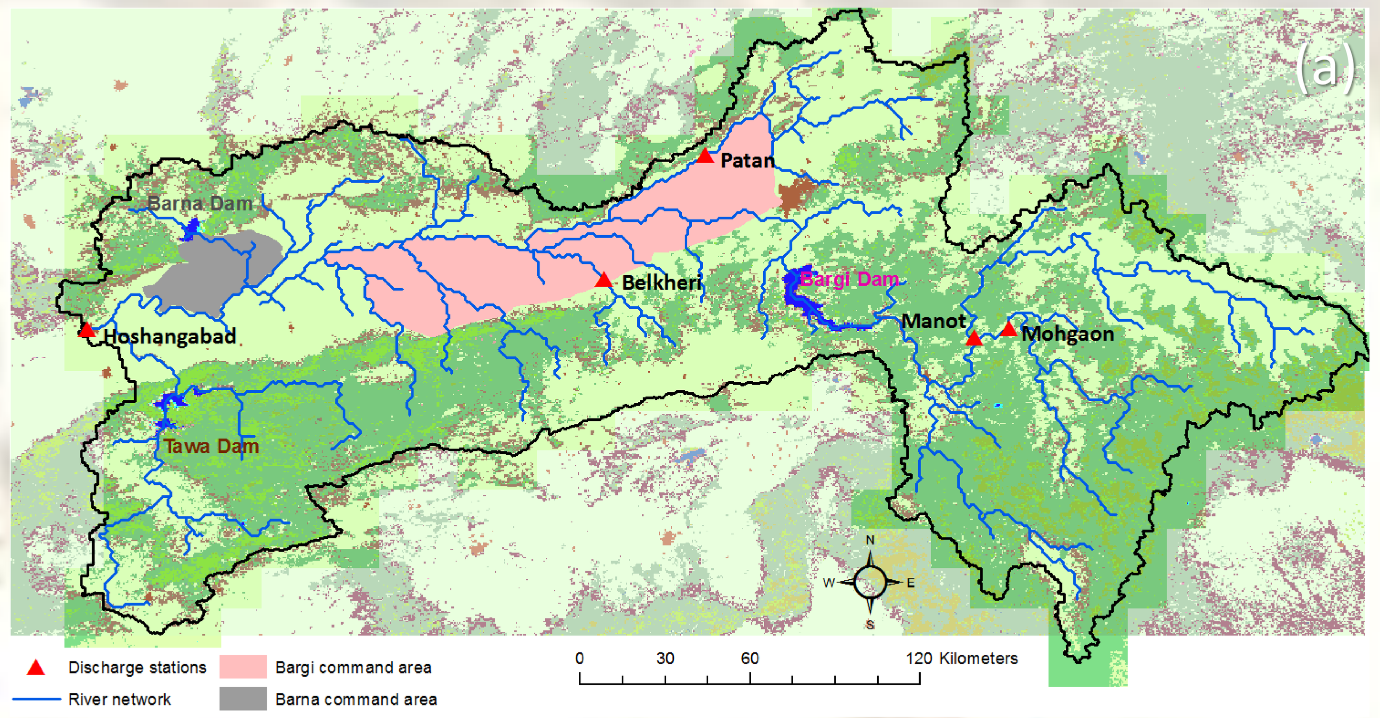
1. The Narmada basin, India

- The Narmada river basin is a **highly regulated** & **artificially influenced** catchment in Peninsular India, covering 98 796 km². The basin includes the states of Madhya Pradesh, Maharashtra & Gujarat, supporting a population of **over 16 million people**.
- **Agriculture** is the dominant land use within the basin, accounting for **over 56%** of the basin area. There are **over 3000 interventions**, with up to another **30 dams** planned for construction over the next half-century.
- The study of the Narmada basin is part of an ongoing collaboration between **CEH (UK) & NIH (India)** with the goal of **increasing water security** for those living within the basin & surrounding watersheds.

2. Research objectives

- The upper-Narmada was chosen for an initial analysis of water resources. This area of the basin contains **three major dams**, & **two irrigation command areas** (Fig. 2.1).



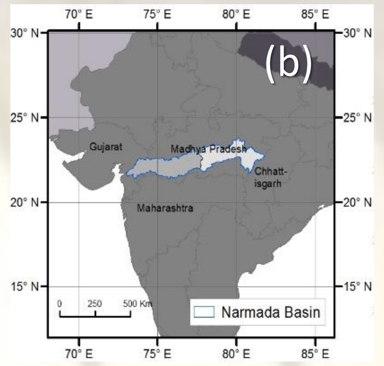


Figure 2.1: (a) Map of Upper-Narmada basin down to Hoshangabad displaying gauging station sites & command areas; (b) Narmada extent

The following objectives were identified for the study:

- Assess the impact of natural & anthropogenic change on the water resources of the upper-Narmada basin.
- Produce a range of plausible climate & socio-economic scenarios of basin futures.
- Deliver quantitative information about potential future states of the regions freshwater resources.
- Evaluate options for adaptation at the regional scale.

Figure 2.2: (a) View from top of Tawa Dam spillway; (b) Backwaters of the Tawa Dam, March 2018; (c) CEH & NIH research team

3. Methodology

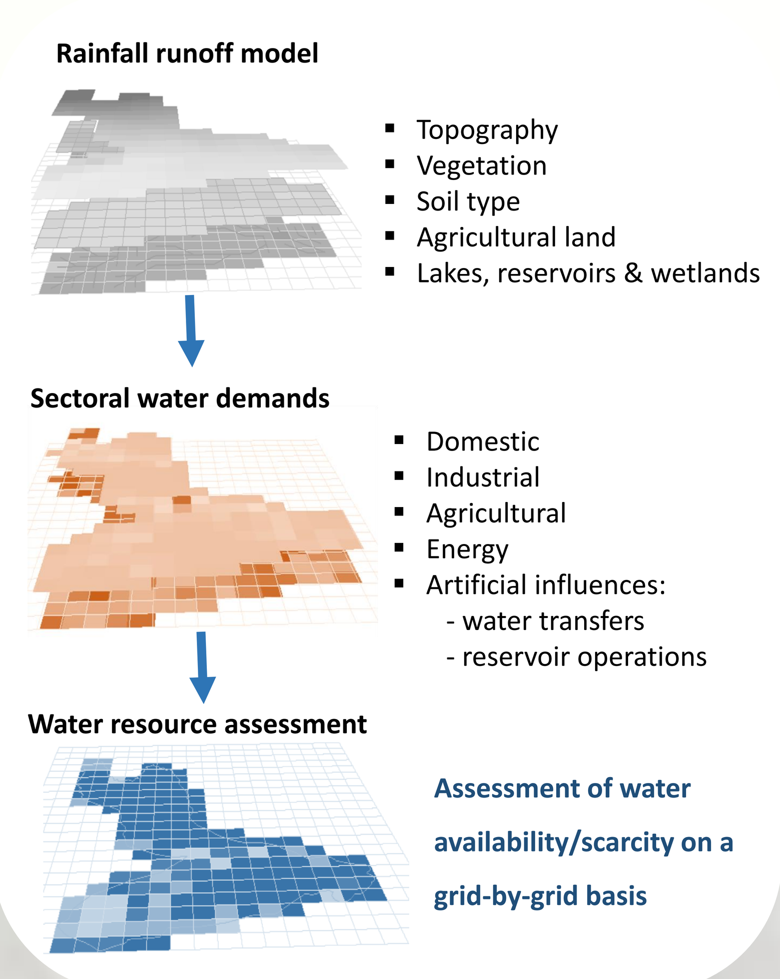


Figure 3.1: The GWAVA model structure

- The **Global Water AVailability Assessment tool (GWAVA)** is a gridded, semi-distributed hydrological model, incorporating a rainfall-runoff model structure with components of river infrastructure & sectoral demands.
- GWAVA was parameterised for the upper-Narmada using observed weather data, then forced with **CMIP5 climate** ensemble data for historical & future periods (1981-2010 & 2031-2060 resp.). Fig. 3.2 displays the % change in precipitation from the baseline for the CMIP5 ensemble.

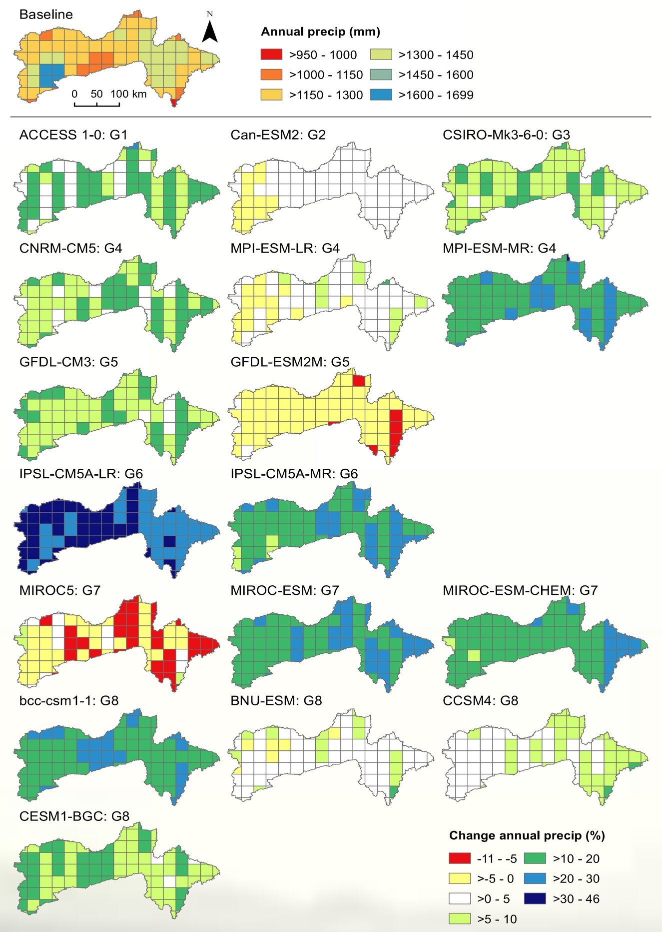


Figure 3.2: Modelled % change in future precipitation from CMIP5 ensemble

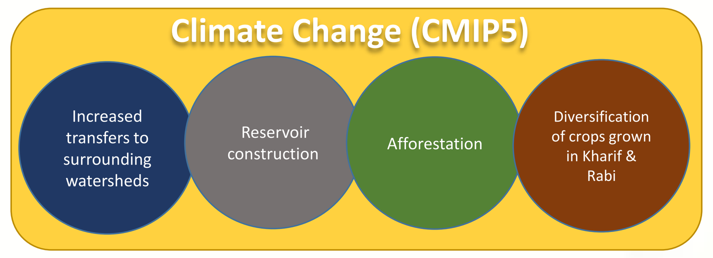


Figure 3.3: Elements used in design of scenarios, alongside CMIP5 climate data

- **Socio-economic scenarios** were designed with NIH & basin stakeholders, capturing future alterations in water use & management (Fig. 3.3).
- Key themes include **maximising water resources** across the basin & **changing trends** within sectors.

4. Research findings & dissemination

Model Calibration/Validation

- Model performance for calibration-validation periods produced Nash Sutcliffe metrics of 0.79 – 0.95 for all discharge stations (Fig. 4.1). Sequencing of the monsoon season is well represented throughout.

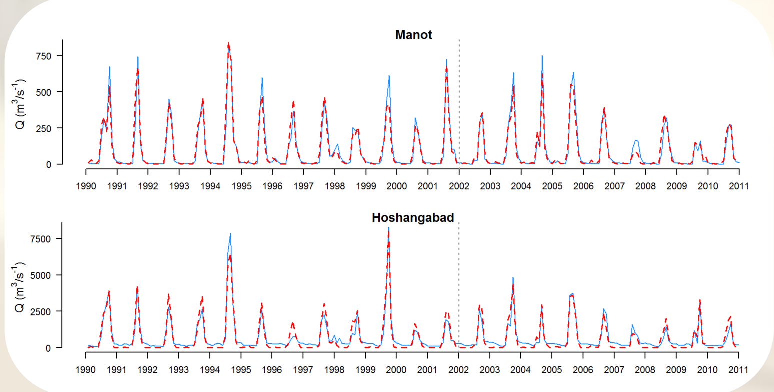


Figure 4.1: GWAVA model performance for calibration & validation at Manot & Hoshangabad. Blue=Baseline; Red=Simulated; Grey= cal-val divide

Future scenario flows

- General trends show an **increased magnitude in high flows** during monsoon seasons & **reduced flows in the dry season** throughout (Fig. 4.2).

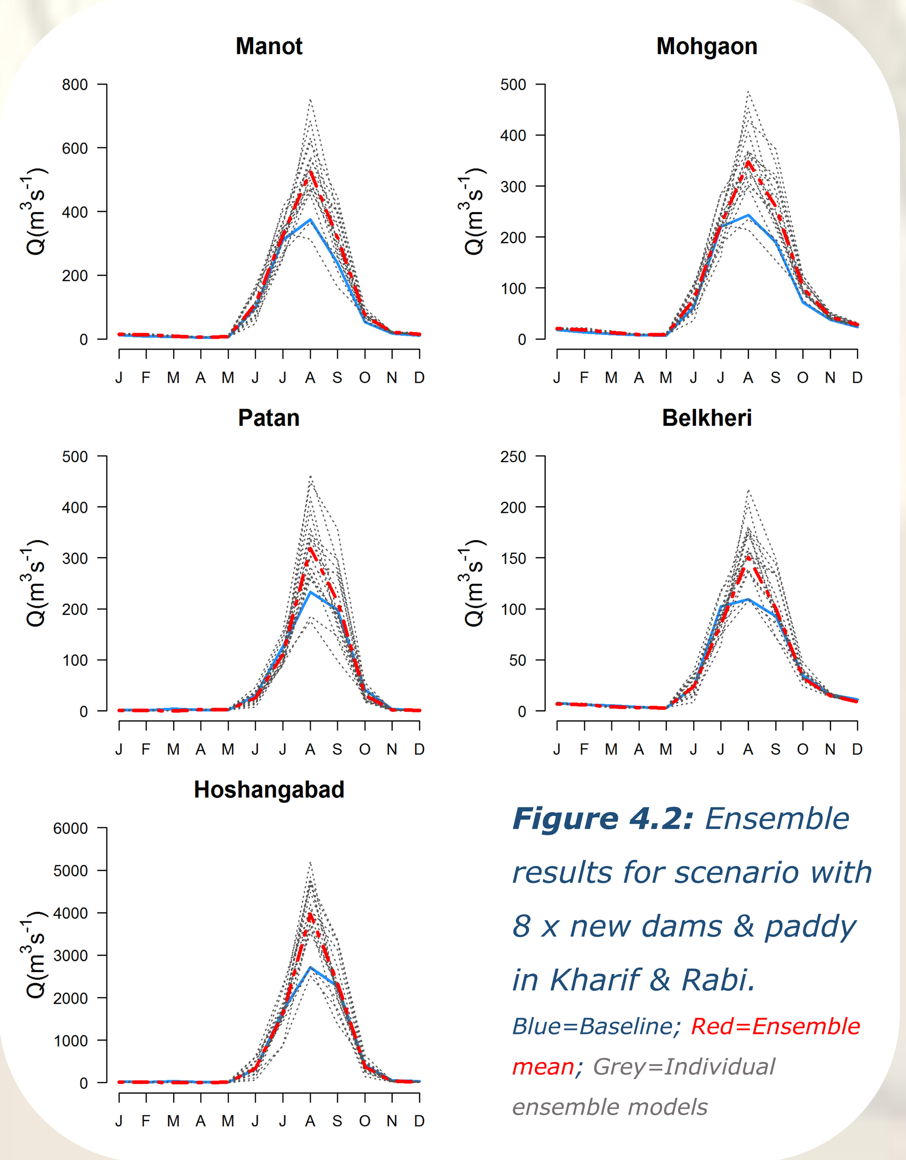


Figure 4.2: Ensemble results for scenario with 8 x new dams & paddy in Kharif & Rabi.
Blue=Baseline; Red=Ensemble mean; Grey=Individual ensemble models

- These changes in flow are the result of longer dry spells & more intense rainfall events, driven by climate & modelled reservoir operations to utilise maximum water yields.

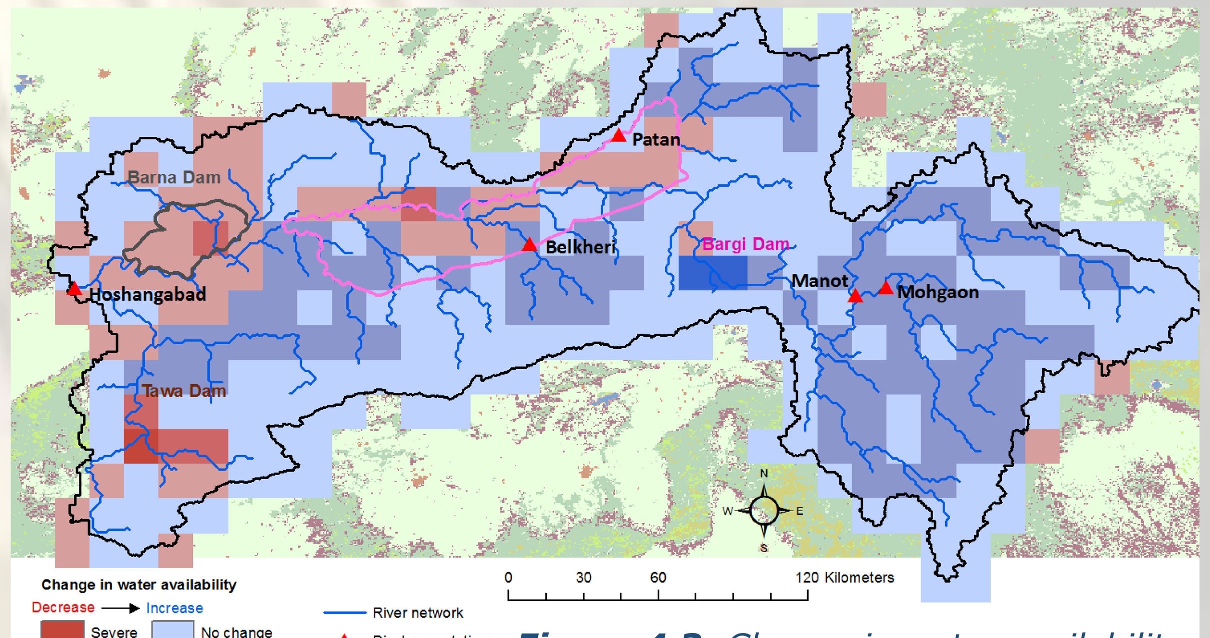


Figure 4.3: Change in water availability between baseline & future scenario

Water resource impact

- Changes in climate & anthropogenic activity are likely to result in **more water-scarce areas** (Fig. 4.3). A stakeholder workshop was held in Bhopal in March 2018, to discuss how people living in the basin would be affected, and how policy can be shaped to mitigate this.
- Modelling for the rest of the Narmada basin is underway, with refinement of scenarios & outputs based on stakeholder feedback.

Figure 4.4: Participants of the stakeholder workshop

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