Water resource management and climate change adaptation in Central India

June 2020
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मध्य भारत में जल संसाधन प्रबंधन और जलवायु पररवत्तन अनुकूलन

CITATION

The India-UK Water Centre (IUKWC) promotes cooperation and collaboration between the complementary priorities of NERC-MoES water security research.

Front Cover Photo: Lift irrigation site of Indira Sagar Dam (Emma Bennett, IUKWC)
All other images: Emma Bennett and Pankaj Kumar

This State of Science Brief was produced as an output from an India-UK Water Centre Grassroots Field Exposure Session and User Engagement Initiative held in Bhopal, India from 25th February to 2nd March, 2019.

विश्व सार संसाधन की यह स्थिति भारत-यूके जल केंद्र द्वारा 25 फरवरी से 2 मार्च, 2019 तक भोपाल, भारत में आयोजित अध्ययन सत्ता पर क्षेत्रीय अनावरण सत्त तथा उपयोगकता सहभागिता पहल का प्रस्तर पता था।

This figure shows a group of people in the field during the Grassroots Field Exposure Session.
1. Background

The India UK Water Centre (IUKWC) hosted a joint Grassroots Field Exposure Session (GFES) followed by a User Engagement Initiative (UEI) on “Water Resource Management and Supply in Central India” from 25th February to 2nd March 2019. The GFES took place in different locations throughout the State of Madhya Pradesh, India, while the UEI was held in the city of Bhopal.

The GFES and UEI, together, first aimed to understand the water resource situation and trends in the State of Madhya Pradesh and the impacts of the agricultural, domestic, industrial, and energy sectors on abstraction of surface and groundwater resources. Second, the challenges involved in the management of this resource were discussed with the aim to help design scientifically and socially sound strategies to better monitor and manage the water resources of the state. An underlying objective of these two events was to formulate research ideas for future joint India-UK collaborative projects on the basis of gaps in knowledge and end users’ requirements.

The GFES brought together a team of 24 scientists from across India and the UK and involved visits to three villages (Parwalia, Sehore and Pandhana) where three different projects are underway to improve the management of land and water resources through grassroots initiatives, including public private partnership with farmers. The group also visited
the Indira Sagar Project, a multi-functional dam that provides water to irrigate over 1200 km² of land. Scientists met with the managers on the ground and visited the power generation and irrigation sites.

The UEI consisted of a three-day workshop between scientists and end users, which enabled the communication of relevant joint India-UK scientific outputs to state-level stakeholders through presentations by Indian and UK scientists. In addition, presentations from selected stakeholders our understanding of how scientific outputs are used in water management and policy were also given, as well as highlighting the challenges that different sectors face with regard to water supply and management.

2. Summary of Key Issues

Central India demonstrates a complex water nexus, with high growth rates in the agricultural, industrial and energy sectors, as well as an increase in the domestic demand for water. Moreover, the region has experienced continuous warming and a decline in precipitation (though not significant) in recent decades, further influencing the regional hydrological balance. Hence, the impacts of climate change compounded by an increasing and urbanising human population have resulted in increasing pressures on the regional water resources.
The agricultural, industrial, and energy sectors, together with domestic users, require its demand for water to be met. Thus, the challenge for policy makers and governmental institutions is to meet this growing demand for water in a sustainable manner without adversely impacting the environment in the face of diminishing supplies due to climate change.

This Water Brief presents an overview of the water resource situation and trends in water supply in the State of Madhya Pradesh, Central India. Current water management practices are then presented followed by information on the need for – and proposed – adaptation strategies in the water sector in view of recent and projected changes in water supply. The lack of the accessibility and availability of data collected in a standardised format across time and space is presented, highlighting the need for improving water monitoring. The Brief concludes by presenting end users' suggestions for areas requiring further research through community visits and dialogue with UK and Indian scientists.

2.1. Water resource situation and trend in water supply

The Narmada River Basin is an important source of water for the State of Madhya Pradesh. This basin is highly regulated; it crosses the states of Madhya Pradesh, Maharashtra and Gujarat, and supports a population of over 16 million people. The basin contains over 3000 dams, with up to another 30 planned for construction over the next half-century. This basin has experienced a decrease in surface water in recent years; with changes
in the occurrence of droughts being one reason for such a decrease in surface water availability. For instance, the Bundelkhand region, which covers part of Madhya Pradesh, has experienced several intense drought events in recent decades, with analysis of historical climatic data showing trends towards an increase in the frequency and intensity of droughts.

In addition to surface water resources, the State of Madhya Pradesh has experienced depleting groundwater levels. The UEI participants attributed the depletion in groundwater levels and surface flows to water usage by the agricultural sector, particularly for rice and sugarcane cultivation.

Moreover, climate change is expected to influence the availability of water resources in river basins across the state. Hence, climate change needs to be taken into account in catchment management, as it could increase uncertainties in the timing and extent of rainfall and the rates of evaporation (Molina-Navarro et al., 2018). Changes in precipitation, temperature and evapotranspiration affect hydrologic processes such as runoff generation and groundwater recharge, as well as water demand patterns. Given the current hydro-climatic changes that have taken place and the possibility that those will continue under climate change, there is a need for efficient and effective water management, but this requires an accurate assessment of the available water resources and the use of modelling techniques to examine how water availability might evolve into the future in relation to different plausible scenarios of change. Although groundwater and surface water resources are highly variable, they are,
nonetheless, renewable resources and changes in water management practices are required to reverse the currently degrading trends and maintain the sustainability of this resource.

2.2. Current water resource management

Water resource management in Madhya Pradesh parallels the approach across India where civil engineering solutions are favoured to traditional nature-based solutions (Everard et al., 2020) to address decreasing trends in water supply and a growing demand for water. This includes the interlinking of rivers to transfer water from a basin with a perceived surplus to a water-deficient basin, as done for the Narmada river system to increase its water supply. This has led to a tendency to look increasingly further to improve the water supply of a region. However, water resources in the donor catchment are not without limit and can eventually become depleted and face water scarcity (Verdhen, 2016). This is in addition to the degradation of ecosystems in the donor catchment and the often marginalisation of communities relying on this water resource (Birkenholtz, 2016) to the benefits of specific stakeholders’ groups. Such a management approach ignores alternative means of water supply, for example, from nature-based solutions, which aim to regenerate and ensure the sustainability of the local resource (Everard et al., 2020). Adaptation measures will be required as the climate continues to change, notably to mitigate against more extremes of the hydrological cycle. The consideration of solutions beyond those offered by engineering
approaches need to be explored, including nature-based solutions, and a
hybridisation of both approaches depending on the local context.

2.3. Adaptation of the water sector
In addition to large-scale scale adaptation such as diverting the flow
of rivers across catchments, in catchments across Madhya Pradesh,
water security in agriculture is promoted through small-scale adaptive
practices. An Integrated Watershed Management Programme (IWMP)
was created in Madhya Pradesh in 2008, which consisted of subdividing
a watershed in a number of units in which interventions are targeted to
enhance water resources with the aim of achieving co-benefits for both
local communities and the hydrology of the overall catchment. One
of those units, a sub-catchment of the upper Kolans River covering
9,700 ha in Phandra Block of Sehore District, was visited as part of the
GFES on the 25th February 2019. In this sub-catchment, a number of
adaptation measures are implemented, including percolation tanks to
facilitate recharge of the aquifers in areas mapped as recharge areas,
restricting excessive groundwater abstraction, farm ponds for storing
water collected during the monsoon season for use by farmers, and the
installation of a range of water harvesting structures in 16 villages. Such
small-scale approaches are potentially helpful in not only facilitating local
climate resilience, but also cumulatively contributing to the replenishment
of shallow aquifers and surface water resources.

समाधान और स्थानीय संदभ्भ के आधार पर दोनों दृष्कोण का एक संकरण शामिल है।

2.3. जल क्षेत्र का अनुकूलन
बड़े पैमाने पर पैमाने के अनुकूलन के अलावा, पूरे मध्यप्रदेश में जलवायु क्षेत्रों में नदियों
के प्रवाह को मोड़ने के अलावा, कृषि में जल सुरक्षा को छोटे पैमाने पर अनुकूली पानी के
माध्यम से बढ़ावा दिया जाता है। 2008 में मध्य प्रदेश में एक एकीकृत वाटरशेर
प्रबंधन काय्तक्रम (IWMP) बनाया गया था, जिसमें कई इकाइयों में एक वाटरशेर को उप-भिन्न करना
शामिल था, जिसमें स्थानीय समुदायों और दोनों के सह-लाभ प्राप्त करने
के उद्देश्य से जल संसाधनों को बढ़ावा देने के लिए हस्ताक्षर किया जाता है। सामान्य जलवायु
का जल विकास।

उन इकाइयों में से एक, सीहोर स्थल के फर्स्ट कोट में 9,700 हेक्टेयर में कारने
देने वाली उप-स्थल नदी का एक उप-क्षेत्र 25 फरवरी 2019 को जीए्फईएस के
हिस्से के रूप में देखा गया था। इस उप-क्षेत्र में, कई अनुकूलन इकाइयों को लागू किया
जाता है। सही, पूर्वरूप इकाइयों में स्थानीय क्षेत्रों के उपरचारण का सुभाष के लिये, क्षेत्रों
में अनुपस्थित भूमि अनुपस्थित करना, क्षेत्रों के द्वारा पानी के सह-लाभ को मान्सूस के
माध्यम के दौरान एक फिरे गए पानी के भंदारण के लिये खेत तलाव, और 16 गांवों में जल
संचयन संस्थानों की एक खुलासा की स्थापना। इस तरह के छोटे पैमाने पर दृष्कोण
न केवल स्थानीय जलवायु भंदारण को सुभाषानगर करने में सहायक होते हैं, बल्कि
उससे एक्साइर्स और स्थानी जल संसाधनों का पूर-पूरी में भी गोभराना देते हैं।
3. Specific knowledge and data gaps/specific recommendations

3.1. Data for research and management

Sustainable management of water resources across the energy and food systems is a multi-disciplinary challenge. The development of effective management strategies requires information based on evidence, however, access to appropriate datasets to gather this evidence was identified to be a challenge because of the temporal and spatial variability of resources and also the lack of consistency in relation to data collection across different agencies.

The implementation of adaptation measures to improve the management of water resources needs more accurate information about water availability during the monsoon and non-monsoon seasons for both surface and groundwater resources, as well as a better understanding of the regional water balance, including groundwater recharge, and runoff variability, amongst others. Data availability to address this issue is currently a problem. Various barriers pertaining to the accessibility to data and information, the inadequacy of resources, and implementation gaps exist particularly due to inter-institutional network fragmentations.

As a way to address this data gap, a theme during the UEI was how remote sensing, local knowledge and big data can improve assessment
of both surface and groundwater resources.

With regard to determining the potential impacts of climate change on water resources, modelling techniques are used linking outputs from general circulation or regional climate models projecting future changes in climatic conditions, but baseline climatic and hydrological data are still required to calibrate and validate the runoff model that translates changes in climatic variables into surface runoff, in addition to values for the different model parameters such as soil types, land cover, etc. The potential for community-based measurements was also mentioned and is practiced in parts of India to determine the depth of water in boreholes, for instance. Given its importance to the water supply of the region, and in view of an ever-increasing demand for its water, an assessment of the water resource potential of the Narmada river system is a priority, as such information would assist water resource planners and managers, in addition to a more in-depth examination of the various hydrological fluxes and states at diverse spatial scales. Geospatial techniques combined with isotopes have shown significant potential in studies of surface ground interaction and groundwater dynamics.
3.2. End users’ information and knowledge exchange requirements

Forest management was shown to affect the sustainability of the water resource and the need to identify the most effective strategies in that regard was identified as a research priority to inform policy.

The need to incorporate traditional knowledge in adaptation was promoted by the UEI participants, however, as it appears not to be given sufficient attention in government sponsored water management initiatives, it is recommended that the efficacy of traditional knowledge and practices be demonstrated in relation to current water resource management strategies.

Given the important and growing use of water by the agricultural sector, the implementation of technological interventions such as remotely sensed and in-situ observations for smart agriculture and the implementation of irrigation scheduling are recommended, together with the transfer of the results of research on the water efficiency of different crops for the benefits of increasing the resilience of local farmers.

Table 1 summarises the research requirements identified during the GFES and UEI through dialogues with end users and amongst scientists.
Assessment of the available water resources, both surface and ground water, in the state under current climatic conditions for both monsoon and non-monsoon seasons, including their year-to-year variability

An in-depth examination of the various hydrological fluxes and states at diverse spatial scales of the Narmada river system

Determine the potential of local knowledge and technology such as remote sensing and big data sensing to improve the assessment of both surface and groundwater resources

Examine how water availability might evolve in the future under different climate change scenarios

Exploring nature-based solutions to water resource management as alternatives or complementary to engineering approaches

Identification of the most effective forest management strategy for the sustainability of the water resource

Demonstrate the efficacy of traditional knowledge and practices in relation to current water resource management strategies

<table>
<thead>
<tr>
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4. Future

The GFES and the UEI underpinning this Water Brief aimed to identify the key scientific needs of the water resource management and supply sector in Central India to inform the development of projects that will meet end users’ requirements. The region demonstrates a complex water nexus with increasing water demand in the agricultural, industrial and energy sectors, as well as increased demand for domestic users due to population growth. The challenge for policy makers and governmental institutions is to meet the water demands of these growing sectors in a sustainable manner in the face of a diminishing supply without adversely affecting the environment. This requires accurate information on water availability, including surface and groundwater, and its variability during the monsoon and other seasons, and the identification of best practice for adaptation. An assessment of current water resources and the development of management strategies and the identification of potential paths for improvement are urgently needed given the decreasing trend in water availability.

4. भविष्य

जीएफईएस और युईआई ने इस जल संस्थान को रेखांकित किया जिसका उद्देश्य मध्य भारत में जल संस्थान प्रबंधन और आपूर्ति क्षेत्र की प्रमुख वैज्ञानिक आवश्यकताओं की पहचान करना है ताकि उन परियोजनाओं के विकास को सुनिश्चित किया जा सके जो अंत में उपयोगकर्ताओं की आवश्यकताओं को पूरा करें। यह क्षेत्र कृषि, वैद्युत और उद्योग क्षेत्रों में पानी की बढती मांग के साथ-साथ जनसंख्या वृद्धि के कारण पानी के उपयोगकर्ताओं की बढती मांग के साथ एक जीटि जल संसाधन का प्रदर्शन करता है। नीति निर्देशित और सरकारी संस्थानों के लिए जीएफआई यह है कि इस बढते हुए उपयोगकर्ताओं की मांगों को साधील सूत्र से पानी की प्रतिकृति के निर्धारण में सही करना रही आपूर्ति की स्थिति में पूरा किया जाए। इसके लिए सरकार और उपहार सहायता पानी की उपलब्धता, और नानापुर्व और अंग भूमि संस्थान के दौरान इंस्क्रिप्टियों, और अनुमति के लिए सत्स्राण होने के पहचान आवश्यकता की पहचान करने की सटीक जलसंख्या की आवश्यकता होती है। प्रभावित पानी संसाधनों का अनुमान और प्रबंधन उपलब्धियों के विकास और सुधार के लिए संयमित रास्तों की पहचान के लिए पानी की उपलब्धता में कमी को देखते हुए उत्कृष्ट आवश्यकता है।
5. References


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Back cover photo: Lift irrigation site of Indira Sagar Dam (Emma Bennett, IUKWC)