Water: Brief

Water resource management and climate change adaptation in Central India

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

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.

Figure 1: GFES Group in the field visit to Parwaliya village
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 climatic conditions, the basin has seen a decline in the availability of water. The basin has been monitored using a standardised format across time and space, 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. जल संसाधन की स्थिति और जल आपूर्ति के तरीके के निर्देश नदी का बेससन मध्य प्रदेश राज्य के सलए पानी का एक महत्वपूर्ण स्वरूप है। यह बेससन अत्यसधक व्यवस्थत है; यह मध्य प्रदेश, महाराष््र  और गुजरात राज्यों को पार करती है तथा 16 समसलयन से असधक लोगों की आबादी का भरण-पोषण करती है। बेससन में 3000 से अधिक बांध हैं, जो में से 30 अन्य प्रबंधन के माध्यम से भारी असंख्य से अपराधिक बांधों की आबादी को पार करती है। यह बेससन में 3000 से अधिक बांध हैं, जो में से 30 अन्य प्रबंधन के माध्यम से भारी असंख्य से अपराधिक बांधों की आबादी को पार करती है।

इस बेससन ने हाल के वर्षों में सतह के पानी में कमी का अनुपात खराब किया है, जबकि जल की
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,

उपरब्द में कमी सुखे की पट्टनों में हो रही बदलावों की एक वजह हो सकती है। उदाहरण के तौर पर, बुंदेलखंड क्षेत्र, जो मध्य प्रदेश का हिस्सा है, ने हाल के दशकों में कई भीषण सूखे की पट्टनों को छोड़ा है, जिसमें पालतूकाम्य वातावरण उद्योग के विकल्पों से सूखे की अवरोध एवं तीव्रता में बढ़ी के सुझाव दिए गए हैं।

सतही जल संसाधनों के अतिरिक्त, राज्य प्रदेश में भूजल के स्तर में पिंडक का अनुभव किया गया है। सूखे के स्तर में बना तथा कुंड क्षेत्र द्वारा सतह पर प्रभावित पानी के उपयोग को विशेष रूप से चालन एवं अन्य की खोज का विविधता तहराया।

इसके अलावा, जलसतत मात्रा से राज्य भर में नदी संसाधनों की उपलब्धता को प्रभावित करने की उम्मीद है। इसलिए, जलसतत परिवर्तन को पकड़ने के प्रभाव में भावना में रखी की मांग को अप्रसंशा करता है। क्योंकि पानी के स्तर एवं भावना में अप्रसंशा और वातावरण की दर (साल्निन-नालो एट आउट, 2018) को बढ़ा सकते हैं। ब्राह्म, तापमान और वातावरण में परिवर्तन अवात सूत्र और भूजल सुरक्षा जैसे वातावरण प्रभावों को अप्रसंशा करने में सहाय, साथ ही पानी की मांग में भी। वातावरण जल-जलसतत परिवर्तन की देखभाल एवं संसाधन है जो जलसतत परिवर्तन के बाद जैसे रोने, उत्पादन और रोने वातावरण प्रभाव को अप्रसंशा करता है, तेजी से इसके लिए, उपजाति जल संसाधनों और राष्ट्रीय तत्कालिनों के उपयोग का नीती वानांक अप्रसंशा यह भविष्य में पानी की उपलब्धता परिवर्तन के विषय प्रसंशा परिवर्तन के संबंध में कैसे विविधता हो सकती है, इससे जात करने के लिए। यद्यपि भूजल और सतही जल संसाधन अवात वातावरण परिवर्तन के कैसे का विविधता है, फिर भी, वे, वह भी, नवीकरणीय संसाधनों और जल द्वारा प्रभावित प्राकृतिक परिवर्तनों की विविधता है।
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 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.
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.

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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.
5. References


5. संदभ

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वर्डेन ए (2016)। जल संसाधन प्रबंधन में नदियों की जोड़ने का अंतर और अंतर बीसिंस। जन्तल ऑफ साइंटिफिक एंड इंडस्ट्रियल रिसर्च, वॉल्यूम 75: 150-155।