

Water Resource Management & Supply in Central India

Report of User Engagement Initiative February 2019

June 2020



INDIA-UK
Water Centre
भारत-यूके
जल केन्द्र

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www.iukwc.org

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

भारत-ब्रिटेन जल केंद्र एमओईएस-एनईसीआरसी (यूके) जल सुरक्षा अनुसंधान के पूरक प्राथमिकताओं के बीच सहयोग और सहयोग को बढ़ावा देने के लिए करना है

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Figure 1: Delegates of UEI at IISER Bhopal Visitor Hostel (Event Venue)

Executive Summary

This report presents an overview of the joint India-UK User Engagement Initiative (UEI) held in Bhopal from 28th February to 2nd March 2019. The event was convened by the India-UK Water Centre (IUKWC), which is co-ordinated in India by Dr A.K. Sahai (Indian Institute of Tropical Meteorology, Pune) and in the UK by Professor Harry Dixon (UK Centre for Ecology & Hydrology, Wallingford). This initiative was organised by the IUKWC Secretariat in collaboration with Dr Pankaj Kumar (Indian Institute of Science Education and Research (IISER) Bhopal, India), Dr Alexandre Gagnon (Liverpool John Moores University, UK) and Dr Sumit Sinha (University of Leeds, UK). The event aimed to engage state and regional level water policy and management bodies in discussions about how the latest India-UK scientific outputs could be used to help improve the management of water resources in Madhya Pradesh, Central India. To tackle the multi-faceted and intertwined nature of the various water related issues in the state, the event was divided into the water resource and supply management for agriculture, domestic and industrial uses, and energy generation.

The discussion at the event focused on improving water resource management in view of the current water resource situation and trend in water supply, particularly on the themes of improving freshwater monitoring frameworks and data for research and management. Scientists from the UK and Indian institutions presented the latest research of relevance to the theme of the UEI and particularly showcasing joint India-UK research outputs in the area of water supply and management.

Representatives from Indian academic institutions at the event included the National Institute of Hydrology - Roorkee, the National Institute of Technology - Karnataka, Jamia Millia Islamia University - Delhi, the Indian Institute of Tropical Meteorology - Pune, IISER Bhopal, Amity University - Jaipur, TERI School of Advanced Studies - New Delhi, Symbiosis International (Deemed University) - Pune, the Indian Institute of Soil Sciences - Bhopal, the Indian Institute of Science - Bangalore, the Indian Institute of forest Management - Bhopal, the Central Institute of Agriculture Engineering – Bhopal, and Banaras Hindu University - Varanasi. UK participants included scientists from Loughborough University, the UK Centre for Ecology & Hydrology, the University of the West of England, Liverpool John Moores University, Cranfield University, Heriot-Watt University, the University of Dundee, and the University of Leeds.

The event was multi-sectoral and multi-stakeholder in nature. It was attended by representatives from various organisations responsible for the development of water policy and the management of water resources. This included stakeholders from government organizations such as the Department of Water Resources of Madhya Pradesh (M.P.), the National Water Development Agency, M.P. State Council of Science and Technology, M.P. Jal Nigam & Public Health Engineering Department, Central Ground Water Board, M.P. Department of Horticulture, Madhya Pradesh Forest Department, the Environmental Planning and Coordination Organisation, and Rajiv Gandhi Mission for Watershed Management. Non-Governmental Organisations (NGOs) also attended the workshop, notably Water Aid India, Lakshya, Towards Action & Learning (TAAL), the Neer foundation, Action for Social Advances, the Centre for Advanced Research and Development, and Development Alternatives Group.

This report outlines the structure, participation, presentation and discussion sessions undertaken during the course of the event. The report is intended for the UEI participants, IUKWC Open Network members and stakeholders.

1. UEI Conveners Activity Leads

The User Engagement Initiative (UEI) was convened by the India-UK Water Centre (IUKWC) and led by the Activity Leads:

Stakeholder Lead

Dr Pankaj Kumar

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The UEI was held at the Indian Institute of Science Education and Research (IISER), Bhopal, 28th February – 2nd March 2019.

2. UEI Aims

The IUKWC is based around five key cross-sectoral themes and aims to deliver a portfolio of activities across these themes. This activity focused on the themes:

- a. The translation and communication of India-UK water security science to end users, notably for policy design;
- b. The collection of information on stakeholders' needs to inform future research directions and innovation;
- c. The co-design and development of research projects.

The UEI aimed to address the key scientific needs of the water resource management and supply sector in Central India. The region demonstrates a complex water nexus with high growth rates in the agricultural, industrial and energy sectors, as well as increased demand for domestic water and a decreasing supply. Moreover, the region has experienced continuous warming and a decline in precipitation (though not significant) in recent decades, further influencing the regional hydrological balance. The efficient management of water resources in the region requires accurate information on water availability and its variability during the monsoon and other seasons, including consideration of surface and groundwater supplies, and the identification of best-practice to adaptation. 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.

The specific sectors that were addressed through this initiative include the water resource and supply management for:

- Agriculture;
- Domestic and industrial uses;
- Energy generation.

To support the transfer of science into water management and policy, a dialogue is required between scientists and stakeholders at different scales of water resource management to raise their awareness and understanding of the rapidly evolving scientific knowledge as well as current limitations of scientific information. Such a dialogue is also required to facilitate the exchange of information that would allow for a better understanding of the needs of end users and for co-designing projects aiming at deriving cross-sectoral solutions for the challenges of decreasing supplies and an increasing demand for water. Such an initiative is particularly important in view of the potential additional stresses that a changing climate might bring.

The specific objectives of this UEI were:

- To better understand the food-water-energy nexus and its spatio-temporal evolution under present and future climates;
- To examine the efficacy of traditional knowledge and practices and current water resource management mechanisms in risk mitigation, and potential paths for further improvement;
- To inform stakeholders of latest research findings and current research activities in India, as well as, UK scientific outputs from the UK that are relevant to the monitoring and management of water supply in Central India;
- To identify research gaps and to promote collaboration and the co-design of projects amongst participating UK-based and Indian scientists, and together with end users.



Figure 2: Visit to sewage treatment plant in Bhopal

3. UEI Participants

An open call was held amongst the IUKWC Open Network members and 20 scientists from both countries (11 Indian and 9 UK) were invited to attend the UEI. In addition, 40 stakeholders representing state level water resource management authorities, scientists having expertise in regional water resource management, and representatives from NGOs were also invited to attend the event. Invitations were sent to the Heads of relevant organisations for them to nominate experts from their own organizations. Participants from NGOs and authorities were not limited to those working in the region, but also extended to those with regional expertise and working outside the state. All stakeholders and scientists were provided with toolkits to provide information on what to expect, assist in preparation for the event and details of attendees (see Annex C).

The event had representatives from the following organisations:

- State and national government organizations such as M.P. Jal Nigam, M.P. Public Health Engineering Department, Central Ground Water Board, M.P. Water Resources Department, M.P. Forest Department and Department of Horticulture;
- NGOs, private sector, and national programmes including Rajiv Gandhi Mission for Watershed Management, Narmada Hydroelectric Development Corporation, TAAL, the Environmental Planning and Coordination Organisation, the Centre for Advanced Research and Development, and WaterAid;
- Scientists from UK institutions including the University of the West of England, University of Dundee, Cranfield University, Herriot Watt University, and UK Centre for Ecology & Hydrology. Academic organisations from India included, Indian Institute of Technology, Roorkee, National Institute of Hydrology, Roorkee, Amity University, Symbiosis International (Deemed University), National Institute of Technology, Karnataka, Jamia Millia Islamia (A Central University), TERI School of Advanced Studies, Development Alternatives Group, Indian Institute of Science Education and Research Bhopal, Indian Institute of Tropical Meteorology, Madhya Pradesh Centre of Science and Technology, Indian Institute of Forest Management, Banaras Hindu University, ICAR, Indian Institute of Soil Science, and the Water and Land Management Institute.

Table 1. List of Delegates

Name		Institution
UK		
1	Dr Diganta Das	Loughborough University
2	Prof. Harry Dixon	Centre for Ecology and Hydrology
3	Dr Mark Everard	University of the West of England
4	Dr Alexandre Gagnon	Liverpool John Moores University
5	Dr Manoranjan Muthusamy	Cranfield University
6	Mr Nathan Rickards	UK Centre for Ecology & Hydrology
7	Prof. Bhaskar Sengupta	Heriot-Watt University
8	Dr Sophie Sherriff	University of Dundee
9	Dr Sumit Sinha	University of Leeds
INDIA		
10	Dr Azhoni Adani	National Institute of Technology Karnataka
11	Prof. Shakeel Ahmed	Jamia Millia Islamia University
12	Mr Kushank Bajaj	Indian Institute of Tropical Meteorology, Pune
13	Dr Vijaya Lakshmi Koneru	Development Alternatives Group
14	Mr Amit Kumar	Indian Institute of Science Education and Research, Bhopal
15	Dr Pankaj Kumar	Indian Institute of Science Education and Research, Bhopal
16	Dr Akhilesh Mishra	Amity University
17	Ms Vinni Munjal	TERI School of Advanced Studies
18	Dr A.K. Sahai	Indian Institute of Tropical Meteorology
19	Mr Md Saquib Saharwardi	Indian Institute of Science Education and Research, Bhopal
20	Dr Dharmaveer Singh	Symbiosis International (Deemed University)

Table 2. List of Stakeholders

Name		Institution
INDIA		
1	Shri Vijay Agarwal	Department of Horticulture, Bhopal
2	Prof. Vivek Bhatt	Water and Land Management Institute, Bhopal
3	Dr R. S. dhary	Indian Institute of Soil Sciences
4	Shri Vivek Dave	Rajiv Gandhi Mission for Watershed Management
5	Shri Prashant Dongre	Mahindra & Mahindra, Bhopal
6	Dr Venu Gopal	Indian Institute of Science, Bangalore
7	Shri Jitendra Jain	Madhya Pradesh Water Resources Department
8	Shri N.C Jain	National Water Development Agency

9	Dr Sharad Jain	National Institute of Hydrology (NIH), Roorkee
10	R K Jaiswal	NIH, Bhopal
11	Shri Amod Khanna	TAAL
12	Dr Om Prakash Madguni	Indian Institute of forest Management
13	Satabdi Mohapatra	Development Alternatives, Delhi
14	Shri Ashis Mondal	Action for Social Advances
15	Dr P C Nayak	Director, IMD Bhopal
16	Dr T R Nayak	NIG, Bhopal
17	Shailendra Pathak	Mahindra & Mahindra, Bhopal
18	Shri. Amar Prakash	WaterAid
19	Shri. H.K Pandey	National Water Development Agency
20	Dr S.K. Pandey	Madhya Pradesh State science council
21	Shri Bhagwan Singh Patel	Action for Social Advances
22	Abhishek Patel	Central Institute of Agriculture Engineering, Bhopal
23	Shri P.K. Raghuwanshi	M.P. Jal Nigam & Public Health Engineering Dept.
24	Dr K. V. Ramana Rao	ICAR - Central Institute of Agriculture Engineering
25	Dr Dipankar Saha	Central Ground Water Board
26	Shri Satyanand	Department of Horticulture, M.P.
27	Shri Vivek Sharma	Centre for Advanced Research and Development
28	Dr Subhash Singh	Central Ground Water Board
29	Shri G.P Soni	Madhya Pradesh Water Resources Department
30	Shri Anurag Srivastava	Madhya Pradesh Forest Department
31	Dr Prashant Srivastava	Banaras Hindu University
32	Prof S K Tandon	Indian Institute of Technology, Kanpur
33	Shri Lokendra Thakkar	The Environmental Planning and Coordination Organisation, Bhopal
34	Dr C Thivya	Madras University
35	Dr T Thomas	NIH, Bhopal
36	Shri. Naresh S Tomar,	Department of Horticulture
37	Dr D K Umak	MAPCOST, Bhopal
38	Dr J KS Yadav	IMD, Bhopal
IISER Faculty and Students		
39	Nafees Ahmad	IISER Bhopal
40	Khandare Ajinkya	
41	Zafar Beg	
42	Sandeep Devaliya	
43	Monish Deshpande	
44	Aditya Kumar Dubey	
45	Sonkar Gaurav	
46	Aaquib Javed	
47	Ajinkya Khandare	

48	Amit Kumar	IISER Bhopal
49	Navajyoth M P	
50	Prem Maheshwarkar	
51	Nagesh Mishra	
52	Abul Qasim	
53	Gaurav K Sonkar	
54	Aparna P Ravi	
55	Disha Sachan	
56	Nibedita Samal	
57	Sahil Sharma	
58	Akanksha Singh	
59	Ankit Singh	
60	Gaurav Sonkar	
61	Divyareshmi. T.R	
62	Amol Vibhute	

4. UEI Structure

The UEI was held over three days and consisted of oral and poster presentations by scientists and stakeholders involved in policy-making and the management of water resources in Madhya Pradesh and Bundelkhand. The stakeholders represented key sectors of water resource management in the region (agriculture, industrial and domestic users, energy generation). The event also included targeted breakout group discussions between scientists and stakeholders as a way to encourage dialogue. The team also visited a sewage water treatment plant, which treats the water before discharging it into Upper Lake located to the west of Bhopal.

First Day: The first day started with an inaugural session and continued with talks by scientists and stakeholders categorised into four different themes. The first session focused on water resources in Central India including the current situation and techniques used to assess water availability. The second session focused on climate variability over Central India. The third session looked at the impacts of climate change on water resources, while the fourth session consisted of presentations on approaches to water resource management. A number of posters were also presented during the tea breaks when discussion amongst the participants also took place.

Subsequent to the presentations in each thematic session, an interactive question and answer session took place. This interactive session was also an opportunity for a stakeholder representative of each theme to provide information on the management of water resource in their sector and the current uptake of scientific outputs. In total, 17 presentations were delivered during the first day of the event.

Second Day: The first half of the day consisted of presentations and time for discussion. The themes of the sessions were: approaches to water resource management, continuing on the presentations on the same topic on the first day, and continuing with presentations on adaptation in the water sectors. There were a total of 13 presentations on the second day. As for the first day, the presentations were delivered by both scientist and stakeholders. The second half of the day consisted of a visit to Bhopal Lake and then to a sewage treatment plant.

Third Day: The third day was dedicated to discussion. The participants were divided into small break-out groups with a facilitator leading the discussion. Three exercises were designed to encourage participants to share perspectives on various aspects of freshwater monitoring

specific to a sector and the scientific knowledge available to improve monitoring (including their potential use and limitations). A copy of these exercises was provided to participants on the first day so as to give them time to prepare their thoughts for the discussion.



Figure 3: Inauguration of the UEI and audience

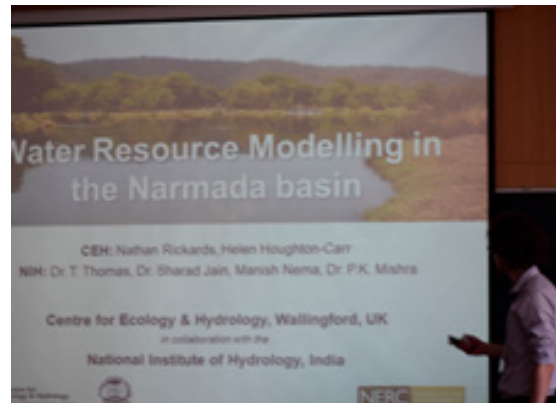


Figure 4: Poster and presentation session



Figure 5: Last day discussion session

5. UEI Conclusions and Outputs

5.1. Key Points Arising

Session One: Water resources in Central India – current situation and techniques used to assess water availability

Session one started with the objective to gain an overview of water supply and demand issues in Central India and techniques available to assess water resource availability. The first talk was given by forest department representative with focus on impact of competing land use, forest cover including surface water depletion in Narmada River Basin. Second talk focused on the importance of ground water and surface water and importance was given to monitoring sustainability of water supply schemes for rural areas in Madhya Pradesh. A very insightful presentation was given by hydrogeologist with focus on depleting ground water levels in the region and need for community based measurement and management. It was stated that models could be used for both predictive and management purposes. Key discussions attributed the depletion in water levels and surface flows to the agricultural sector; particularly rice and sugarcane cultivation. With ever increasing demand of the resource, it was thought to be extremely useful to assess the availability of the water in the Narmada river system by estimating all possible fluxes at entry and exit; prediction of water balance using the probabilistic values of all fluxes was also discussed. This information was thought to have the potential to assist decision makers in planning for water distributions and utilization.

Session two: Climate variability in Central India and the impacts of climate change on water resources

The session started with the objective of presenting the results of empirical research examining the temporal and spatial variability of droughts in the region and the use of a physical modelling approach in the assessment of past and future droughts. Drought variability over India was highlighted in both El Niño and non-El Niño Years. Large negative anomalies were observed in July and August during El Niño years associated with drought while in non El Niño drought, less rainfall was observed in the month of September. The second talk was associated with Hydro - Geo morphological scenario of Madhya Pradesh State; various morphological features of MP were shown both at state and district levels.

This session also highlighted the latest research and modelling techniques for examining the impacts of climate change on water resources in the region and to gain an understanding of the stakeholders' perspectives on the influence of climate variability on water resources in Central India. It was observed that data is usually a challenge and collaborations are helpful to solve the problem and act as a bridge between national and international organizations. The application of hydrological modelling could be very useful to determine the impacts of climate change and anthropogenic activities on water availability and flow discharge. Effective forest management and its impacts on sustainable water resources was also discussed; a need for more studies to enhance the knowledge of forest hydrology was felt.

To solve the problems at community level, site specific, affordable and scalable solutions were thought to be the need of the hour. Further, implementation of technological interventions like remotely sensed and *in-situ* observations for smart agriculture, and implementation of irrigation scheduling were also thought to be worth exploring.

Session three: Approaches to water resource management

The objective of this session was to assess current water resource management mechanisms in risk mitigation and potential pathways for further improvement. The presentations focussed on issues like water and energy productivities of major field crops under different irrigation management practices in Central India; current irrigation practices in Madhya Pradesh and importance of water security in agriculture through promotion of small scale climatic adaptive practices and mechanisms. Achieving the sustainable management of water, food and energy resources was discussed to be a considerable multi-disciplinary challenge; effective management strategies were thought to be supported by an empirical evidence base. However, access to appropriate datasets in India was reported to be challenged by the variability of resources through space and time and also consistency of data collection from different agencies.

Session Four: Adaptation in the water sector

The final session aimed to examine current adaptive strategies in the water sector and their application in Central India. The first talk presented river interlinking challenges and prospectus in Madhya Pradesh focussing on the Ken – Beta river system of the region. The linking of these two rivers under non-monsoon and dry conditions would allow for better adaptation to issues associated with water availability. The second talk highlighted the importance of water resource stewardship for protecting the wellbeing of interconnected beneficiaries of catchment ecosystem services. Water extraction and management technologies were reported to often prioritise maximisation of technical efficiency in meeting the demands of discrete stakeholder groups, frequently favouring influential sectors of society. The presentation highlighted the importance of better understanding the wider systemic implications of different technological approaches to water management – their benefits but also their externalities and mitigation options – to plan for more sustainable stewardship and allocation of water resources. Small-scale traditional, generally community-based approaches of water harvesting and stewardship were discussed to be potentially helpful in not only facilitating local climate resilience, but also cumulatively contributing to the replenishment of clean, shallow aquifer and surface water resources at catchment scale.

Dr Dipankar Saha from Central Ground Water Board presented the present scenario of Indian groundwater use and explained reasons behind the current crisis of water in several parts of the country. He emphasized the fact that situation is less severe in North-Eastern part of the country. Dr Saha talked about various initiatives by government of India which can help in sustainable use of groundwater in the country on a longer run. Dr R.S. Chaudhary from Indian Institute of Soil Sciences spoke on facilitating the highest possible water productivity using conservation agriculture, soil quality monitoring and water-shed development and management. He shared his experience with local farmers and presented some of the results from their field experiments; he also emphasized how the presented methods are currently helping farmers in various parts of the country to increase their farm production. Dr Chaudhary's talk was very informative and followed by discussions about the methods and applicability of IISS experiments. Last talk of the session was by Shri Prashant Dongre who highlighted the work done by his company Mahindra & Mahindra under its CSR wing; the company has been working under Rajiv Gandhi Integrated Watershed Management Mission to maintain and manage Bhoj Taal catchment. They helped form 280 self-help groups, 29 watershed committees, 70 water user groups and 36 Farmer clubs as part of their community participation mission. They have provided assistance in building a 19.8 km natural drainage to avoid water-logging in monsoons; which has also proved useful in recharging local tube wells and conserving water. They have also been working with locals and providing assistance for building school boundary walls and other community infrastructure facilities.

5.2. Conclusions

The discussions at the workshop recognised the depleting levels of groundwater all over the country, especially in the northern states, as a major and alarming concern that needs to be addressed with utmost priority. A need was felt to systematically organise and analyse the extensive amount of groundwater related data collected in MP and in the rest of the country by the Central Ground Water Board needs. Given the pressing nature of various water related issues in MP and India and establishment of network of scientist and stakeholders following this UEI, it is strongly felt that this consortium is uniquely placed to design and bid for various projects and proposals. The consortium will be keenly looking out for opportunities to collaborate on Global Challenge Research Fund (GCRF) projects and other proposals of similar nature. An accompanying Brief, summarizing the key thematic points and the identified future needs for WRM and supply in Central India arising from the UEI, can be found at www.iukwc.org.

5.3. Participant Feedback

At the conclusion of the Activity a feedback form was circulated to participants who were asked to provide comment on:

- The content of the event;
- The meeting venues and organisation;
- Networking opportunities; and
- Provide an overall score out of 10 for the workshop.

A total of thirty four respondents rated the activity an 8.7 out of 10, appreciating the diverse spectrum of issues covered, focus on both local and regional scale impacts and cross sectoral and cross cultural networking opportunity. The participants especially commended the case study oriented nature of presentations which created a higher level of impact and understanding; however, they expressed a need to learn more on policy and state law/legislation to conserve and manage water resources. The feedback also highlighted the need of increasing frequency of such initiatives to facilitate follow-up of ideas and continued engagement with stakeholders.

The respondents all appreciated the level of organisation and the quality and location of the venue. Some of the areas that should be considered for improvement included arranging transport for stakeholders living in the city to facilitate their participation throughout the event and more time for informal interaction and discussions.

“The meeting showed how there is a communication gap between the policy makers, grassroots implementation and the scientific community. It also highlighted the diversity of issues under a particular sector faced by different types of stakeholders”

6. Annexes

Annex A: Agenda

Day 0 – Wednesday 27th February

Time	Agenda item
19:00	Ice Breaker at IISER, Bhopal

Day 1 – Thursday 28th February

Time	Agenda item
08:30 – 09:00	Arrival and Registration (Refreshments - Tea / coffee)
08:45 – 09:00	Poster set up at the venue (IISER, Bhopal); Presentation upload for day one
09:00 – 10:15	<p>Welcome Addresses</p> <ul style="list-style-type: none"> • Welcome and Introduction to the IUKWC (15 mins) Dr Atul Sahai, IUKWC Coordinator, Indian Institute of Tropical Meteorology Prof. Harry Dixon, IUKWC Coordinator, Centre for Ecology & Hydrology • Welcome to IISER and UEI objectives, structure, and process (15 mins) Prof. Saptarshi Mukherjee, Dep. director, IISER, Bhopal Dr Pankaj Kumar, IISER, Bhopal • Introduction of delegates (20 min) Dr Alexandre Gagnon, Liverpool John Moores University • Plenary speaker (15 min + 5 min discussion) Dr Sharad Jain, Director, National Institute of Hydrology, Roorkee
10:15 – 10:45	Tea / Coffee break

<p>10:45 – 12:30</p>	<p>Session 1: Water resources in Central India – Current situation and techniques used to assess water availability</p> <p>Objective: To gain an overview of water supply and demand issues in Central India and techniques available to assess water resource availability</p> <p>Chair: Prof. Harry Dixon, Centre for Ecology and Hydrology, UK</p> <p>Rapporteur: Dr. Sumit Sinha, University of Leeds</p> <p>Format: 5 *15' talks</p> <ul style="list-style-type: none"> • Water resource management with respect to forests in Central India (tentative) Shri. Anurag Srivastava, PCCF – IT, MP Forest Department • Monitoring sustainability of water supply schemes for rural areas in Madhya Pradesh Mr P K Raghuvanshi, MP Jal Nigam/ Madhya Pradesh (MP) Public Health Engineering Department • Sustainability in the management of groundwater through effective incorporation of scientific outputs in decision-making Prof. Shakeel Ahmed, Jamia Millia Islamia University • Advanced Geophysical Techniques for Groundwater Exploration, Development and Management Dr Subhas Singh, Central Ground Water Board • Applications of geo-spatial and isotope technology in water resources mapping and monitoring Dr Dharmaveer Singh, Symbiosis international, Deemed University <p>Discussion : (30 minutes)</p>
<p>12:30 – 13:15</p>	<p>Session 2.1: Climate variability in Central India</p> <p>Objective: To present the results of empirical research examining the temporal and spatial variability of droughts in the region and the use of a physical modelling approach in the assessment of past and future droughts</p> <p>Chair: Prof. S. K. Tandon, IISER Bhopal Rapporteur: Md. Saquib Saharwardi, IISER Bhopal Format: 2* 15' talks</p> <ul style="list-style-type: none"> • Monsoon droughts and their space-time structure Dr Venu Gopal (Indian Institute of Science, Bangalore) • Hydro - Geo morphological scenario of Madhya Pradesh State Dr S.K. Pandey, Senior Scientist (MPCoST) <p>Discussion (15 minutes)</p>
<p>13:15 – 14:00</p>	<p>Lunch break</p>

14:00 – 15:30	<p>Session 2.2: The impacts of climate change on water resources Objective: To present the results of latest research and modelling techniques examining the impacts of climate change on water resources in the region and to gain an understanding of the stakeholders' perspectives on the influence climate variability on water resources in Central India</p> <p>Chair: Prof. Shakeel Ahmed, Jamia Millia Islamia University</p> <p>Rapporteur: Mr. Kushank Bajaj, IITM Pune</p> <p>Format: 4* 15' talks</p> <ul style="list-style-type: none"> • A modelling approach to assess the impact of climate change and anthropogenic activity on the water resources of the Narmada river Mr Nathan Rickards, Centre for Ecology & Hydrology • Agri-water solutions in Semi - arid Central India- CARD experience Mr Vivek Sharma, Centre for advanced research and development • Forests are integral to water cycle Dr Om Prakash Madguni, Indian Institute of Forest Management, Bhopal • Irrigation scheduling and demand application development Dr Prashant Srivastava, Banaras Hindu University <p>Discussion (30 minutes)</p>
15:30 – 16:15	<p>Poster session with Tea / Coffee</p>
16:15 – 18:00	<p>Session 3: Approaches to water resource management</p> <p>Objective: To assess current water resource management mechanisms in risk mitigation, and potential paths for further improvement</p> <p>Chair: Dr. A.K. Sahai, Indian Institute of Tropical Meteorology, Pune Rapporteur: Dr. Manoranjan Muthuswamy, Cranfield University</p> <p>Format: 4* 15' talks</p> <ul style="list-style-type: none"> • Overview of hydro power sector of Madhya Pradesh Shri Anurag Seth/ Shri. R.K. Jhawar, Narmada Hydroelectric Development Corporation Ltd. • Water and Energy productivities of major field crops under different irrigation management practices in Central India Dr K.V Ramana Rao, ICAR • Using regional water-food-energy security indicators to support sustainable resources management in India Dr Sophie Sherriff, University of Dundee • Current irrigation practices in Madhya Pradesh in the field of planning, execution and management Shri G.P Soni, MP Water Resources Department • Water Security in Agriculture through Promotion of Climatic Adaptive Practices in Small Scale Fisheries Mr Amod Khanna, Towards Action & Learning (TAAL) <p>Discussion (30 minutes)</p>
18:00 – 18:15	<p>Wrap-up of Day 1 (Activity Leads)</p>
18:30 – 19:30	<p>Cultural evening at IISER Bhopal: Kathak Performance by Vishal Krishna</p>

19.30 – 21.30	Dinner at IISER Bhopal
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Day 2 – Friday 1st March

Time	Agenda item
08:45 – 09:00	Presentation upload for day two
09:00 – 09:15	Welcome and opening remark Dr Alexandre Gagnon, Liverpool John Moores University
09:15 – 11:00	<p>Session 3: Approaches to water resource management</p> <p>Objective: To assess current water resource management mechanisms in risk mitigation, and potential paths for further improvement</p> <p>Chair: Dr. Dipankar Saha, CGWB</p> <p>Rapporteur: Dr. Alexandre Gagnon, Liverpool John Moores University</p> <p>Format: 5* 15' talks</p> <ul style="list-style-type: none"> • Significance of horticulture activities for water resource management in context of Bhopal and Madhya Pradesh Shri Naresh S Tomar, Department of Horticulture • Low cost soil and water treatment to reduce arsenic exposure from food grain and drinking water Prof. Bhaskar Sengupta, Heriot-Watt University • Urban water resource management, wetland management and CDM activities in context of Bhopal and Madhya Pradesh Lokendra Thakkar The Environmental Planning and Coordination Organisation • Simulation of water and solute in subsurface systems: Lysimeter based study in Ningbo, China Dr Sumit Sinha, University of Leeds • Ensuring Drinking Water Security in forest villages of Dindori district, Madhya Pradesh Shri Amar Prakash, Wateraid <p>Discussion (30 minutes)</p>
11:00 – 11:30	Poster Session with Tea / Coffee

11:30 – 13:15	<p>Session 4: Adaptation in the water sector</p> <p>Objective: To examine current adaptive strategies in the water sector and their application in Central India.</p> <p>Chair: Dr. Pankaj Kumar, IISER, Bhopal</p> <p>Rapporteur: Dr. Dharamveer Singh, Symbiosis International</p> <p>Format: 4* 15' min talks</p> <ul style="list-style-type: none"> • River Inter linking challenges and prospectus in M.P, Part-1 Mr N C Jain (Chief Engineer), National Water Development Agency, Lucknow • River Inter linking challenges and prospectus in M.P, Part-2 Mr H. K. Pandey, (Exe Engineer) , National Water Development Agency, Lucknow • Water resource stewardship: protecting the wellbeing of interconnected beneficiaries of catchment ecosystem services Dr Mark Everard, University of the West of England • Bundelkhand (Central India) Water Problems and Solution Possibilities Dr Vijaya Lakshmi Koneru, Development Alternatives Group <p>Discussion (15 minutes)</p>
13:15 – 14:00	Lunch break
14:00 – 15:30	<p>Session 4: Adaptation in the water sector Cont'd...</p> <p>Chair: Dr. Mark Everard, University of the West of England</p> <p>Rapporteur: Dr. Akhilesh Mishra, Amity University</p> <p>Format: 4*15' talks</p> <ul style="list-style-type: none"> • Towards Sustainable Use of Groundwater in Central India, special reference to Chhattisgarh and Madhya Pradesh Dr Dipankar Saha, Central Ground Water Board • Conservation agriculture, soil quality, water shed, development, management, resource conservation (soil-water) Dr R. S. Chaudhary, Indian Institute of Soil Sciences • Water Resources and Supply management in MP - A Virtual Water Perspective. Prof. Vivek Bhatt, Water and Land Management Institute, Bhopal • Watershed management in Madhya Pradesh: Case study of Bhoj Taal Shri Prashant Dongre/ Shri. Shailendra Pathak, Rajiv Gandhi Watershed Mission <p>Discussion (30 minutes)</p> <p>Wrap up of day 2 and logistics for afternoon trip</p>
15:30 – 16:00	Tea / Coffee break

16.00 – 18.30	Field visit Visit to Upper Lake Bhopal, informal discussions on field
19.00 – 21.00	Dinner in Bhopal city

Day 3 – Saturday 2nd March

Time	Agenda item
09.00 – 09.15	Welcome to day 3 and introduction to group exercises Dr Sumit Sinha, University of Leeds
9.15 – 10.30	Session 5.1: Breakout Group Discussion 1
10.30 - 10.50	Tea / Coffee break
10.50 – 12.00	Session 5.2: Breakout Group Discussion 2
12.00 – 12.15	Time for collation of presentations
12.15 – 13.00	Plenary talks by groups and discussion
13.00 – 14.00	Lunch
14.00 – 15.00	Plenary talks by groups and discussion
15.00 – 15.30	Conclusion and Next Steps
15:30	CLOSE OF UEI

All presentations that delegates have agreed to share are available at: <https://iukwc.org/workshop-presentations>.

Annex B: Poster Papers

Name	Organisation	Poster
Dr Azhoni Adani	National Institute of Technology Karnataka	Change adaptation by water management institutions in India
Mr Kushank Bajaj	Indian Institute of Tropical Meteorology	Anthropogenic roots of drought: Investigating the footprint of agriculture and hydro-climatic variables in a semi-arid region
Mr Md Saquib Saharwardi	Indian Institute of Science Education and Research Bhopal	Long-term drought spatial and temporal variability over Bundelkhand region of central India using multiple droughts Index
Mr Amit Kumar	Indian Institute of Science Education and Research Bhopal	Hydrological response of Ken-Betwa river basin under land use and climate change
Dr Akhilesh Mishra	Amity Interdisciplinary Center for Climate Research and Policy, Amity University	Regional coupled ocean-Atmospheric model for hydroclimate research
Ms Vinni Munjal	TERI School of Advanced Studies, New Delhi, India	People and Urban Wetlands: a case study of Delhi
Dr Manoranjan Muthusamy	Cranfield University	Hydrological uncertainty due to spatio-temporal variability of rainfall
Mr Saquib Saharwadi	Indian Institute of Science Education and Research Bhopal	Understand the resource flows, management, adaptations and scope for science integration.
Mr Aditya Dubey	Indian Institute of Science Education and Research Bhopal	Temperature extremes study over Central India

Annex C: Delegate toolkit

What to expect

This knowledge exchange event aims to engage regional level water policy and management bodies in discussions around Water resource Management and supply in Central India.

The specific objectives of this UEI are:

1. To better understand the food-water-energy nexus and its spatiotemporal evolution under present and future climates;
2. To examine the efficacy of traditional knowledge and practices and current water resource management mechanisms in risk mitigation, and potential paths for further improvement;
3. To inform stakeholders of latest research findings and current research activities in India, as well as, UK scientific outputs from the UK that are relevant to the monitoring and management of water supply in Central India;
4. To identify research gaps and to promote collaboration and the co-design of projects amongst participating UK-based and Indian scientists, and together with end users.

The event will be spread over three days. The first two days will be dedicated to talks by scientists and stakeholders; the scientists will be presenting the state of art in joint India-UK water security research while the stakeholders will talk on the current water resource management scenario and practices in central India. The talks and discussions will focus on the following sectors of Water resource and supply management in Central India:

- Energy;
- Domestic and Industrial water supply;
- Irrigation for agriculture;

The talks will be followed by joint question and answer sessions at the end of each session directed specifically at the topics presented (for further details on the speakers and talks please refer to the event agenda).

The third day will be dedicated to breakout group discussions and plenary sessions wherein the participants will consider:

- The potential uses of previous UK-India joint research;
- The impact of using this new science;
- Factors/ barriers associated with uptake of different scientific methods;
- Further research needs to enable the sector to make use of the science;
- Best way to achieve the above needs.

Expectations & Preparation for stakeholders

This event has been designed to adopt a step by step approach to understand the issue at hand, including state of art scientific capacities available to handle the issues and feasibility of its application on the ground. The participants are therefore expected and requested to attend all sessions so that they can actively participate in the discussions on day three around the potential applications of joint India-UK research to improve freshwater monitoring frameworks and data at the state level.

The event is multi-sectoral and multi-stakeholder in nature. Representatives from state governmental bodies, NGOs and academic organisations from the state of Madhya Pradesh are expected to attend the event along with scientists working on joint India – UK projects. Scientists working in collaboration with the state government on various projects have also been invited. All delegates are expected to initiate and contribute actively to all discussions

It is anticipated that delegates will have a range of local (and sector specific) perspectives on the issues under discussion which we hope you will share during the event however, wherever possible, we encourage you to focus on problems and solutions with common applicability across central India.

Delegates can prepare in advance for the discussions by considering:

- The current pressing issues in water resource management and supply within their sector
- The way in which research outputs are/have been used to improve water resource management in their own organisation;
- Future science and technological needs of their sector in relation to water resource management;
- Methods which could be used to increase the update of research outputs and improve collaboration between researches and the organisation. to address the above needs and explore ideas for collaboration

Expectations & Preparation for scientists

This event has been designed to disseminate the outputs of joint India – UK research to regional stakeholders and identify limitations in translation of science into practice. The event is multi-sectoral and multi-stakeholder in nature. Representatives from governmental bodies managing water resource, NGOs and academic organisations from the state of Madhya Pradesh are expected to attend the event. Scientists working in collaboration with the state government on various projects have also been invited.

To achieve effective engagement with the invited stakeholders; scientists presenting are requested to present the outputs of their previous joint India – UK research work, concentrating on how the results can be practically used on ground. Presentations should clearly outline the research and resulting benefits in a way which is accessible to those who aren't scientific experts in the field.

The stakeholder talks aim to expose the scientists to the stakeholder' side of the issue including, current water resource management scenario, issues, adaptation practices and technologies used in central India. This understanding will ensure active participate in the discussions on day three around the potential applications of joint India-UK research to improve water resource management at the state level.

During day three, scientists will be expected to take a lead in initiating discussions during group breakout sessions. It is important that these discussions focus on how the output of India-UK water science could be used to help solve the operational and policy issues faced by stakeholder participants. To this end, it is important that discussions give due consideration to the range of issues expressed by stakeholders, whether they be day-to-day field problems, longer-term policy matters or anything in between.

Given the above the key expectations from scientists are

- To demonstrate the utility of their previous joint India–UK research in freshwater monitoring;
- To represent the current capabilities of their research area more widely, conveying information about potential benefits and utility for stakeholders;
- To ensure delivery of presentations in a simple and applied manner and, where possible, provide practical demonstrations of tools/equipment/findings;
- To interact with stakeholders and explore ideas for coproduction of scientific outputs.

Scientists can prepare in advance for the discussions with stakeholders by considering:

- The practical benefits and potential uses of their joint India-UK research;
- The current uptake of the research by governmental bodies/stakeholders in India and its application on ground;

- Any lessons which can be shared from use of similar research outputs by stakeholders in other parts of the world;
- Methods which could be used to increase the uptake of research outputs and improve collaboration between researchers and stakeholders. For example:
 - How could we improve the integration of stakeholder knowledge into the scientific research process and;
 - What practical role could researchers play in helping integrate scientific findings into operation use within water policy/management bodies beyond the end of a research project.

Logistical information

Travel

Flight bookings: You are requested to make your own Air India flight bookings if your institution is located outside Madhya Pradesh. IUKWC India Centre, Indian Institute of Tropical Meteorology will reimburse the expenses for Air India flights (booked through Air India website / Blamer & Lawrie Co. Ltd. Only) post the workshop, subject to submission of original tickets and boarding passes.

Train/Bus reservations: You are requested to book your own Train (2AC) or Bus tickets, the same will be reimbursed to you after the workshop, subject to submission of original tickets/receipts.

Local Transport: Local taxi services/ airport taxis maybe used for airport transfers or to travel to IISER, Bhopal from your place of work. The expenses for the same will be reimbursed to you after the workshop subject to submission of original tickets/ receipts.

Accommodation

Accommodation will be provided to outstation delegates only, kindly confirm with IUKWC secretariat regarding your accommodation needs. Accommodation for the event will be booked at IISER, Bhopal; the complete address for the venue is as below

Indian Institute of Science Education and Research Bhopal Bhopal Bypass Road, Bhauri
Bhopal 462 066, Madhya Pradesh, INDIA

Distance from Bhopal International Airport: 11.2 Kms (20 mins) Distance from Bhopal Railway Station: 18.7 Kms (50 mins)

Google maps link: <https://goo.gl/maps/essy1FS1o632>

Meals

Lunch, Tea and Dinner from 28th February 2019 – 2nd March 2019 will be arranged by IUKWC. Expenses for Breakfast/ Lunch and Dinner taken in transit or in Bhopal on 27th February 2019 and 2nd / 3rd March 2019 will be reimbursed subject to submission of original receipts.

Reimbursements

Reimbursements for travel and meals will be processed only after the workshop subject to submission of original tickets/ receipts and boarding passes. An IITM reimbursement form will be circulated after the workshop. The reimbursement process may take up to 2 – 4 months after submission of receipts along with completed claim form

Further information is available on our website:

<https://iukwc.org/iukwc-uei-2-water-resource-management-supply-central-india>

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



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