

Climate Resilient and Sustainable Ganges Basin

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Background

The CGIAR Policy Innovations Science Program (PISP) aims to bridge the gap between rigorous research and effective policymaking to transform food, land, water, and economic systems across the Global South. It brings together CGIAR's analytical expertise and its partners — including governments, national think tanks, and civil society organizations — to co-develop evidence-based policy interventions that address real-world trade-offs and system complexities. In practice, the program focuses on strengthening institutional and analytical capacities of national think tanks, producing knowledge products on foresight, impact assessment, and governance, and informing a wide range of policy responses at local, national, regional, and global levels.

Within this framework, the program emphasizes several Areas of Work (AoW). Under the Water–Energy–Food–Environment (WEFE) Nexus Policy AoW 4, it seeks to overcome the fragmentation of sectoral policies by developing integrated system models and nexus-based solutions for climate-resilient water management, irrigation, and water governance.

A national-level workshop on “**Climate Resilient and Sustainable Ganges Basin**” was organized on December 1, 2025, in Delhi, India, to convene key stakeholders from government agencies, research institutions, and development partners to discuss pathways for strengthening groundwater security and climate resilience in the Ganga Basin.

Session 1: Strengthening Managed Aquifer Recharge Investments through Evidence: Insights from the Ganges Basin and Beyond

In the first session, the workshop presented and discussed findings from the field assessment of representative Managed Aquifer Recharge (MAR) sites in the groundwater-stressed Ramganga basin in the Ganges basin, to generate evidence on their hydrologic performance. The findings aim to guide future design, operational management, and investment decisions under development programs, supporting more sustainable groundwater recharge and improved water security in the Ganges basin and beyond. The two policy briefs from the study “*Strengthening managed aquifer recharge investments through evidence: insights from the Ramganga Basin in India*”¹ and “*Managing water quality risks for expanding managed aquifer recharge from village ponds: evidence from the Ramganga Basin in India*”² were released.

In the opening session, Dr. Faiz Alam welcomed all stakeholders and outlined the workshop's objectives. He introduced the first session entitled “Strengthening Managed Aquifer Recharge (MAR) Investments through Evidence: Insights from the Ganges Basin and Beyond”. Dr. Alok Sikka, Country Representative, IWMI India briefly gave an overview of the work, which was started under the CGIAR NEXUSGains initiative, which is now part of the Policy Innovation Science program, and emphasized the importance of cross-institutional collaboration among different CGIAR centers.

In his opening address, Dr. Sikka provided an overview of the Indian MAR policy landscape. He noted that the Indian agricultural system is predominantly irrigation-dependent, with approximately 85% of total water use allocated to irrigation. Within this, nearly 65% of irrigation demand is met from groundwater resources. This high reliance has led to overexploitation of groundwater in many regions, where groundwater development has exceeded the generally accepted safe limit of around 70%. He further emphasized that climate change is intensifying rainfall variability, with a tendency towards short-duration, high-intensity events that increase surface runoff and reduce the residence time available for infiltration. As a result, the potential for natural recharge of aquifers is reduced, thereby increasing pressures on groundwater storage, thus necessitating recharge interventions. He highlighted Managed Aquifer Recharge as a targeted, goal-oriented approach in which recharge sources (such as rainfall, canal water, and treated wastewater) are systematically linked with high-demand aquifer zones. He showcased India's history

¹ Alam, M.F., Sharma, N., Pavelic, P., Sikka, A., 2026. Strengthening managed aquifer recharge investments through evidence: insights from the Ramganga Basin in India. <https://hdl.handle.net/10568/181470>

² Pavelic, P., Sharma, N., Alam, M.F., Sikka, A., 2026. Managing water quality risks for expanding managed aquifer recharge from village ponds: evidence from the Ramganga Basin in India. <https://hdl.handle.net/10568/181705>

with MAR over the years and recent emphasis on implementation through flagship programs like the Catch the Rain campaign and the Jal Shakti Abhiyan, which encourage rainwater harvesting and artificial recharge. He underlined the need to assess dynamic recharge patterns and to implement community-driven, decentralized aquifer recharge plans, drawing on concepts such as Jal Sanchay and Jal Bhagidari, in which local communities and panchayats actively participate in design, implementation, and monitoring.

Following this, Dr. Sikka invited Dr. Thakur Bramanda Singh, Member Secretary, Central Ground Water Board (CGWB), Government of India, to deliver the special address. Dr. Singh focused on CGWB's experience in promoting MAR and artificial recharge structures across India, particularly in over-exploited, critical, and semi-critical blocks in low-rainfall regions such as Gujarat and Rajasthan. In these areas, rainfall is the primary water source, and artificial recharge structures such as small check dams, recharge wells, and underground tanks are used to slow or obstruct runoff so that more water percolates into the subsurface. He underlined that these structures are crucial for capturing monsoonal rainfall and storing it in aquifers for utilization during dry periods.

Dr. Singh also discussed how changing rainfall patterns have important implications for the design of recharge structures. In some parts of Rajasthan, for instance, the long-term rainfall regime has shifted from approximately 300–400 mm to 400–600 mm in recent years. This shift has resulted in the overtopping of existing check dams designed for lower rainfall scenarios, necessitating redesign and capacity enhancement to accommodate higher inflows. He emphasized the need to explicitly account for both groundwater draft and recharge in planning, as their balance ultimately determines resource availability and must guide both supply-side interventions and demand management strategies.

Building on this broader framing, Dr. Faiz presented field-based evidence of MAR implementation in the Rampur and Moradabad districts of the Ramganga Basin in Uttar Pradesh, India. The IWMI team has been monitoring the recharge performance of small-scale MAR interventions, with a focus on four types of ponds: regular ponds without additional interventions, ponds with desiltation and bunding measures, ponds with recharge wells and ponds with recharge pits. Based on the results, several technical and operational recommendations were proposed. First, inlet design and catchment treatment must be improved through upstream conservation and field/farm bunding to reduce erosion and sediment inflow. Second, ponds should be desilted at least once every three years, with funding provided by local budgets or schemes like the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNRES), and this should be part of long-term O&M plans. Third, guidance was provided on the siting and design of the recharge wells and pits. Recharge wells are suitable only where groundwater levels are deeper than about 10 m, with regular filter cleaning essential. For ponds with dead storage or linked to fisheries/agriculture, low-cost recharge pits were recommended as a simpler alternative that enhances recharge, especially when their combined area is at least 1% of the pond area. For ponds focused on recharge, lowering dead-storage levels (currently ~1–1.5 m) was advised to increase active recharge volume.

Finally, Dr. Faiz emphasized the importance of participatory monitoring and incentive-based governance. He proposed that citizen groups and panchayats be involved in routine monitoring of pond water levels, groundwater levels and maintenance, and that incentive mechanisms be designed to link measurable outcomes, such as improved water availability, better maintenance and stabilized groundwater levels, to local rewards or support, thereby encouraging sustained community engagement.

Complementing these research insights, Dr. Singh from CGWB presented experiences from MAR implementation in Rajasthan, Gujarat, and other regions. He provided evidence that properly designed and maintained recharge structures can significantly increase aquifer storage, thereby enhancing water security for both drinking water and irrigation in water-stressed areas. These examples reinforce the conclusion that MAR is a critical instrument for building climate resilience, especially in over-exploited and critical aquifer systems in semi-arid and arid regions.

Dr. Paul Pavelic, Senior Researcher at IWMI, presented his work on "Managing Water Quality Risks for Expanding MAR from Agricultural Ponds: Evidence from the Ramganga Basin." His presentation focused on understanding how pond water quality varies with land use, and how this directly influences the suitability of water for Managed Aquifer Recharge. He emphasized that water quality risks from MAR are particularly important because, while contaminated surface water can be treated relatively easily due to its accessibility and known volume, contaminated groundwater is much more difficult to address. Once pollutants infiltrate into aquifers, the extent of contamination becomes uncertain, and remediation is costly and often technically challenging. Dr. Pavelic presented results for water quality sampling taken from 9 monitored ponds. Dr. Pavelic presented findings that showed in the Ramganga Basin small, locally sourced MAR systems in agricultural areas are largely chemically safe, with microbial risks being short-lived and manageable through simple safeguards. These decentralized systems offer a low-cost, low-risk option to strengthen groundwater security in the Gangetic Plain, but expanding them under national

programmes requires stronger water-quality safeguards in higher-risk zones. Based on the work, he provided four recommendations: (1) develop national, risk-based water-quality guidelines for MAR, led by BIS with CGWB and states, focusing on achieving potable quality at the point of recovery and allowing flexibility during recharge; (2) establish a coordinated national framework for monitoring source and groundwater quality across MAR typologies; (3) mainstream low-cost operational improvements—such as sediment control, regular desilting, livestock exclusion, and wastewater diversion—to reduce sediment and microbial risks; and (4) strengthen community awareness and capacity, as local practices heavily shape contamination risk and long-term MAR performance.

Dr. Thomas presented on “Effectiveness of Experiential Learning for Collaborative Management and Governance of Groundwater in India,” which emphasized how experiential learning tools, particularly role-playing games, strengthen collective decision-making and improve water governance. The groundwater game enables farmers to experience long-term extraction and recharge dynamics and their economic implications through pumping costs. By playing with communication with and without it, communities better understand cooperation, recharge limits, and sustainable cropping choices.

The Surface Water Game, implemented in 2017 across 60 villages, similarly demonstrated how experiential learning helps communities understand the consequences of water use and the need for shared rules to manage tanks and check dams. Follow-up interviews in 60 treated and 30 control villages, conducted nearly two years later, showed a significant rise in maintenance efforts, especially where women participated more actively, underscoring their vital role in governance. Scaling efforts through government and NGO partnerships have trained 7,634 extension workers and 511 NGO/private staff, enabling widespread adoption of these tools across thousands of communities.

Following this, Dr. Proloy Deb, Researcher from the International Rice Research Institute (IRRI) presented on “Managing Groundwater Demand in Rice Systems: Understanding Water Productivity and Irrigation Decisions in Rice Fields.” Drawing on field experiments, he compared Direct-Seeded Rice (DSR) and Puddled Transplanted Rice (PTR) systems to quantify potential water savings while maintaining or improving yields. His work also aimed to understand farmer irrigation behaviour, which is a crucial determinant of groundwater demand.

The study, conducted in Haryana (Karnal and Panipat districts), involved 100 field plots, 50 under DSR and 50 under PTR. Results indicated that while yields were generally comparable, DSR achieved water savings of approximately 22–30% relative to PTR. However, yield variability within DSR plots was higher, which Dr. Deb attributed not to agronomic factors but to farmer behaviour, particularly tendencies toward over-irrigation despite DSR requiring less water. He concluded that improving water productivity in rice systems requires behavioural change among farmers in addition to technological or agronomic interventions, as DSR has clear potential to outperform PTR in terms of water-use efficiency.



Figure 1. IWWI researchers presenting their work and discussing research outcomes with participants at a workshop held in New Delhi on 1 December 2026. (photo: Tanmoy Bhaduri/IWWI)

Panel Discussion

A panel discussion followed, moderated by Dr. Paul Pavelic and joined by Ms. Anjali Makhija (Trustee and CEO, Sehgal Foundation), Dr. Anil Kumar Mishra (Technical Expert, NRAA), Sh. Vivek Grewal (Managing Partner, Well Labs), Dr. R. C. Jain (Advisor–Groundwater, Gujarat Water Resources Development Corporation), and Mr. Stephen Dohm (Advisor, GIZ).

The panelists offered varied perspectives on scaling MAR and enhancing groundwater governance. One key point discussed was the need to adapt MAR techniques to the local hydrogeological gradient. For example, recharge pits are effective in shallow settings with depths of around three meters, whereas recharge wells are required in deeper aquifers, typically greater than 10 meters, where direct injection into the aquifer is necessary.



Figure 2. Panelists engage in a discussion during Session 1 on strengthening Managed Aquifer Recharge (MAR) investments, sharing evidence and insights from the Ganges Basin and beyond. (photo: Tanmoy Bhaduri/IWMI)

Ms. Anjali highlighted the important role of women in water conservation and household water management in rural India, noting that any water governance strategy must incorporate gendered perspectives to be effective. Dr. Anil Kumar Mishra reflected on the substantial spatial and temporal variability of rainfall across India and how this affects irrigation scheduling for different crops from east to west and north to south. He emphasized the need for region-specific MAR approaches that are dynamic, sustainable and supported by strong policy frameworks.

Dr. Mishra further noted that data integration remains a significant challenge, arguing that datasets generated from different projects and institutions should be brought together on a unified platform. Such convergence is essential for monitoring, assessment and decision-making, particularly as water quality concerns differ for surface water and groundwater. While contamination in surface water can often be addressed relatively quickly, groundwater contamination is more persistent and difficult to remediate.

The discussion also underscored the importance of community engagement, particularly in aligning demand-side groundwater management with MAR through a targeted, participatory approach. Panelists stressed that communities should be encouraged and trained to adopt groundwater recharge practices locally. They collectively recommended that the Bureau of Indian Standards (BIS) develop guidelines for MAR inlet structures, to reduce sediment entry into ponds, a major cause of declining recharge efficiency. The panel further called for promoting community-driven maintenance and monitoring systems to ensure sustained performance and long-term effectiveness of MAR interventions.

Session: 2 Water–Energy–Food–Environment (WEFE) Trade-offs and Synergies in the Ganges Basin

Dr. D. R. Sena, Researcher at IWMI, commenced **Session 2** on “**Water–Energy–Food–Environment (WEFE) Trade-offs and Synergies in the Ganges Basin.**” In his opening remarks, he emphasized the growing recognition of the WEFE nexus as a crucial framework for addressing interconnected challenges in India’s water and agricultural sectors. He highlighted that the Ganga Basin, being the largest river basin in India and home to one of the world’s most densely populated regions, represents a complex mosaic of diverse cropping systems, heterogeneous soil classes, and highly fertile alluvial plains. This unique combination makes it not only a critical food production region, often referred to as one of India’s “food bowls” but also a hotspot for competing water, food, and energy demands among upstream and downstream users.

Dr. Sena then invited Dr. Alok Sikka to address the stakeholders and provide an overarching perspective on the WEF nexus approach. Dr. Sikka underscored the importance of irrigation in Indian agriculture and discussed the mounting risks associated with groundwater over-extraction, increasing dependence on borewells, and the consequent rise in energy demand for pumping. He explained how the intensification of groundwater use has led to escalating electricity consumption, creating pressures on both water security and the energy sector. His remarks aligned with the broader understanding that the intrinsic interdependence of water, energy, and food makes Indian agriculture an ideal case for adopting the WEFE nexus framework. This approach, he stressed, supports integrated modelling, optimized resource-use efficiency, and the development of productivity metrics that help harmonize synergies across sectors with water acting as the central unifying element.

Building on this, Dr. Sena elaborated on the need for Integrated Hydrological Modelling to move from qualitative understanding to quantitative assessment of the complexities of conjunctive water use in the Ganga Basin. He explained that such models allow the simulation of interconnections between surface water and groundwater systems, quantify upstream–downstream dependencies, and assess how soil moisture depletion influences crop yield and irrigation requirements. Groundwater flow modelling, in particular, helps quantify pumping needs, seasonal storage shifts in aquifers, and their cascading effects on the water–food–energy–environment dimensions. He stressed that without such integrative tools, it becomes difficult to fully understand or manage the multi-directional feedback that defines the WEFE nexus.

He further emphasized that integrated hydrological modelling serves multiple purposes: enabling system-wide interdependency analysis; quantifying trade-offs and identifying synergies; supporting evidence-based decision-making; integrating multiple spatial and temporal scales for comprehensive planning; assessing climate change impacts across sectors and strengthening cross-sectoral governance and policy coordination.

These capabilities make integrated modelling indispensable for sustainable planning in large, complex basins like the Ganga.

Dr. Sena then presented his detailed talk titled “From Models to Metrics: Quantifying Water–Food–Energy (WFE) Linkages through Integrated SW–GW Modelling and Dashboard Intelligence for the Ganga Basin.” He elaborated on a detailed integrated modelling framework to stakeholders, that combines surface water and groundwater simulations using SWAT+ and GWFlow, and integrates them into a WEF-Nexus Decision Support System (DSS). This web-based DSS supports scenario generation, Nexus calculations, WEFNI (Water–Energy–Food Nexus Index) computation, and policy-linked insights. He emphasized that the framework is generic and can be adapted to other basins, provided appropriate calibration and validation are performed.

He showcased results from multiple scenarios modelled for the Ganga Basin: a) Increasing water-use efficiency, b) Enhancing groundwater recharge, c) Crop diversification (e.g., shifting from rice to maize), d) Expanding irrigated area (converting rainfed areas to groundwater-irrigated). The scenario’s impact on changes in water fluxes relative to the baseline (BAU) condition, and changes in Water-Food-Energy Nexus Index (WEFNI) relative to the baseline (BAU) condition were shown.

He demonstrated how the dashboard visualizes WEFE outcomes. The triangular Nexus plots allow users to compare BAU and scenario metrics, highlighting regions where improvements occur. Dr. Sena explained that while the WEFNI may remain constant across scenarios, individual components such as water, food, and energy may shift significantly. For example, increasing groundwater recharges raises water tables, reduces pumping

requirements, lowers energy consumption, decreases input costs, and enhances water productivity, even if crop yield remains constant. This illustrates the interconnected and dynamic nature of Nexus relationships. He concluded that scenario-based modelling helps identify where strategic interventions and policy investments are necessary to achieve sustainable agricultural outcomes while balancing water, food, and energy objectives across the Basin.

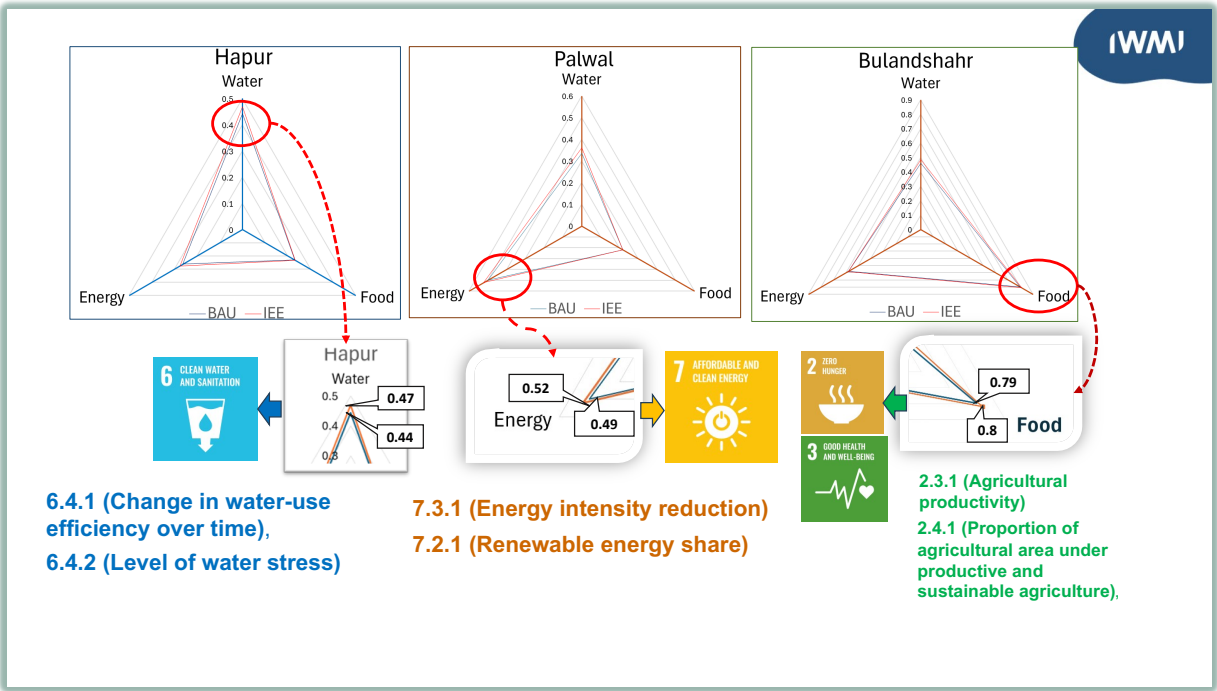


Figure 3. Water–Food–Energy Nexus Index (WEFNI) performance under the baseline (BAU) condition versus simulated scenarios reflecting irrigated area expansion, increase in groundwater, and increase in irrigation efficiency.

Mr. Dhyey Bhatpuria, Researcher at IWMI, presented the *waTer fRom space* (TRACE) tool: Harnesses satellite and Earth Observation datasets to assess surface water storage in water bodies”. The presentation emphasized that mapping surface water storage is critical for informed decision-making on water allocation, risk management, and sustainable resource planning, especially under increasing climatic variability.

TRACE follows a surface water storage mapping methodology that combines water surface area extraction from satellite imagery with terrain-derived information to estimate depth and volume. A key component is bathymetry derivation using a distance-based method, in which depth is related to the Euclidean distance of water pixels from the shoreline and the estimated maximum depth, and the derived bathymetry is merged with DEM to generate a contiguous elevation surface for volume estimation. The tool architecture integrates Google Earth Engine with a web-based backend and frontend for scalable analysis and delivery. Validation was demonstrated using daily water levels and reservoir volumes from CWC (2017–2019), with comparisons against IWMI’s approach and NRSC’s reservoir monitoring methods. Overall, TRACE offers a practical, dynamic pathway to estimate storage trends across reservoirs, tanks, and ponds, supporting evidence-based planning for multi-sector water use. This dynamic storage intelligence is essential for understanding seasonal water availability, strengthening surface–groundwater planning, and improving allocation strategies across agriculture, domestic use, and ecosystem needs.

Panel Discussion

The panel discussion brought together distinguished experts Dr. K. Yella Reddy (Vice President Hon., ICID), Dr. Sharad Jain (Former Director, NIH Roorkee), Dr. Sushma Sudhishri (Technical Expert, National Rainfed Area Authority, Government of India), Mr. Abhisek Sinha (Director NWP, Central Water Commission) and Dr. Anjali Bhagwat (Scientist C, National Mission for Clean Ganga) to reflect on the emerging role of the WEFN (Water–Energy–Food–Environment) Nexus and digital decision-support tools for sustainable planning in the Ganga Basin.



Figure 4. Panelists engage in a discussion during Session 2 on Water-Energy-Food-Environment (WEFE) Trade-off and Synergies in the Ganges basin. (photo: Tanmoy Bhaduri/IWMI)

Opening the discussion, Dr. Yella Reddy emphasized that although WEF nexus thinking has advanced significantly, its benefits do not always reach the end-user, the farmer. Even as India appears food-secure, many farmers still struggle with economic insecurity. He illustrated this with an example from Chittoor district, where a mango farmer adopted solar energy and drip irrigation, yet the absence of an assured market resulted in unsold produce. This gap, he stressed, shows that water-saving practices must be supported by strong market linkages, procurement assurance, and value chains. The key leverage point for improving water productivity, therefore, lies in strengthening the economic and policy ecosystem that enables farmers to confidently adopt water-efficient agriculture.

Responding to how integrated SW–GW modelling can enhance basin planning, Dr. Sharad Jain explained that traditional hydrological assessments often miss the dynamic linkages between surface water and groundwater. Integrated modelling reveals how pumping alters river flows, how canals recharge aquifers, and how upstream interventions influence downstream water availability. He recalled an instance when reduced river flows limited hydropower generation, underscoring how scarcity in one component cascades across sectors. Integrated modelling, he noted, aligns with national IWRM efforts and supports more resilient, cross-sectoral decision-making.

On digital twins and monitoring dashboards, Dr. Anjali Bhagwat observed that while current digital systems extensively include surface water, groundwater, and climate parameters, the food and agriculture dimension remains underrepresented. She highlighted the need for deeper collaboration with institutions like IWMI to ensure crop water use, agricultural demand, and food-system linkages are integrated into basin-scale digital frameworks. Standardization of data protocols, modelling approaches, and environmental-flow components, she added, would help build a unified digital ecosystem for the Ganga.

Speaking from CWC's perspective, Mr. Abhisek Sinha affirmed that WEFE-linked DSS tools offer strong potential for national water planning. However, their adoption requires clarity on data standards, modelling criteria, and validation processes, as government agencies must undergo multiple technical reviews before institutionalizing new tools. He welcomed collaboration with IWMI and similar initiatives, provided the tools align with national protocols and support transparent, evidence-based planning.

Turning to watershed programs, Dr. Sushma Sudhishri highlighted the opportunity to embed WEFE principles in flagship initiatives such as RKVY, PMKSY-Watershed, and state watershed missions. She described ongoing work in the REWARD program in Odisha and Karnataka, where DSS platforms and SWAT-based modelling are being

developed. Tools like TRACE and the WEFE DSS, she said, could be integrated to support PMKSY 3.0, particularly for assessing surface water storage, monitoring watershed dynamics, and incorporating environmental-flow considerations. She expressed interest in mainstreaming these tools within the Department of Land Resources to strengthen national watershed mission planning. The flexibility of the WEFE framework across district and sub-district scales, combined with TRACE's spatial estimates of storage potential, makes the tools adaptable to diverse basins and stakeholder needs.

Lessons learned / Outputs / Deliverables

Lessons Learned

The workshop reinforced the importance of integrating scientific evidence with policy processes. Bridging the gap between research outputs and field-level implementation remains a persistent challenge: while modelling tools and field assessments can provide robust data, uptake by government agencies requires alignment with existing institutional frameworks and data standards. The experience of CGWB and CWC highlighted that technical credibility and transparent validation are prerequisites for policy adoption.

Multi-stakeholder engagement enhances the quality and relevance of research. The participation of government bodies (CGWB, CWC, NRAA, NMCG, BIS), research institutions (IWMI, IRRI, NIH), and civil society organizations (Sehgal Foundation, WELL Labs, GIZ) generated richer discussions and more actionable recommendations than sector-siloed approaches. Gender-inclusive governance, underscored by the role of women in water management, emerged as a cross-cutting lesson that must be embedded in future programme design.

Two peer-reviewed policy briefs were released during the workshop: (i) "Strengthening Managed Aquifer Recharge Investments through Evidence: Insights from the Ramganga Basin in India" and (ii) "Managing Water Quality Risks for Expanding Managed Aquifer Recharge from Village Ponds: Evidence from the Ramganga Basin in India." Six technical presentations covering MAR performance monitoring, WEFE Nexus modelling, the TRACE satellite tool, rice-system water productivity, experiential learning in groundwater governance, and the MAR policy landscape in India were prepared and shared with participants (links in Annexure III). These presentations serve as reference training materials for government departments, extension workers, and future capacity-building programmes.

Action Plans Drafted

Panel discussions in both sessions resulted in the articulation of several priority action areas: (i) development of national, risk-based water-quality guidelines for MAR in collaboration with BIS, CGWB, and state agencies; (ii) establishment of a unified national data platform to integrate datasets across institutions for monitoring and decision-making; (iii) mainstreaming low-cost operational improvements for pond-based MAR (desilting, sediment control, livestock exclusion) within existing government schemes such as MGNREGS and PMKSY; and (iv) integration of the WEFE Nexus DSS and TRACE tools into the Department of Land Resources' watershed mission (PMKSY 3.0) planning cycle. These action priorities, identified collectively by workshop participants, will guide IWMI's engagement with government partners in the next programme phase.

Tools / Frameworks Introduced

The workshop introduced three principal tools and frameworks: (i) the WEFE Nexus Decision Support System (DSS), an integrated SW–GW modelling platform combining SWAT+ and GWFlow that enables scenario analysis and computes the Water–Energy–Food Nexus Index (WEFNI) across the Ganga Basin; (ii) the TRACE (waTer fRom spACE) tool, which harnesses Google Earth Engine and satellite Earth Observation datasets to dynamically map surface water storage in reservoirs, tanks, and ponds; and (iii) the Experiential Learning Framework (Groundwater Game and Surface Water Game), which uses role-playing simulations to build community and extension-worker capacity for participatory groundwater governance. These tools are generic and adaptable to other basins, provided appropriate calibration data are available.

Recommendations

Building on the discussions and outputs of the workshop, the following recommendations are proposed to sustain momentum and translate evidence into policy impact.

1. Institutionalize MAR water-quality guidelines. IWMI should work with BIS, CGWB, and state groundwater departments to co-develop national, risk-based water-quality standards for MAR inlet structures and recharge sources.

2. Scale the WEF Nexus DSS and TRACE into national planning frameworks. A follow-up technical workshop with CWC, the Department of Land Resources, and NRAA is recommended to demonstrate tool integration within PMKSY 3.0 and national IWRM processes. IWMI should develop a validation and documentation package aligned with government data standards to facilitate formal adoption.

3. Expand MAR monitoring and community engagement pilots. The participatory monitoring model piloted in the Ramganga Basin should be extended to additional over-exploited blocks. Future activities should include farmer and panchayat training on pond desilting schedules, recharge structure maintenance, and citizen-science water-level monitoring, leveraging MGNREGS funding and linking outcomes to measurable local incentives.

4. Strengthen data integration across institutions. A unified data-sharing platform for surface water and groundwater quality, quantity, and recharge monitoring should be developed collaboratively with CGWB, NIH, CWC, and NMCG. This platform should adopt interoperable standards to allow datasets from different programmes to be combined for basin-wide assessment and scenario modelling.

5. Organize a focused follow-up workshop on rice-system water productivity and farmer behaviour. Given the significant water-saving potential of Direct-Seeded Rice and the finding that over-irrigation by farmers constrains efficiency gains, a targeted workshop with IRRI, ICAR, and Haryana state agricultural departments is recommended to co-design behavioural change interventions and extension strategies for DSR adoption.

Annexure I - Agenda

Time (in Hrs)	Session	Lead
10:00 – 10:15	Context setting	Dr Alok Sikka Country Representative-India and Bangladesh/ Senior Fellow, IWMI
10:00 – 10:30	Opening remarks	Shri TB Singh Member (Innovation & Rejuvenation), CGWB
10:30 – 10:45	Managed Aquifer Recharge (MAR) Policy landscape in India	Dr Alok Sikka, IWMI
10:45 – 11:05	Recharge performance of small-scale MAR in Ramganga basin	Dr Faiz Alam Senior Regional Researcher, IWMI Dr Navneet Sharma Consultant, IWMI
11:05 – 11:25	Managing Water Quality Risks for Expanding MAR from Agricultural Ponds: Evidence from the Ramganga Basin	Dr Paul Pavelic Senior Researcher, IWMI Dr Navneet Sharma
11:25 – 11:40	Tea Break	
11:40 – 11:55	Effectiveness of experiential learning for collaborative management and governance of groundwater in India	Dr Thomas Falk Research Fellow, IFPRI
11:55 – 12:10	Managing Groundwater Demand in Rice Systems: Understanding Water Productivity and Irrigation Decisions in Rice Fields	Dr Proloy Deb Postdoctoral Fellow, IRRI
12:10 – 13:00	Panel discussion and Way Forward <ul style="list-style-type: none"> • Dr Anil Kumar Mishra, Technical Expert (Water Management), National Rainfed Area Authority (NRAA) • Ms. Anjali Makhija, Trustee and Chief Executive Officer - S M Sehgal Foundation • Dr. RC Jain, Formerly Chairman, Central Ground Water Board • Mr. Vivek Grewal, Managing Partner, WELL Labs • Mr. Stephen Dohm, Advisor, GIZ 	
13:00	Lunch	
Time (in Hrs)	Session	Lead
14:00 – 14:30	Opening and Context Setting	TBC
14:30 – 15:00	WEFE Modelling for Identifying Synergies and Trade-offs through an Innovative WEF Index Framework	Dr Alok Sikka Country Representative-India and Bangladesh/ Senior Fellow, IWMI
15:00 – 15:15	From Models to Metrics: Quantifying Water–Food–Energy (WFE) Linkages through Integrated SW–GW Modelling and Dashboard Intelligence for the Ganga Basin	Dr D R Sena Researcher – Hydrology & Water Resources Management, IWMI
15:15-15:30	TRACE: Harnessing satellite data and Earth Observation datasets for assessing surface water storage in water bodies	Mr Dhyey Bhatupuria Researcher, IWMI
15:30 – 16:15	Panel discussion and Way Forward <ol style="list-style-type: none"> 1. Dr K Yella Reddy, VPH, ICID 2. Dr Sharad Jain, Former Director, National Institute of Hydrology, Roorkee 3. Dr Sushma Sudhishri, Technical Expert, National Rainfed Area Authority 4. Shri Abhishek Sinha, Director, NWP, CWC (TBC) 5. Sh. Anup Kumar Srivastava, Executive Director (Technical), NMCG (TBC) 	
16:15 – 16:30	Tea	
16:30 – 17:00	Demo of the WEFE DSS	Dr D R Sena & Team

Annexure II - Participants

Sl. No.	Name	Organisation
1	Alok Sikka	International Water Management Institute
2	Mohammad Faiz Alam	International Water Management Institute
3	Dipaka Ranjan Sena	International Water Management Institute
4	Abhijit Behera	International Water Management Institute
5	Shivam Chaudhary	International Water Management Institute
6	Ruchi Sharma	International Water Management Institute
7	Mehdi Alam	International Water Management Institute
8	Tanmoy Bhaduri	International Water Management Institute
9	Chitra Yadav	International Water Management Institute
10	Navneet Sharma	International Water Management Institute
11	Paul Pavelic	International Water Management Institute
12	Thomas Falk - Virtual	International Food Policy Research Institute
13	T B Singh - Virtual	Central Ground Water Board
14	Proloy Deb	International Rice Research Institute
15	Anil Kumar Mishra	National Rainfed Area Authority
16	Anjali Makhija	S M Sehgal Foundation
17	R C Jain	Central Ground Water Board
18	Vivek Grewal	WELL Labs
19	Stephen Dohm	GIZ

20	Dhyey Bhatupuria	International Water Management Institute
21	K Yella Reddy	International Commission on Irrigation and Drainage
22	Sharad Jain	National Institute of Hydrology
23	Sushma Sudhishri – Virtual	National Rainfed Area Authority
24	Abhishek Sinha	Central Water Commission
25	Anjali Bhagwat	National Mission for Clean Ganga
26	Ajit Kumar Behera	National Institute of Hydrology
27	Dushyant Prajapati	Bureau of Indian Standard
28	Vaibhav Jindal	Bureau of Indian Standard
29	Pallavi Rajkhowa	International Water Management Institute
30	D K Panda	ICAR-Indian Institute of Water Management
31	Munish Upadhyay	CEEW
32	Manas Sathpathy	PRADAN
33	Bharat Sharma	International Water Management Institute
34	Sabyasachi Puhan	Freelance
35	Warman Kulkarni	BAIF

Annexure III - Presentations

[Managed Aquifer Recharge \(MAR\) Policy landscape in India – Alok Sikka](#)

[Recharge performance of small-scale MAR in Ramganga basin – Faiz Alam](#)

[Managing Water Quality Risks for Expanding MAR from Agricultural Ponds: Evidence from the Ramganga Basin – Paul Pavelic](#)

[Managing Groundwater Demand in Rice Systems: Understanding Water Productivity and Irrigation Decisions in Rice Fields – Proloy Deb](#)

[TRACE Harnessing satellite data and Earth Observation datasets for assessing surface water storage in water bodies – Dhyey Bhatpuria](#)

[Effectiveness of experiential learning for collaborative management and governance of groundwater in India – Thomas Falk](#)



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