

Topic Concept Note Template

Thematic Process, 11th World Water Forum

- **Theme Number:** 5
- **Theme Title:** INNOVATION FOR WATER MANAGEMENT
- **Topic Number:** 5A
- **Topic Title:** HYDRO INFORMATICS AND AI TOOLS FOR WATER MANAGEMENT:
Leveraging AI, Earth observation, and digital tools with strong governance, cybersecurity, and tech-sector collaboration
- **Topic Coordinator:** Ambre Grimault, Deputy coordinator for the Initiative One Water Vision, INRAE (French National Research Institution of Agriculture, Food, and Environment)

I. Topic Overview

Rationale and Context

The water cycle is undergoing unprecedented disruptions due to climate change, ecosystem degradation, and increasing human pressures. Extreme droughts, floods, agricultural water stress, tensions over transboundary basins, excessive withdrawal and depletion of aquifers and deteriorating water quality challenge both natural and human systems. Moreover, the potential contamination by a wide range of pollutants and micropollutants places extreme pressure on clean water resources.

In this context, hydro-informatics, AI, and digital tools represent not only as technical innovations but also as strategic levers for strengthening climate resilience, for improving proactive water management, post-incident handling and fostering international cooperation.

This topic aims to contribute to the creation of more predictable, inclusive, and sustainable decision-making processes in a time of increasing uncertainty by placing digital and AI-based solutions at the heart of water management (forecasting, resource allocation, and decision-making for agriculture, urban water supply, ecosystem management, ...).

The topic has significance at multiple scales:

Global: AI, Digital water tools, internet of things (IoT), sensors, Earth observation, and advanced models provide large scale, high-dimensional datasets with wide spatial and temporal coverage

that can be applied globally. FAIR (Findable, Accessible, Interoperable, Reusable) principles ensure that these datasets are shared and usable across countries, supporting global water assessments, climate impact studies, and AI-driven analyses for water management.

Regional: At the regional scale, particularly in transboundary river and lake basins, coordinated programs and shared data frameworks enable collaborative water governance.

Local: At the local level, integrating earth observation, earth cartography, weather data, IoT models and AI with in-situ measurements and hydrological models allows precise, actionable insights for water managers (forecasting, resource allocation, and decision-making for agriculture, urban water supply, and ecosystem management).

Consistency across scales is one of the most critical added values of digital water tools. Integrating globally developed data and models into local decision-making processes through regional cooperation mechanisms enhances both policy alignment and implementation effectiveness.

This topic addresses several pressing water challenges, including the need for stronger international cooperation, a better understanding of the water cycle, and the use of innovative tools to meet the growing needs of water managers, scientists, and communities facing increasing water stress, water related natural disasters, and water ecological degradation.

In regions where in-situ monitoring networks are sparse or underfunded, innovation tools could provide freely accessible data. Moreover, AI and hydro-informatic tools are easily transferable across regions with similar conditions.

This topic is strongly aligned with **SDG 6 (Clean Water and Sanitation)** by promoting innovative tools, such as Earth observation, hydrological modelling, AI-based analytics, and integrated data systems, that support more accurate monitoring, improved forecasting, contribute in water quality protection and sustainable water management. The widespread adoption of digital water tools increases monitoring and reporting capabilities, making it easier to measure progress towards the SDGs.

A key dimension of the topic also contributes directly to **SDG 17 (Partnerships for the Goals)**. Ensuring FAIR (Findable, Accessible, Interoperable, Reusable) data, promoting shared digital platforms, and encouraging scientific and technical cooperation are essential for addressing water challenges across borders.

Progress in SDG 6 and SDG 17 also reinforces other goals. Advancing digital and modelling capabilities contributes to **SDG 13 (Climate Action)** by improving the ability to understand and anticipate climate-driven impacts such as droughts and floods. Similarly, these tools support **SDG 11 (Sustainable Cities and Communities)** by enabling better urban water management, early warning systems, and resilience planning. Although more indirectly, improved hydrological monitoring and water-quality indicators may also contribute to **SDG 14 (Life Below Water)** in contexts where freshwater–coastal interactions are critical.

Climate resilience is strengthened through the use of innovative tools that support countries facing increasing hydrological variability. By providing consistent, comparable datasets, practical

tools and actionable forecasts across regions, including areas with limited monitoring capacities, these tools encourage information exchange, help anticipate climate-related risks, and support evidence-based decision-making. There is also a need to improve connections with end-users to provide useful and efficient data and analysis.

Gender and youth inclusion are also embedded in the development and use of innovative tools. Digital innovation, AI applications, and new data ecosystems tend to attract and involve younger generations with emerging technical skill sets. Furthermore, promoting inclusive capacity-building, training, and open access to digital tools helps ensure that women and under-represented groups can participate more fully in the water information and technology sectors. This approach considers technological progress in conjunction with societal transformation

Digital innovation is at the core of this topic. Advances in Earth observation, including new satellite missions, together with AI, digital twins, and integrated modelling systems are transforming how water is monitored, understood, and managed.

Strong **partnerships** are essential to the effectiveness of these tools. Collaboration among scientific institutions, international organizations (such as UN agencies), space agencies, national hydrological services, and initiatives enables coordinated action, shared standards, and harmonized approaches.

Finally, **financing** remains a key enabling factor. Developing and maintaining innovative tools, from satellite missions to digital infrastructures and capacity-building efforts, requires sustained investment.

In addition, strong governance, cybersecurity, and collaboration with the technology sector are essential to build trust and ensure the sustainable use of digital and AI based water tools. The management of water infrastructure is subject to unprecedented level of complexity, due to regulatory pressure to water issues, but also to ensure resilience to physical and cyberattacks (risk-free testing of alternative decisions, ensuring preparedness and timely responses to malicious events, ...).

Objectives of the Topic

Technical objectives

- Promote the use of innovative digital tools, including Earth observation, AI, hydrological modelling, and digital twins, for improved monitoring, forecasting, early warning, anticipatory actions and management of water resources.
- Integrate innovative tools data with in-situ measurements to enhance hydrological understanding at global, regional, and local scales.
- Define appropriate and verifiable on-site water measurement techniques and methods for quality results
- Facilitate the development and implementation of interoperable and FAIR data systems and the research and development of evidence-based decision-making instruments.

Policy and institutional objectives

- Support transboundary and international cooperation by providing standardized, accessible water and associated data and tools to inform policy and governance decisions.
- Promote the operational integration and institutionalization of digital and AI tools within water utilities and basin organizations, ensuring their routine use in system operation, asset management, and risk-responsive decision-making beyond pilot stages.

Capacity-building and knowledge objectives

- Strengthen the technical and institutional capacity of stakeholders to use digital tools, AI, and modelling in water management.
- Foster knowledge management, exchange and collaboration among countries, scientific institutions, and private sector actors through shared platforms and joint initiatives.
- Engage youth and early-career professionals, and promote inclusivity in training programs, ensuring broad participation in the development and use of innovative water management tools. This can be done well by industry-university partnerships and scholarships adapting the university curriculum to real industry-level water management challenges

II. Key Issues, Opportunities, and Scope

Key Challenges

- **Data gaps and limited accessibility:**
Many regions still lack sufficient in-situ monitoring networks, and despite the availability of global innovative data, access and usability remain uneven across countries and institutions.
- **Need for fit-for-purpose tools.**
Many water information systems are not fit for purpose because they generate outputs that are overly technical or insufficiently connected to the decision-making needs of end users and key stakeholders. A significant gap remains in translating complex, multi-purpose water information—particularly in international or transboundary river-basin contexts—into indicators and language that are easily understood and usable by those who rely on them. One solution could be to improve the feedback loops.
- **Limited capacity to characterize uncertainty and support anticipatory action:**
Traditional hydrological and monitoring approaches often rely on deterministic analyses and retrospective assessments, with limited ability to explicitly quantify uncertainty, extend early-warning lead times, or support anticipatory decision-making for floods, droughts, and compound climate risks. (This is why we have above added 3rd technical objective).
- **Fragmented governance and institutional silos:** Water information is often managed by multiple agencies with limited coordination (local, regional, and global scales), while global datasets require cross-institutional and cross-border collaboration to be effectively used.
- **Limited operational integration and institutionalization of digital and AI tools:**

Many digital water solutions remain at pilot or analytical stages and are not fully embedded into routine water operations, operational rules, or decision protocols of utilities and basin organizations, limiting their sustained impacts.

- **Resource and financing constraints:**

Developing, maintaining, and operationalizing innovative tools requires sustained funding, which is often lacking for digital infrastructure, capacity-building, or long-term monitoring programs.

Opportunities and Strategic Importance

- **Scaling up the use of digital tools** to improve decision-making on water resources, droughts, floods, and ecosystem management.
- **Accelerating innovation** through AI, cloud platforms, modelling, and open-source analytics tools that make data more accessible and actionable.
- **Promote transfer of knowledge and experience.**
- **Enhancing user engagement (agile methodology) and co-design** to ensure new products meet real operational needs and can be rapidly adopted.
- **Supporting policy coherence** by linking hydrological information to climate adaptation, agricultural planning, disaster preparedness, data security and resilience, and water governance reforms.
- **Encourage policymakers to establish frameworks** for financing, producing, and sharing water data and technologies.
- **Leveraging international partnerships and financing mechanisms** to sustain data production, capacity building, and digital infrastructure development.

Proposed Priorities of the Topic / Guiding Questions

- How can AI-enabled approaches improve uncertainty characterization, early warning, and anticipatory action for floods, droughts, and compound climate risks, beyond traditional monitoring and modelling systems?
- How can digital and AI tools be effectively translated into routine operational decision-making, including operational rules, thresholds, and risk-responsive actions within water utilities and basin organizations?
- What strategies can be adopted to overcome institutional barriers and promote effective coordination among agencies for integrated water information management?
- How can innovative tools be leveraged to enhance the uptake of quantitative findings and insights from water information systems among key stakeholders and end users?
- How can innovation ecosystems (academia, startups, public agencies) be strengthened to generate user-driven and operational solutions?
- What capacity-building approaches are most effective to empower countries and users to interpret and use advanced hydrological information?
- How can financing be mobilized to support digital water transformation, from infrastructure to analytics tools and training programs?

- How can global datasets enable cooperation, especially in transboundary basins or regions with limited ground observations?

Proposed Sessions of the Topic

1. Integrating Earth Observation and In-Situ Data for Water Resource Management

Focus: Earth observation–based systems combined with in-situ and weather data for monitoring, forecasting, and managing water resources; applications for floods and droughts; handling data gaps and uncertainty in data-scarce regions; global datasets supporting regional and local decision-making; ensuring preparedness and timely responses to malicious event (cybersecurity); relevance for end-users and key stakeholders’ translation of integrated data into operational thresholds and decision-support inputs for end-users and key stakeholders

2. AI and Hydro-informatics for Water and Risk Management

Focus: AI-enabled analytics and hydro-informatics tools for water-related risk management, including flood and drought forecasting and early warning, contingency planning, impact assessment, uncertainty reduction, spatial downscaling, and automated synthesis of complex water information for decision-makers and practitioners.

3. Knowledge Management and Capacity Strengthening for Operational Water Tools

Focus: Connecting water research, digital tools, and operational needs; knowledge management, capacity strengthening, and user support to enable effective and routine operational use of Earth observation, AI, and modelling tools by practitioners, institutions, and local authorities, including interpretation of uncertainty and integration into operational rules and workflows

4. Financing Digital Water Transformation (Joint Session)

Joint with: Theme 2 (Water Finance) and Topic 5C (Data and Information Systems)

Focus: Financing models, partnerships, and long-term investment strategies for digital water infrastructure, research and development, operational services, and capacity strengthening; role of development banks, donors, and public-private partnerships.

III. Expected Outcomes and Deliverables

Policy and Strategic Outcomes

- Recommendations for integrating digital tools into national and regional water policies.
- Guidance notes on best practices for data governance, FAIR data implementation, and cross-border water information sharing.
- Frameworks to align water management strategies with SDG, climate resilience, and international cooperation objectives.
- Guidance notes for water research and development financing and water data production locally

Technical and Knowledge Deliverables

- Operational tools and methodologies combining digital tools for monitoring, forecasting water resources, water infrastructure security and water data quality.
- Data platforms and dashboards to facilitate access, visualization, and analysis of hydrological information.
- Case studies and synthesis notes illustrating successful applications of digital water tools in different regional contexts.

Partnerships and Financing Outcomes

- Strengthened collaborations among scientific institutions, public agencies, international organizations, and private sector actors.
- Exploration of innovative financing models to sustain infrastructure, capacity-building, and technology deployment.

Actions and Initiatives for Implementation

- Pilot projects at basin, city, or regional levels to test integrated water monitoring solutions.
- Support the transition of digital and AI-enabled tools into routine operational use by utilities and basin organizations, beyond the pilot stage.
- Development of collaborative networks and MoUs to promote data sharing, joint research, and coordinated action.
- Innovation challenges or hackathons to stimulate user-driven solutions and technology uptake.
- Present pilot projects on satellite monitoring under the framework of the INBO/WMO Task Force and as a contribution to the One Water Vision and linked to the Basin Segment of the Political Process
- Projects covering cybersecurity preparedness (CityFlow Live, DHI).

Communication and Visibility

- Key messages highlighting the benefits of innovative digital tools for water management, climate resilience, and international cooperation.
- Contributions to public communications, awareness campaigns, and Forum publications.
- Inputs to the 11th World Water Forum declaration to ensure visibility of data-driven and partnership-oriented initiatives.

IV. Monitoring and Post-Forum Action

The outcomes of this topic are expected to contribute to a long-term legacy of the 11th World Water Forum by establishing frameworks, tools, and partnerships that continue to inform water management practices beyond the event.

- *Long-term Forum legacy*
 - Creation of operational guidelines, recommendations, and technical tools that remain accessible to stakeholders after the Forum.
 - Strengthening a culture of data-driven decision-making, with FAIR principles embedded in water information systems.
 - Data Platform digital tools
 - Encourage the participation of technical, scientific, academic and organizational leaders in the forum by helping them develop a plan for sharing information from this forum.
- *Follow-up initiatives toward the **12th World Water Forum***
 - Pilot projects and regional collaborations initiated under this topic can provide case studies and evidence for future Forum discussions.
 - Continuous refinement of methodologies and platforms based on user feedback and lessons learned during the 11th Forum.
- *Contributions to global agendas (e.g. UN processes, climate conferences, basin networks)*
 - Alignment of outputs with SDG 6 and related goals, climate action frameworks, and international water governance processes.
 - Support to basin networks, UN processes, and climate conferences through the provision of shared data, modeling insights, and actionable recommendations.
- *Continued partnerships, knowledge-sharing, and monitoring mechanisms*
 - Sustained international and cross-sector collaborations fostered through joint projects, shared platforms, and regular exchanges.
 - Monitoring mechanisms established to track the use and impact of digital tools, models, and datasets in supporting water management and policy decisions.
 - Knowledge-sharing initiatives, including workshops, webinars, and open-access publications, to maintain engagement and build capacity across regions.

V. Proposed Cross-Process Dialogue Areas

Integrating digital water tools across sectors

- Explore how Earth observation, AI, modelling, and FAIR data systems can support multiple sectors: agriculture (1E, 1D), urban planning and resilience (3A, 1C, 1B), climate adaptation (1B), and ecosystem management (3C, 3D), and insurances.
- Foster synergies with topics on innovation (5B–5E), urban water management, and water-energy-food-health interlinkages (3E) to develop shared methodologies and cross-sectoral applications.

Data governance, interoperability, and institutional collaboration

- Facilitate dialogue on harmonized data policies, FAIR principles, and cross-border cooperation (1A, 4A–4C, 5C).
- Engage governance and diplomacy topics (4A–4E) to ensure that institutional frameworks and regulations enable effective data sharing, integration, and decision-making.
- Engaging fundings (2A, 2C)

Innovation and user-centered solutions for water challenges

- Discuss mechanisms to connect technological innovation with operational needs, policy uptake, and end-user feedback, linking Innovation for Water Management (5A–5E) with Water Security (1D, 1E) and Water for Humans and Nature (3D, 3E).
- Explore co-development of tools and citizen-science approaches to enhance adoption, relevance, and inclusivity.

Ministerial and basin authorities' collaboration

- Support transboundary water governance and climate adaptation planning using shared digital platforms, and innovative tools.

Local and regional authorities' engagement

- Enable operational applications of digital tools at the city or basin level, enhancing resilience, early warning, and integrated water management practices.

Potential collaboration with regional process

- **Regions with limited in-situ monitoring and high-water stress** (Asia, Africa, South America) – Where innovative tools can fill critical data gaps and support risk-informed decision-making.
- **Transboundary basins** (Europe, Africa, South America, ...) – Where cooperation between countries is essential and shared datasets, digital platforms, and modelling outputs can facilitate equitable and sustainable water management.