Water4All
Water security for the planet

European Partnership

# Strategic Research and Innovation Agenda



SRIA

Co-funded by the European Union

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# Foreword



**In a situation with wars and conflicts in many parts of the world, also in Europe's own backyard, the need for scientific cooperation within Europe and beyond is ever increasing. To counteract deterioration of water sources and climate change effects and ensure enough water of a decent quality for all is everybody's responsibility, and to develop water solutions for mankind is something which unites more than it divides. This is the legitimacy of Water4All.**

Water4All was launched in June 2022, and the first Strategic Research and Innovation Agenda (SRIA) of the Partnership was released soon after on the 30th September 2022. When it was launched, the Partnership was one of the largest Research and Innovation (R&I) water networks and funding mechanisms ever established, and it offered a unique opportunity for all water professionals involved in research and innovation in Europe to bring knowledge and solutions to a new level.

After having been in operation for 4 years, a number of initiatives within the priority themes identified at that time have seen daylight. The Partnership is constantly and collectively delivering new knowledge and solutions, both in terms of more holistic thinking and interactions of the whole water cycle with nature and society and in terms of management approaches and new technologies.

However, the world is changing, for the time being faster than we have experienced for many decades, and so is the perception of priorities and how the global situation is encoded by the water professionals within the Partnership. The SRIA of the Partnership therefore has to reflect this change, and it has now been updated accordingly in this second version taking departure in three key water-related challenges: water and ecosystem degradation, hydroclimatic extremes and water scarcity and imbalance. This update is at the same time an indication of the ability of the Partnership to absorb and adapt to changes, balancing existing and new upcoming challenges and still keep the strategic orientations which were set in 2022 in the context of the EU Green Deal. The updated and reformulated SRIA also shows the potential of the Partnership to reflect new tendencies in the world in the water domain. As such, it is well aligned with the three strategic goals of the European Water Resilience Strategy, which was launched by the Commission in 2025 as a guiding policy document for all upcoming water initiatives in Europe. The Partnership also answers the global call for science-based adaptation to a new hydrological reality made by United Nations University - Institute for Water, Environment and Health in the 2026 report on 'Global Water Bankruptcy'.

Furthermore, in a situation with wars and conflicts in many parts of the world, also in Europe's own backyard, the need for scientific cooperation within Europe and beyond is ever increasing. To counteract deterioration of water sources and climate change effects and ensure enough water of a decent quality for all is everybody's responsibility, and to develop water solutions for mankind is something which unites more than it divides. This is the legitimacy of Water4All. The framework for the ambitious efforts of Water4All is the SRIA. Building on the work of the Partnership until now by dedicated water professionals and organisations, this updated SRIA sets the priorities for the remaining period of the Partnership and paves the way for new water initiatives along the same path, when the Partnership has to be replaced by other multilateral water ventures with renewed ambitious research and innovation goals within or outside the upcoming 10th framework programme.

**Bjørn Kaare Jensen**
Chair 2022-2026 of Water4All



# Abstract

**This document presents the Strategic Research and Innovation Agenda (SRIA) Version 2 (2026) of the Water4All Partnership, a comprehensive update reflecting 3.5 years of collaborative research, stakeholder engagement, and policy evolution since the partnership's launch in 2022.**

Water4All is a Research and Innovation (R&I) Partnership established under Horizon Europe, with the long-term ambition of ensuring water security for all. It seeks to accelerate systemic transformations across the entire water R&I landscape, notably by strengthening connections between those facing water-related challenges and those developing solutions. Beyond the implementation of joint calls for proposals, the Partnership supports a broader range of activities, including the alignment of national and regional programmes, demonstration initiatives, international collaboration, knowledge sharing and dissemination, as well as networking and capacity-building efforts.

This updated SRIA is grounded in a rigorous evidence base. A bibliometric analysis of over 10,000 research abstracts from the Web of Science, combined with AI-assisted full-text analysis of 2500 papers, identified emerging research trends and gaps. These findings were validated and enriched through foresight workshops, partner and stakeholder consultations, and a broad public consultation across the European water community. The result is a research agenda that is both scientifically robust and responsive to stakeholder needs.

Through its activities, Water4All aims to contribute to a deeper understanding of water-related processes across multiple scientific domains, while supporting key European and global policy frameworks such as the European Water Resilience Strategy (EWRS), the European Green Deal, and the United Nations Sustainable Development Goals (SDGs). At the time of publication, the partnership brings together over 90 organisations, including research funding bodies, public authorities (notably at local level), research organisations, and water-related associations and networks operating at European, national and regional scales. These partners have joined efforts to collectively address the pressing challenge of water security. The Partnership is structured around five operational pillars: strategic coordination (Pillar A), R&I funding through calls (Pillar B), the science–policy–society interface (Pillar C), demonstration activities (Pillar D), and international cooperation (Pillar E).

The SRIA identifies priority areas for R&I to be addressed through Water4All activities. It builds on previous strategic work in the water domain, including earlier initiatives, and integrates input gathered through extensive consultations with partners and stakeholders, as well as a broad public consultation conducted across the European water community. Based on this process, **the SRIA is organised around five key thematic areas:**

- Water-smart, circular and competitive economy
- Water for ecosystems and biodiversity
- Integrated water management
- Water and health
- Water infrastructures

Each theme is further detailed through specific sub-themes and research topics presented in this document.

To maximise its impact, Water4All also seeks to create synergies with other European initiatives, particularly Horizon Europe partnerships and missions. The SRIA therefore highlights areas of complementarity and outlines how its activities and operational pillars can contribute to broader European and international

policy objectives. Strengthened cooperation is expected to enhance critical mass, facilitate knowledge exchange, and promote the uptake of best practices and lessons learned.

The SRIA includes a comprehensive monitoring framework aligned with the SDGs, particularly SDG 6 (Clean Water and Sanitation). The framework defines key performance indicators (KPIs) across four objective levels—general, specific, operational, and thematic—enabling systematic assessment of the partnership's contributions to water security, ecosystem restoration, climate resilience, and inclusive governance. This evidence-based approach ensures accountability and supports adaptive management throughout the partnership's lifecycle.
The monitoring framework also incorporates a set of Key Performance Indicators (KPIs) for tracking progress towards the implementation of the SRIA. Amongst other objectives, such KPIs aim to help Water4All partners determine whether the SRIA is used as a strategic document guiding R&I options in partnering countries and regions.

The development of this updated SRIA has been significantly informed by the EWRS, which sets ambitious targets for water security, ecosystem restoration, and climate adaptation across the EU.



Under Horizon Europe, the EU 2021-2027 Research & Innovation Framework Programme, European Partnerships bring the European Commission (EC) together with public and private partners to address some of the most pressing challenges through joint development and implementation of R&I. These partnerships should accelerate the transition towards a green, resilient and competitive Europe and thus support the achievement of major EU policy objectives, such as those set for instance in the European Green Deal. Water4All is a co-funded Partnership addressing the challenges related to water: It aims at enabling water security for all on the long term through a broad range of activities including the launch of calls for proposals, data sharing, vocational training, impact assessment, valorisation and alignment, to cite just a few examples[1]. A description of Water4All is available on www.water4all-partnership.eu.

The thematic strategic orientations of Water4All are outlined in its SRIA. The Water4All's SRIA is structured into themes and subthemes, which are further divided into specific R&I topics. These topics are derived from identified knowledge in the water domain, based on literature reviews of key water-related strategic documents, as well as stakeholder and public consultations, and foresight analyses. The first Water4All's SRIA (https://www.water4all-partnership.eu/sites/default/files/2023-02/Water4All_SRIA-2022-2025_A4_2311_bd.pdf) was published in September 2022, prior to the official launch of the programme in Brussels that year. Following the publication of the first SRIA, Water4All partners initiated an update process leading to the identification and refinement of R&I topics.

Today, the SRIA plays a crucial role in Water4All's strategy. It not only defines the scope of annual calls for proposals, but also provides a detailed understanding of specific water-related areas where R&I and/ or policy action is needed to secure water for all.

The present document contains the second and updated version of Water4All's SRIA. It is the result of more than three and a half years of intense work during which partners have consulted numerous and different types of stakeholders, analysed tens of documents and integrated multiple perspectives. The current SRIA is organised as follows:

- Section 1: Vision, objectives and directions of Water4All.
- Section 2: Guidance principles for Water4All R&I projects.
- Section 3: Aims and development process.
- Section 4: Water4All's added value in the European context.
- Section 5: Water4All's R&I themes.

This document has been drafted by a Working Group composed of Water4All consortium members, under the leadership of ANR.

1 - Importantly, Water4All has developed a framework for best practices in data sharing. Further information is available at https://www.water4all-partnership.eu/joint-activities/data-sharing



# 1. Water4All's vision, objectives and directions

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## a. Key water-related challenges across Europe

Water is a fundamental resource underpinning life on Earth, ecosystems, and human activities. However, water is increasingly under pressure due to a combination of climatic, environmental, and socio-economic drivers. These pressures are no longer isolated or localised; they affect all European regions, albeit with varying intensity. Recent assessments highlight that water systems are under growing and increasingly interconnected pressures (EEA, 2024)[1].

### Deterioration of water bodies and ecosystem health

Despite decades of European, national, and local water policies and investments, the ecological and chemical status of European water bodies remains a major concern. Around 60% of surface water bodies in the EU are in poor ecological status, while approximately 30% of groundwater bodies fail to achieve good status. This persistent degradation reflects multiple pressures including diffuse and point-source pollution from agriculture, industry, and urban areas; nutrient pollution, chemical contaminants, emerging pollutants, and microbial contamination; hydromorphological alterations such as river regulation and abstraction; over-exploitation of groundwater resources; and cumulative impacts of climate change. This situation demonstrates that compliance with regulatory frameworks such as the Water Framework Directive (WFD) remains a major challenge. Moreover, pollution-related challenges are compounded by climate change, which can intensify pollutant concentrations during droughts and increase pollutant transport during floods.

### Increasing frequency and severity of hydroclimatic extreme events

90% of disasters worldwide are water-related, underlining the central role of water in climate risks (UNDRR, 2018)[2]. In Europe, both droughts and floods are becoming more frequent, more intense, and more damaging. A striking illustration is the European drought of 2022, during which 50% of the European territory received only 19% of its normal annual rainfall, with severe impacts on soils, ecosystems, biodiversity, agriculture, energy production, and water supply systems (ECMWF, 2023)[3]. Flood risks are also increasing due to more intense precipitation events, land-use changes, and the sealing of soils. Together, droughts and floods amplify damage to water resources, ecosystems, infrastructure, and economies, creating cascading effects across sectors.

### Growing water scarcity and imbalances in availability

Water scarcity is no longer confined to traditionally arid regions of Europe. Over the past two decades, and according to the EEA, renewable freshwater resources per capita have declined significantly in southern Europe with particularly strong pressures in countries such as Spain and Malta due to climate change and increasing demand (EEA, 2019)[4]. Water scarcity challenges the sustainability of socio-economic development and increases competition between uses, while also placing additional stress on aquatic ecosystems. In many regions, with water availability becoming a limiting factor for development, a fundamental rethinking of allocation, efficiency, reuse, and long-term planning is required.

## b. State of the art of European water research and innovation

### Strengths, key institutions and funding mechanisms

European water R&I has grown substantially over the past decade, establishing the EU27 as one of the world's leading contributors to the global water knowledge base. A bibliometric analysis of over 40,000 Web of Science records (2020–2025), conducted in support of this SRIA update, confirms that EU27 countries collectively produce approximately 13,000 water-related publications over this period—second only to China—with a distinctive comparative advantage in open-access dissemination (~75% of EU27 output versus ~57% globally), facilitating rapid knowledge diffusion and policy uptake. Research is carried out across a well-developed institutional landscape comprising national research agencies, European research infrastructures, Horizon Europe partnerships, and EIT (European Institute of Innovation and Technology) Knowledge and Innovation Communities. Funding mechanisms such as Horizon Europe, the PRIMA Partnership (Partnership for Research and Innovation in the Mediterranean Area), and coordinated national programmes under the Water Joint

1 - EEA, 07/2024. Europe's state of water 2024. The need for improved water resilience. https://www.eea.europa.eu/en/analysis/publications/europes-state-of-water-2024
2 - High Level Panel on Water. UNDRR, 05/2018. https://www.undrr.org/news/action-needed-water-and-disasters
3 - European Centre for Medium-Range Weather Forecasts (ECMWF), 2023. European State of the Climate 2022. https://climate.copernicus.eu/esotc/2022
4 - EEA, 2019. Trends and projections in Europe. Tracking progress towards Europe's climate and energy targets. https://www.eea.europa.eu/en/analysis/publications/trends-and-projections-in-europe-1

Programming Initiative (Water JPI) have enabled large-scale, interdisciplinary research programmes addressing the full water cycle from source to sea. European water research is characterised by strong integration across hydrology, ecology, engineering, economics, and social sciences, and by a proven capacity to produce governance-relevant knowledge and nature-based solutions (NbS).

EU27 water research is strongly anchored in SDG 6 (Clean Water and Sanitation, with pronounced co-alignment with SDG 3 (Good Health), SDG 15 (Life on Land), SDG 14 (Life below Water and SDG 13 (Climate Action), and reflecting the EU's integrated approach to water security across environmental, climate, and health dimensions.

### Major Gaps and Emerging Priorities

Despite these strengths, the bibliometric evidence and full-text synthesis underpinning this SRIA update reveal persistent gaps and rapidly evolving priorities that the current research portfolio does not yet fully address. Climate change adaptation remains a critical and cross-cutting need: compound extreme events (simultaneous droughts and floods), non-stationary hydrological regimes, and cascading risks across water-dependent sectors require integrated, forward-looking research approaches that go beyond incremental improvements to existing methods. Emerging contaminants—notably PFAS, pharmaceuticals, antimicrobial resistance (AMR), and microplastics/nanoplastics—pose growing risks to human and ecosystem health that current regulatory frameworks and treatment technologies are not yet equipped to manage at scale. The digital transformation of water systems, including AI-powered decision support, digital twins, IoT-based sensor networks, and real-time forecasting, is accelerating globally but remains unevenly adopted across Europe, with significant gaps in standardisation, interoperability, and governance of data-driven systems.

Innovation capture is a strategic vulnerability: EU27 accounts for only less than 5 % of global water-related patents (2020–2025) compared to China's over 50%, indicating a structural gap between Europe's strong publication output and its ability to translate research into intellectual property and scalable technologies. International scientific collaboration—a traditional EU27 strength—may have declined sharply in 2024–2025, weakening Europe's ability to shape global standards and co-develop solutions for transboundary water challenges. Finally, the circular economy approach to water management, while prominent in European policy, remains the lowest-priority research theme globally across all regions, signalling a need for stronger evidence-building and international engagement to build critical mass in this domain.

### How Water4All Addresses These Gaps

Water4All is specifically designed to bridge the identified gaps between European research strengths and the persistent challenges outlined above. The Partnership's thematic structure—organised around five R&I themes (Water-smart, circular and competitive economy; Water for ecosystems and biodiversity; Integrated water management; Water and health; Water infrastructures) — directly maps onto the priority areas identified through the bibliometric evidence synthesis, stakeholder consultations, and foresight analyses that informed this update. Each theme is further articulated through specific sub-themes and research topics that target the most pressing knowledge and implementation gaps. Beyond research funding, Water4All operates through five operational pillars—strategic coordination (Pillar A), joint calls for proposals (Pillar B), the science–policy–society interface (Pillar C), demonstration and living lab activities (Pillar D), and international cooperation (Pillar E)—that together create a full pipeline from knowledge generation to real-world implementation and policy uptake. This structure allows Water4All to address not only technical research gaps but also the regulatory, institutional, financial, and social barriers that have historically slowed the uptake of water innovations in Europe and beyond. By aligning its priorities with the EWRS, the WFD, the European Green Deal, and the SDGs, Water4All positions European water R&I as a cornerstone of both EU policy implementation and global water security.

## c. Scope of Water4All

According to the proposal by UN Water (2013)[5], "**water security**" stands for "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability"[6]. The Water4All Partnership is guided by this definition and tackles its various dimensions

5 - UN Water, «Water Security & the Global Water Agenda,» 2013. [Online]. Available: https://www.unwater.org/publications/water-security-global-water-agenda
6 - https://www.unwater.org/publications/water-security-infographic/

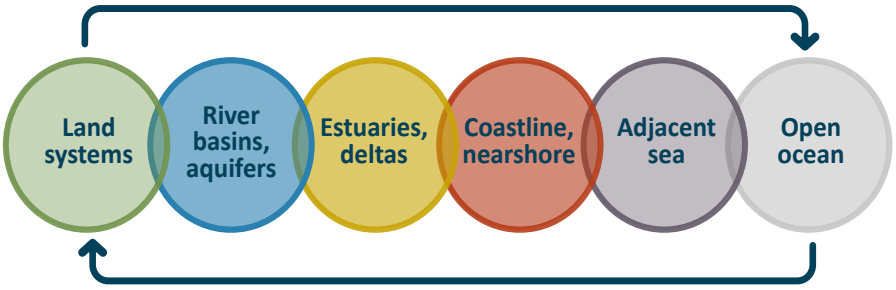



**FIGURE 1. SEGMENTS COMPRISING THE SOURCE TO SEA SYSTEM.**

Arrows indicate the upstream-downstream linkages between the segments (adapted from the Source to Sea -S2S- Platform)

(i.e., preservation of ecosystems, health, safeguarding of water resources for sustaining livelihoods and economic development, water-related disasters, governance).

As shown in **Figure 1**, Water4All adopts a **systemic approach from source to sea** that recognises the physical, ecological, and socio-economic connections across the entire water cycle. Rather than addressing freshwater challenges in isolation, this approach considers the water systems as continuous and interconnected, from their origins on land to their final discharge into marine environments. It encompasses land areas drained by river basins, hydraulically connected surface waters and aquifers, and the downstream recipients that depend on upstream water quantity and quality. These downstream systems include deltas and estuaries, coastlines and near-shore waters, adjacent seas and the open ocean. By addressing interactions and cumulative impacts along this continuum – including pressures such as nutrient and contaminant transfer, marine litter, underwater noise, sediment disruption, dredging, habitat loss, aquaculture pressures, and cumulative impacts of maritime activities on transitional and coastal ecosystems, Water4All aims to support integrated water management solutions that account for upstream-downstream linkages, cross-sectoral pressures, and land-sea interactions.

The **physical domains** covered in the Water4All Partnership are:

- Inland surface waters: rivers, streams, lakes, wetlands and upland source areas (glaciers, snow).
- Transitional and coastal waters (hyporheic zone, estuaries, coastal lagoons).
- Underground water, including both saturated and unsaturated zones. Explicit attention is paid to transboundary aquifer systems.

It considers all kinds of territories crossed by freshwater streams, i.e. rural areas, urban areas and peri-urban areas.

## d. Water4All's Vision

Water4All's Vision is to **"boost the systemic transfomations and changes across the entire water research –innovation – implementation pipeline, fostering the matchmaking between problem owners and solution providers for ensuring water security for all in the long term"** through:

- Provision of knowledge and tools for Integrated Water Resource Management (IWRM) and decision making in the face of current and emerging challenges around water quantity and quality. Through the IWRM approach, Water4All will guide short-term decisions (management) and long-term strategies (planning) of water resources systems.
- Conservation, restoration, regeneration and best use of the natural functions of groundwater, surface water and dependent or associated ecosystems.
- Demonstration, from pilot- to full-scale, and implementation of solutions, respecting integrated and nexus approaches. This covers both technical and non-technical solutions, e.g. relating to governance or economics.
- Support to European and international action plans and regulatory frameworks related to water (e.g. EU Green Deal, WFD, and specific directives, SDGs or having an influence on water (e.g. Common Agricultural Policy, Soil Thematic Strategy) through the provision of scientific evidence and validated approaches.
- Support to efficient collaboration and integration of European and international R&I activities.
- Enabling the provision and adoption of tools and methodologies for fair and efficient water management and planning through enhanced participation and inclusion of the public in decision-making processes, empowerment, capacity building, accountability and transparency.
- Open access to water knowledge and web services via communication and valorisation activities.

- Protection of water infrastructure and data systems through robust cybersecurity frameworks, addressing the growing digital threat landscape to critical water infrastructure.

The rationale for the Partnership instrument to address water security challenges, as compared to previous R&I instruments or other Horizon Europe instruments, is to **cover the whole range of activities from knowledge** creation **to practical implementation and practice**. The Partnership emphasises the innovation part and the implementation of solutions, as many have already been developed by scientists, but their uptake by policy makers, end-users and the society is often too limited or too slow to deliver on water challenges at a sufficient pace. To this end, Water4All prioritises innovation and strengthens Europe's innovation generation capacity through enhanced R&I investment, technology transfer mechanisms, intellectual property strategies, and international collaboration frameworks.

In addition, Water4All develops **broad international cooperation** in R&I programming to create joint solutions for global societal challenges and mutual economic benefits. The ambitious goals of Water4All are solution-driven and include the establishment of new relationships to facilitate multidisciplinary networking across the water challenges on a wider scale, with respect to research and to targeted geographical areas. Water4All therefore seeks to make a significant contribution to the SDGs related to water, in particular SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), and SDG 14 (Life Below Water), by speeding up the systemic transformation of European societies but also by pulling other countries in this direction and associating them to the Partnership dynamics. It will do so in an adaptive manner, building on the knowledge and on the socio-economic and governance capacities of partner countries and regions.

## e. Water4All Expected impacts

Joint activities in Water4All should contribute, in the long term, to achieving the objectives set by UN Water's definition for Water Security and in the **SDGs** related to **water**:

- Firstly, **SDG 6 "Ensure availability and sustainable management of water and sanitation for all**", and
- In a correlated way, SDGs addressing Poverty (1), Hunger (2), Health (3), Clean Energy (7), Cities (11), Responsible Consumption and Production (12), Climate (13), Life below Water (14) and on Land (15), Peace, justice and strong institutions (16), and Partnerships for implementation within and beyond Europe (17).

The actions from Water4All should then enable the following expected impacts:

- Populations have **improved access to water** to meet basic needs and safeguard health and well-being.
- **Adequate water supplies are available** for food and energy production, agriculture, industry, transport, tourism.
- **Ecosystems are preserved and restored** and can better **deliver their services**, on which both nature and people can rely, including the provision of freshwater.
- Populations are more **resilient to global changes and water-related hazards**, including floods, droughts, pollution.

To effectively produce these impacts, Water4All is meant to achieve the following specific objectives:

- Deliver **sound knowledge, tools and evidence basis on water** for policy- and decision-making.
- Improve consideration of **water impacts in all relevant policies**.
- Enhance the **field/market use of innovative solutions** to water challenges.
- Increase **people's awareness** and engagement for an **inclusive water governance**.

The activities carried out in Water4All shall deliver the following outputs, contributing towards those specific objectives:

- **Strengthen the water R&I collaboration** at European and international levels.
- **Coordinate and leverage the activities** of the Water R&I community.
- Support and **promote the demonstration and access to market** of innovative solutions.
- Produce, share and **better communicate and disseminate water-related knowledge and data**, from local to global scales.
- Enhance **talent development of water R&I professionals**.
- Foster capacity development and **life-long training of water policymakers, stakeholders** and civil society.
- Design and implement approaches for **participatory development of innovation.**

**Figure 6** further down in the text depicts the intervention

logic adopted by Water4All, showing how its outputs are intended to practically lead to outcomes meeting the specific objectives, in order to ultimately generate the expected impacts. **Section 6** further details the specific indicators used for monitoring the progress of Water4All towards its objectives.

## f. Water4All Themes, Drivers and Enablers

**Figure 2** presents Water4All's thematic fields of interest, together with the key **drivers** and **enablers** shaping the water sector. **Drivers** refer to the major environmental, societal, economic, and policy forces that generate needs and influence priorities for R&I. **Enablers**, in turn, encompass the conditions and capacities, stemming from Water4All and outside the Partnership, supporting the development and implementation of solutions. The Water4All's SRIA is structured around five main themes. Each theme is then broken down into specific sub-themes and topics, i.e., R&I issues addressing the knowledge gaps identified by the Water4All consortium and for which joint actions are recommended.

Possible **drivers** for change include:

- **Climate change preparedness and resilience:** Water is the primary medium through which the impacts of climate change are experienced (UN Water, 2019)[7]. Climate change is altering the hydrological cycle, with projections indicating an increase in the frequency and intensity of extreme events, both within and beyond Europe. More frequent floods and more severe droughts are expected, affecting water quantity and quality and, consequently, all water-related sectors. In addition, climate change – together with sea-level rise – drives a range of interconnected risks, including natural hazards, soil erosion, glacier and ice melt, biodiversity loss, water scarcity or excess, and declining water quality. These impacts can cascade into broader societal challenges, such as food insecurity, economic instability, loss of ecosystem services, increased migration, and heightened political tensions.
- **Human and environmental health (One health), also including biodiversity loss:** As highlighted by the recent COVID-19 pandemic, health and water security are closely interlinked. Water plays a central role in the transmission and control of human pathogens, while exposure to xenobiotic and toxic compounds can generate long-term risks for both human and ecosystem health. At the same time, health crises can undermine water security by affecting the availability of safe water and limiting access to adequate hygiene and sanitation services. Biodiversity is a critical component of this nexus. Healthy and diverse ecosystems contribute to water purification, pathogen regulation, and the resilience of natural systems. Conversely, bio-

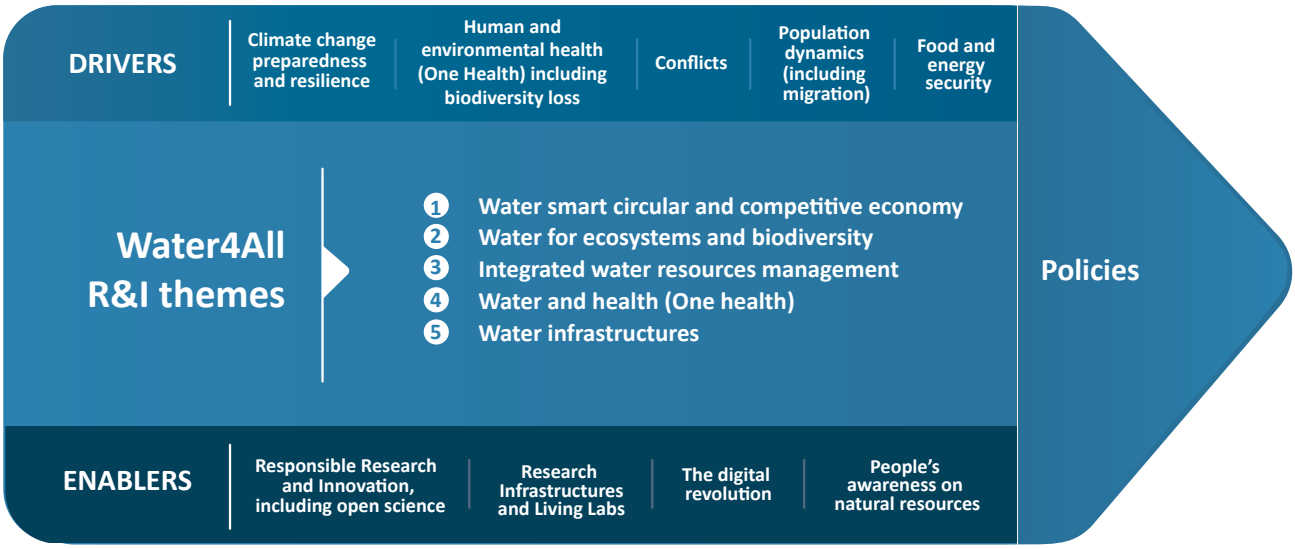



FIGURE 2. WATER4ALL'S R&I THEMES, DRIVERS AND ENABLERS.

7 - UN Water. Water Facts. Last visited in February 2026: https://www.unwater.org/water-facts/climate-change/.

diversity loss can disrupt these functions, increasing the risk of disease emergence and transmission, degrading water quality, and reducing ecosystem resilience to environmental pressures. These interconnected dynamics highlight the importance of adopting a One Health approach, recognising that the health of humans, ecosystems, and biodiversity are fundamentally interdependent.

- **Conflicts:** Conflicts over water resources can arise from competing demands, policy gaps, governance challenges, and economic pressures, both within and across borders. Effective water governance, management, and diplomacy are critical to prevent and resolve tensions, particularly in transboundary basins. Ensuring security and preparedness—including geopolitical stability, resilient infrastructure, and risk management—is essential to safeguard water availability and support sustainable development. Addressing these challenges requires coordinated policies, cross-sector collaboration, and proactive planning to reduce the likelihood of disputes and to maintain access to safe and reliable water supplies.
- **Population dynamics, including migration:** Climate change, economic crises, political instability, and inadequate water management and services are likely to intensify both migration and population shifts in certain regions of the world. These dynamics – both internal and across borders – can increase pressure on water resources in destination areas, affecting water availability, quality, and infrastructure. Global trends indicate that urbanisation and population growth will continue to concentrate populations in water-stressed regions, highlighting the need to integrate population dynamics into water planning and management strategies. In addition, seasonal tourism represents a significant and often under-addressed driver of water demand and environmental pressure in many regions, particularly in coastal and Mediterranean areas, requiring dedicated management strategies.
- **Food and energy security:** In the same vein, population growth is expected to put increasing pressure on water availability, quality, and on food and ener-



gy security in many regions worldwide. The efficient, sometimes conjunctive, use of surface and groundwater, and NbS for the sustainable management of water for agricultural purposes – including managed aquifer recharge (MAR) and rainwater harvesting – are crucial in maintaining agricultural productivity. Water use must be optimised, and water reuse technologies further developed, to ensure that water is available for different uses at the quality levels required by end-users. Advances in technology should be leveraged to facilitate the adoption of alternative water sources. Meeting the water demands for food and energy security will require innovative water planning and management strategies that support the sustainable use of water resources while responding to evolving societal needs. Particular attention should be paid to the water–energy nexus in regulated basins, such as hydropower operation, reservoir management under changing hydrological regimes, environmental flow requirements, and integration with renewable energy systems.

Key **enablers** are:

- **Digital transition** (AI, big data and data spaces). The combination of data surplus stemming from new systems and devices along with an increasing computer capacity offer an untapped potential for the monitoring of water resources and ecosystems, the visualisation and evaluation of management/ policy options, increased connectivity of water users, the real time access to water information, and the communication of decisions. In this context, it is crucial to develop integrated water data spaces that facilitate the transparent sharing of knowledge across borders and sectors. These environments must be grounded in FAIR principles (Findable, Accessible, Interoperable, Reusable) to ensure that water quality, health, and environmental data are not only accessible but also usable for practitioners and policymakers.



- **Research infrastructures and Water-oriented Living Labs (WoLLs):** Research infrastructures and WoLLs play a key enabling role in achieving Water4All's objectives. Water-related research infrastructures support the creation of robust and policy-relevant knowledge across the entire source-to-sea continuum by providing long-term observation systems, experimental and analytical facilities, data platforms, and advanced modelling capacities. They foster the co-development, testing and validation of innovative solutions in close interaction with policy makers, practitioners and end users, while supporting FAIR data principles, interoperability and Open Science. In this context, Water4All will maximize the impact of relevant European and national research infrastructures by strengthening their enabling role in developing innovative solutions, enhancing resilience and sustainability, and supporting stronger collaboration with policy decision makers, stakeholders and end-users. Research infrastructures also facilitate the harmonisation and networking of water-related capacities at European scale, enabling the exchange of best practices, shared access to infrastructures and the interoperability of long-term datasets. Their role includes integrating satellite Earth Observation systems with in-situ monitoring networks to improve high-resolution mapping and monitoring of water quality and quantity. Research infrastructures can further support the transformation of raw observatory data into actionable evidence for water policy and river basin management planning.

  WoLLs complement research infrastructures by providing participatory, real-world environments where innovative approaches, technologies and governance models can be co-designed, tested and scaled in collaboration with local communities, public authorities, researchers, businesses and civil society actors. WoLLs facilitate user-driven innovation and accelerate the uptake of sustainable water solutions by connecting scientific knowledge with practical implementation needs. Through multi-actor engagement and experimentation in diverse socio-environmental contexts, WoLLs can strengthen societal resilience, improve stakeholder ownership, and support the transition towards more adaptive and inclusive water management practices.

- **Responsible Research and Innovation, including open science:** Open Science provides opportunities for the transparent sharing of data and knowledge, enabling reproducibility, wider access to research results, and greater collaboration across disciplines and regions. At the same time, the collection and sharing of data – such as remote sensing, smart meters (related to water consumption), and digital trace data – can raise privacy and security concerns (Zipper et al. 2019)[8]. Water4All is therefore committed to ethical data management, ensuring that sensitive information is protected and shared responsibly.

  In addition, Water4All promotes gender equality, inclusiveness, and diversity in R&I processes. This includes fostering equitable participation in project activities, ensuring that research priorities consider the needs of all societal groups, and integrating gender and social dimensions into the design and use of water management tools and solutions. By embedding these principles, Water4All aims to strengthen the societal relevance and impact of its research, while supporting a more responsible, transparent, and inclusive water innovation ecosystem.

- **People's awareness of natural resources:** Communication and global outreach play a key role in shaping people's awareness of, and behaviour towards, water challenges. Water4All seeks to harness social networks, digital media, and citizen science initiatives to engage the public actively in water research and monitoring. By involving the general public in data collection, observation, and local problem-solving, Water4All can both enhance understanding of water issues and empower communities to take informed action.

8 - Zipper et al. 2019. Balancing open science and data privacy in the water sciences. Water Resources Research. Volume 55, issue 7. Available at: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019WR025080

## g. Addressing barriers to implementation

Achieving the desired water security level requires a combination of a solid legal and regulatory framework setting, government capacity for enforcement, available technological solutions and, importantly, a market demand. The alignment of funding programmes (from research to innovation implementation, and efficiency demonstration) and timelines is necessary for creating the critical mass required to tackled existing challenges. Moreover, the building of new knowledge insights and the development of new solutions may be in vain without:

- adequate **incentives**, e.g. innovation uptake and transformation shift in public procurements, pricing and tariff setting (development of economic and financial governance frameworks such as full cost recovery, polluter-pays principles, tariff design, affordability safeguards, and long-term financing models for water services and ecosystem restoration), or allowing / facilitating synergistic solutions between sectors and actors;
- **sound economic framework conditions** for the service and solutions providers (e.g. water utilities) to be able to scale-up the solutions and implement them. This includes connecting R&I funding programmes with "downstream" funding programmes (equipment investments, demonstration at policy scales) to demonstrate the effectiveness and fairness of new innovations at the field scale, and transform pilots into operations;
- and also, a **global environmental governance paradigm**, which encourages market demand and roll-out of **integrated solutions** (e.g. carbon-neutral wastewater treatment plants).

Already today, state-of-the-art solutions exist, which yet have to become market mainstream. Water4All works on developing solutions driven by societal and market demand, and on decreasing the barriers to the implementation of solutions, either existing or newly developed.

Water4All is organised in five pillars, shown in **Figure 3**, and proposes a broad range of activities along the whole R&I value chain to investigate the identified themes and foster the implementation of innovations. These activities include in particular:

- Leading alignment of national and regional programmes; creating research synergies among networks and existing R&I initiatives; communication and dissemination of results (Pillar A);
- Implementing Joint transnational calls for projects, including calls for innovation transfer to the relevant end-users, maturation calls (Pillar B);
- Launching Thematic Annual Programming actions (clusters of projects funded through national calls) (Pillar B);
- Running knowledge hubs bringing experts to communicate with decision and policy makers (Pillar C);
- Producing science – policy interface documents and events (Pillar C);
- Digital data and web services, promoting Open innovation / Open science (Pillars A&C);
- Supporting the uptake of innovation by the economic sectors: access to financial programmes, creation of start-ups, confirmation of business relevance (Pillar C);
- Designing capacity development programmes for targeted groups such as river basin management authorities, decision-makers, service providers: dissemination programmes, Massive Open Online Courses (MOOC), webinars (Pillar C);
- Building capacity for entrepreneurs and start-ups from the Water sector (training, mentoring) (Pillar C);
- Designing training programmes for students or young professionals (Pillar C);
- Proposing mobility schemes (Pillar C);
- Engaging with ongoing or new WoLLs to test and implement solutions (Pillar D);
- Conducting roadshows for promoting innovative approaches (Pillars D&E);
- Feeding data and evidence from R&I programmes into SDGs monitoring (Pillar E);
- Testing innovative tools to strengthen international cooperation (Pillar E).




FIGURE 3. WATER4ALL STRUCTURE IN FIVE PILLARS

Depending on the nature of the bottleneck[9] (e.g. research gap or lack of uptake by decision-makers or the economic sector), the most suitable tool(s) to address each considered topic will be chosen at the stage of the Implementation Plan, which will thoroughly describe the activities performed by the Partnership each year. The **SRIA applies to, and guides, all activities carried out under Water4All;** section 4 below lists priority Water4All's R&I themes and related topics.

We acknowledge the strong interrelations between the themes presented below. While the presentation requires assigning topics to a theme, most, if not all of the topics have relevance for one or several other themes. In its systemic vision, Water4All aims at an encompassing approach breaking the silos of disciplines or applications. Therefore, and in particular in the calls for proposals that will be launched, we foster to jointly address several topics across the themes (including the two cross-cutting themes).

## h. Guidance Principles for Water4All Research and Innovation Projects

Achieving water security in Europe and beyond requires not only high-quality scientific knowledge, but also the **ability to translate R&I into effective, inclusive and lasting solutions.** In this context, the Water4All SRIA introduces a set of **guiding principles, represented in Figure 4, to support the design and implementation of R&I activities funded under the Partnership.** These principles reflect both the experience gained from the previous SRIA and the insights gathered through the update process, including stakeholder consultations, thematic and foresight workshops, and expert input. The guiding principles are:

**Implementation-oriented R&I:** Water4All projects should go beyond the development of technical solutions and explicitly address the conditions required for their uptake, deployment and scaling. Particular attention should be paid to understanding and overcoming barriers that may hinder implementation in real-world contexts (see Section 1.g for further information). Hence, projects are expected to

9 - For instance, the development of "Smart water systems" under Subtheme III.V may include activities close to market such as transfer calls or or support to start-up creation; exploring the response of ecosystems to hydro-climatic events under Subtheme II.II would rather be addressed through knowledge creation and sharing activities such as joint calls or TAP; the development of Risk Assessment procedures under Subtheme IV.IV may combine knowledge creation activities with science-policy interface actions.

(i) identify regulatory, institutional, financial, organisational or social barriers; (ii) consider user needs and operational constraints; (iii) propose realistic pathways to facilitate uptake, including governance arrangements, financing approaches, capacity building or stakeholder engagement.

**Strategic and policy alignment:** Projects should demonstrate how their results can support policy implementation, decision-making processes and societal learning. Ensuring the alignment of projects with relevant strategic frameworks will strengthen the policy relevance and usability of project outcomes. Projects are therefore expected to contribute to the implementation of key European policy frameworks such as the EU Water Resilience Strategy, the WFD, the Floods Directive, the Drinking Water Directive, the Urban Wastewater Treatment directive or the European Green Deal, as well as international frameworks i.e. SDGs.

**Fair, inclusive and just transition:** Water-related transitions must be socially fair, inclusive and attentive to potential distributional impacts, with explicit attention to gender equity, social justice, and the inclusion of vulnerable and marginalised groups. Water4All projects are encouraged to integrate these dimensions throughout their design and implementation. Projects should promote inclusiveness, including the involvement of youth, women, early-career researchers, under-represented groups/ communities, and widening countries. In this context, Water4All promotes a shift from "citizen science" to "participatory approaches", ensuring that the perspectives of all stakeholders are fully included.

**Use of European research infrastructures and living labs:** To maximise scientific excellence, efficiency and impact, projects are encouraged to build on existing European capacities and collaborative environments. In particular, projects should make use of relevant European research infrastructures for water, including those identified within Water4All, to enhance interoperability, data quality and resource efficiency. Similarly, projects should consider the use of WoLLs as a way to test and validate solutions under real operating conditions, and facilitate mutual learning, replication and scaling of results.

WoLLs are considered cross-cutting implementation environments within Water4All. They enable the validation of solutions under real operational conditions, support stakeholder engagement and co-creation, and facilitate the transition from R&I to real-world deployment, scaling and replication, "from lab to ground".

**Open science, public engagement, transferability and lasting impact:** Water4All projects are expected to generate benefits that extend beyond their duration, contributing to long-term knowledge, capacity and impact. To this end, projects should (i) support open, FAIR and responsible data and knowledge sharing; (ii) contribute to capacity building of stakeholders, including institutions, problem-owners and communities, and promote participatory approaches where relevant; (iii) deliver outputs that are applicable and usable in real-world decision-making and operational contexts; and, (iv) identify pathways for sustaining, replicating or scaling results beyond the project lifetime.

**Guiding Principles of Water4All**

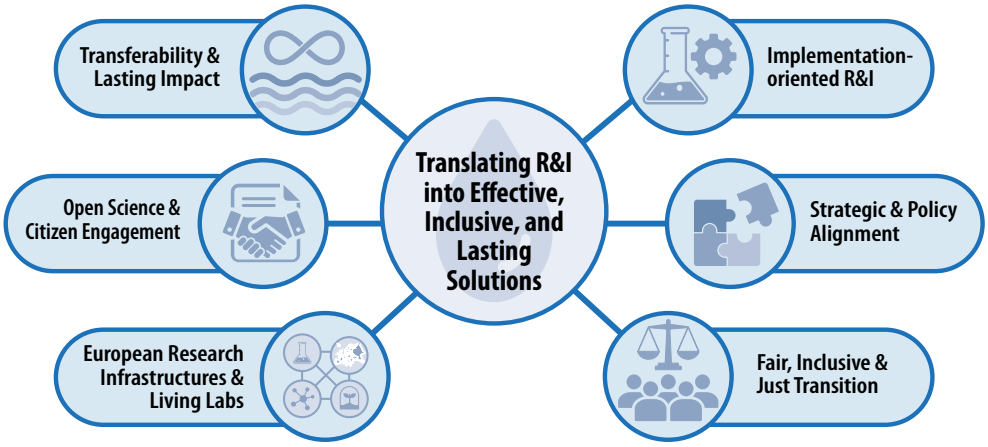



FIGURE 4. WATER4ALL'S SIX GUIDING PRINCIPLES FOR RESEARCH AND INNOVATION PROJECTS



# 2. SRIA: Aims and development process

# 2. SRIA: Aims and development process

The SRIA allows having a better understanding of R&I priority areas and their implementation to be explored and funded within the timeline of the Partnership, its objectives and expected impacts. The SRIA guides representatives The SRIA allows having a better understanding of R&I priority areas and their implementation to be explored and funded within the timeline of the Partnership, its objectives and expected impacts. The SRIA guides representatives from national/ regional funding agencies, research operators, academia, industry, policy and society in addressing water security challenges. The SRIA is therefore conceived as the **"strategic backbone" of the Water4All Partnership that aligns partners' R&I priorities in the field of water and supports a coherent and coordinated approach to addressing water security challenges.**

In particular, it plays a central role in **supporting the preparation of Water4All call texts**, by serving as the basis for the scoping of calls for projects and ensuring that funded activities are aligned with agreed strategic priorities. Beyond Water4All calls, the SRIA can also be used as a reference framework for other relevant programmes and initiatives operating in the water domain. Furthermore, the SRIA supports partners in the development of **Water4All's annual implementation plans**, helping to define which activities should be carried out and when. It also promotes, towards national funders and the EC, the key water-related topics that should be supported to secure water for all, thereby contributing to greater alignment between national, European, and international R&I efforts. Finally, the SRIA serves as a **communication tool with other initiatives**, facilitating dialogue, cooperation, and complementarity across the broader water R&I landscape.

**The primary target audience of the SRIA is funding organisations, which are the key actors responsible for the design, launch, and implementation of calls for proposals. By providing a shared strategic framework and clearly articulated R&I priorities, the SRIA supports funding organisations in translating R&I objectives into concrete funding instruments, in particular joint and coordinated calls under Water4All.**

The SRIA update process was initiated in October 2022, following the submission of the **first version**. The update process aims to refine and complement the first SRIA by reflecting new perspectives, thematic developments, and stakeholder inputs. It has been carried out through a structured and inclusive process designed to integrate scientific evidence, stakeholder perspectives, and forward-looking insights. The update process is summarised in **Figure 5**. A key component of this process was the organisation of two thematic consultative workshops, which allowed gathering in-depth input on Water4All's thematic priorities. The first workshop, held in Helsinki in February 2023, focused on biodiversity and ecosystem services with particular emphasis on their role in ensuring water security and supporting sustainable water management. Building on this, a second thematic workshop took place in Lisbon in June 2024, addressing digital tools for smart water management, including data-driven approaches, decision-support systems, and digital innovation for water governance and operational practices. To complement these discussions, a broader public consultation was launched during the summer of 2024. The objective of the public consultation was to capture perspectives from the wider water R&I community, as well as from other relevant stakeholders, thereby ensuring openness and inclusiveness in the update process. Moreover, a foresight workshop was organised in January 2025 to explore emerging trends, uncertainties, and long-term challenges affecting water systems. This forward-looking exercise played a key role in identifying future-oriented R&I priorities and strengthening the strategic dimension of the SRIA. Several countries also held national seminars, which allowed identifying additional R&I needs and priorities. The key lessons and feedback from national seminars will be

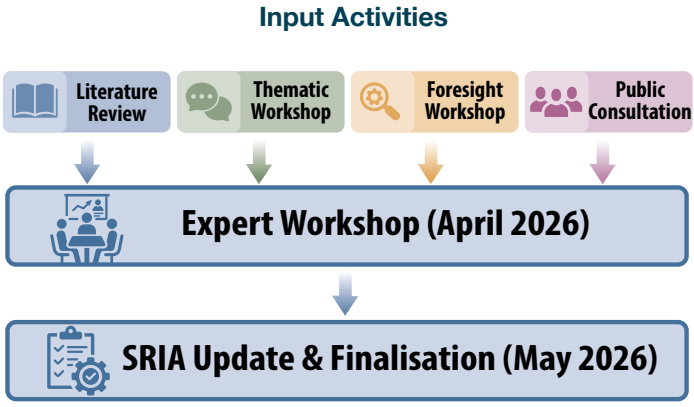



FIGURE 5. WATER4ALL'S SRIA DEVELOPMENT PROCESS.

fully exploited by Task A.2.4 on alignment.

The process was further underpinned by a comprehensive review of both grey literature and peer-reviewed publications conducted between October 2022 and April 2025. The bibliometric a nalysis covered the 2020-2025 period. The literature review ensured that the updated SRIA reflects the latest scientific knowledge, policy developments, and strategic analyses at European and global levels. It included an AI-enhanced living review of approximately 40,000 Web of Science records and full-text thematic analyses across all Themes of the SRIA, providing robust evidence for strategic priority setting (Water4All 2026). The review provided quantitative insights into global research trends, EU27 positioning, open access rates, patent distributions, and emerging technology priorities. The bibliometric analysis allowed the identification of critical research gaps, priority scores, and strategic recommendations for each theme.

A key milestone in the update process was the expert workshop organised in April 2025. Experts were selected through a dedicated call launched at the end of 2024, resulting in the participation of nearly 30 specialists from across Europe. Their contributions were instrumental in validating and enriching the strategic orientations of the SRIA. In addition, a final coordination meeting with Water4All partners was held in February 2026 to consolidate preliminary findings, refine contributions, and advance work on the broader structure and content of the document.





# 3. Water4All's added value in the European context

# 3. Water4All's added value in the European context

*"Europe's environment is at a tipping point. We have a narrow window of opportunity in the next decade to scale up measures to protect nature, lessen the impacts of climate change and radically reduce our consumption of natural resources"*. These are the words of the European Environment Agency (EEA) Executive Director, Hans Bruyninckx[10]. It reflects the concerns of high-level EU environmental policy actors. Water is scarce in many European regions (especially in southern areas or highly densely populated regions) and projections indicate that **water scarcity episodes will aggravate** in the future.

Only around 40% of surface waters are in good ecological status and only 38% are in good chemical status (EEA, 2024)[11]. To make matter worse, **water quality is expected to further decrease** due to higher diffuse pollution loading released during precipitation events and/ or reduced dilution capacity of rivers in low flow periods. Persistent pollutants and xenobiotics constitute a strong risk to human and ecosystem health.

Results are better for groundwater resources as 74% of the aquifers achieve good chemical status. However, uncontrolled and even illegal abstraction puts water availability of these resources at risk in some European regions and for specific uses (e.g. ecosystem maintenance, agriculture, tourism, hydropower sector). Furthermore, recent research indicates that the current EU and WHO drinking water standard for nitrate is too high, as serious health risks appear at much lower concentrations than the current 50 mg/l standard. If the drinking water standard for nitrate is ultimately further reduced, more groundwater bodies will not comply with the good chemical status objectives. In this context, further research on the health risks of nitrate and other critical pollutants is needed.

Water4All's SRIA is closely aligned with evolving European Union (EU) water policy objectives to ensure that R&I directly support regulatory implementation, societal needs and long-term water resilience. EU water legislation and strategies provide both a policy framework and a set of concrete challenges that reveal persistent knowledge gaps, systemic barriers and emerging risks. These challenges guide the identification of priority R&I needs within Water4All.

The **WFD** remains the cornerstone of EU water policy, aiming to achieve good ecological and chemical status of water bodies. Current implementation gaps translate into clear research needs related to improved monitoring and assessment tools, cost-effective restoration methods, NbS, pollutant reduction strategies, and integrated catchment management approaches that combine ecological, social and economic dimensions.

The **Drinking Water Directive** and the **Urban Wastewater Treatment Directive** further highlight the need for innovation across the water cycle, from source protection to treatment, reuse and safe discharge. Emerging contaminants (e.g., PFAS, pharmaceuticals, microplastics), energy efficiency requirements, circular economy objectives, and digitalisation demands require new treatment technologies, real-time monitoring systems, risk-based management frameworks, and resource recovery solutions. Research is also needed to enhance resilience of drinking water supplies and sanitation systems to climate extremes, ageing infrastructure and cybersecurity risks.

The **Floods Directive** and the **Nitrates Directive** address specific water-related risks, requiring research on flood risk assessment, early warning systems, agricultural pollution reduction, and integrated land-water management. The **Marine Strategy Framework Directive** extends water quality objectives to coastal and marine environments, calling for research on source-to-sea pollution pathways, marine ecosystem health, and cumulative impact assessment.

More recently, the **EU Strategy on Water Resilience**, the **Nature Restoration Regulation**, and related **Green Deal initiatives** (i.e. Biodiversity Strategy 2030, From Farm to Fork, Clean energy, Sustainable industry, Building and renovating, Sustainable mobility, Zero Pollution Action Plan, Climate action) emphasise adaptation to climate change, drought and flood risk management, ecosystem restoration, and water efficiency across sectors. The proposed **Soil Health Law** recognises the critical role of soil-water interactions in ecosystem functioning and agricultural sustainability, while the **Critical Entities Resilience Directive** addresses the security and resilience of water infrastructure as critical infrastructure. These policy developments call for systemic, cross-sectoral knowledge and innovation.

By linking R&I needs directly to policy objectives, Water4All ensures that funded activities contribute to measurable impacts: supporting Member States in achieving compliance, enabling evidence-based policymaking, accelerating market uptake of solutions, and strengthening Europe's overall water resilience.

10 - Abstract of the EEA's State of the Environment Report 2020 (SOER). Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12183-Sustainable-food-farm-to-fork-strategy/F508970_en

11 - EEA (2024). EEA Report 07/2024: Europe's state of water 2024: the need for improved water resilience. Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2019:095:FIN

# 3. Water4All's added value in the European context



Water is also an essential asset in at least **4 of the 5 Horizon Europe Missions** on:

- Adaptation to climate change including societal transformation;
- Climate-neutral and smart cities;
- Soils health and food; and
- Healthy oceans, seas, coastal and inland waters.

**Current trends in water quantity and quality will also undermine progress towards EU policy targets and achievement of the SDGs** on Water (SDG6), Poverty (1), Hunger (2), Health (3), Gender Equality (5), Clean Energy (7), Decent Work (8), Industry, Innovation, Infrastructure (9), Cities (11), Responsible Consumption and Production (12), Climate (13), Life below Water (14) and on Land (15), Peace, justice and strong institutions (16), and Partnerships for implementation within and beyond Europe (17).

The rationale for Water4All is to **gather water actors and stakeholders at scale and appropriate duration to generate the necessary transformations** to solve water-related challenges. The European water sector is strongly fragmented. The experience accumulated by existing initiatives, and quite notably that of the Water JPI, will be seized to **spur cooperation amongst national/ regional funding agencies, academia, research operators, water authorities, water utilities, and the water private sector.** Key lessons will be exploited at most in order to **capitalise human and financial resources**. This cooperation should support the achievement of the Green Deal.

Water is essential to basically any sector of life, from natural functions of the environment through health, food, energy or industrial production, building industry, etc. In this context, Water4All seeks synergies and collaboration opportunities with other EU initiatives connected to water and aquatic ecosystems challenges, in order to leverage the actions and maximise the respective impact of the initiatives. Such collaborations take various forms, such as joint workshops, common knowledge hubs, joint capacity building programmes, etc. The modalities for collaboration are regularly discussed with each initiative, either through bilateral meetings or workshops in small groups. **Table 1** indicates the main thematic connections between Water4All and other EU initiatives.

# 3. Water4All's added value in the European context

| Initiative / Partnership | Description & Thematic Synergies with Water4All | Main distinction vs Water4All's scope |
|---|---|---|
| **Partnership Biodiversity** | **Description:** Focused on halting biodiversity loss across terrestrial, freshwater, and coastal ecosystems, with emphasis on restoring ecosystem services and resilience to climate change.<br>**Synergies with Water4All:**<br>■ **II. Water for ecosystems & biodiversity:** Restoration of rivers, wetlands, and coastal habitats; NbS for climate adaptation; functional ecosystem services integration.<br>■ **III. Integrated water management:** Data-driven management and monitoring of aquatic ecosystems to inform river basin planning and resilience. | Broader **biodiversity-first approach** (terrestrial + marine), whereas Water4All is **water-centric**. |
| **Partnership Circular Bio-Based Europe** | **Description:** Promotes the development and scaling of circular bio-based solutions, including industrial symbiosis, reuse of organic materials, and integration of water efficiency in industrial processes.<br>Synergies with Water4All:<br>■ **I. Water-smart, circular and competitive economy:** Water efficiency and reuse; nutrient recovery from wastewater and industrial streams; sludge recycling.<br>■ **IV. Water and health:** Improved water sanitation and pollutant removal technologies. | Focus on **bio-based materials and industrial value chains**, with water as a component—not the central system. |
| **Partnership Processes 4Planet** | **Description:** Supports the transformation of European process industries towards climate neutrality and circularity by developing resource-efficient, low-carbon and water-smart industrial processes, including innovations in waste valorisation and industrial symbiosis.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Water efficiency in industrial processes, water reuse and recycling, urban-industrial symbiosis.<br>■ **V. Water infrastructures:** Wastewater management and infrastructure for water reuse and resource recovery. | Strong **industry and decarbonisation focus**, while Water4All covers **broader water systems (natural + urban + governance).** |
| **Partnership DUT (Driving Urban Transitions)** | **Description:** Supports sustainable urban development, blue-green infrastructure, and smart city strategies integrating water, energy, and circularity principles.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Efficient urban water use, water reuse, innovative water technologies/ processes/ services in cities and municipalities.<br>■ **III. Integrated water management:** Integrated urban water management, digital tools, and predictive modelling.<br>■ **V. Water infrastructures:** Resilient and adaptive urban water infrastructure; integration of stormwater and flood management; blue infrastructure for sustainable urban development. | Focus limited to **urban environments**, whereas Water4All spans **all spatial scales (basins, rural, groundwater, ecosystems).** |

# 3. Water4All's added value in the European context

| Initiative / Partnership | Description & Thematic Synergies with Water4All | Main distinction vs Water4All's scope |
|---|---|---|
| **Partnership Agroecology** | **Description:** Focused on sustainable agriculture, agroecosystem management, and integrating ecosystem services into farming systems.<br>Synergies with Water4All:<br>■ **I. Water-smart, circular and competitive economy:** Irrigation efficiency, nutrient reuse, water-smart agriculture.<br>■ **II. Water for ecosystems & biodiversity:** Soil-water-plant interactions, agroecosystem resilience, biodiversity-friendly water management.<br>■ **III. Water for the future:** Integrated water-land management, adaptive practices for climate resilience. | Primarily **agriculture-driven**, while Water4All integrates **multiple sectors beyond food systems** |
| **Partnership Data for Agriculture** | **Description:** Harnesses agricultural and environmental data to enable precision farming, optimize water use, and integrate digital decision-support tools.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Optimising irrigation and water reuse; precision water management.<br>■ **III. Integrated water management:** Digital monitoring, predictive models for irrigation and water management. | Focus on **data-driven agriculture,** whereas Water4All addresses **full water cycle governance and management.** |
| **Partnership Sustainable Food Systems** | **Description:** Ensures sustainable, safe, and resilient food supply chains, including environmental and water-related impacts on food quality and safety.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Water reuse and resource-efficient food production practices.<br>■ **III. Water for the future:** Risk assessment and monitoring of water in agricultural production.<br>■ **IV. Water and health:** Monitoring of contaminants and emerging pollutants affecting food and water safety; AMR pathways. | Focus on **food safety and supply chains,** with water as a **supporting factor rather than central system.** |
| **Partnership Water-Borne Transport** | **Description:** Supports environmentally sustainable and safe inland and maritime water transport, integrating water quality and infrastructure resilience considerations.<br>**Synergies with Water4All:**<br>■ **III. Integrated water management:** Water system monitoring for transport compliance and resilience.<br>■ **IV. Water and health:** Pollution prevention and water quality protection.<br>■ **V. Water infrastructures:** Resilient ports, waterways, and digital twins for transport infrastructure planning. | Sector-specific focus on **navigation and transport,** not IWRM. |

# 3. Water4All's added value in the European context

| Initiative / Partnership | Description & Thematic Synergies with Water4All | Main distinction vs Water4All's scope |
|---|---|---|
| **Sustainable Blue Economy Partnership (SBEP)** | **Description:** Steers the transition to a regenerative, resilient, sustainable, and climate-neutral blue economy across EU seas and oceans.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Desalination.<br>■ **II. Water for ecosystems & biodiversity:** Cumulative effects of contaminants, coastal NbS, valuing ecosystem services in coastal areas.<br>■ **III. Integrated water management:** Smart water management: observation, monitoring and data collection/ sharing, water intrusion.<br>■ **IV. Water and health:** Pollution. | Focus on **marine and coastal systems,** whereas Water4All covers **freshwater systems and full hydrological cycle.** |
| **Partnership Chemical Risks Assessment** | **Description:** Assesses and manages chemical risks in water, food systems, and the environment, harmonizing data for policy and safety measures.<br>**Synergies with Water4All:**<br>■ **III. Integrated water management:** Tools for assessment, monitoring, and prediction of chemical impacts in water systems.<br>■ **IV. Water and health:** Contaminants of emerging concern (CECs), risk thresholds, and water quality monitoring. | Focus on **chemicals and risk science,** not on **holistic water system management** |
| **Partnership Clean Energy Transition** | **Description:** Supports the transition to a climate-neutral energy system.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Water–energy nexus, water efficiency and reuse in energy systems.<br>■ **IV. Water & health:** Reduced pollution from cleaner energy production.<br>■ **V. Water infrastructures:** Energy-efficient water systems, resilient and integrated infrastructures. | Energy-driven; water is part of the **energy nexus,** while Water4All is **water-driven across sectors.** |
| **Partnership EUP OHAMR** | **Description:** Supports coordinated R&I to reduce antimicrobial resistance (AMR), addressing its environmental, human, and animal health dimensions through a One Health approach.<br>**Synergies with Water4All:**<br>■ **IV. Water & health:** AMR in aquatic environments; contaminants of emerging concern; risk assessment and monitoring of water quality. | Focus on **health risks and microbiological contamination,** not broader water management. |
| **EU Missions** | **Description:** Large-scale initiatives including Healthy Oceans, Adaptation to Climate Change, Climate-Neutral & Smart Cities, Soils Health & Food, aiming to restore ecosystems, enhance climate resilience, and protect urban/rural water resources.<br>**Synergies with Water4All:**<br>■ **II. Water for ecosystems & biodiversity:** Restoration of freshwater, coastal, and marine ecosystems; nature-based adaptation.<br>■ **III. Integrated water management:** Risk assessment, predictive modelling, early-warning systems, integrated water management.<br>■ **V. Water infrastructures:** Climate-resilient urban and rural water infrastructures. | **Challenge-driven and place-based,** whereas Water4All is a **research and coordination partnership on water systems.** |

# 3. Water4All's added value in the European context

| Initiative / Partnership | Description & Thematic Synergies with Water4All | Main distinction vs Water4All's scope |
|---|---|---|
| **PRIMA** | **Description:** Integrates R&I on water, agriculture, food systems, and climate resilience in the Mediterranean, promoting sustainable socio-economic development and circular water management.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Water efficiency, reuse, and integration in agriculture and food production.<br>■ **II. Water for ecosystems & biodiversity:** Ecosystem-based adaptation, restoration of freshwater systems.<br>■ **III. Integrated water management:** Monitoring, modelling, and integrated river basin management. | Strong **regional (Mediterranean) and nexus focus,** while Water4All is **pan-European and water-system focused.** |
| **EIT Water (KIC Water)** | **Description:** Knowledge & Innovation Community accelerating circular and sustainable water solutions, addressing water scarcity, floods/droughts, freshwater and marine ecosystem degradation, and blue economy development.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Water efficiency, reuse, nutrient recovery, blue economy integration.<br>■ **II. Water for ecosystems & biodiversity**: Protection and restoration of freshwater and marine ecosystems.<br>■ **III. Integrated water management:** Integrated water management, climate-resilient systems, monitoring and modelling.<br>■ **IV. Water and health:** Safe water technologies, water quality monitoring. | Focus on **innovation, business, and skills,** whereas Water4All focuses more on **R&I coordination and knowledge generation.** |
| **Climate KIC / Clean Energy Transition** | **Description:** European innovation community targeting climate solutions, energy-water nexus, and circular economy adoption.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Industrial water reuse, efficiency, and urban-industrial symbiosis.<br>■ **V. Water infrastructures:** Climate-resilient and energy-efficient water/wastewater systems. | Broad **climate transition scope,** water is one component among many sectors. |
| **ESA / Copernicus & Digital Data Initiatives** | **Description:** Space-based Earth observation, remote sensing, and digital infrastructures supporting water management, environmental monitoring, and predictive analytics.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Digital monitoring of industrial and agricultural water use.<br>■ **III. Integrated water management:** Predictive modelling, monitoring, and early-warning systems. | Provides **data and tools,** while Water4All focuses on **application, governance, and water system solutions.** |

| Initiative / Partnership | Description & Thematic Synergies with Water4All | Main distinction vs Water4All's scope |
|---|---|---|
| **EuroGeoSurveys/ European Geological Data Infrastructure (EGDI)** | **Description:** It provides FAIR access to geoscience data relevant for e.g. groundwater – surface water interaction monitoring and modelling, conjunctive water management and groundwater/ subsurface integrated spatial planning.<br>**Synergies with Water4All:**<br>■ **I. Water-smart, circular and competitive economy:** Competing uses of groundwater/ water resources.<br>■ **III. Integrated water management:** Groundwater/ subsurface integrated spatial planning, climate change mitigation and adaptation, FAIR data access for groundwater quantity assessments.<br>■ **IV. Water and health:** FAIR data access for groundwater chemical status assessments. | It provides a European platform (EGDI) to easily access and use **groundwater and geological data.** |

Water4All will remain attentive to developments in the EU R&I system, as new initiatives are expected to be launched (e.g. Forests and Forestry for a Sustainable Future) or may emerge under the next Framework Programme.





# 4. Water4All proposed R&I themes

# 4. Water4All proposed R&I themes

The Water4All's SRIA is structured in three levels. First, it lays out main **Themes**, conceived as general overarching areas of R&I in the field of water. A number of **sub-themes** are then established for each theme. Finally, each sub-theme contains a variable number of **topics** that refer to specific issues for which R&I activities are recommended.

This section outlines Water4All's R&I themes, sub-themes and topics. The presentation of themes is structured as follows: first, a short description on why each theme has been included in the agenda is provided (i.e. environmental, political, socioeconomic relevance). This is followed by a list of main keywords. A table then details the sub-themes and specific topics, as well as possible links between identified topics and other sub-themes in the SRIA.

According to the water security definition mentioned above **(Section 1), enabling water security** is not only about ensuring access to safe and sufficient drinking water at an affordable cost in order to meet basic needs and human rights, including water access, sanitation and hygiene. Water security embraces as well:

- **The sustainability of economic development and activities (such as energy, agriculture, industry)** (Theme I)
- **The conservation and restoration of ecosystems and biodiversity** (Theme II);
- **Sustainable management and planning of water resources** (Theme III).
- **The safeguard of human health** (Theme IV);
- **The protection of society and related infrastructures against natural hazards** (Theme V);
- **Good governance** (cross-cutting).

The synthesis list of core Water4All's Themes is provided in the **Table 2**, together with the EU policies and strategies they are contributing to.

TABLE 2. SRIA'S THEMES AND LINKS WITH KEY EU POLICIES/ STRATEGIES.

| THEMES | I. Water-smart, circular and competitive economy | II. Water for ecosystems and biodiversity | III. Integrated water management | IV. Water and health | V. Water infrastructures |
|---|---|---|---|---|---|
| EU Policies & Strategies supported by Water4All | EU Water Resilience Strategy, EU Green Deal<br>Water Framework, Bathing Waters, Urban Wastewater Treatment, Groundwater Directives<br>Common Agricultural Policy<br>Circular Economy Action Plan | EU Water Resilience Strategy, EU Green Deal<br>Water Framework, Shellfish Waters, Dangerous Substances (and its 'daughter' directives), Nitrates, Freshwater Fisheries, Exchange of Information on the Quality of Surface Freshwaters, Groundwater Directives<br>EU Biodiversity Strategy | EU Water Resilience Strategy, EU Green Deal<br>Water Framework, Dangerous Substances (and its 'daughter' directives), Nitrates, Freshwater Fisheries, Exchange of Information on the Quality of Surface Freshwaters, Groundwater Directives<br>Shaping Europe's Digital Future<br>European strategy for data | EU Water Resilience Strategy, EU Green Deal<br>Water Framework, Bathing Waters, Dangerous Substances (and its 'daughter' directives), Urban Wastewater Treatment Directives<br>Marine Strategy | EU Water Resilience Strategy, EU Green Deal<br>EU Adaptation Strategy |

## Theme I: Water-smart, circular and competitive economy

**Relevance of this theme.** At the EU level, water stress is primarily driven by two interacting factors: (1) increasing water demand, especially from agriculture, energy, and tourism, and (2) changing climate conditions, which reduce water availability and increase the frequency of droughts. According to the EEA (2023)[12], around 20% of European territory is affected by water stress, highlighting the combined impact of these drivers.

Topics within this theme will look at tools, methodologies, approaches, innovative technologies, governance and management practices and models enabling water resource efficiency, water allocation and water value optimisation **for competitiveness of relevant economic sectors (agriculture, forestry, aquaculture, industry, tourism, energy efficiency) in rural, urban and peri-urban areas.** Water4All **will boost synergies across water uses and needs as an alternative strategy to trade-offs** strategies and in support of the fair distribution of water. New approaches based on eco-innovation and circular economy will be explored, which will in turn open up new business opportunities for Europe. Through this synergistic approach, Water4All wishes to contribute to the resilience of sustainable water systems and climate change preparedness. Opportunities arising from the optimal integration of infrastructure and technologies as enablers of the transition to a circular economy will be supported.

Closely linked to water availability is the growing emphasis on circular and resource-efficient water management. Water systems are increasingly studied as part of broader resource cycles, where wastewater and residual streams are viewed as sources of valuable materials rather than waste. In this context, Water4All will favour the development and implementation of best available solutions for water treatment and reuse, resource recovery (nutrients, energy, materials) and resource valorisation (reduce, reuse, recycling) in all types of water systems. Water4All will develop new, safe, and sustainable circular feedstocks and value chains from water systems through technologies and solutions to enable the circular economy. Traceability systems will also be developed to ensure the quality of recovered products. R&I activities will look at strategic and alternative water resources in water-scarce regions, including stormwater, desalination and aquifer recharge schemes. The Water4All Partnership will also contribute to ensuring the ecologically sustainable use of water and the promotion of cross-sectoral approaches through activities on the Water-Energy-Food-Ecosystems interlinkages (WEFE nexus).

Water has both an economic and non-economic value, and its use largely depends on how individuals and societies perceive and assign value to this resource. Water4All will explore these dimensions by generating data, knowledge, and evidence to support participatory frameworks, raise social awareness, strengthen capacity-building, and foster public acceptance. **Questions on awareness through innovative tools, water footprint, virtual water and water use paradigms will be addressed within this theme.**

**Strategic goals:** 1. To strengthen social acceptance, public engagement, and stakeholder participation in water-smart and circular economy transitions, addressing barriers to adoption through evidence-based communication, co-creation processes, and inclusive governance; 2. To mainstream, including the upscaling of, circular economy models for water security and resilience; 3. To optimise water reuse and water recycling from an economic, financial, social, technical and environmental point of view; 4. To develop top-down (training, equity, justice, affordability) and bottom-up approaches (engagement, behavioural changes) for the adoption of circular economy models.

**Links:** This theme is mainly linked to all the Green Deal policy areas, the Mission on Adaptation to climate change including societal transformation and the Partnership Processes4Planet (Cluster 4). This theme is strongly linked to the Theme VII on Governance.

**Key words:** circular economy, fit for use, WEFE nexus, water value, partnerships and business models, water pricing, bio-based feedstocks, value chains, resource recovery, WoLLs, real-scale validation environments.

**Sub-themes:**

I.I. Water efficiency and integrated supplies for competitiveness.

I.II. Water for circularity and resource security.

I.III. Water-smart empowerment of water users and stakeholders.

12 - EEA, 2023. Water scarcity conditions in Europe (water exploitation index plus), published in CLIMATE-ADAPT: https://www.eea.europa.eu/en/analysis/indicators/use-of-freshwater-resources-in-europe-1

# 4. Water4All proposed R&I themes

## Theme I

### Priority topics:

| Sub-theme | Topics |
|---|---|
| I.I. Water efficiency and integrated supplies for competitiveness. | ■ Developing, deploying and optimising smart water solutions to enhance water-use efficiency, circularity, and adaptive management across sectors and scales. |
| I.II. Water for circularity and resource security. | ■ Progressing in sustainable and cost-effective resource (water, energy, nutrients and materials) recovery and safe reuse in urban and industrial water cycles through the development and optimisation of technologies.<br>■ Optimising energy recovery and efficiency in wastewater systems to target energy neutrality.<br>■ Quantifying the environmental and health risks associated with unregulated CECs in water reuse. |
| I.III. Water-smart empowerment of water users and stakeholders. | ■ Advancing the understanding of the factors that determine the value of wastewater reuse and recycling under climate change stressors, in order to increase public and stakeholder acceptability. |

### Other R&I topics identified:

► **Sub-theme I.I**

- Developing scalable and innovative water allocation approaches to support integrated long-term planning of conventional and alternative water sources for enhanced EU competitiveness and preparedness.
- Developing evidence-informed, water-smart planning to support efficient and sustainable decision-making and promote circularity at regional and local scales.
- Advancing the systemic optimisation of efficient, symbiotic and circular water use across urban and industrial value chains to support clean industrial and digital transformation while enhancing EU strategic autonomy.
- Systemic optimisation of water-smart and sustainable food systems across the entire value chain, from production to consumption, by enhancing water and nutrient efficiency, circularity, and climate resilience.
- Advancing technologies and solutions in new water sources to reduce water stress in targeted regions.
- Maximising efficiency in the water-energy nexus by integrating environmental data with energy and water infrastructure and demand patterns to support investment and spatial planning decisions.
- Encouraging the use of WoLLs to test and validate water efficiency solutions and integrated supply approaches under real operational conditions.

► **Sub-theme I.II**

- Integrating urban greening and decentralised NbS into wastewater systems to promote clean, circular water management and reduce pollution and reuse risks.
- Defining water quality standards to enable the uptake of water reuse beyond agriculture, supported by harmonised regulatory frameworks and risk assessment procedures.
- Developing and standardising innovative traceability systems and certification schemes to ensure the quality of recovered products and strengthen market confidence.
- Developing circular business models (economic feasibility, long-term affordability, market incentives, financing and investments mechanisms) for centralised and decentralised systems.
- Progressing with the assessment of circularity and resource efficiency within the Water –Energy – Food – Ecosystems (WEFE) Nexus, focusing on the interlinkages, interdependencies and trade-offs among water, food and energy sectors, and ecosystems. This also includes developing operational frameworks for WEFE nexus governance and creating decision-support tools that enable integrated planning and resource allocation under competing demands and climate uncertainty.
- Better using WoLLs to validate circular water solutions, including water reuse, resource recovery and industrial symbiosis, in real-life environments while also supporting their scaling-up and replication.

### ► Sub-theme I.III

- Exchanging and scaling up best practices to strengthen evidence-based and stakeholder engagement in the co-creation of circular water solutions.
- Developing methodologies to support stakeholders in designing water-as-a-service models and pricing policies that reflect full cost recovery and the true economic value of water reuse.
- Identifying innovative and transformative routes to enable paradigm changes in water and resource reuse governance, strengthening the integration of efficiency and circularity principles into governance and decision-making processes.
- Developing information and communication technologies (ICT) tools (e.g., sensors, smart meters, smartphone apps) integrated with citizen science approaches to enhance transparency, empower water users and stakeholders, and promote circular and efficient water use.
- Better seizing the opportunities provided by WoLLs to enable stakeholder engagement, co-creation processes and the validation of user acceptance in real-world contexts.



## Theme II: Water for ecosystems and biodiversity

**Relevance of this theme:** Freshwater ecosystems face unprecedented pressures from habitat degradation, pollution, climate change, and invasive species, resulting in catastrophic biodiversity loss. More than half of river and lake water bodies in Europe are reported to hold less than good ecological status (EEA, 2025)[13]. Poor chemical status of water can be a risk for the structure and functioning of aquatic ecosystems (surface and subsurface aquatic ecosystems from source to sea). Today, the quality of surface and subsurface aquatic ecosystems as well as on transitional and coastal waters is mainly threatened by the presence of pollutants - mainly originating from agricultural land use, but still also from cities and industry -, changes in the water cycle, climate change, habitat degradation (including the destruction of ecological corridors, habitat connectivity), biodiversity and forest loss, damages to hydraulic connectivity and exotic species invasions. The third River Basin Management Plans (RBMPs) are a critical opportunity to meet the WFD's objectives and deliver on the EWRS. Key opportunities to accelerate progress and foster synergies with the Nature Restoration Regulations are an opportunity to amplify results across policies.

Other effects of the poor ecological status of aquatic ecosystems include the degradation of fragile and rare ecosystems (wetlands, intermittent rivers, Arctic and boreal ecosystems) and the loss of ecosystem services such as water purification, regulation of the flow of flood events, and provision of clean drinking water. Improvements in quality levels of aquatic ecosystems cannot happen without an appropriate management of water from catchments to sea. For this reason, **this Theme and Theme III (Integrated Water Resource Management) are intrinsically linked.**

This theme prioritises research to understand, monitor, restore and conserve biodiversity, ecosystem functions and services, moving beyond simple species counts to functional diversity metrics that better predict and improve ecosystem resilience.

This theme will tackle topics for the monitoring and evaluation of the functioning of surface aquatic and groundwater dependent ecosystems from a source to sea perspective. It will look in particular at synergies between green/ blue infrastructure and NbS for climate change resilience and adaptation, as well as the effectiveness of NbS in improving water quality, and enhancing flood and drought resilience. Issues for improving the uptake of monitoring strategies, methods and technologies into routine use (including by decision-makers and non-experts), and ensuring the interoperability of tools will also be considered within this theme.

**Strategic goal:** Successful implementation of environmental policies for a just and sustainable protection and restoration of water ecosystem services and biodiversity.

**Links:** With this theme, Water4All will contribute directly to the EWRS, the European Biodiversity strategy, the WFD, the Nature Restoration Regulation, and other water and nature specific directives. It will also contribute to the EU Restore Our Oceans and Water, A Soil Deal for Europe, and Adaptation to Climate Change Missions. Activities will also support the UN Decade Ecosystem Restoration.

**Key words:** ecosystems quality, multiple stressors, resilience, ecosystem conservation, restoration, ecosystem services, Nature-Based Solutions, nutrient and pollution loadings, groundwater, surface water, biodiversity, policy, WoLLs.

**Sub-themes:**

II.I. Functioning and biodiversity.

II.II. Stability, mitigation and adaptation of aquatic ecosystems and ecosystem services to global changes.

II.III. Improving, developing and applying solutions for ecosystems restoration.

II.IV. Integrating ecosystem services into the management of water resources and aquatic ecosystems.

13 - https://www.eea.europa.eu/en/europe-environment-2025/main-report/report/@@download/file

## Priority topics:

| Sub-theme | Topics |
|---|---|
| II.I. Functioning and biodiversity. | ■ Improving freshwater biodiversity and ecosystem services monitoring, indicators, and assessment of drivers and impact of pressures at appropriate temporal and spatial scales through most recent advances in digital technology and predictive modelling.<br>■ Knowledge on meta-ecosystem dynamics (including range, traits and connectivity) for the improvement of biodiversity conservation, restoration and ecosystem service delivery. |
| II.II. Stability, mitigation and adaptation of aquatic ecosystems and ecosystem services to global changes. | ■ Protection and restoration of aquatic ecosystems in the face of climate change (including hydroclimatic extreme events) in a multi-stressor perspective.<br>■ Increasing the ecosystem resilience by understanding cumulative pressures and feedback loops (e.g. climate-biodiversity-pollution interactions). |
| II.III. Improving, developing and applying solutions for ecosystems restoration. | ■ Exploring opportunities provided by technology (including NbS) to manage and restore aquatic ecosystems while delivering co-benefits for biodiversity, carbon sequestration and human well-being.<br>■ Developing and assessing the impact and efficiency of NbS and engineered solutions (including hybrid grey-green) for improved freshwater security at a large basin scale.<br>■ Understanding social impacts and enhancing stakeholder engagement (including end-users and the general public) in the design and implementation of solutions for ecosystems restoration. |
| II.IV. Integrating ecosystem services into the management of water resources and aquatic ecosystems. | ■ Developing methodologies for the valuation of ecosystem services, including intrinsic social and economic values e.g. well-being, cultural, as well as approaches to include the intrinsic value of ecosystem services in decision-making. |

## Other R&I topics identified:

### ► Sub-theme II.I

- Exploring synergies between the ecological status (WFD) and conservation status (Habitats Directive) and the role of aquatic systems in climate mitigation (C sequestration, Greenhouse Gas emissions, GHG ICT).
- Understanding the impacts of freshwater availability and quality on biodiversity and ecosystem services beyond the freshwater ecosystem boundary (i.e., terrestrial and marine environments).

### ► Sub-theme II.II

- Exploring the connection between biodiversity (in particular invasive species), ecosystems services and waterborne diseases as a result of climate change, including the role of water systems in facilitating disease vector expansion (e.g., mosquito-borne diseases) and pathogen transmission under changing climatic conditions.
- Exploring synergies between green and blue NbS to both mitigate and adapt to water related natural hazards, providing water quality, water quantity, biodiversity and GHG mitigation both in natural and urban environments.

- Developing cross-disciplinary methods and tools to identify, quantify, and anticipate risks across hydrological, ecological and societal dimensions. This topic involves the integration of different disciplines (climate sciences, ecology, social sciences, natural hazards).
- Reinforcing the use of WoLLs as real-life environments for testing, monitoring and scaling ecosystem restoration measures and NbS across different territorial contexts.

### ► Sub-theme II.III

- Evaluating the effects of water management, water planning, conservation and restoration measures on ecosystems and biodiversity.
- Evaluating the impact of pollution (including nutrient loads) of aquatic ecosystems in biodiversity and ecosystem services to improve policy implementation and governance (e.g. standards).

### ► Sub-theme II.IV

- Exploring innovative governance and policy instruments (including environmental justice) to ensure cost-efficient, flexible and fair regulation of water and aquatic ecosystems.
- Improving synergies between the Nature Restoration Law and other water-related policies (WFD, EWRS, Nature Directives).
- Expanding the scope of the WEFE Nexus to integrate common goods and a wider scope of societal challenges (biodiversity, health and climate).



## Theme III: Integrated water management

**Relevance of this theme.** The primary purpose of EU water policy is to guarantee access to adequate water quantity and quality water for all and the good status of water bodies/ ecosystems across Europe. Considerable policy efforts have been made by the EC and Member States to support the achievement of this objective, but evidence shows that many obstacles remain in the implementation of the WFD and other specific pieces of legislation.

Building upon a multi-disciplinary approach to water, including natural and social sciences, **Water4All will seek to improve, assess and demonstrate the IWRM approach with a source to sea perspective to enable sustainable water management.** The impact of land use, water demand and global change (including climate and conflicts) on water will be further investigated and proposed solutions will be communicated in support of the EWRS, WFD and related water policies. Water4All therefore aims to provide models, approaches, tools and participatory methodologies to underpin the implementation of EU policy and EU water management plans/ strategies for natural resource efficiency, natural resource protection, adaptation and resilience to hydroclimatic extreme events, and better governance. This work must be based on observation processes, experimentation and models, including the development of new, reliable and cost-efficient measuring instruments.

Many regions and sectors will face increased water scarcity with climate change. Water4All will look into tools to support the **short-term management of water and the long-term planning of water resources.** In Europe, irrigation accounts for roughly 40-50% of total water use annually, and up to around 80% in southern regions (WISE, 2025)[14]. In this context, Water4All will promote the development of water saving irrigation strategies including (ground) water, soil and airborne near real-time sensor technologies. In synergy with other existing or upcoming EU initiatives, Water4All aims to contribute to the optimal use of water use in water-dependent sectors.

Relevant tools for decision support will be developed or improved in order to respond more efficiently to emerging water issues and hydroclimatic hazards. In this sense, Water4All will promote and support **water R&I data** (according to the principle of Open Science) **and infrastructures** for a better understanding of hydrological processes at different spatial and temporal scales.

Finally, the application of concepts for **smartening the water system will be further explored** to guarantee a more efficient use of available water resources whilst satisfying water demand of different economic sectors and human consumption needs. Water4All will promote the development and use of innovative digital-based tools, including improved/ new sensors, models, communications and computing technologies.

**Strategic goal of Theme III:** To build economic, socio-cultural and environmental resilience based on sustainable IWRM by:

- Improving digital tools to enhance conceptual models of socio-hydrological systems so that results can be more effectively interpreted by stakeholders.
- Promoting participatory governance approaches that support fair water allocation and better decision-making, advancing equity, gender equality, and the inclusion of vulnerable groups.
- Enhancing accountability and transparency of water service providers (duty-bearers, such as water utilities, river basin authorities, local authorities) through improved monitoring, reporting, and stakeholder engagement mechanisms.
- Enhancing the effectiveness of socio-economic, nature-based and technological solutions for long-term adaptation.
- Strengthening preparedness and resilience to hydro-climatic extremes.
- Enhancing water-related data collection and sharing through emerging technologies.

Theme III should be all about developing ways/ knowledge to enhance accountability and transparency of water service providers (duty-bearers, such as water utilities, river basin authorities, local authorities, etc.)

**Links:** This theme is directly related to the Missions on Healthy oceans, seas, coastal and inland waters, and on Soil health and food.

14 - WISE, Freshwater information system for Europe (2025). Information available at https://water.europa.eu/freshwater/europe-freshwater/freshwater-themes/water-resources-europe?utm_source=chatgpt.com

# 4. Water4All proposed R&I themes

## Theme III

**Key words:** IWRM, resilience, river basin management, groundwater management, conjunctive use, data and monitoring, source-to-sea approach, nexus, participation, inclusiveness, hydroclimatic extreme events, Nature-Based solutions, decision support tools, WoLLs.

**Sub-themes:**

III.I. Integrated water resources management tools.

III.II. Governance and behaviour.

III.III. River basin and Groundwater management.

III.IV. Resilience, adaptation and mitigation to hydroclimatic extreme events.

III.V. Data and monitoring for IWRM.

### Priority topics:

| Sub-theme | Topics |
|---|---|
| III.I. Integrated water resources management tools. | ■ Developing integrated, robust and multiscale modelling tools on the water cycle, ecosystems and economic systems (including the diverse social and non-market values of water) to support a nexus approach towards long term water resource management and planning, revealing trade-offs between different water uses. |
| III.II. Governance and behaviour. | ■ Innovative (or improved) participatory approaches, including foresight techniques, to design economically and socially acceptable IWRM governance and rules, including water rights and allocation reform under competing demands for water (agriculture, domestic use, industry, energy, environment…), operationalisation of nexus approaches and conjoint surface and groundwater management. |
| III.III. River basin and Groundwater management. | ■ Evaluating the cost-effectiveness, efficiency, acceptance, and trade-offs of NbS and Management Aquifer Recharge (MAR) in supporting the integrated management of surface and groundwater, including through demonstration activities. |
| III.IV. Resilience, adaptation and mitigation to hydroclimatic extreme events. | ■ Predicting short term and seasonal variability for groundwater, soil moisture and surface water for improving hydro-climate services to respond to specific user needs at different levels. This topic will contribute to improved early warning systems and disaster preparedness for extreme hydroclimatic events e.g. by including data from real-time sensor monitoring systems. |
| III.V. Data and monitoring for IWRM. | ■ Combine physical and digital water data systems to improve data use, modelling and decision-making, helping practitioners and policymakers better apply real-time and large-scale information in water management e.g. AI, sensors, monitoring networks, BIM/GIS, Big Data & Machine Learning, Earth Observation. |

## Other R&I topics identified:

► **Sub-theme III.I**

- Developing methodologies to assess current and alternative water management practices considering in an integrated manner issues such as erosion, soil/ subsoil stability, sediment transport, soil/ water quality and water quantity, and hydrological regime of surface water and groundwater.
- Developing and testing scalable and affordable solutions to support water planning, in particular in the face of climate change and climate change resilience (i.e. water planning is understood as the medium and long-term strategy dealing with water availability and provision in a particular area vs water management deals with short-term measures for optimised water use).
- Developing tools and multi-disciplinary approaches to link landscape management to water management and planning, to understand and manage land-water-ecosystem-human relationships and to assess the effect of different land uses on groundwater, inland and coastal water resources (including e.g. nutrients, hazardous substances and brownification).
- Developing new methodologies, tools and models for assessing/ modelling water resources in scarcely monitored /data scarce areas.
- Understanding the dynamics and functioning of water ecosystems with particular reference to vulnerable and protected areas of ecological interest (including intermittent rivers, wetlands, lagoons, alpine areas, Arctic and boreal water systems, peatlands, estuaries, ecological corridors in river networks).
- Strengthening the use of WoLLs to test and validate IWRM tools, models and decision-support systems under operational conditions.

► **Sub-theme III.II**

- Understanding and raising awareness about equity, gender, culture, and vulnerability issues in order to facilitate inclusive and socially just water policies.
- Understanding user and decision maker reponses, perceptions and prefrences with regards to sustainable water management solutions/ innovations, including the use of social science methods, in order to evaluate the acceptance, effectiveness and efficiency of policy instruments to achieve IWRM.
- Strengthening incorporation of local knowledge and stakeholder inputs to amplify the role of co-creation and participatory methods in research activities.
- Testing participatory governance approaches, water allocation mechanisms and stakeholder-driven decision-making processes in real territorial contexts through WoLLs.

► **Sub-theme III.III** Understanding the cumulative effect of the patchwork of different measures (PoMs) to manage river and groundwater basins on the global quality of the environment at the systematic level (water quantity and quality, ecosystem restoration and functioning), in regard to the goals of the WFD, EWRS, Biodiversity Strategy and the Habitats Directive.

- Understanding and placing the role of groundwater in climate adaptation and long-term water security.

► **Sub-theme III.IV**

- Designing robust adaptative strategies and disaster management plans that take into consideration regional differentiation, local conditions, and tailored adaptation pathways in response to deep uncertainty related to hydroclimatic extreme events. This topic includes the development of tools to support this objective e.g. multi-risk approaches, decision support tools.
- Developing innovative (or improved) participatory approaches, including foresight techniques, to design economically and socially acceptable adaptation and mitigation strategies to cope with hydro-climatic extreme events, especially floods and droughts. Effects on society, gender, equity and social vulnerability will be considered.

► **Sub-theme III.V** Developing innovative, low-cost and inclusive monitoring approaches and strategies, especially in scarcely monitored areas, for the WFD implementation and specific directives, e.g. Floods Directive.

## Theme IV: Water and health

**Relevance of this theme:** This Theme follows the one-health approach, therefore considering human, animal and environmental health. Water quality is threatened by contaminants from point and diffused sources. Today, CECs, defined as "chemicals that are not commonly monitored but have the potential to enter the environment and cause adverse ecological and human health effects"[15], represent an important threat both for human health and aquatic ecosystems. CECs comprise several classes of compounds, including organic and inorganic micropollutants, microplastics, nanomaterials, viruses, and cyanotoxins, originating from different sources such as disinfection by-products (DBPs), pesticides (especially metabolites), and pharmaceuticals. Their growing relevance stems from their occurrence in aquatic environments, their environmental fate and behaviour, particularly for persistent and mobile compounds, and their potential adverse and cumulative impacts on ecosystems and human health, including toxicity, endocrine disruption, and antibiotic resistance. Advances in analytical methods and monitoring technologies enable the detection and characterisation of contaminants at increasingly fine spatial and temporal scales. The integration of bioanalytical tools supports even more comprehensive assessments of water quality status and risks to human health and ecosystems.

At the same time, significant effort is devoted to the development and optimisation of advanced treatment technologies capable of removing complex mixtures of pollutants. Risk-based approaches to water quality management are increasingly emphasised, enabling the prioritisation of control measures based on exposure pathways, vulnerability, and intended water uses.

Beyond contaminant-related risks, the Water & Health theme also covers access to safe water in sufficient quantity and sanitation, recognising that water security and health are closely interconnected within the Water, Sanitation and Hygiene (WASH) framework and SDG 6. Access to clean water is essential not only to meet drinking water needs but also to ensure hygiene and sanitation conditions that prevent the spread of water-related and infectious diseases. However, major inequalities remain, with around 40% of the global population still lacking access to adequate sanitation services, making communities particularly vulnerable to health risks[16]. These inequalities are often gendered, with women and girls disproportionately affected by inadequate WASH access, and are exacerbated by climate change, conflict, and displacement. Within Europe, marginalised communities, migrants and residents of informal settlements, continue to face WASH access challenges. Recent global pandemics such as COVID-19 and crisis (originating from extreme events and political instabilities/conflicts) have further highlighted these longstanding deficiencies, reinforcing the need for R&I to improve resilience, continuity of service, and equitable access to safe water and sanitation.

In this context, Theme IV will look at existing **knowledge gaps regarding the occurrence, concentration and behaviour of contaminants (including CECs) in aquatic ecosystems.** Attention should particularly be paid to mixtures of pollutants[17], and related interactions whose effects are poorly understood. Technologies are needed to guarantee access to high quality water for the sake of human, animal and environment health, and in line with the One Health perspective. **Advanced methods of water quality monitoring, protection and treatment take a prominent role in this theme.**

One of the sub-themes focuses on **Anti-Microbial Resistance (AMR) as an imminent global public health threat.** The prevalence of AMR is regarded as one of the greatest risks to human and animal health and one of the most serious global threats, second only to climate change. At the current rate of spread, it is estimated that 10 million people will die from resistant infections by 2050[18]. Wastewater treatment processes are not designed to remove Antibiotic-Resistant Bacteria (ARB) and Antibiotic Resistance Genes (ARGs) and they may spread into outgoing environmental systems and humans depending on proximity to workers and nearby residents[19]. Activities on AMR will be articulated between Water4All and the European Partnership on One Health Antimicro-

15 - Geissen, V. et al (2015). Emerging pollutants in the environment: a challenge for water resource management. International Soil and Water Conservation Research 3, 57-65. Available at: https://www.sciencedirect.com/science/article/pii/S2095633915000039
16 - World Health Organisation (WHO) & UNICEF Joint Monitoring Programme (JMP), 2025. Progress on household drinking water, sanitation and hygiene 2000 – 2024: Special focus on inequalities. Available at https://www.who.int/publications/i/item/9789240115149
17 - Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. OJ L 327, 22.12.2000, pp. 1–73 https://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF
18 - Water JPI's SRIA 2025 April 2020. Available at: https://www.waterjpi.eu/sites/default/files/2025-09/Water%20JPI%20SRIA%202025.pdf
19 - Rodríguez-Molina, D. et al. (2019). Do wastewater treatment plants increase antibiotic resistant bacteria or genes in the environment? Protocol for a systematic review. Available at: https://epub.ub.uni-muenchen.de/72984/

bial Resistance (EUP OHAMR) to avoid duplications and potentiate synergies.

**Strategic goal of Theme IV:** The overarching strategic goal of the Water and Health theme of the SRIA is to fill knowledge gaps regarding the occurrence, concentration and behaviour of contaminants that potentially affect environmental, animal and human health with a particular focus in CECs in aquatic ecosystems. Advanced methods of water quality monitoring, protection and treatment take a prominent role in this theme. In order to achieve these strategic objectives, the group has identified the following challenges in particular:

- Close the evidence loop between water and health. Enable interoperable, FAIR and accessible water-quality and health data; turn data into actionable information for policy and services.
- Protect public health under water stress and crisis. Ensure safe water and sanitation during extreme events and political instabilities; strengthen preparedness and response capacities from catchment to tap (including remote/Arctic contexts).
- Tackle CECs and One-Health risks at source and along the water cycle. Advance understanding, monitoring and cost-effective removal of Persistent Mobile and Toxic (PMT) substances (as PFAS, pharmaceuticals, pesticide metabolites), Micro Plastics/Nano Plastics (MPs/NPs); pathogens; integrate AMR and agri-water interfaces.
- Modernise monitoring and early warning systems. Deploy time-effective, low-cost sensors, non-targeted omics/analytics, and AI-assisted detection; scale from experiments to catchment-level decision support.
- Strengthen risk assessment and communication. Progress on threshold values (e.g., pharmaceuticals/mixtures) and improve risk communication to the public and decision-makers.
- WoLLs should be used to test and validate water quality monitoring systems, treatment technologies and risk assessment frameworks under real operational conditions, ensuring their effectiveness in managing health-related water challenges.

**Links:** This theme is strongly related to the WFD and the Groundwater Daughter Directive (as well as Common Implementation Strategy WFD guidance documents)[20]; the Drinking Water Directive[21], the new Urban Wastewater Treatment Directive[22], the European Water Resilience Strategy[23], the Zero pollution Action Plan[24] and to the EU Mission: Restore our Ocean and Waters[25] by, among other, developing smart monitoring and control systems that may contribute to better delineate affected areas.

**Key words:** drinking water and sanitation (WASH), contaminants of emerging concern (CECs), Persistent Mobile and Toxic (PMT) substances, Anti-Microbial Resistance (AMR), risk assessment and communication, treatment technologies, micropollutants, one-health, wastewater, sewage sludge, WoLLs, real-world validation environments.

**Sub-themes:**

IV.I. Behaviour and effects of chemical and microbial contaminants including AMR.

IV.II. Innovative methods and tools for water quality monitoring.

IV.III. Innovative processes, technologies and tools for water treatment.

IV.IV. Risk assessment and threshold values for protection of human health and ecosystems, risk management and communication.

20 - Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration. OJ L 372, 27.12.2006, pp. 19–31. http://data.europa.eu/eli/dir/2006/118/oj
21 - Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (recast). OJ L 435, 23.12.2020, pp. 1–62. http://data.europa.eu/eli/dir/2020/2184/oj
22 - Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment (recast). PE/85/2024/REV/1 OJ L, 2024/3019, 12.12.2024. http://data.europa.eu/eli/dir/2024/3019/oj
23 - COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS European Water Resilience Strategy. COM/2025/280 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0280
24 - COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'. COM/2021/400 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0400
25 - EU Mission: Restore our Ocean and Waters. Restoring the health of the ocean, seas, and inland waters by 2030. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/restore-our-ocean-and-waters_en

Theme IV

## Priority topics:

| Sub-theme | Topics |
|---|---|
| IV.I. Behaviour and effects of chemical and microbial contaminants including AMR. | ■ Bridging experimental/clinical (in vitro) with field scales/in vivo: designing up-down-scaling studies connecting lab findings to real-life environments. |
| IV.II. Innovative methods and tools for water quality monitoring. | ■ Developing methods and tools for monitoring pathogens, CECs and PMT in complex water matrices, sludges, sediments and soils.<br>■ Accelerating the development of time-effective, low-cost sensors and early-warning systems for pathogens, CECs and PMT from source to sea (including urban waste water), with validated statistical analysis and AI analytics (AI as an enabling tool (not a black box): anomaly detection, prediction and integration with Earth Observation and legacy networks; promote model building despite data gaps, with transparent uncertainty).<br>■ Developing methods and tools for monitoring ARGs/ ARB in aquatic environments and accelerating the integration of AMR data with environmental and health datasets for surveillance use. |
| IV.III. Innovative processes, technologies and tools for water treatment. | ■ Accelerating the development of cost-effective removal/inactivation technologies for pathogens, ARGs/ARB, CECs and PMT, deployable at scale with low energy/ carbon footprints; explore synergies with existing facilities. |
| IV.IV. Risk assessment and threshold values for protection of human health and ecosystems, risk management and communication. | ■ Ensuring open, public-oriented access to water and health data with FAIR principles, interoperability and usability across regions/ countries; turning data into decisions.<br>■ Enhancing the preparedness of the public and practitioners for emergencies in remote local areas, ensuring safe drinking water and sustainable sanitation under access constraints: plans, tools and training linking monitoring to action. |

## Other R&I topics identified:

► **Sub-theme IV.I**

- Improving the understanding and modelling of fate and transport processes from source-to-target (human/ animal/ environment), including catchment scale pathways under climate and land-use change.
- Developing advanced knowledge of the food-water One Health link: bioaccumulation of chemicals, nutrients spread, pathogens and AMR selection and spread via water reuse, sludge and manure land application.
- Better understanding the role of water in the diffusion of non-native species and chemicals acting as (potential) vectors of diseases, including the expansion of disease vectors (e.g., mosquitoes, ticks) and waterborne pathogens under changing climatic conditions, and the implications for public health surveillance and preparedness. This is a relevant topic for Theme II too.

► **Sub-theme IV.II**

- Investigating groundwater biodiversity as a proxy of contamination/ health risk, introducing groundwater bioindicators into surveillance.

## Theme IV

- Exploring the connection between biodiversity (in particular invasive species), ecosystems services and waterborne diseases as a result of climate change.
- Connecting Earth Observation to local/ regional monitoring (including real-time sensor data) of water resources for improved water quality assessments.
- Enhancing knowledge about pollution sources (including sources of discrimination, environmental forensics), processes (transformation, degradation, natural attenuation) and fate in order to attenuate the impact of anthropogenic activities on water resources.
- Developing new approaches to analyse the combined effects of chemicals (i.e. chemical mixtures, "cocktail" effects), integrative bio-assessment tools and new chemicals/ molecular biomarkers and bioassays.

### ► Sub-theme IV.III

- Developing new solutions and product controls for decentralised drinking water systems and sanitation.
- Developing pollution prevention methodologies to reduce the investment and operational costs of treatment applications.

### ► Sub-theme IV.IV

- Strengthening integrated water exposure (nutrients, pathogens, ARGs/ ARB, CECs and PMT) and its integration in global exposure (air, water, soil, food, social and psychological effects/ stressors) – One Health concepts.
- Developing integrated risk assessment procedures, and progressing on threshold values considering the effects of long-term exposure and cocktail effects, under realistic exposure scenarios (chronic/ low dose; multi-stressors) for nutrients, pathogens, ARGs/ ARB, CECs and PMT.
- Enhancing preparedness for crisis water supply and sanitation under political instability and conflicts, considering case-specific contamination risks (e.g., radionuclides) and service disruptions.



## Theme V: Water infrastructures

**Relevance of this theme:** In a competitive Europe, **resilient water infrastructure** is essential. Water infrastructures—including drinking water, wastewater, hydropower production, stormwater utilities, and infrastructures within inland, transitional and groundwater systems—are long-lived, capital-intensive and highly interdependent systems that underpin **water security, ecosystem protection, public health and socio-economic development.** These systems include infrastructures related to inland surface waters such as rivers, regulated river reaches, lakes, wetlands and canals; transitional waters such as estuaries and coastal lagoons; groundwater systems including saturated and unsaturated zones as well as submarine groundwater discharge; and water services for urban, agricultural and industrial uses. Inland navigation infrastructures, including canals, locks, and inland ports and harbours are also considered, with the focus placed on their **water-related functions and impacts** rather than on transport or logistics. Water treatment technologies are also a critical component of water infrastructure, requiring continuous innovation to address emerging contaminants, energy efficiency, resource recovery, and climate resilience.

The ability of water infrastructures to provide water at the **quantity and quality levels required by end-users** could be increasingly challenged in the future by global changes, particularly **climate change, cybersecurity threats, and ageing infrastructure.** Extreme hydroclimatic events can have major consequences: excessive water volumes during flooding episodes may cause the rupture of drinking water and sewage pipelines, while drought conditions can deteriorate water quality and reduce water supply. At the same time, water infrastructures are persistent systems that evolve through successive cycles of operation, renewal and partial replacement. Their management therefore requires a **systemic and lifecycle-based perspective**, especially in a context of increasing uncertainty, stricter environmental and health regulations, and growing societal expectations.

Significant investments are already made annually to replace or rehabilitate ageing infrastructures in order to reduce leakage rates, maintain service reliability and protect public health. However, these renewal cycles should increasingly be seen as **strategic opportunities** to embed resilience, adaptability, circularity, digitalisation and nature-based approaches, while maximising co-benefits for ecosystems and communities. Rather than focusing on isolated assets, this Theme therefore emphasises **transition pathways** that support the progressive transformation of water infrastructure systems.

Within this Theme, a distinction is made between **adaptation and mitigation** approaches to water infrastructure resilience. Adaptation topics focus on actions aimed at preventing or minimising potential damages, while mitigation topics concentrate on reducing the severity of impacts when risks occur. Finally, the **security of water infrastructures** is becoming an increasingly critical concern. Protection against external attacks, including cyber threats and potential acts targeting water supply systems, is essential for water utilities. The development and deployment of robust technologies, monitoring systems and operational practices should enable more effective responses to such risks and reduce the vulnerability of water infrastructures.

Another area of interest within this Theme is the growing role of digitalization and data-driven water management. Advances in sensing technologies, remote monitoring, modeling, and data analytics support more dynamic and adaptive water system operation. Research needs remain regarding the use of real-time data, forecasting tools, and decision-support systems to improve efficiency, resilience, and responsiveness across water supply, wastewater treatment, and environmental management. Key innovations in the field of digitalization include Digital Twin & AI-powered water management systems, using virtual replicas of water infrastructure, predictive analytics, and artificial intelligence/machine learning for automated decision-making.

As emphasised in all previous Themes, WoLLs should be used in topics within this Theme to test, validate, and optimise innovative water infrastructures, including digitalized, hybrid and nature-based systems, under real operational conditions, supporting their scalability and replication across territories.

**Strategic goal of Theme V:** To enable the transition of water infrastructures towards resilient, adaptive and sustainable systems, by integrating lifecycle thinking, foresight, digitalisation, circularity and NbS into infrastructure planning, renewal, operation and governance, and WoLLs.

**Links:** Research in this Theme contributes directly to the implementation of key European policy frameworks, including the **WFD**, the **Floods Directive**, the recast **Drinking Water Directive,** the recast **Urban Wastewater Treatment Directive,** and the **EU Water Resilience Strategy.**

## Theme V

**Key words:** Water infrastructure safety and security; asset management; lifecycle and capital maintenance; resilience; adaptive and safe-to-fail design; digitalisation and digital twins; machine learning (ML); Internet of Things (IoT); smart sensors; cybersecurity; hybrid grey–green infrastructures; centralized and distributed systems; groundwater–surface water interactions; subsurface integrated spatial planning; transitional waters; inland navigation infrastructures; WoLLs; cost-recovery principle; affordability and equity principles; financing and investment mechanisms.

**Sub-themes:**

V.I. Transition and lifecycle management of aging water infrastructures.

V.II. Resilient and adaptive infrastructure design under climate uncertainty.

V.III. Digitalisation, monitoring and smart operation of water infrastructures.

V.IV. Hybrid, distributed and nature-based infrastructure systems.

V.V. Infrastructures at the interface of surface water, groundwater, coastal zone/ transitional waters and inland navigation.

### Priority topics:

| Sub-theme | Topics |
|---|---|
| V.I. Transition and lifecycle management of aging water infrastructures. | ■ Transitioning existing infrastructure to more effective, efficient and resilient solutions (e.g. NbS, hybrid, circular and decentralized) while renewing aging assets.<br>■ Integration of foresight and scenario analysis into long-term infrastructure investment planning and design under deep uncertainty. |
| V.II. Resilient and adaptive infrastructure design under climate uncertainty. | ■ Develop novel business, financing and governance models enabling the implementation and long-term operation exploiting the co-benefits of multi-purpose grey or nature-based water infrastructure (e.g. stormwater storage plus recreational / parking areas, ecosystem services of NbS). |
| V.III. Digitalisation, monitoring and smart operation of water infrastructures. | ■ Integration of multi-source monitoring (in-situ real-time sensors, Earth observation, proxy parameters) with ML and AI analytics for early warning, anomaly detection, predictive maintenance, and decision support. |
| V.IV. Hybrid, distributed and nature-based infrastructure systems. | ■ Hybrid grey–green configurations of water systems, combining engineered assets with NbS, delivering co-benefits and enhancing resilience, flexibility and equity across water systems. |
| V.V. Infrastructures at the interface of surface water, groundwater, coastal zone/ transitional waters and inland navigation. | ■ Adaptation of regulated rivers, canals, locks and associated structures under changing hydrological regimes and climate extremes. |

## Other R&I topics identified:

► **Sub-theme V.I**

- Alignment of operational, tactical and strategic planning with financial and investment governance frameworks, including the management of accumulated maintenance backlogs and legacy design choices.

► **Sub-theme V.II**

- Safe-to-fail and adaptive design concepts for infrastructures exposed to floods, droughts and cascading risks, including cyber security and power outage.

► **Sub-theme V.III**

- Digital twins for water infrastructures and systems to support operation, stress-testing and adaptive planning.
- Data governance, transparency, cybersecurity and human oversight in digitally enabled infrastructure management.

► **Sub-theme V.IV**

- Integration of NbS into existing infrastructures, including implications for asset management, performance assessment and maintenance.
- Governance and operational challenges of scaling distributed and nature-based infrastructure solutions including trade-offs, performance limits and long-term maintenance implications.

► **Sub-theme V.V** Integrated management of infrastructures operating across rivers, aquifers, estuaries, coastal lagoons and canals, including salinisation risks, sediment dynamics and ecological continuity.

- Developing new infrastructures and tools for enhancing groundwater recharge capacities and setting sustainable extraction limits.



# Concluding remarks

This SRIA represents a key guiding document for the Water4All Partnership, defining shared priorities for R&I in the water domain. Compared to its previous version, this updated SRIA introduces two major novelties. First, it provides a **clearer and more structured identification and prioritisation of thematic areas,** strengthening the strategic focus of the Partnership. Second, it introduces a set of **Key Performance Indicators (KPIs)** designed to support the monitoring and tracking of SRIA implementation over time.

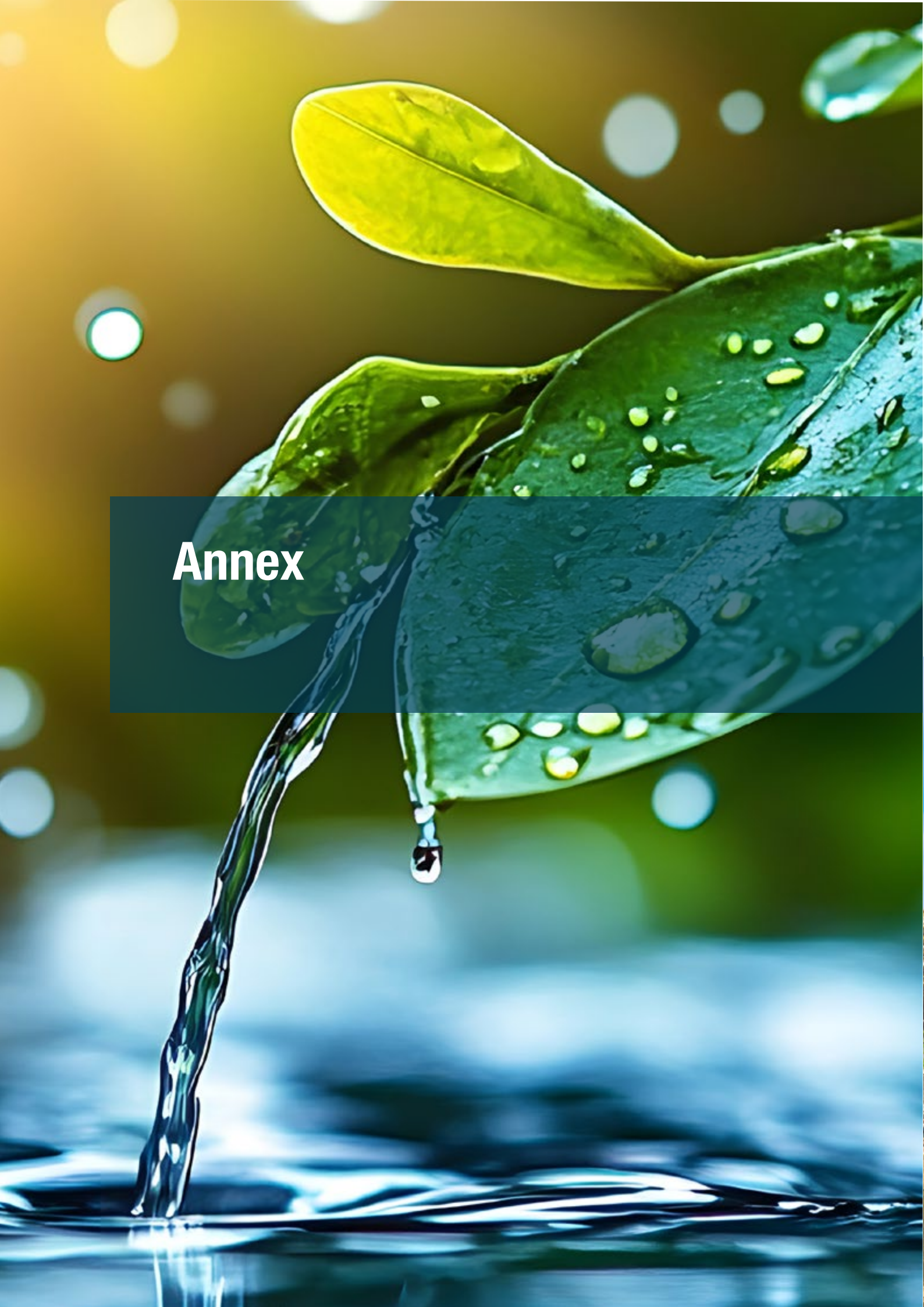
Building on these advancements, the SRIA is intended to guide the programming of R&I funding within Water4All, as well as to serve as a reference framework for related European initiatives, in particular under the Horizon Europe Framework Programme.

The next stage of implementation will focus on the preparation of targeted thematic papers addressing the main priority areas identified in the SRIA. These papers will allow for a more in-depth exploration of selected topics, key challenges, and potential solutions, thereby strengthening the evidence base and supporting the operationalisation of the SRIA priorities.

In parallel, other Water4All activities will complement this work, in particular the **alignment activity.** This process aims to further reinforce the role of the SRIA as a key reference document for national R&I programmes across participating countries. It will also support a better understanding of the extent to which the SRIA addresses the needs of key end-users in the water sector, in particular water utilities and agricultural stakeholders.

**While no further full update cycle of the SRIA is foreseen at this stage, the alignment activity will provide an opportunity to identify emerging or underrepresented R&I needs that may not have been fully captured**. In this respect, it will function as a form of light, continuous update mechanism, ensuring the continued relevance and responsiveness of the SRIA over time.





# Annex

# Water4All initial monitoring template

**Figure 6** depicts the intervention logic of Water4All towards its vision: "boost the systemic transformations and changes across the entire research – water innovation pipeline, fostering the matchmaking between problem owners and solution providers for ensuring water security for all in the long term". It describes the general objectives of Water4All (long term societal impacts), its specific objectives (expected outcomes), and its operational objectives (actions). The coloured arrows between objectives depict the Partnership's Specific Impact Pathway, i.e. the ways the joint performance of actions in Water4All is anticipated to lead to the expected outcomes, which combined achievement will, in turn, deliver the Partnership's impacts.

The Consortium, with the methodological support from the expert group set up by the EC to support the strategic coordinating process of European partnerships[26], identified 20 Key Performance Indicators (KPIs) to monitor the progress of Water4All towards its objectives. These indicators, shown in **Table 3**, will be periodically reviewed by the Consortium. The list of indicators may evolve if the successive reviews reveal some irrelevance, or if additional, more relevant indicators are discovered.

The progress against these indicators will be regularly discussed with the members of the consortium and with its AB, and reported to the EC. This analysis will drive the inflexion of the activities of the partnership and will in particular feed into the elaboration of the annual work plans.

Note that the impact of projects funded through the Water4All calls for proposals will be specifically assessed. This detailed analysis will feed data into the monitoring of the KPIs.

KPIs to track the SRIA Implementation are displayed in **Table 4.**

26 - https://ec.europa.eu/transparency/expert-groups-register/screen/expert-groups/consult?lang=en&groupID=3738



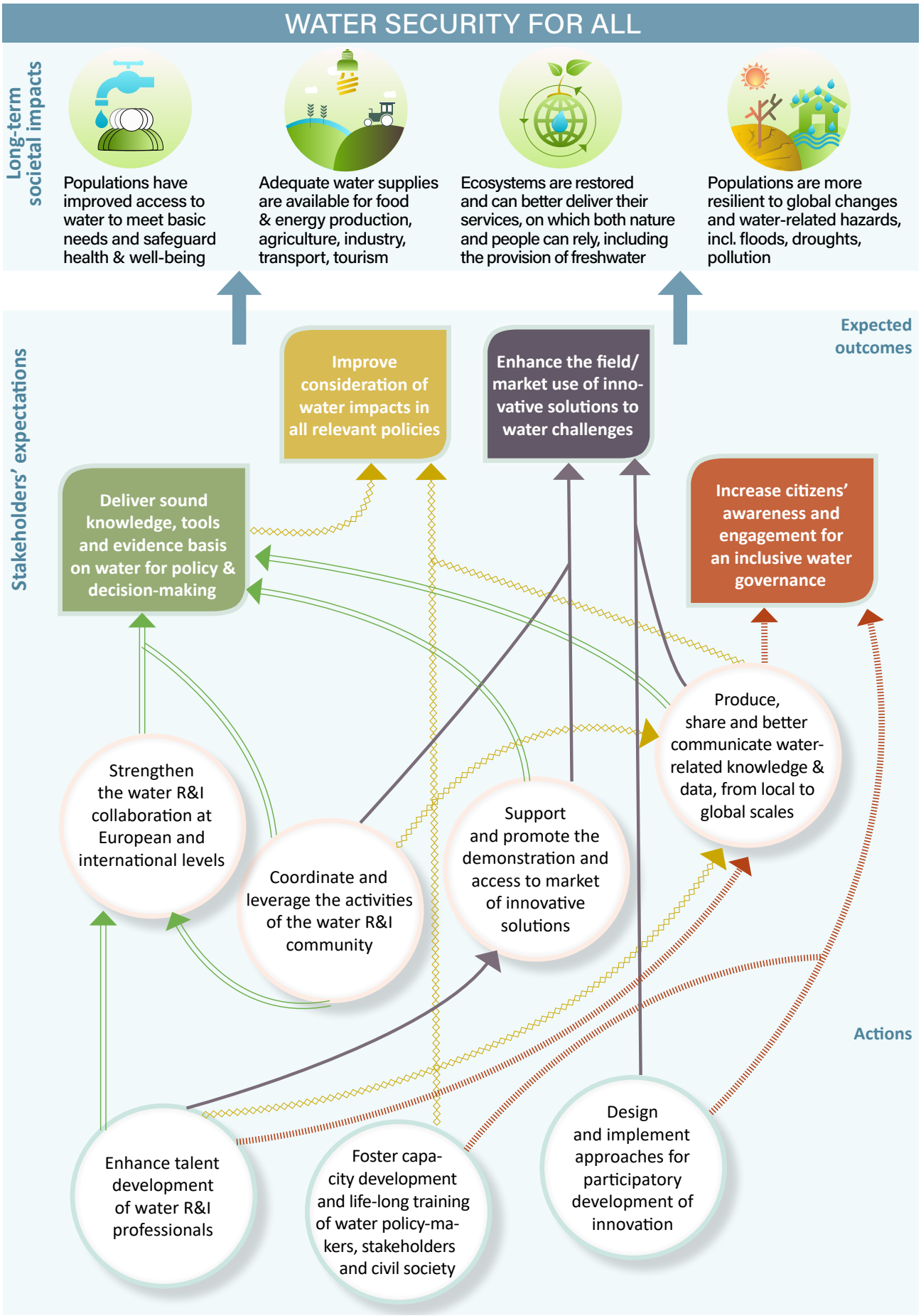



FIGURE 6. WATER4ALL'S SPECIFIC IMPACT PATHWAYS

TABLE 3: WATER4ALL MONITORING AND EVALUATION FRAMEWORK

| European Partnership Water4All | | | Monitoring and evaluation framework |
|---|---|---|---|
| **Overall vision:** Boosting the systemic transformations and changes across the entire research – water innovation pipeline, fostering the matchmaking between problem owners and solution providers for ensuring water security for all in the long term | | | |
| | | **Objectives** | **Indicator** |
| General objective | GO1 | Populations have improved access to water to meet basic needs and safeguard health & well-being | SDG 6.1.1. Proportion of population using safely managed drinking water services |
| | | | SDG 6.2.1. Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water |
| | GO2 | Adequate water supplies are available for food & energy production, agriculture, industry, transport, tourism | SDG 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources |
| | GO3 | Ecosystems are restored and can better deliver their services, on which both nature and people can rely, including the provision of freshwater | SDG 6.6.1 Change in the extent of water-related ecosystems over time |
| | GO4 | Populations are more resilient to global changes and water-related hazards, incl. floods, droughts, pollution | SDG 1.5.2: Direct economic loss attributed to disasters in relation to global gross domestic product (GDP) |
| Specific objective | SO2 | Deliver sound knowledge, tools and evidence basis on water for policy- & decision-making | Number of countries gathering their water data in a transnational platform |
| | | | Success stories of projects/actions/results or contributing to public policy and strategic documents |
| | SO2 | Improve consideration of water impacts in all relevant policies | Qualitative study on the integration of water challenges in sectoral national and European policies and regulations |
| | SO3 | Enhance the field/market use of innovative solutions to water challenges | Number of research-produced tools taken up by SMEs as pre-commercial prototypes |
| | SO4 | Increase people's awareness and engagement for an inclusive water governance | Number of case studies with demonstrated inclusive water governance |
| Operational objective | OO1 | Strengthen the water R&I collaboration at European and international levels | Composition of the consortium: number of member organisations per type and per country |
| | | | Number, types and countries of newcomer organisations in supported projects |
| | OO2 | Coordinate and leverage the activities of the Water R&I community | No. of joint calls launched |
| | | | Number of European partnerships with which Water4All is coordinating its activities (launch of joint activities, regular coordination meetings) |
| | OO3 | Support and promote the demonstration and access to market of innovative solutions | Number of innovative solutions presented in a central Web portal |
| | OO4 | Produce, share and better communicate water-related knowledge & data, from local to global scales | Number of peer-reviewed scientific publications |
| | | | Number of followers on social media |
| | OO5 | Enhance talent development of water R&I professionals | Number of researchers involved in upskilling activities |
| | OO6 | Foster capacity development and life-long training of water policy-makers, stakeholders and civil society | Number of individuals benefitting from capacity and knowledge building activities |
| | OO7 | Design & implement approaches for participatory development of innovation | Number and share of supported projects where the general public and end-users contribute to the R&I content |

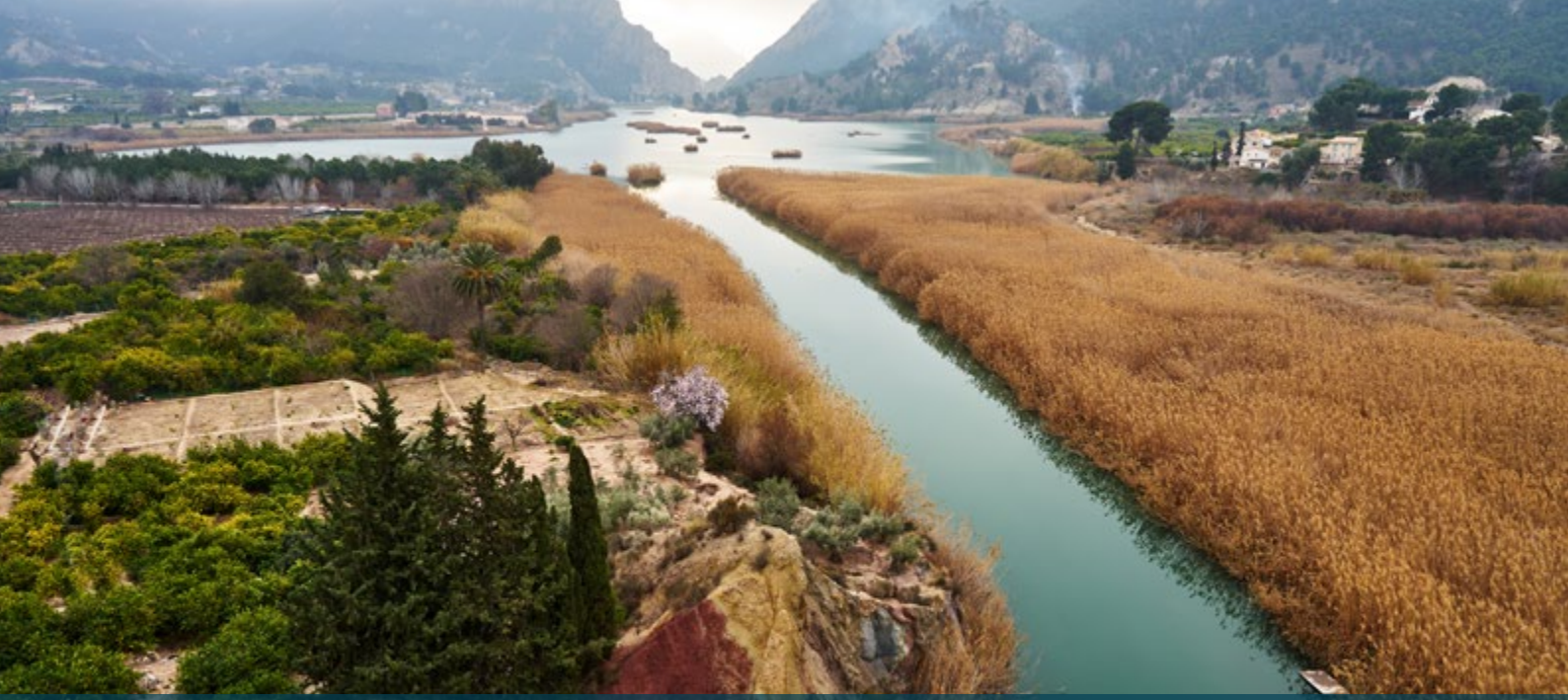
TABLE 4: MONITORING OF THE SRIA IMPLEMENTATION VIA POTENTIAL INDICATORS

| Objectives | Assessment | Potential indicators |
|---|---|---|
| **SO1 - Provide strategic direction** | Coherence between SRIA and thematic Water4All activities | Share of thematic Water4All activities aligned with SRIA priorities |
| | Alignment of funded research with SRIA priorities | Share of funded projects addressing SRIA priority topics |
| | Influence of SRIA on R&I policies | Use of SRIA in EU and national R&I policies |
| | | Use of SRIA in R&I policies outside EU |
| | SRIA dissemination | Share of SRIA themes covered with white papers or policy briefs |
| | | Annual presentations of SRIA |
| **SO2 - Guide programmes and calls** | Use of SRIA in call design | Share of EU calls on water explicitly referencing SRIA priorities |
| | Alignment of funded portfolio with SRIA guiding principles | Share of funded projects consistent with SRIA guiding principles |
| **SO3 - Translate knowledge into practice** | Uptake of SRIA into practice | Share of Water 4All WOLLs uptaking SRIA recommendations. |
| | Dissemination of SRIA to practitioners | Share of the target platforms/Associations that share SRIA to their members |



# List of acronyms

| Acronym | Full title |
|---|---|
| AI | Artificial Intelligence |
| AMR | Anti-Microbial Resistance |
| ARB | Antibiotic-Resistant Bacteria |
| ARGs | Antibiotic Resistance Genes |
| BIM/ GIS | Building Information Modelling/ Geographic Information System |
| CECs | Contaminants of Emerging Concern |
| COVID-19 | Coronavirus disease of 2019 |
| DBPs | Disinfection by-products |
| DUT | Driving Urban Transition |
| EC | European Commission |
| EEA | European Environment Agency |
| EIT | European Institute of Innovation and Technology |
| ESA | European Space Agency |
| EU | European Union |
| EUP OHAMR | European Partnership on One Health Antimicrobial Resistance |
| EWRS | European Water Resilience Strategy |
| FAIR | Findable, Accessible, Interoperable, Reusable |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gas |
| ICT | Information and Communication Technologies |
| IoT | Internet of Things |
| IWRM | Integrated Water Resource Management |
| JPI | Joint Programming Initiative |
| KIC | Knowledge Innovation Communities |
| KPIs | Key Performance Indicators |
| MAR | Managed Aquifer Recharge |
| ML | Machine Learning |
| MOOC | Massive Open Online Courses |
| NbS | Nature-Based Solutions |
| PFAS | Per- and Polyfluoroalkyl Substances |
| PMT | Persistent Mobile and Toxic substances |
| PoMs | Programmes of Measures |
| PRIMA | Partnership for Research and Innovation in the Mediterranean Area |
| RBMPs | River Basin Management Plans |
| R&I | Research and Innovation |
| SBEP | Sustainable Blue Economy Partnership |
| SRIA | Strategic Research and Innovation Agenda |
| SDGs | Sustainable Development Goals |
| WASH | Water, Sanitation and Hygiene |
| WEFE | Water-Energy-Food-Ecosystems nexus |
| WFD | Water Framework Directive |
| WHO | World Health Organization |
| WoLLs | Water-oriented Living Labs |



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# SRIA