Water4All's Strategic Research and Innovation Agenda (SRIA): 2022-2025

September 2022

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TABLE OF CONTENTS

List of acronyms

Acronym	Full title
AB	Advisory Board
AMR	Anti-Microbial Resistance
ARB	Antibiotic-Resistant Bacteria
ARG	Antibiotic Resistance Genes
BIM/ GIS	Building Information Modelling/ Geographic Information System
CECs	Contaminants of Emerging Concern
CEFIC	European Chemical Industry Council
CEWP	China Europe Water Platform
Climate-KIC	Knowledge and Innovation Community working to accelerate the transition to a zero-carbon economy
CSA	Coordination and Support Action
DBPs	Disinfection by-products
DSS	Decision Support System
DUT partnership	Partnership on Driving Urban Transitions to a sustainable future
EC	European Commission
EEA	European Environment Agency
EEB	European Environmental Bureau
EH-NBS	Ecohydrology Nature-Based Solutions
EIB	European Investment Bank
EJP	European Joint Programme
EO4WATER	Earth Observation for Water resource management
ERIC	European Research Infrastructure Consortium
ESA	European Spatial Agency
EU	European Union
EURAQUA	European Network of Freshwater Research Organisations
EUREAU	European federation of national water services
EWA	European Water Association
FACCE JPI	Joint Programming Initiative on Agriculture, Food Security and Climate Change
FAIR	Findable, Accessible, Interoperable, Reusable
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	GreenHouse Gas
HEU	Horizon Europe
ICT	Information Communication Technology
IoT	Internet of Things
IT/OT	Information Technology/ Operational Technology

Acronym	Full title
IWRM	Integrated Water Resource Management
KPIs	Key Performance Indicators
JPI	Joint Programming Initiative
JPI Climate	Joint Programming Initiative "Connecting Climate Knowledge for Europe"
JRC	Joint Research Center
MAR	Managed Aquifer Recharge
MENBO	Mediterranean Network of Basin Organisations
MOOC	Massive Open Online Courses
NBS	Nature-Based Solutions
OECD	Organisation for Economic Co-operation and Development
PHA	Polyhydroxyalkanoates
PoMs	Programmes of Measures
PRIMA	Partnership for Research and Innovation in the Mediterranean Area
RIs	Research Infrastructures
R&I	Research and Innovation
SDGs	Sustainable Development Goals
SRIA	Strategic Research & Innovation Agenda
UN	United Nations
UN SDGs	United Nations Sustainable Development Goals
VFA	Volatile Fatty Acids
Water4All	European partnership on Water security for the planet
Water JPI	Water Joint Programming Initiative
WEFE	Water-Energy-Food-Ecosystems nexus
WFD	Water Framework Directive
WoLLs	Water-oriented Living Labs

FOREWORD

Bjørn Kaare Jensen,
Chair of Water4All

As one of the largest R&I water networks and funding mechanisms ever established, Water4All offers a unique opportunity for all water professionals involved in research and innovation in Europe to bring knowledge and solutions to a new level.

There is an urgent need for such 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 technology. The challenges to get enough water for the globe of a quality fit for the purpose are ever increasing, both due to climate change effects on the water cycle and other anthropogenic activities and are accelerating despite a huge effort to counteract these challenges.

We must insist on the ambition to strive for excellence to attract the best institutions and brightest water professionals.

For that purpose, we need more than resources. We need new ways of thinking, we must dare to tread new paths, and we must insist on the ambition to strive for excellence to attract the best institutions and brightest water professionals. But first of all we must join forces, and we must bring the innovative researchers and forward-thinking entrepreneurial brains to the table. All that Water4All is aiming for.

The framework for this ambitious effort is the strategic agenda. Building on the experience from previous and current networks, the strategic agenda covers in an excellent way the basis for fostering the match-making between those who are faced with the problems, and those who provide solutions for managing the problems. However, a strategy is a dynamic instrument, and in Water4All we will insist on an open-minded, respectful and dynamic working attitude to keep the strategy alive.

ABSTRACT

Water4All is a Research and Innovation (R&I) Partnership set up in Horizon Europe (HEU). It aims at enabling water security for all on the long term by boosting systemic transformations and changes across the water R&I pipeline, fostering the matchmaking between problem owners and solution providers. In addition to the launch of calls for R&I proposals, Water4All offers a portfolio of additional activities including the alignment of water programmes, demonstration projects, international cooperation, the wide transfer and dissemination of activities and results, networking and capacity building.

The project will provide relevant outcomes for a better understanding of water processes in a number of scientific fields and it will support European and international policy-oriented initiatives, notably the European Green Deal and the United Nations Sustainable Development Goals. At the date of publication of this SRIA, the consortium counts more than 70 partners stemming from national research funding agencies, public authorities including local authorities, research performing organisations, water associations and networks at European, national or regional levels. Partners have decided to join forces to address the big challenge of water for all. The project is structured around 5 operational pillars looking at strategic issues (pillar A), development of knowledge through calls for proposals (pillar B), science – policy – end-users interface (pillar C), demonstration (pillar D) and international cooperation (pillar E).

The SRIA lays out key water R&I areas that should be addressed by Water4All through the implementation of activities. The contents of this SRIA are mainly based upon the priorities identified in other water related initiatives e.g. Water JPI; successive consultations with members and a large public consultation open at the end of 2020 and targeting all European water R&I actors have been used to enrich its contents. Based upon this work, the SRIA is broken down into 7 key themes:

I. Water for circular economy: smart water value
II. Water for ecosystems and biodiversity
II. Water for the future: sustainable water management
IV. Water and health
V. Infrastructures for water
VI. International cooperation
VII. Governance

Specific sub-themes and related topics are detailed in this report for each of these themes.

Water4All will seek to enhance the societal impacts of activities through synergies with other European initiatives, in particular other HEU's partnerships and missions. Hence, the SRIA details possible thematic synergies with other programmes and the potential contribution of each pillar to European and international policies and strategic frameworks. This analysis shows that collaboration with other partnerships and missions should be enabled as numerous thematic priorities are shared; such cooperation should therefore pave the way for enhanced critical mass, knowledge sharing, and the exchange of good practices and key lessons.

The last chapter of the SRIA focuses on Water4All's monitoring template, which proposes an approach for the monitoring of Water4All's long-term objectives. This monitoring template will ultimately allow partners to determine how the project has been efficient in achieving its expected impacts.

STRATEGIC RESEARCH AND INNOVATION AGENDA

European Partnership Water4All "Water Security for the Planet"

Introduction

Under HEU, the EU 2021-2027 R&I 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 activities. 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. Among the 49 candidate Partnerships, **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. A description of Water4All is available on www.water4all-partnership.eu.

The coordination of activities carried out under the Partnership will be based on a shared long-term vision. The key thematic areas for which coordinated and joint activities are needed have to be agreed in a **Strategic Research and Innovation Agenda (SRIA)**. In the end, the activities of the Partnership should rely on three complementary documents that have to be considered together:

- The Partnership's **work description**, describing its rationale and objectives, as well as the organisation and the various tools to be implemented to reach these objectives. This description is formalised in the Grant Agreement with the EC, as the result of the submission to the HEU HORIZON-CL6-2021-CLIMATE-01 call for proposals on the 6th October 2021. It constitutes the reference document for the whole duration of the Partnership.
- The SRIA, describing the themes and topics that the Water4All Partnership should address in order to enable water security for all on the long term. The first version of the SRIA is published in month 4 of the Partnership, which officially launched its activities in June 2022. It will be reviewed and updated halfway through the Partnership lifetime. The SRIA will make the object of a mid-term review. A second version is due in 2025.
- Annual Implementation Plans will be issued along the duration of the Partnership, describing for the next year which actions are to be carried out. The initial Implementation Plan describing the work for the first year of activity was established with the HEU proposal submission.

In addition, a Monitoring template is agreed with the EC describing the Key Performance Indicators (KPIs) to monitor the progress of the Partnership. The initial version of this monitoring template is included in the SRIA; the monitoring template may evolve after publication, as the indicators will be periodically reviewed, in terms of achievement but also of relevance.

The present document **contains the first version** of the SRIA of Water4All, based on the assessment of existing relevant SRIAs, an open Stakeholders Consultation (December 2020 – January 2021), and the inputs from members of the Partnership and external stakeholders during dedicated meetings.

The purpose of this agenda is to provide a general overview of the Water research, innovation and implementation priorities of Water4All in order to respond to the challenge of **"enabling water security for all on the long term"**. The structure of the document is as follows:

> Section 1: Vision and objectives of Water4All.

> Section 2: Aims of Water4All's SRIA and development process.

> Section 3: Water4All's added value in the European context.

> Section 4: Detailed outline of Water4All's research, innovation and implementation areas to be addressed in order to respond to the overall challenge of enabling water security.

> Section 5: Links between the Water4All's R&I areas outlined in Section 4 and EU frameworks (e.g. the EU Green Deal) and other EU programs and initiatives (notably, under HEU).

> Section 6: Initial monitoring template and key performance indicators for Water4All.

This document has been drafted by a Working Group bringing together Water4All participants with representatives of the EC and major water-related initiatives, networks of experts and associations in Europe *(Water JPI, EurAqua, EurEau, Aqua Publica Europea, Water Europe, European Water Association).*

These partnerships should accelerate the transition towards a green, resilient and competitive Europe

1. Water4All's vision, objectives and strategic orientations

A. SCOPE OF WATER4ALL

According to the proposal by UN Water (2013), **"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"[1]. The Water4All Partnership is guided by this definition and tackles its various dimensions (i.e., preservation of ecosystems, health, safeguarding of water resources for sustaining livelihoods and economic development, water-related disasters, governance).

Water4All adopts a **systemic approach from source to sea** by addressing freshwater security challenges in land areas drained by river basins, connected aquifers and downstream recipients including deltas and estuaries, coastlines and near-shore waters, adjacent seas and the open ocean. With this purpose, Water4All will highlight a new perspective, new tools and new systemic solutions for enhancement of water sustainability and protection.

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, coastal and harbour zones).
- Underground water, including both saturated and unsaturated zones.

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

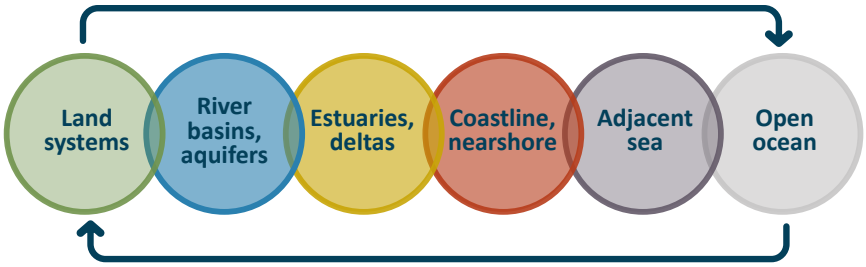

FIGURE 1. SEGMENTS COMPRISING THE SOURCE TO SEA SYSTEM.

Arrows indicate the upstream-downstream linkages between the segments (adapted from the S2S Platform and SIWI report: https://siwi.org/wp-content/uploads/2019/07/source-to-sea-guide_webb.pdf)

B. WATER4ALL'S VISION

Water4All's Vision is to **"boost the systemic transformations 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

[1] https://www.unwater.org/publications/water-security-infographic/

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, Water Framework Directive – WFD - and specific directives, UN 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 citizens in decision-making processes, empowerment, capacity building, accountability and transparency.
- Open access to water knowledge and web services via communication and valorisation activities.

The rationale for the Partnership instrument to address water security challenges, as compared to previous R&I instruments or other HEU 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 requires multidisciplinary R&I activities, from physical and biological sciences to human and social sciences.

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, by speeding up the systemic transformation of European societies but also by pulling other countries on 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.

Water4All develops broad international cooperation in R&I programming to create joint solutions for global societal challenges and mutual economic benefits.

C. WATER4ALL'S 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 **citizens' 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 policy-makers, stakeholders** and civil society.
- Design and implement approaches **for participatory development of innovation.**

Figure 5 in Section 6 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. **Table 5 in Section 6** further details the specific indicators used for monitoring the progress of Water4All towards its objectives.

D. WATER4ALL'S THEMES, DRIVERS AND ENABLERS

Figure 2 depicts Water4All's **thematic fields of interest as well as potential drivers and enablers**. Water4All themes respond to specific needs of society at large (socioeconomic, political and health needs), ecosystems, and infrastructures. The SRIA is structured around five main themes (1-5 in the list below) and two cross-cutting themes – regarding respectively governance and international cooperation. Each theme is then broken down into specific sub-themes and topics, i.e., specific R&I issues for which joint actions are recommended (a full description of sub-themes and topics is provided in **Section 4**).

DRIVERS refer to overarching factors that may lead to changes in the strategic priorities identified in the SRIA for the next years of the programme. Possible drivers for change include:

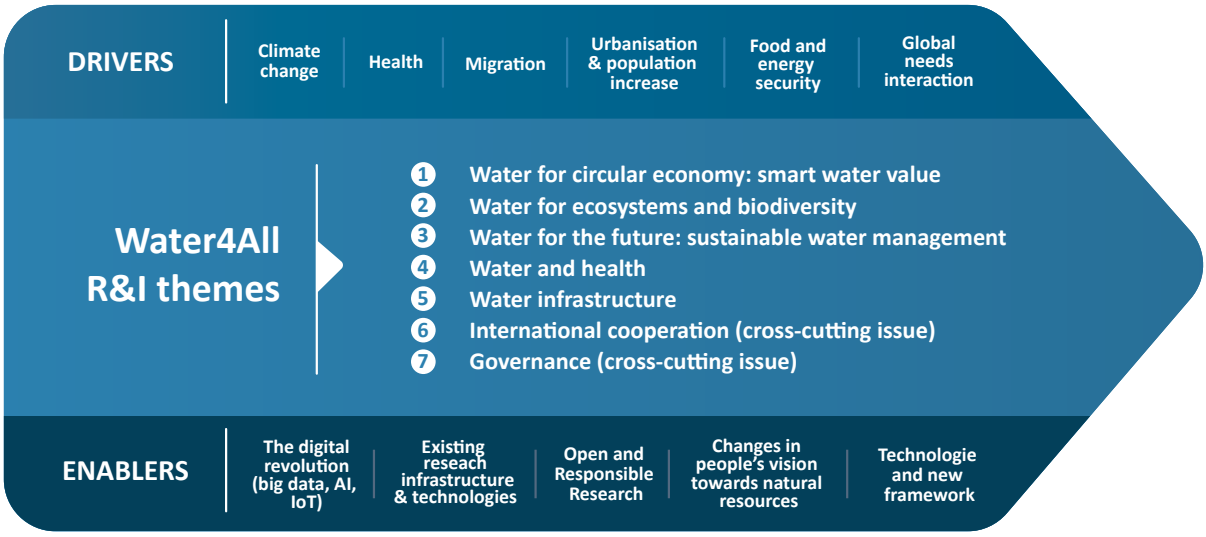

FIGURE 2. WATER4ALL'S R&I THEMES, DRIVERS AND ENABLERS.

[2] https://www.unwater.org/water-facts/climate-change/

- **CLIMATE CHANGE:** Water is the primary medium through which we feel the effects of climate change (UN Water, 2019)[2]. Changes in climate will affect the hydrological cycle and current weather projections predict more extreme hydrological events inside and outside Europe. More floods and severe droughts are expected, impacting both water quantity and quality and, hence, all water related sectors. Climate change and the associated sea-level rise are responsible for natural hazards, soil erosion, ice melting, biodiversity loss, water scarcity (or excess), and water quality reduction. This may ultimately trigger food shortage, population impoverishment, economic crisis, loss of ecosystem services and natural assets, migration dynamics and political instability.
- **HUMAN AND ECOSYSTEM HEALTH:** As we recently experienced with the recent Covid-19 pandemic, health and water security determine each other. Health issues due to human pathogens, xenobiotic and toxic compounds can generate chronic risks to both human and ecosystem health. Health issues may undermine secure water availability and jeopardise washing and sanitation access.
- **MIGRATION:** Migration phenomena are likely to intensify in some regions of the world due to climate change, economic crisis, political instability, water mismanagement and inadequate water services. Migration may result in higher pressure on water resources in destination areas.
- **URBANISATION AND POPULATION INCREASE:** Population dynamics towards urban and coastal areas account for water stress, water quality degradation and water sanitation needs. Global trends indicate that this phenomenon is expected to exacerbate.
- **FOOD AND ENERGY SECURITY:** In the same vein, population growth is likely to compromise water availability, quality and food and energy security in many regions of the world. The efficient use of surface water and groundwater and the sustainable management of water for agricultural purposes (including irrigation and rainwater harvesting) have crucial roles in agricultural systems productivity. Water use must be optimised and water reuse technologies improved to ensure the availability of water for different uses at the quality levels required by end-users. Technological advances should be further seized to enable the adoption and use of alternative sources of water. Water needs for food and energy security will call for innovative water planning and management strategies for the sustainable use of water resources whilst responding to demands.
- **GLOBAL NEEDS AND HUMAN-WATER INTERACTIONS.** Water4All will boost systemic transformations in water management and planning through the better understanding and integration of both local and distant human-nature interactions in decision making tools, e.g. two-way influence between water-dependent human activities and the hydrological cycle. Recent and future progress in human impact modelling and environmental modelling should be grasped for more sound policy-oriented outputs and more informed strategic decisions.

ENABLERS represent any factors facilitating activities and the attainment of Water4All objectives:

- **THE DIGITAL REVOLUTION** (big data, AI, IoT, remote Earth observation, water sensors real-time monitoring, data assimilation). 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.
- **EXISTING RESEARCH INFRASTRUCTURE AND TECHNOLOGIES**. Research infrastructures offer a broad range of services for research activities, including for example functionalities for the collection, sharing, analysis and modelling of data for water management and planning. Water4All will strengthen collaboration with relevant national and European research infrastructures in order to exploit at best those functionalities.
- Global and European initiatives that support **OPEN SCIENCE AND RESPONSIBLE RESEARCH AND INNOVATION.** Open Science provides opportunities for the sharing of data and knowledge, which enables reproducibility and access to research data. Data privacy / security violations are particularly likely to occur in the collection of data from remote sensing, smart meters (related to water consumption) and digital trace data (Zipper et al. 2019[3]). Water4All will then be attentive to privacy and security issues stemming from the sharing of sensitive data and information (ethical data management).
- **CHANGES IN PEOPLE'S VISION TOWARDS NATURAL RESOURCES.** Communication and global outreach play a key role in shaping people's awareness of, and behaviour towards, water challenges. Water4All must grasp the opportunities provided by social networks and digital media to inform objectively and responsibly on a permanent

[3] 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

basis of the work carried out by the initiative, current challenges and best possible ways to safeguard water security for all.

- **TECHNOLOGIES AND NEW (REGULATORY AND ECONOMIC) FRAMEWORKS** for more efficient water management and planning. Water4All embraces forward-thinking applications and solutions to progress in safe and clean water for all. The Partnership seeks to promote the implementation and practice of innovative solutions in all sectors across Europe and abroad through new technologies and governance (see section e below for more information on possible barriers for the implementation of innovative solutions).

E. ADDRESSING BARRIERS TO IMPLEMENTATION – WATER4ALL'S ACTIVITIES

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 (e.g. prices reflecting the full cost of water services), 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 (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, 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 demonstration sites or living labs to test and implement solutions (Pillar D);
- Socio-economic studies, analysis of market barriers and comparisons of framework conditions to improve market uptake of new solutions (Pillar D).
- Conducting roadshows for promoting innovative approaches (Pillars D&E);
- Feeding data and evidence from R&I programmes into UN 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 (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).

Water4All aims at an encompassing approach breaking the silos of disciplines or applications, in particular in the joint transnational calls, to jointly address several topics across the themes and cross-cutting issues.

2. SRIA: Aims and development process

A 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**.

Water is the object of numerous initiatives as water security (both in terms of quantity and quality) is an issue in many Member States. Some of these initiatives have established their own strategic R&I agenda as a way to guide their activities and influence the EU R&I setting. Water4All did not aim at developing a SRIA from scratch. On the contrary, **it builds upon these agendas**. Following a mapping exercise carried out by the Drafting Group of Water4All, existing SRIAs from major water initiatives, networks of experts and associations were identified and critically reviewed (i.e. agendas from the Water JPI, EurAqua, Water Europe, EurEau, PRIMA, FACCE JPI). All R&I needs identified in those agendas were grouped together into different themes according to the overarching aim they refer to. R&I needs identified in conferences or events held during the development of the Water4All Partnership (Water Europe, EWA, GeoERA, EuroGeoSurveys, ESA EO4Water...) have also been considered, as well as the draft versions of the SRIA from upcoming EU Partnerships and Missions within the framework of HEU: the Sustainable Blue Economy Partnership, the Biodiversity Partnership, the Driving Urban Transitions – Sustainable future for cities Partnership, as well as the Missions on Adaptation to Climate Change, Oceans and Waters, Climate-Neutral and Smart Cities, and Soil.

The process for developing the agenda and its schedule are summarised in **Figure 4**. A first draft was produced on the 7th December 2020, on the basis of the review and assessment of R&I needs in EU water agendas and of exchanges during a meeting of the Advisory Boards (AB) of the Water JPI at the

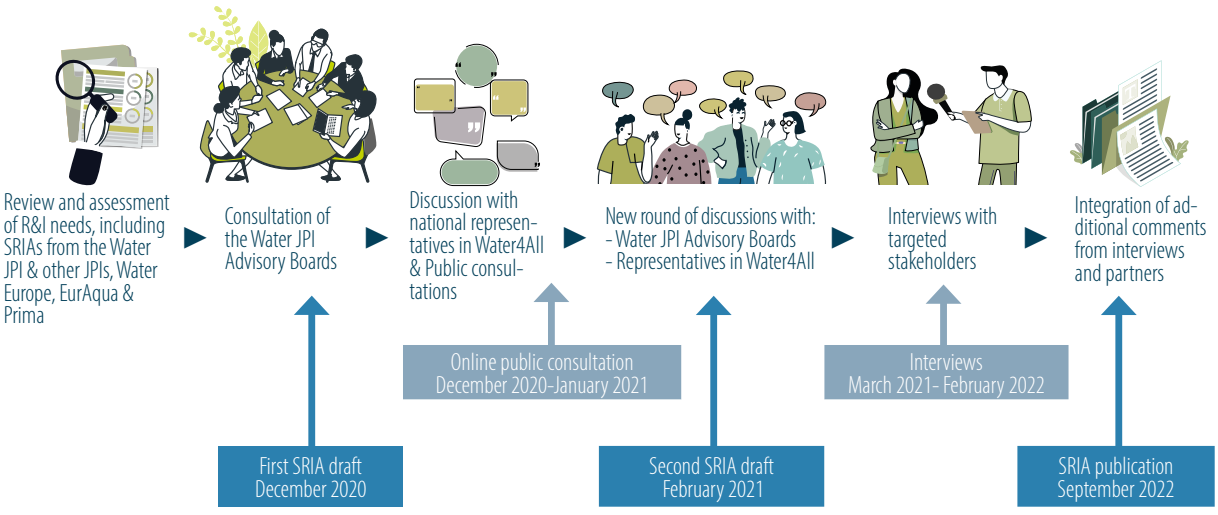

FIGURE 4. WATER4ALL'S SRIA DEVELOPMENT PROCESS.

beginning of October 2020. Water4All participating countries were consulted on this first draft, and an open consultation was online between the 10th December 2020 and the 18th January 2021, attracting 93 valid contributions[4,5]. A second draft taking account the feedback received from these consultations was produced on the 8th February 2021. It was shared again with the representatives of the participating countries and discussed again with the experts from the Water JPI's AB in March 2021.

Following suggestions from the Water JPI's AB and approval by partners, from Spring 2021 to mid-February 2022, specific experts and stakeholders were targeted through interviews to broaden the scope of the consultation and enrich the content of the agenda. Some of these stakeholders provided written feedback (some of the organisations contacted did not provide any feedback to our requests but they will be contacted at later stages of the programme). **Table 1** lists the entities interviewed for additional feedback. Incorporating the feedback received led to the final version of the document, resulting in the official Water4All SRIA, version 1.0. The SRIA will be re-evaluated and updated for publication of a second version halfway during the Partnership.

TABLE 1. LIST OF STAKEHOLDERS CONTACTED FOR ADDITIONAL FEEDBACK

Organisation*	Date of the interview
UN Water	April 2021
Aqua Publica Europe	May 2021
Rhine Commission	June 2021
CEFIC – written feedback	November 2021
Human Right 2 Water	December 2021
EIB	January 2022
MENBO	February 2022
ERIC	February 2022

* Other organisations contacted but with no follow-up: JRC, EEA, FAO, EurElectric, EEB.

[4] As explicitly mentioned in the Privacy policy of the survey, anonymous contributions to the consultation were not accepted. One contribution was disregarded for this reason.

[5] The contributions received through the online consultation can be accessed at: https://ec.europa.eu/eusurvey/publication/Water4All_SRIA_2020 (last accessed: 29 August 2022)

The Water4All's 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. It also guides representatives from national/regional funding agencies, research operators, academia, industry, policy and society in addressing water security challenges.

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 EEA Executive Director, Hans Bruyninckx. 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 (EC COM(2019) 95 final)[6]. 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).

Enough fit-for-purpose water is a prerequisite for achieving the Green Deal. Water is essential in all its policy components: Biodiversity, From Farm to Fork, Clean energy, Sustainable industry, Building and renovating, Sustainable mobility, Eliminating pollution, Climate action. Water is also an essential asset in at least **4 of the 5 HEU 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), 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 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. **Table 3** at the end of this document (Section 5) highlights the anticipated contributions of the seven themes of the SRIA to the components of the Green Deal across the five pillars of Water4All activities.

Water security being a global challenge, Water4All will boost synergies and cooperation with other international water initiatives (SDG 17 on partnerships for the goals). Cooperation agreements with international partners and strategic geographical regions for Europe should be developed. Water4All builds upon the work carried out in the Water JPI and its dedicated Coordination and Support Action, IC4WATER - International cooperation for Water, as well as within the frame of the EU-India Partnership and the China-Europe Water Platform (CEWP). **Diplomacy issues, international cooperation water management/ planning and cooperation modalities** will be explored.

Water is essential to basically any sector of life, from natural functions of the environment through health, food, energy or industrial production, building industry... Therefore, Water4All interfaces with many other initiatives at EU-scale. Interfaces may correspond to:

[6] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2019:095:FIN

- Geographical connections:

- Coastal areas and transition waters connect to the Climate Neutral, Sustainable and Productive Blue Economy Partnership and JPI Oceans.
- Underground waters connect to the CSA for a Geological Service for Europe.
- Water in soils and water sediment transportation connects to the EJP Soil.
- Water in cities connects to the Driving Urban Transition to a sustainable future Partnership.
- The Mediterranean is an area with specific concerns regarding water, addressed in PRIMA (2017 – 2027).

- Uses of water:

- Agricultural water consumption connects to the Agro-ecology living labs and research infrastructures and Environmental observations for a sustainable EU agriculture Partnerships, and to the FACCE JPI; food production at large connects to the Safe and Sustainable Food System Partnership.
- Water in production processes connects to the Processes4Planet and the Circular bio-based Europe Partnerships.
- Water for energy production connects to the Clean Energy Transition Partnership.

- Water as a medium:

- Aquatic ecosystems, as habitats, connect to the Rescuing biodiversity to safeguard life on Earth Partnership; as victims of climate change and contributors to its mitigation, they connect to the Climate-KIC and JPI Climate.
- Pollutant's inputs, transportation and transformative/fate in waters connect to the One Health European Joint Programming and the Chemical Risk Assessment Partnership.
- Rivers as a support for transportation connect to the Zero-emission Water Borne transport Partnership.
- The production and sharing of accurate data related to water, which connects to the European Metrology and the European Open Science Cloud Partnerships.
- The production and sharing of imagery-based information for decision making support, which connects to the ESA Copernicus programme.

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 may take various forms, such as joint workshops, common knowledge hubs, joint capacity building programmes, etc. The modalities for collaboration will be regularly discussed with each initiative, either through bilateral meetings or workshops in small groups. These modalities will be detailed in successive implementation plans. **Table 4** at the end of this document indicates the main thematic connections between Water4All and other EU initiatives (specific themes have not been identified for certain initiatives as they are at a preliminary stage in their development; in this case, links are shown by an «X» in **Table 4**).

Attention is paid especially to the simultaneous implementation of European Missions. In particular the 'Restore our Ocean and Waters by 2030' mission displays the following goals[7]:

- Protect and restore aquatic ecosystems and biodiversity;
- Prevent and eliminate pollution;
- Make the EU's blue economy carbon-neutral and circular, including a focus on sustainable aquaculture.

Water4All will ensure communication with mission governance structures throughout the two phases of the mission's implementation process (2021-2025: development and piloting phase, 2026-2030: deployment and upscale phase), in order to maximise mutual benefit and avoid the duplication of efforts.

[7] COM(2021) 609 final, September 2021: https://op.europa.eu/en/publication-detail/-/publication/7e2fad00-2716-11ec-bd8e-01aa75ed71a1/language-en

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.

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 1);
- **The conservation and restoration of ecosystems and biodiversity** (Theme 2);
- **The safeguard of human health** (Theme 4);
- **The protection of society and related infrastructures against natural hazards** (Theme 5);
- **Collaborative approaches to international cooperation in water management and planning** (Theme 6);
- **Good governance** (Theme 7).

The synthesis list of core Water4All's themes and sub-themes is provided in the following **Table 2**, together with the SDGs they are contributing to.

4.
Water4All proposed R&I themes

TABLE 2. Water4All proposed R&I themes

THEME VII

GOVERNANCE

INTERNATIONAL COOPERATION

THEME VI

Research theme and sub-themes	EU Policies supported by Water4All
THEME I - WATER FOR CIRCULAR ECONOMY: SMART WATER VALUE	
I.I Water supplies for socio-economic development and activities	EU Green Deal Water Framework, Bathing Waters, Urban Waste Water Treatment, Groundwater Directives Common Agricultural Policy Circular Economy Action Plan
I.II Circular economy	
I.III Empowering the public, water users and stakeholders in valuing water	
THEME II - WATER FOR ECOSYSTEMS AND BIODIVERSITY	
II.I Functioning and biodiversity	EU Green Deal Water Framework, Shellfish Waters, Dangerous Substances (and its 'daughter' directives), Nitrates, Freshwater Fisheries, Exchange of Information on the Quality of Surface Freshwaters, Groundwater Directives EU Biodiversity Strategy
II.II Resilience, mitigation and adaptation of aquatic ecosystems and ecosystem services to global changes	
II.III Developing and applying ecological engineering and ecohydrology for ecosystems restoration	
II.IV Integrating ecosystem services into the management of water resources	
THEME III - WATER FOR THE FUTURE: SUSTAINABLE WATER MANAGEMENT	
III.I Water Resources Management	EU Green Deal Water Framework, Dangerous Substances (and its 'daughter' directives), Nitrates, Freshwater Fisheries, Exchange of Information on the Quality of Surface Freshwaters, Groundwater Directives Shaping Europe's Digital Future European strategy for data
III.II River basin management	
III.III Groundwater management	
III.IV Resilience, adaptation and mitigation to hydroclimatic extreme events	
III.V Tools for water management	
THEME IV - WATER AND HEALTH	
IV.I Behaviour and effects of contaminants of emerging concern, plastics, endocrine disruptors	EU Green Deal Water Framework, Bathing Waters, Dangerous Substances (and its 'daughter' directives), Urban WasteWater Treatment Directives Marine Strategy
IV.II Water dimension in antimicrobial resistance	
IV.III Innovative water tools and technologies for water quality monitoring and water treatment, remediation and disinfection	
IV.IV Risk Assessment	
THEME V - INFRASTRUCTURES FOR WATER	
V.I Adaptation of existing water infrastructures to new challenges	EU Green Deal EU Adaptation Strategy
V.II Water infrastructures resilience	
V.III Water Infrastructures security (including cyber and terrorism security)	
VI.I Water diplomacy VI.II Establishing tools for trans-boundary cooperation VI.III Developing integrated, fair and adaptive water resource management systems	(EU Green Deal)
VII.I Developing methods for more efficient citizen and wider stakeholder engagement VII.II Strengthening policy integration, alignment, coherence and water policy coordination in order to exert a real change in society VII.III Enhancing the regulatory framework	Common Agricultural Policy EU Green Deal EU Adaptation Strategy Circular Economy Action Plan Water Framework Directive

THEME I: WATER FOR CIRCULAR ECONOMY: SMART WATER VALUE

Relevance of this theme. Climate conditions and water demand are the two main factors currently driving water stress. Topics within this theme will look at tools, methodologies, approaches, innovative technologies, and management practices and models enabling water resource efficiency, water allocation and water use optimisation **for different economic sectors (agriculture, forestry, aquaculture, industry, tourism, energy production) 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. Through this synergistic approach, Water4All wishes to contribute to the resolution of conflicts around the use of limited water resources whilst ensuring the availability of water for existing demands.

The effects of proposed solutions for water use efficiency and the conjunctive use of surface and subsurface waters in reducing resource interdependencies and increasing climate change resilience will be further analysed.

In a context of global changes, Water4All will favour the development and implementation of best available solutions for water treatment and reuse, resource recovery and resource valorisation (reduce, reuse, recycling) both in centralised and decentralised water systems. **New approaches based on eco-innovation and circular economy will be explored, which will in turn open up new business opportunities for Europe.** Opportunities provided by Nature-Based Solutions (NBS), Ecohydrology Nature-Based Solutions (EH-NBS), as facilitators towards the transition to circular economy and catchment sustainability will be supported. Water4All will develop new circular feedstocks and value chains from water and industrial sectors through water technologies to enable the circular and bio-based economy. Traceability systems will also be developed to ensure the quality of recovered products. The Partnership will also contribute to ensuring the ecologically sustainable use of globally essential resources and the promotion of cross-sectoral approaches through activities on the Water-Energy-Food-Ecosystems interlinkages (WEFE nexus).

Water circularity for the recovery and storage of water in aquifers or other bodies is not considered in this topic as it is an object of interest within theme 3 (sustainable water management).

Water has a value: an economic, a societal and an environmental value. The use of water is heavily dependent on the value that individuals allocate to the resource. Water4All will explore that value through participatory approaches and the empowering of users. **Questions on awareness through innovative tools, water footprint, virtual water and water use paradigms will be addressed within this theme.**

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 proposed 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.

Sub-themes:

I.I. Water supplies for socio-economic development and activities, such as agricultural, aquaculture, urban, industrial and energy uses.

I.II. Circular economy.

I.III. Empowering the public, water users and stakeholders in valuing water.

Sub-themes

I.I.
Water supplies for socio-economic development and activities, such as agricultural, aquaculture, urban, industrial and energy uses.

Related topics	Links to other sub-themes
Developing innovative water allocation policies and management practices that perform well across a range of conditions and can adapt to changing conditions at least cost.	III.I VII.II
Developing innovative water demand management strategies for addressing the efficient and equitable use of water. Strategies will benefit from technological and scientific improvements (e.g. forecasting tools, scenarios) and will promote public participation.	III.I
Developing smart water use and efficient technologies for agricultural and urban and industrial purposes, e.g. technologies for water at source separation, water use optimisation in irrigation through new sensors, GPS applications, DSS, remote sensing, ICT.	III.I III.V
Adapting and improving existing technologies for the management of water in agriculture, including advanced sensors for the assessment of soil water content and evapotranspiration, water delivery and irrigation systems and techniques, crop selection and management in water scarce areas.	III.I III.II III.III III.V
Mitigating impacts from energy and raw materials production on water and water ecosystems.	II.I V.II
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).	III.I V.I V.II
Advancing in new water sources to reduce water stress, e.g. harvesting water from water vapour, saline sources, etc.	III. IV V.I

Sub-themes

I.II.
Circular economy.

Related topics	Links to other sub-themes
Progressing in circular economy approaches in urban and industrial wastewater treatment plants through the development and optimisation of technologies for: - The recovery and valorisation of resources from wastewater and sediments (including energy, minerals, metals, salts, nutrients, cellulose). - The production of novel feedstocks from wastewater (e.g. nutrients, fertilisers, hydrogen, VFA, ethanol, ammonia, bio-plastics, PHA, natural flocculants, kaumera), brines and sludges.	III.I III.II IV.III V.I
Water –Energy – Food – Ecosystems (WEFE) Nexus: - Assess the interlinkages and interdependencies of water, food and energy sectors and ecosystems in a context of climate change in different water bodies, in particular cross-border ones, to implement a real water-energy-food nexus approach and increase efficiencies, social equity and sustainability. - Advancing in the development of a more holistic approach in the WEFE Nexus through the inclusion of health (One Health concept). - Identifying and investigating drivers, pathways, nature and types of barriers of the Nexus.	I.I II.II III.I IV.IV VII.II
Enabling the transition to circular water systems through the integration of NBS. R&I actions in this topic should address current challenges, requirements, limitations and barriers.	III.I III.V
Developing and implementing the “Fit-for-use” concept for water-dependent sectors.	I.I IV.III
Developing innovative traceability systems to guarantee the quality of recovered products and improve confidence of the market.	IV.IV VII.III
Quantifying and guiding the management of environmental and health risks associated with water reuse.	II.I IV.IV
Providing efficient pathways (technological, policy and/ or economic) for end-of-waste status for recovered products from waste streams.	VII.III
Developing new management tools and methodologies, partnerships and business models for measuring transition to circularity, its benefits, challenges and trade-offs for industrial processes and agricultural water reuse and recycling. This topic will also look at the development of matchmaking platforms for the valorisation of wastewater based on its value for different industries (and sectors), and the implementation of decentralised treatment systems in synergy with existing centralised treatments.	IV.III V.I VII.III

Developing alternative approaches for wastewater collection and treatment, including decentralised systems.	IV.III V.I
Sustainable management and valorisation of residues from desalination plants to protect land, water and sea ecosystems altogether.	II.I III.I IV.III
Progressing in the understanding of the factors that explain the acceptability of water reuse.	VII.I VII.III

Sub-themes

I.III. Empowering the public, water users and stakeholders in valuing water.	
Related topics	**Links to other sub-themes**
Developing a bottom-up participatory approach for the co-design and co-construction of solutions for water users (e.g. living labs). The participation of women and indigenous peoples will be promoted.	I.I VII.I
Raising awareness about, understanding and assessing the value of water for the public and stakeholders.	VI.III VII.I
Developing methodologies to help stakeholders set appropriate pricing policies that reflect the full cost and the economic value of water.	VI.III VII.I
Exploring the possible routes to conduct paradigm changes to be innovative for water governance. Concepts like water value, water footprint and virtual water will be explored.	I.I III.I VII.I
Developing ICT tools (sensors, smart meters, smart phone applications) combined with citizen science to increase information and transparency over water use (awareness raising)	III.V VII.I

THEME II: WATER FOR ECOSYSTEMS AND BIODIVERSITY

Relevance of this theme. The purpose of the WFD is the long-term protection of the aquatic environment and the good status of water bodies by 2015. As of 2018, more than half of river and lake water bodies in Europe are reported to hold less than good ecological status (EEA, 2018)[8]. Poor chemical status of water can be a risk for the structure and functioning of aquatic ecosystems (surface and subsurface aquatic ecosystems from catchment to coast). 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), biodiversity and forest loss, damages to hydraulic connectivity and exotic species invasions.

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 II and Theme III (Water for the future: Sustainable Water Management) are intrinsically linked.**

This theme will address issues concerning aquatic ecosystems and their drainage basin as well as in "interface areas" (capillary fringe, vadose zone, hyporheic zone, sediment-water, air-water) with a source to sea perspective. Linkages between upstream and downstream water management and planning and land use impacts on water resources will therefore be considered. More specifically, this theme will tackle topics for the monitoring and evaluation of the functioning of surface aquatic and groundwater dependent ecosystems, resilience and adaptation to global changes and restoration measures, and tools for decision making support. It will look in particular at synergies between green/ blue infrastructure and NBS for climate change resilience and adaptation. Issues for improving the uptake of monitoring strategies, methods and technologies into routine use (including by non-experts), and ensuring the interoperability of tools will also be considered within this theme.

Links: With this theme, Water4All wants to contribute mainly to the Green Deal Action Plan, the European Biodiversity strategy, the WFD and other water specific directives, and the Missions on Healthy oceans, seas, coastal and inland waters and on Soils health

[8] https://www.eea.europa.eu/publications/state-of-water

and food. Activities will come to support the UN Decade on Restoration initiative.

Key words: ecosystems quality, multiple stressors, resilience, ecosystem restoration, ecosystem services, NBS, eutrophication, nutrient and pollution loadings, groundwater, surface water, biodiversity.

Sub-themes:

II.I. Functioning and biodiversity.

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

II.III. Developing and applying ecological engineering and ecohydrology for ecosystems restoration.

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

Sub-themes

II.I. Functioning and biodiversity	
Related topics	**Links to other sub-themes**
Setting minimum requirements and standards for meta-data descriptions, data accuracy, data handling and processing for sequencing data produced by molecular methods.	III.V
Monitoring and assessing the functioning and evolution of ecosystems, ecosystem goods and services. Attention will be paid to: - Understanding of the C, O2, P, N, S, Fe, Mn cycles; - GHG emissions from aquatic ecosystems; - GHG buffer capacity of aquatic ecosystems; - Energy cycles (i.e. energy flow through trophic levels). - Understanding the effects of pesticides, microplastics and micropollutants on ecosystems, ecosystems services and biodiversity. Opportunities provided by new data and interoperable easy-to-use tools will be seized at the local and catchment levels e.g. big data, models, observatories, computing power, artificial intelligence, innovative molecular sensor, biosensors.	III.V
Implementing innovative and adaptive biodiversity and ecosystems monitoring tools at different scales (from eDNA in water to Earth observations) and systems (from ponds to large rivers) and their integration into information technology observatories that combine data and model prediction.	III.V
Using novel monitoring methods for managing the risks posed by invasive species and monitoring remediation options.	III.V
Enhancing the role of inland and coastal aquatic ecosystems in carbon sequestration and the reduction of GHG emissions, and its link to the ecological status (sensu WFD), the conservation status (sensu Habitats Directive) and the pressure levels experienced.	II.II III.I III.II
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).	III.I V.I V.II
Understanding and predicting multiple pressure (including anthropogenic pressures)–impact–response relationships in aquatic ecosystems (cumulative effects, domino effects) and ecosystem services through advanced methods and techniques.	II.II
Developing prediction models of ecosystem “tipping points”, sustainability, productivity and resilience in response to environmental stressors e.g. hydro-climatic extreme events.	II.II
Understanding the dynamics and functioning of a range of vulnerable water ecosystems of regional interest (including intermittent rivers, wetlands, lagoons, alpine areas and glaciers, Artic and boreal water systems, peatlands, estuaries).	III.I
Developing evaluation and prediction methodologies to assess the economic and social value of ecosystem services and the intrinsic value of biodiversity across the diverse regions of the EU. Concepts and indicators of ecological economics will be explored.	II.IV
Analysing the linkage between upstream and downstream areas, the role and functional importance of floodplain/ lateral connectivity and channel dynamics, and the interaction zones (capillary fringe, vadose zone, hyporheic zone, sediment-water, air-water).	III.I
Improving knowledge on the quantity and quality of matter flowing across the various reactive zones between soil-plant systems and the different water bodies (vadose zone, capillary fringe, hyporheic zone, estuary continuum and coastal zone).	III.I

Sub-themes

II.II. Resilience, mitigation and adaptation of aquatic ecosystems and ecosystem services to global changes.	
Related topics	**Links to other sub-themes**
Using the understanding gained in multiple pressure-impact-response relationships to counteract pressure factors/ stressors in ecosystems (including biodiversity).	II.I
Exploring the connection between biodiversity (in particular invasive species), ecosystems services and waterborne diseases as a result of climate change.	II.I IV.IV
Developing improved tools for adaptation and mitigation to hydro-climatic extreme events, especially floods (including "flash-floods"), heat waves and droughts in a catchment to sea context.	III.IV III.V
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.	I.II II.III III.IV V.II

Sub-themes

II.III. Developing and applying ecological engineering and ecohydrology for ecosystems restoration.	
Related topics	**Links to other sub-themes**
Understanding, managing and restoring the ecological functioning of aquatic systems (morphological conditions, river continuity and connectivity, sediment flows, hydraulic connectivity, habitat dynamics and ecological flow), ecosystem services and biodiversity. Opportunities provided by technology (sensors, digitally derived biodiversity indicators, artificial intelligence, digital platforms) will be seized.	II.I III.V
Developing and evaluating in the short- and long-term NBS and engineered solutions (including hybrid grey-green) for the remediation and mitigation of degraded water bodies and aquatic ecosystems.	II.I
Understanding the social and environmental impacts of proposed solutions for ecosystems restoration.	II.I II.IV III.I
Analysing the effect of current conservation practices and new approaches based on ecological engineering and ecohydrology to mitigate current pressures and impacts on aquatic biodiversity, especially at longer time scales and larger spatial scales.	II.I III.I

Sub-themes

II.IV. Integrating ecosystem services into the management of water resources and aquatic ecosystems	
Related topics	**Links to other sub-themes**
Monitoring the effects of water management and water planning measures on ecosystems (including biodiversity).	II.I II.III III.I
Developing methodologies for the valuation of ecosystems services, including intrinsic social and economic values as well as approaches to include the intrinsic value of ecosystem services in decision-making.	II.I III.I
Exploring land-sea continuity and interactions above and below the surface for biodiversity and ecosystem services conservation at global scale.	II.I II.II III.I
Exploring innovative policy instruments to ensure cost-efficient, flexible and fair regulation of water and aquatic ecosystems.	II.IV VII.II

THEME III: WATER FOR THE FUTURE: SUSTAINABLE 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, **Water4All will seek to improve, assess and demonstrate the Integrated Water Management approach with a source to sea perspective to enable sustainable water management.** The impact of land use,

water demand and global change (including climate) on water will be further investigated and proposed solutions will be communicated in support of the WFD and related water policies. Water4All therefore aims to provide models, approaches, tools and 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**. Since a huge share of water abstraction (60-90 %) is used for irrigation, 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.

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

Key words: river basin management, integrated water monitoring and assessment systems, groundwater management, integrated water management, conjunctive use, source to sea approach, hydroclimatic hazards and extreme events, NBS solutions, land-sea continuum, disaster risk reduction, decision support tools, water retention measures.

Sub-themes:

III.I. Integrated water resources management.

III.II. River basin management.

III.III. Groundwater management.

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

III.V. Tools for water management.

Sub-themes

III.I. Integrated water resources management	
Related topics	**Links to other sub-themes**
Developing integrated, robust and multiscale numerical modelling tools on the water cycle, ecosystems and economic systems to simulate and predict the long-term co-evolution of water resources, ecosystems and economy, and support water resource management and planning.	I.I II.IV III.V VI.III
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.	II.I VI.III
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).	I.I III.II III.III VI.III
Developing new methodologies, tools and models for assessing/ modelling water resources in scarcely monitored /data scarce areas. Opportunities provided by citizen science should be considered.	I.III III.V VII.I
Understanding the dynamics and functioning of a range of vulnerable and protected water ecosystems of ecological interest (including intermittent rivers, wetlands, lagoons, alpine areas, Artic and boreal water systems, peatlands, estuaries, ecological corridors in river networks).	II.I

Sub-themes

III.II.
River basin management

Related topics	Links to other sub-themes
Understanding the connection between different measures (e.g. Programmes of Measures (PoMs), specific legal frameworks in the EU, water pricing, funding mechanisms) and their effect on ecological indicators (flora, fauna, process-based indicators) as well as the temporal and spatial cumulative effects of measures in regard to the goals of the WFD (water quantity and quality, ecosystem restoration and functioning), the Biodiversity Strategy and the Habitats Directive.	II.I II.II II.III III.I
Developing innovative, low-cost and inclusive (e.g. citizen science) monitoring approaches, schemes and global strategies for the WFD implementation and the specific directives, e.g. Floods Directive.	I.III III.V VII.I VII.II
Better understanding of effectiveness, cost/efficiency, acceptance, trade-offs of natural water retention measures through demonstration activities at river basin scale.	III.I VII.I
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.	I.II II.III III.IV V.II

Sub-themes

III.III.
Groundwater management

Related topics	Links to other sub-themes
Supporting integrated groundwater management in urban areas to control groundwater pumping to sustainable levels, control discharges and manage aquifer recharge. Approaches based on NBS, including EH-NBS, for water table control will be encouraged.	II.III III.I
Developing MAR projects for the joint management of surface water, groundwater and recycled water resources to stretch limited water supplies and increase the availability of groundwater resources.	I.I III.I VI.III

Sub-themes

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

Related topics	Links to other sub-themes
Understanding the causes of water scarcity, predicting drought events and water scarcity (including short-term and seasonal variability) for developing climate change adaptation and mitigation measures. This topic will focus on both groundwater, soil moisture and surface water.	I.I II.II III.I III.II III.III VI.III
Developing tools (e.g. multi-risk approaches, decision support tools, including monetary/ non-monetary costs valuation) to support the design of strategies in response to hydroclimatic extreme events.	I.I II.II III.I III.II III.III III.V V.I V.II VI.III
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.	I.III III.I III.II III.III III.V V.I V.II VI.III VII.I
Understanding the disaster management cycle in the face of climate change, effects on society and mitigation measures.	VI.III

Sub-themes

III.V.
Tools for water management, including: Big data, Earth observation, sensor/monitoring tools, artificial intelligence, DSS and scenario analysis

Related topics	Links to other sub-themes
Developing smart infrastructure by combining physical and digital facilities (IoT, sensors, monitoring networks, BIM/GIS, Big Data & Machine Learning) to increase data value and develop hybrid modelling approaches.	Enabler
"Smartening the water system" for advanced decision support and priority setting: Earth observation, sensor networks, big data, information and control systems for water, network communications, digital twin models, advanced technologies and capabilities (i.e. high-performance computing, advances in communication 5G and 6G solutions) for quasi-real time data collection, analysis, modelling, forecasting and visualisation technologies.	I.I III.I III.II III.III V.I V.II
Investigating how to strengthen the use of large amounts and variety of observation data (e.g. Earth Observation data) by end-users and decision-makers.	VII.I VII.II

THEME IV: WATER AND HEALTH

Relevance of this theme. Water quality is threatened by pollutants from point (e.g. discharge pipes, drainage pitches) and diffused (e.g. agriculture, urban land, forestry, atmospheric deposition, rural dwellings) sources. Today, Contaminants of Emerging Concern (CECs) represent an important threat both for human health and aquatic ecosystems. CECs are defined as "chemicals that are not commonly monitored but have the potential to enter the environment and cause adverse ecological and human health effects"[9]. Examples of CECs include endocrine disruptors, Disinfection By-Products (DBPs), Antibiotic-Resistant Bacteria (ARB) and viruses and Antibiotic-Resistant Genes (ARGs), cyanotoxins, microplastics and nanomaterials.

Furthermore, global pandemic outbreaks like Covid-19 pose new challenges for water management and health and underscore longstanding deficiencies. Clean water is not only essential to satisfy drinking needs but it also plays a key role in impeding the spread of diseases. Yet 40% of the global population live without water sanitation facilities, which makes them vulnerable to Covid-19 and other diseases. The lack of access to basic water and sanitation has then become a bigger issue than ever that needs to be tackled with no further delay.

In this context, Theme IV will look at existing **knowledge gaps regarding the occurrence, concentration and behaviour of CECs in aquatic ecosystems**. Attention should particularly be paid to mixtures of pollutants, whose effects are poorly understood. Technologies are needed to guarantee access to high quality water for the sake of human, animal and ecosystems health, and in line with the One Health perspective. **Advanced methods of water quality monitoring, conservation 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[10]. Wastewater treatment processes are not designed to remove ARB and ARGs and they may spread into outgoing environmental systems and humans depending on proximity to workers and nearby residents[11].

Links: This theme is strongly related to the Zero pollution Action Plan and to the Mission on Healthy oceans, seas, coastal and inland waters by, among others, developing smart monitoring and control systems that may contribute to better delineating affected areas.

Key words: drinking water and sanitation, CECs, emerging pollutants, risk assessment, treatment technologies, micropollutants.

Sub-themes:

IV.I. Behaviour and effects of contaminants of emerging concern, litter, plastics, endocrine disruptors.

IV.II. Water dimension of anti-microbial resistance.

IV.III. Innovative water tools and technologies for water quality monitoring and water treatment, remediation and disinfection.

IV.IV. Risk assessment and threshold values for protection of human health and ecosystems

[9] 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

[10] Water JPI's SRIA 2025. Available at: http://www.waterjpi.eu/mapping-agenda/strategic-research-and-innovation-agenda-sria/waterjpi_sria2025_web.pdf

[11] 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://systematicreviewsjournal.biomedcentral.com/track/pdf/10.1186/s13643-019-1236-9.pdf

Sub-themes

IV.I.
Behaviour and effects of contaminants of emerging concern, litter, plastics, endocrine disruptors

Related topics	Links to other sub-themes
Understanding and predicting the environmental occurrence, concentration, behaviour and effects of CECs, transformation products and pathogens (including Covid-19), and their responses to water treatment.	IV.III IV.IV
Understanding and predicting the occurrence of opportunistic pathogens and their vectors in water resources along the global water cycle, water distribution networks and other engineered water systems aggravated under climate change.	II.I IV.IV V.I V.II
Monitoring of invasive species as (potential) vectors of (tropical) diseases.	II.I II.II IV.III IV.IV

Sub-themes

IV.II.
Water dimension of anti-microbial resistance

Related topics	Links to other sub-themes
Understanding the mechanisms determining the selection and spread of ARGs in aquatic environments.	II.I
Developing new tools for monitoring ARGs and the surveillance use of AMR data in aquatic environments.	II.I III.V IV.I IV.III IV.IV
Developing technologies and innovative interventions that rapidly reduce and control AMR in wastewater treatment.	IV.III IV.IV V.I V.II

Sub-themes

IV.III.
Innovative water tools and technologies for water quality monitoring and water treatment, remediation and disinfection

Related topics	Links to other sub-themes
Water quality monitoring: • Developing and testing reliable, affordable and low impact methods, including real-time methods, for monitoring water quality, with a focus on CECs and micropollutants, and assessing related risks (rapid screening, online, targeted & non-targeted, passive samplers) in support to the development of exposome/eco-exposome approaches. • Connecting Earth Observation to local / regional monitoring of water resources for improved water quality assessments. • Enhanced knowledge about pollution sources (including sources 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 chemical/ molecular biomarkers and bioassays.	II.I III.I III.V IV.I IV.II
Water treatment, remediation and disinfection for drinking water and sanitation access: • Developing methodologies and strategies to remediate and reduce CECs at point and non-point sources, including their environmental effects in water, soil, sediment and sludge. • Developing more efficient, cost-effective, less energy dependant, low carbon footprint and easier-to-implement technological solutions for drinking water and wastewater treatment. • Developing new processes and product controls for small decentralised drinking water treatment systems. • Developing pollution prevention methodologies to reduce the investment and operational costs of treatment applications. • Improving wastewater technologies for removal of ARB, the inactivation of ARGs, viruses and CECs.	I.II II.I III.V IV.I IV.II VII.III

Sub-themes

IV.IV.
Risk assessment and threshold values for protection of human health and ecosystems.

Related topics	Links to other sub-themes
Assessing possible effects on humans and ecosystems of (chronic) aquatic exposure to low levels of chemical substances and mixtures.	II.I IV.I IV.II
Integrated water exposure (chemicals, plastics, bacteria, microbes, viruses, protozoa, etc.) and its integration in global exposure (air, water, soil, food, social and psychological effects/stressors) – One Health/Eco Health concepts.	IV.I IV.II

Related topics	Links to other sub-themes
Developing integrated risk assessment procedures, including the effects of long-term exposure and cocktail effects, for antibiotics and other emerging pollutants, toxic trace elements and other pollutants of concern (e.g. nitrate, pesticides and pathogens).	IV.I IV.II
Assessing the effects of NBS and green/ blue ecological engineering in health and ecosystems protection.	I.II II.III

THEME V: INFRASTRUCTURES FOR WATER

Relevance of this theme. The **ability of water infrastructures (i.e. drinking water, wastewater, hydropower production, storm-water utilities and coastal protection structures)** to provide safety to society and water at the quantity and quality levels required by end-users could be challenged in the future by global changes, in particular climate change, cybersecurity and ageing processes. Extreme weather events can damage coastal protection infrastructures, putting into risk coastal activities and population, including critical infrastructures for water safety and security. Excessive volumes of water accumulated at flooding episodes can cause the rupture of drinking water and sewage pipelines whereas droughts can decline water quality and water supply. Huge investments are also made on an annual basis for the replacement of old water infrastructures in order to reduce leakage rates and protect the health of consumers and huge investments are needed to enable e.g. safe water reuse, energy and other resource recovery, CEC and AMR control. In this context, **European water infrastructures must adapt and become more resilient to current and emerging challenges whilst safeguarding the provision of safe water**. Strategic asset management is therefore crucial.

The varied applications of blue and green infrastructure both in urban and rural areas hold a promising potential to overcome water security challenges and deliver valuable ecosystem goods and services such as the provision of clean water and the protection of vast areas threatened by flooding. Water4All will look at the applications of green and blue infrastructures for community resilience in response to hydroclimatic extreme events and the risks posed by ageing infrastructures.

This Theme distinguishes between specific topics for water infrastructures adaptation vs mitigation. Adaptation topics will focus on appropriate actions to prevent or minimise possible damages whereas mitigation will concentrate on reducing the severity of potential impacts.

R&I activities within this Theme intend therefore to deliver water distribution services to end-users as well as natural services through the protection and restoration of aquatic ecosystems. It should be noted that the development, implementation and maintenance of Research Infrastructures (RIs), understood as facilities for conducting research and fostering innovation, are not within the remit of this theme (please refer to Theme III.V for more information). Their added value under theme V is recognised though as research infrastructures enable the undertaking of multiple activities.

Protection of water infrastructure against external attacks is now a critical function for water utilities. The development and deployment of robust technologies and good practices should offer strategies to respond more effectively to external risks, including water supply terrorism, and reduce the vulnerability of water infrastructures. The security of water infrastructure is the centre of preoccupations of some of the topics included in this Theme.

Links: This theme has a direct link with the building and renovation strategy of the Green Deal, making both cities and rural areas climate resilient and circular, and to the Mission on Adaptation to climate change including societal transformation.

Key words: water infrastructures adaptation, resilience, security, green/ blue infrastructure, security.

Sub-themes:

V.I. Adaptation of existing water infrastructures to new challenges.

V.II. Water infrastructures resilience.

V.III. Water infrastructures security (including cyber and terrorism security)

Sub-themes

V.I. Adaptation of existing water infrastructures to new challenges	
Related topics	**Links to other sub-themes**
Developing methodologies to organise effectively and in a cost-efficient and energy-neutral manner the replacement or large-scale renovation of water infrastructure by also considering the potential application of blue and green infrastructure.	II.II V.II
Assessing the environmental impact of water infrastructure, including their contribution to climate change as a result of the emission of GHG.	IV.III IV.IV V.II
Developing new strategies based on smart metering and system analysis that fully cater to the needs of utilities in terms of readability, lifetime, interoperability and cost to optimise distribution networks (consumption patterns, pumping strategies, leakage or contamination detection...) and wastewater and stormwater drainage systems.	III.V V.II
Developing emergency treatment units for drinking water production in emergency response situations.	I.II IV.II
Adaptation of existing dams to climate change, (e.g. reservoir optimization management for different uses and water availability scenarios, discharge capacity of dam spillways, etc.)	III.I III.II III.IV

Sub-themes

V.II. Water infrastructures resilience	
Related topics	**Links to other sub-themes**
Developing smart monitoring and control systems, from assets to water supply, and reclaimed water networks, including strategic asset management for extending the technological and functional lifespan of water infrastructures.	III.V IV.III V.I
Improving models and solutions for systems interoperability to allow critical water infrastructures to exchange data and enhance compatibility.	III.I III.V
Studying the effects of increasing population density caused by mass migration due to climate change on existing water infrastructure.	I.I V.I VI.III
Understanding and minimising the risks associated with water infrastructures and increasing their resilience in response to climate change effects and natural hazards, including design and implementation of green and blue infrastructure and NBS, including EH-NBS.	I.II II.II IV.IV

Sub-themes

V.III. Water Infrastructures security (including cyber and terrorism security)	
Related topics	**Links to other sub-themes**
Developing or improving existing technologies able to differentiate attacks and propose mitigation measures to protect IT/OT (Information Technology/ Operational Technology) infrastructures of water services.	III.V
Improving the security and performance of water assets and infrastructures – water sources reservoir, limiting the risk of any pollution including pathogens from source to tap.	III.V IV.I IV.II IV.III IV.IV
Developing surveillance system through sewage monitoring of potential virus circulation.	IV.I IV.II IV.III IV.IV
Addressing ageing water infrastructure, including water losses management through intelligent monitoring.	III.V V.I V.II

Cross-cutting issues

THEME VI: INTERNATIONAL COOPERATION

Relevance of this theme. Water challenges are global and as such, Water4All encourages cooperation with international partners. Water4All promotes collaborative R&I, knowledge and technology transfer for the internationalisation of the European water sector, networking, capacity-building, education, technical advocacy, expertise and in general any other cooperation modalities in support of water and sanitation access rights for all, both in Europe and abroad. In this context, **Water4All, in particular through the activities carried out within pillar E, will seek specific collaboration agreements with countries/ regions outside of the consortium and will develop innovative tools for international cooperation.**

Water4All's approach for international cooperation is mainly based upon the work conducted these past years by the Water JPI and its dedicated CSA, IC4WATER – International cooperation for water. IC4WATER, which ended on the 30th June 2022, offers practical information on possible tools for R&I with countries outside of the Water JPI network and existing barriers that could preclude future collaboration. It also provides a good understanding of the R&I landscape and capacity in numerous countries all over the world. Results and recommendations of IC4WATER build upon mapping and consultative activities, international workshops and dedicated meetings with external research funding agencies. Amongst others, IC4WATER recommends Water4All to adopt a flexible approach in the identification of priority countries that considers European[12] and international policy developments, as well as the environmental, policy and socioeconomic context. Cooperation may therefore be encouraged with international **knowledge and technology hot spots** (e.g. South Korea, United States, Canada, Singapore, Australia, New Zealand), **countries high strategic value for Europe** (e.g. China, India), **neighbour countries** (e.g. Western Balkans), or **countries requiring capacity building** (e.g. Africa, South America, ASEAN region – Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam).

To achieve the development of strategic international partners, Water4All will ensure a permanent dialogue with third countries through EU political dialogues and bilateral agreements, with other Partnerships, with policy makers and European public Research and Development initiatives as well as multilateral organisations (World Bank, OECD, UN) and international initiatives e.g. EU-India Partnership and the CEWP. Hydro-diplomacy embraces the engagement of both state and non-state actors to allow for diverse stakeholder interests.

As pointed out in the IC4WATER Project, water diplomacy represents one of the key barriers in international cooperation. Several topics under this Theme aim at improving water management through participatory approaches that promote benefit sharing, issue-linkage and trust building for conflict resolution whilst embracing the engagement of both state and non-state actors. **Topics for integrated, fair and adaptive water resource management are also included.** The gender perspective, highlighting how gender roles and relations affect water access and sanitation as well as the sustainable use of water resources, is also integrated within this Theme.

Links: This theme is linked to the EU Green Deal, which aims at making Europe a global leader in the provision of solutions for tackling climate change and related hydrometeorological extreme events.

Key words: water diplomacy, trans-boundary cooperation, mass migrations, water access

Sub-themes:

VI.I. Water diplomacy.

VI.II. Establishing tools for trans-boundary cooperation.

VI.III. Developing integrated, fair and adaptive water resource management systems.

[12] In particular the EC strategy 2021-2024 "A Stronger EU in the world"

Sub-themes

VI.I. Water diplomacy	
Related topics	**Links to other sub-themes**
Improving governance and alignment of research and innovation programmes and initiatives for reduced fragmentation and enhanced cooperation, communication and awareness.	VII.I VII.II
Developing new concepts of benefit sharing, trust building and issue-linkage for water related conflict management.	I.I I.III VI.II
Designing inclusive, partnership oriented, multi-track approaches (political, technical, practices) for improving science-policy interface and inform water diplomacy processes.	I.III VI.II VII.I
Strengthening the link between early warning and early actions in water management and conflict resolution.	I.I III.IV III.V
Improving water management through inclusive participatory approaches (especially women, indigenous peoples and other priority groups), information transparency, empowerment and improved accountability.	I.III VII.I
Assessing sources of conflicts on cross-border water resources in complex contexts (climate change, migration, land use, food security, lack of well-functioning political institutions, social services …)	I.I I.III VII.I

Sub-themes

VI.II. Establishing tools for trans-boundary cooperation	
Related topics	**Links to other sub-themes**
Progressing in international water cooperation through improvements in baseline data.	I.III III.I III.V VII.I
Designing strategies to overcome existing cooperation barriers with Water4All's strategic countries.	VI.I

Sub-themes

VI.III. Developing integrated, fair and adaptive water resource management systems	
Related topics	**Links to other sub-themes**
Understanding the effects of mass migration due to climate change on existing water resources and infrastructures.	III.I V.I V.II VI.I
Understanding the underlying power dynamics and structural barriers that determine the gender dimension in safe water access.	I.I VII.I
Assessing the impacts and risks of extreme weather events and global change on the water cycle and uses.	III.I III.IV
Developing and testing improved plans and methodologies, including water allocation policies and management practices, for integrated and adaptive water management in relation to global change.	I.I III.I VI.I VII.II
Developing indicators of spatial vulnerability to global change.	III.IV
Developing, deepening and testing practical methods (e.g. water footprint) to assess the overall success of different water management schemes.	I.III III.I VI.I

THEME VII: GOVERNANCE

Relevance of this theme. Global water demand will increase by 55% by 2050 due to increasing needs from the manufacturing sector (especially food industry), thermal electricity and domestic use (OECD Water Governance Programme)[13]. Higher demands from these sectors, coupled with higher population density in certain regions of the world and climate change effects, will increase water stress. This projected situation calls for innovative governance models able to underpin robust decisions and legislation over the protection and conjunctive use of groundwater and surface water resources whilst empowering stakeholders and ensuring the sharing of water. In this sense, Water4All follows the principles set out in the OECD's Water Governance Programme and aimed at enhancing the effectiveness, efficiency, trust and social engagement in the decision-making process.

Governance plays a key role in each of the Water4All themes as good governance is a key element in the identification and implementation of best available measures for people, water and other systems. Innovative governance models will be sought through different activities and specific actions will be targeted at enhancing the participation of stakeholders, communities and society at large in water management issues. The co-creation of solutions also requires activities in the fields of communication, public awareness and education. **With water having a cross-sector "profile", water governance should strive to act in a cross-sectorial setting. Hence, multidisciplinary research activities are strongly encouraged within this theme.**

Activities linked to Theme VII of this agenda will enable a dynamic governance style through the democratisation of knowledge, dialogue and mediation tools. In line with the Human Rights-Based Approach, Water4All promotes inclusive participation (in particular of women, indigenous peoples and other priority groups), information transparency, accountability, empowerment and equality in order to facilitate the full engagement of stakeholders, and citizens in general, in the co-design and co-management of water management strategies.

Traditionally, the water management and planning sectors have tended to work with their own communities. Water4All will aim at bridging this disconnection through actions at the institutional level and the operationalisation of frameworks.

Topics within the last sub-theme look at current barriers for the adoption of research products/ solutions. Attention is paid to the market adoption of proposed solutions and the implementation of key lessons from other disciplines in the valorisation of research results.

Links: This theme is linked to all the Green Deal policy issues and is particularly related to the Mission on Healthy oceans, seas, coastal and inland waters and on Adaptation to climate change including societal transformation.

Key words: participatory tools, stakeholder participation, adoption of innovations, policy instruments.

Sub-themes:

VII.I. Developing methods for more efficient citizen and wider stakeholder engagement.

VII.II. Strengthening policy integration, alignment, coherence and water policy coordination to exert a change in society.

VII.III. Supporting the adoption of innovations.

[13] https://www.oecd.org/water/regional/

Sub-themes

VII.I. Developing methods for more efficient citizen and wider stakeholder engagement.	
Related topics	**Links to other sub-themes**
Developing and testing new participatory approaches based on, for example, the co-production and co-design of solutions, integration of indigenous, local and technology knowledge, involvement of women, ICT tools, and telecoupling for water management.	I.III III.V
Advancing in the application of citizen science in data and knowledge generation as a complement to more traditional ways of water monitoring. Actions will address issues linked to the processing, interpretation and use of data, as well as the quantification of uncertainties and complementarity with other data sources.	I.III III.V
Understanding progress in the implementation of a Human Rights-Based Approach in water management through relevant indicators.	I.III VI.I
Developing innovative communication approaches to raise interest and awareness of the public.	I.III
Advancing in social analysis of the perception of water related risks and impacts on behaviour to support the design of risk reduction strategies.	III.IV IV.IV

Sub-themes

VII.II. Strengthening policy integration, alignment, coherence and water policy coordination to exert a change in society	
Related topics	**Links to other sub-themes**
Developing institutional approaches to connect institutions managing water to improve coordination and increase our capacity to tackle extreme events. Research and innovation activities on cross-border waters are of particular relevance.	VI.I VI.II
Studying conditions for establishing innovative institutions for joint management of water resources by state and non-state actors (co-management). Conducting experimental tests of those institutions in real case studies (living labs) should be encouraged.	I.III III.I VI.II VII.I
Improving the alignment of research and innovation and policy programmes for reduced fragmentation in water management.	VI.I
Designing appropriate frameworks to enable the practical application of the WEFE Nexus in water management and planning.	I.II

Sub-themes

VII.III. Supporting the adoption of innovations	
Related topics	**Links to other sub-themes**
Identifying regulatory, market, governance, education, research and innovation, and management conditions enhancing the demand for and the adoption of innovations in water. Specific mechanisms, such as financial credit ratings or sustainability reporting, for incentivising the adoption of innovations will be analysed.	---
Reducing the time to market of proposed solutions through effective policy and management frameworks. Barriers for the market uptake of solutions will be analysed.	---
Favouring knowledge transfer from other scientific fields regarding key lessons in the commercialisation of products and solutions. Supporting the transfer of relevant results from other scientific fields for their application in the water research and innovation domain.	---
Understanding the requirements driving the social adoption of innovations by integrating technical and social sciences and humanities research and innovation, by involving stakeholders at the adequate level and scales of participation, and by enabling large-scale socio-technical experimentation.	I.III VII.I
Identifying and studying opportunities for the creation of new financial mechanisms for an innovative water sector.	---
Envisaging strategies to test, scale up, disseminate and stimulate the market uptake of EU innovative solutions internationally.	VI.II

5. Existing links between Water4All's themes and sub-themes and EU policies and other initiatives

TABLE 3. INTERACTIONS BETWEEN WATER4ALL PILLARS, SRIA'S THEMES AND KEY POLICY ISSUES

Water4All Pillars		**A. Joint Vision**	**B. Developing knowledge &solutions**	**C. Transfer knowledge and innovations**	**D. Demonstrating innovative solutions**	**E. International Cooperation**
Principal tools for implementation		SRIA	Research and Innovation Calls	Policy papers, Knowledge Hub, Training	Demonstrators and pilots	International projects
Green Deal Key Policy Issues	Increasing climate ambition	I,II,III,IV,V,VI	I,II,III,IV, V,VI,VII	I,II,III,IV,V,VI	I.III III.V	VI
	Clean, affordable and secure energy	I,II,III	I,II,III	I,II,III	I.III III.V	VI
	Sustainable and smart mobility	I,V, VII	I,V	VII	I.III VI.I	
	Energy and resource efficient buildings	I,V	I,V		I.III	
	Farm to fork	I,II,III,IV,V,VI, VII	I,II,III,IV,V,VI, VII	I,II,III,IV,V,VI, VII	III.IV IV.IV	VI
	Biodiversity and ecosystems	I,II	I,II	I,II	I.III III.V	
	Zero-pollution, toxic-free environments	I,IV	I,IV, VII	I,IV, VII	I.III III.V	VI
	Water Framework Directive and daughter Directives		VII	I,II,III, VII	I.III VI.I	
	Common Agricultural Policy	VII	VII	I,II,III,VII	I.III	VI
	International cooperation				III.IV IV.IV	

***Legend** – Themes: I: Water for circular economy; II: Water for ecosystems and biodiversity; III: Water for the future: sustainable water management; IV: Water and health; V: Water infrastructure; VI. International cooperation; VII Governance*

5.
Existing links between Water4All's themes and sub-themes and EU policies and other initiatives

TABLE 4. SRIA'S THEMES, SUB-THEMES, KEY TOPICS AND LINKS WITH OTHER EU INITIATIVES.

The table goes from p46 to p51

THEMES	I. Water for circular economy: smart water value	II. Water for ecosystems and biodiversity	III. Water for the future: sustainable water management
Sub-themes	• Water supplies for socio-economic development and activities. • Circular economy. • Empowering the public, water users and stakeholders in valuing water	• Functioning and biodiversity. • Resilience, mitigation and adaptation of aquatic ecosystems and ecosystem services to global changes. • Developing and applying ecological engineering and ecohydrology for ecosystems restoration. • Integrating ecosystem services into the management of water resources and aquatic ecosystems	• Integrated Water Resources Management. • River basin management. • Groundwater management. • Resilience, adaptation and mitigation to hydroclimatic extreme events. • Tools for water management.
Links with HEU Destinations in WP 2021-2022	**6.3.** Circular economy and bioeconomy sectors **6.7.** Innovative governance, environmental observations and digital solutions in support of the Green Deal **2.1.** Democracy and Governance **2.3.** Social and Economic Transformations **4.1.** Climate neutral, circular and digitised production **4.2.** Increased autonomy in key strategic value chains for resilient industry **5.2.** Cross-sectoral solutions for the climate transition **5.5.** Clean and competitive solutions for all transport modes	**6.1.** Biodiversity and ecosystem services **6.5.** Land, oceans and water for climate action	**6.5.** Land, oceans and water for climate action **6.6.** Resilient, inclusive, healthy and green rural, coastal and urban communities **6.7.** Innovative governance, environmental observations and digital solutions in support of the Green Deal **4.3.** World leading data and computing technologies **4.4.** Digital and emerging technologies for competitiveness and fit for the green deal

IV. Water and health	V. Infrastructures for water	VI. International cooperation	VII. Governance
• Behaviour and effects of contaminants of emerging concern, litter, plastics, endocrine disruptors. • Water dimension of antimicrobial resistance. • Innovative water tools and technologies for water quality monitoring and water treatment, remediation and disinfection. • Risk Assessment and threshold values for protection of human health and ecosystems.	• Adaptation of existing water infrastructures to new challenges. • Water infrastructures resilience. • Water Infrastructures security (including cyber and terrorism security).	• Water diplomacy. • Establishing tools for trans-boundary cooperation. • Developing integrated, fair and adaptive water resource management systems.	• Developing methods for more efficient citizen and wider stakeholder engagement. • Strengthening policy integration, alignment, coherence and water policy coordination to exert a change in society. • Supporting the adoption of innovations.
6.4. Clean environment and zero pollution **1.1.** Staying healthy **1.2.** Living and working in a health-promoting environment **1.3.** Tackling diseases and reducing disease burden **1.5.** Unlocking the full potential of new tools, technologies and digital solutions for a healthy society	**6.5.** Land, oceans and water for climate action **3.1.** Better protect the EU and its citizens against Crime and Terrorism **3.3.** Protected Infrastructure **3.4.** Increased Cybersecurity **3.5.** A Disaster-Resilient Society for Europe **3.6.** SSRI (Strengthened Security Research and Innovation) **5.2.** Cross-sectoral solutions for the climate transition	**5.2.** Cross-sectoral solutions for the climate transition **6.6.** Resilient, inclusive, healthy and green rural, coastal and urban communities **2.1.** Democracy and Governance	**6.3.** Circular economy and bioeconomy sectors **6.6.** Resilient, inclusive, healthy and green rural, coastal and urban communities **6.7.** Innovative governance, environmental observations and digital solutions in support of the Green Deal **2.1.** Democracy and Governance **2.3.** Social and Economic Transformations

5.
Existing links between Water4All's themes and sub-themes and EU policies and other initiatives

THEMES	I. Water for circular economy : smart water value	II. Water for ecosystems and biodiversity	III. Water for the future: sustainable water management
EU Policies supported by Water4All	EU Green Deal Water Framework, Bathing Waters, Urban Waste Water Treatment, Groundwater Directives Common Agricultural Policy Circular Economy Action Plan	EU Green Deal Water Framework, Shellfish Waters, Dangerous Substances (and its 'daughter' directives), Nitrates, Freshwater Fisheries, Exchange of Information on the Quality of Surface Freshwaters, Groundwater Directives EU Biodiversity Strategy	EU Green Deal Water Framework, Dangerous Substances (and its 'daughter' directives), Nitrates, Freshwater Fisheries, Exchange of Information on the Quality of Surface Freshwaters, Groundwater Directives Shaping Europe's Digital Future European strategy for data

Main thematic links to other EU initiatives

Mission Healthy oceans, seas, coastal and inland waters	Wastewater treatment. Water use efficiency. Cross-sectoral use of water.	Protection and restoration.	Observations, modelling, predictions of water systems behaviour. Applications of digital tools in Observations, modelling, predictions of water systems behaviour. Applications of digital tools in water management. Risk management. Groundwater management.
Mission Adaptation to climate change		Nature-Based solutions.	Early-warning systems. Risk assessment.
Mission Climate-Neutral and Smart Cities			Water systems resilience to climate change.
Mission Soils Health and Food			Innovative and user-oriented digital applications for decision-making.
Partnership Agro-Ecology Living Labs	X	X	
Partnership Biodiversity			Innovative and user-oriented digital applications for decision-making.
Partnership Sustainable Blue Economy	Desalination.	Cumulative effects of contaminants. Coastal Nature-Based solutions. Valuing ecosystem services in coastal areas.	Smart water management: observation, monitoring and data collection/ sharing. Water intrusion.

IV. Water and health	V. Infrastructures for water	VI. International cooperation	VII. Governance
EU Green Deal Water Framework, Bathing Waters, Dangerous Substances (and its 'daughter' directives), Urban WasteWater Treatment Directives Marine Strategy	EU Green Deal EU Adaptation Strategy	(EU Green Deal)	Common Agricultural Policy, EU Green Deal, EU Adaptation Strategy, Circular Economy Action Plan, Water Framework Directive
Water pollution	Dam optimization. Water storage.	Global leadership.	Stakeholder involvement and governance. Citizen science. Strengthening institutions for better governance and coordination.
	Critical infrastructures.		Governance and inclusive approaches.
Water pollution from targeted soil uses (pesticides and nutrients) Pollution prevention.			
Water pollution from targeted soil uses (pesticides and nutrients) Pollution prevention.			

5.
Existing links between Water4All's themes and sub-themes and EU policies and other initiatives

THEMES	I. Water for circular economy : smart water value	II. Water for ecosystems and biodiversity	III. Water for the future: sustainable water management
Partnership Chemical Risks Assessment			Harmonisation of data and exchange between actors and disciplines (FAIR)
Partnership Circular bio-based Europe	Water use efficiency. Recovery and recycling of nutrients and sludge	Water systems protection.	
Partnership DUT	Efficient use of water resources. Utilisation of new water technologies, processes and services in cities and municipalities.		
Partnership Water-borne transport			Real time monitoring and compliance system.
Partnership Data for agriculture			X
Partnership European Metrology	X		
KIC Climate	Circular, resilient, inclusive transformation.		
JPI Climate		Understanding the impacts of climate change, including uncertainties management. Adaptation opportunities.	Understanding the impacts of climate change, including uncertainties management. Adaptation.
ESA – Copernicus			Tools for water management.
PRIMA	Water demand strategies. Water saving solutions and water treatment technologies.		Catchment and groundwater management.
CSA European Geological Services	X	X	Interoperable, pan-European data and information services on groundwater

IV. Water and health	V. Infrastructures for water	VI. International cooperation	VII. Governance
Water pollution.			
Water pollution. Water sanitation.			
	Blue infrastructure for sustainable urban development.		
X			
			Multi-stakeholder & citizen engagement Support to innovations
			Governance. Support to innovations.
Water pollution.		Transboundary cooperation.	
X	X	X	X

6. Water4All's initial monitoring template

Figure 5 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[14], identified 20 Key Performance Indicators (KPIs) to monitor the progress of Water4All towards its objectives. These indicators, shown in **Table 5**, 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 ABs, 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, in line with the practice developed by the Water JPI. This detailed analysis will feed data into the monitoring of the KPIs.

The Consortium, with the methodological support from the expert group set up by the EC to support the strategic coordinating process of European partnerships, will monitor the progress of Water4All towards its objectives.

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

6.
Water4All initial monitoring template

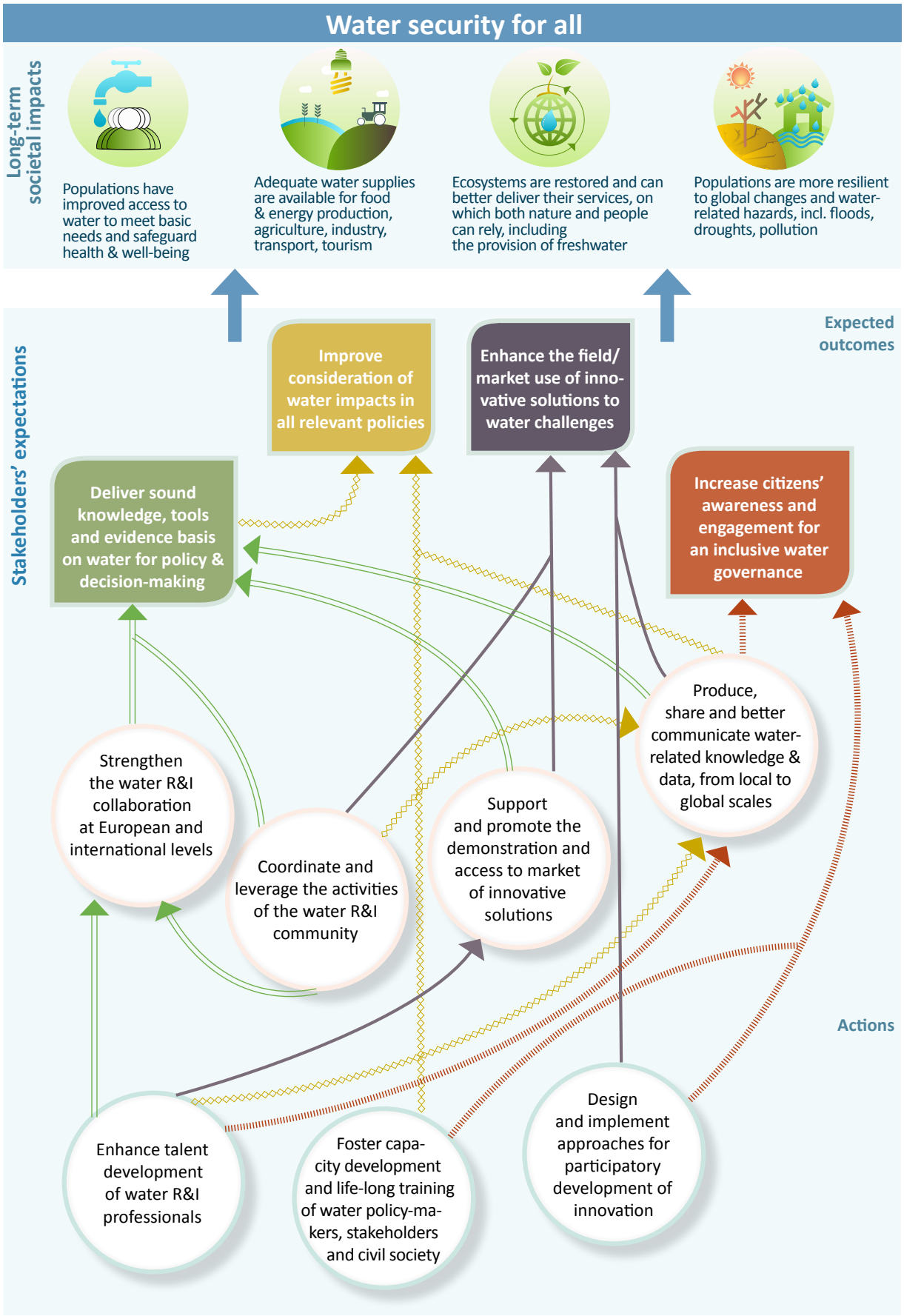

FIGURE 5. WATER4ALL'S SPECIFIC IMPACT PATHWAYS

TABLE 5: WATER4ALL MONITORING AND EVALUATION **FRAMEWORK**

European Partnership Water4All			**Monitoring and evaluation framework,** draft 2, 26/11/2021
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			**Indicators**
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	SO1	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 citizens' 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 portalecosystems over time
	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
	005	Enhance talent development of water R&I professionals	Number of researchers involved in upskilling activities
	006	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
	007	Design & implement approaches for participatory development of innovation	Number and share of supported projects where citizens and end-users contribute to the R&I content

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