WATER JPI STRATEGIC RESEARCH AND INNOVATION AGENDA 2025

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List of Abbreviations

Term	Meaning
AB	Advisory Board
AMR	Antimicrobial resistance
AnaEE	Analysis and Experimentation on Ecosystems
AQUATAP_ES	Thematic Annual Programming Action on Ecosystem Services
BONUS	Joint Baltic Sea Research and Development Programme
DBP	Disinfection By-Products
CAP	Common Agricultural Policy
CEC	Contaminant of emerging concern
DG	Directorate General (of the EC)
EC	European Commission
E-flow	Ecological flow
EIP	European Innovation Partnership
eLTER	European Long-Term Ecosystem and socio-ecological Research Infrastructure
EPA	Environmental Protection Agency
ERA	European Research Area
ERC	European Research Council
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EurAqua	European Network of Freshwater Research Organisations
FACCE	Joint Programming Initiative for Agriculture, Food Security and Climate Change
GB	Governing Board
GWRC	Global Water Research Coalition
ICOS	Integrated Carbon Observation System
IoT	Internet of Things
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
JPI	Joint Programming Initiative
MAR	Managed Aquifer Recharge
MSFD	Marine Strategy Framework Directive
NBS	Nature-based solutions
PoU	Point of Use
PRIMA	Partnership for Research and Innovation in the Mediterranean Area
RDI	Research, development and innovation
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals Directive
RI	Research Infrastructure
SAG	Stakeholders Advisory Group
SDG	Sustainable Development Goal
S-flow	Sediment flow
SMART	Specific, Measurable, Achievable, Relevant and Timely
SRIA	Strategic Research and Innovation Agenda
TAP	Thematic Annual Programming
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UWWTD	Urban Waste Water Treatment Directive
WASH	Water, Sanitation and Hygiene
WEFE	Water–Energy–Food–Ecosystems (Nexus)
WFD	Water Framework Directive
WHO	World Health Organization

Foreword

The Water Joint Programming Initiative (JPI) is entering into a new phase with this new Strategic Research and Innovation Agenda, which will guide our activities over the next 5 years. This living document was achieved through a highly inclusive, comprehensive cross-sectorial process with a general public consultation, national consultation workshops, discussions with the Advisory Boards and finally its adoption by the JPI Governing Board. Four core themes will drive this agenda: (1) Ecosystem, (2) Health and Wellbeing, (3) Water Value and Usage and (4) Sustainable Water Management.

This document, as the basis of the Water JPI activities, details each of the core themes that will in turn form part of an implementation plan with descriptions of tasks and indicators. It will make a direct contribution in addressing the needs of the United Nations (UN) Sustainable Development Goals (SDGs), in particular the UN SDG 6 ("Ensure availability and sustainable management of water and sanitation for all"), and the European Green Deal, while developing European Union (EU) and international cooperation to join efforts to solve the global challenges on water.

Synergies with other relevant EU initiatives, such as the JPIs on Climate, Agriculture, Food Security and Climate Change (FACCE), Oceans, Antimicrobial Resistance (AMR) and the BiodivERsA or international ones (e.g. UN Water, Belmont Forum), will be further strengthened so that we can work collaboratively to face the main challenges, such as protecting, improving, restoring and sustainably managing our shared water resources and aquatic ecosystems, and securing all water demands in the current context of water scarcity while anticipating global changes.

This shared collective, the Research Development and Innovation Agenda, is also a major contribution to the JPI members' national agendas and all stakeholder groups. As such, it is seen as a basis for the new European Framework Programme, Horizon Europe and some of its implementation instruments, and the non-institutionalised partnership proposal Water4All, (under development) between the EU Commission Services, Member States and international partners.

I would like to thank all our Water JPI partners and in particular the Irish Environmental Protection Agency, which coordinated this important work across different consultations.

Maurice Heral

Chair of the Water JPI
Governing Board

Acknowledgements

The Water JPI has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 641715 (WaterWorks2014). The process for revising and preparing the new Water JPI Vision 2030 and SRIA 2025 was devised in collaboration with the Water JPI Governing Board and Advisory Boards members during the period 2018–2019. We also wish to acknowledge the invaluable contribution from all the invited workshop speakers and attendees, the WaterWorks2014 partners, the Water JPI Coordinator, the Water JPI Governing Board and the Advisory Boards, as well as European Commission funding. Reuse of graphics from the European Environment Agency (EEA) and the United Nations Sustainable Development Goals is acknowledged.

Disclaimer

Executive Summary

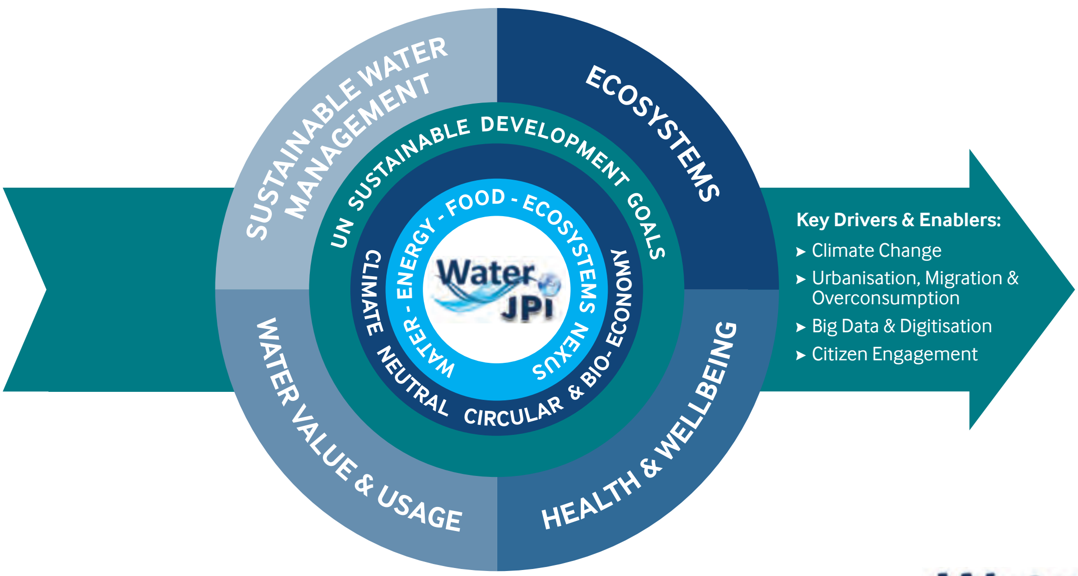
European water policy deals with complex systemic issues and has ambitious goals. This is increasingly set against the backdrop of global trends and issues, such as the quality and quantity of water, the sustainable use and management of water resources, integrated flood risk management and the climate crisis. Research, development and innovation (RDI) in the water area therefore aims to develop knowledge and reinforce mechanisms for knowledge and technology transfer at an international scale. Joint Programming Initiatives (JPIs) focus on strengthening and harmonising public research and innovation activities and align national research agendas. The Water JPI was launched in December 2011, and Water JPI Vision 2030 will reinforce global leadership in water research and foster collaboration to achieve safe, clean and sustainably managed water resources for all.

The Water JPI's Vision 2030 of **Together for a Water-secure World** aims to tackle water challenges through its shared mission of **Jointly Enabling "smart" Water Solutions for a Changing World**. This will be achieved through a multi-faceted and cross-sectoral approach, encompassing policy, environmental, economic, technological and societal considerations.

The Water JPI also develops Strategic Research and Innovation Agendas (SRIAs), which sit under the Water JPI vision and are updated every 5 years. The SRIA is a roadmap for future water-related RDI actions in Europe, including, but not limited to, the Water JPI actions. To this end, it identifies areas in which RDI actions are required. Water JPI SRIA 2025 covers the full range of RDI, including the broad range of activities from academic research to innovation. The identified research priorities were then open for consideration by various stakeholders, such as researchers, regulatory agencies, policymakers, industry and the public.

The development of SRIA 2025 has been borne out of a multi-disciplinary and cross-sectoral consultation process. This has included a strategic foresight literature review, a public consultation, national consultation workshops, a series of semi-structured interviews and consultative workshops with the Water JPI Advisory Boards and Governing Board, as well as a 2-day Experts Stakeholder Workshop.

The core research themes being addressed by the Water JPI in this SRIA are **Ecosystems, Health and Wellbeing, Water Value and Usage** and **Sustainable Water Management**. The SRIA outlines the research priorities under the sub-themes across these four core areas. The SRIA builds on cross-cutting issues that apply across all the research themes, as well as drivers and enablers that both drive change and enable solutions. The SRIA also outlines the expected impacts of research across the themes and key policies.



The Water JPI SRIA 2025 is structured as follows:

Water JPI SRIA 2025			
Research themes and sub-themes		**Key relevant UN SDGs**	**Key policy drivers**
Theme A: Ecosystems			
Sub-theme A.1	Developing approaches for assessing and optimising the structure and function of ecosystem services.		• UN Framework Convention on Climate Change Paris Agreement • International Convention on Biodiversity • EU Biodiversity Strategy to 2020 • The European Green Deal • The EU Strategy on Adaption to Climate Change • EU 2030 Climate and Energy Policy Framework • 7th and 8th Environmental Action Programmes • The Water Framework Directive (WFD) and the basic measures required under the 11 related directives • The Marine Strategy Framework Directive • Floods Directive • EU Regulation on Invasive Species
Sub-theme A.2	Developing and applying an approach to ecological engineering and ecohydrology.		
Sub-theme A.3	Managing and adapting ecosystem services to the effects of hydro-climatic extreme events.		
Theme B: Health and Wellbeing			
Sub-theme B.1	Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans.		• UN Framework Convention on Climate Change Paris Agreement • EU 2030 Climate and Energy Policy Framework • The European Green Deal • The EU Strategy on Adaption to Climate Change • The WFD and the basic measures required under the 11 related directives • Environmental Quality Standards Directive • Marine Strategy Framework Directive • Groundwater Directive • Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Directive • Waste Framework Directive
Sub-theme B.2	Water dimension of antimicrobial resistance; “one health approach”.		
Sub-theme B.3	Understanding and minimising the risks associated with water infrastructures and climate change effects.		
Sub-theme B.4	Assessing and evaluating the sustainable interactions between different users (people, agriculture, industry and nature) and their water demands, to promote a coordinated resource management strategy.		
Theme C: Water Value and Usage			
Sub-theme C.1	Future-proof water technologies, infrastructures and systems for developing climate change resilience.		• UN Framework Convention on Climate Change Paris Agreement • The EU Strategy on Adaption to Climate Change • The European Green Deal • The Common Agricultural Policy (CAP) • EU Circular Economy Action Plan 2015 • The WFD and the basic measures required under the 11 related directives • Groundwater Directive • Environmental Quality Standards Directive
Sub-theme C.1	Water-smart circular economy and societies.		
Sub-theme C.3	Empowering the public, water users and stakeholders in valuing water.		
Theme D: Sustainable Water Management			
Sub-theme D.1	Optimising the Nexus approach.		• UN Framework Convention on Climate Change Paris Agreement • The Common Agricultural Policy • The European Green Deal • The EU Strategy on Adaption to Climate change • EU 2030 Climate and Energy Policy Framework • EU Water Scarcity and Drought Strategy • EU Circular Economy Action Plan 2015 • EU Biodiversity Strategy to 2020 • The WFD and the basic measures required under the 11 related directives • Floods Directive • Environmental Quality Standards Directive
Sub-theme D.2	Adapting water resources management to deal with increased uncertainty.		
Sub-theme D.3	Enabling sustainable management of water resources.		

Chapter 1

Introduction

1 Introduction

1.1 What Are Joint Programming Initiatives?

The Joint Programming Initiatives (JPIs) are intergovernmental collaborations created to tackle major societal challenges that cannot be addressed by individual European and international countries alone, and in doing so contribute to the development of the European Research Area (ERA). Member States and associated countries participate in joint initiatives on a voluntary basis to increase the value of relevant national and European research, development and innovation (RDI) funding through joint planning, implementation and evaluation of national research programmes. This is achieved through common visions and Strategic Research and Innovation Agendas (SRIAs). The key objectives of the JPIs are to:

- align national policy priorities, strategies, competencies and programmes;
- drive scientific excellence through mission-oriented joint actions;
- build trust and encourage new forms of collaboration and partnership between local, regional, national, European and international policymakers, research-funding agencies, research-performing organisations, international initiatives and other stakeholders;
- benefit from institutional alignment and partnering;
- provide effective links between research and knowledge on the one hand and global policy on the other, such as the United Nations (UN) Sustainable Development Goals (SDGs) and the European Green Deal, which is committed to making Europe climate neutral by 2050; and
- extend links to various challenge-related international initiatives for learning from other countries' experiences.

1.2 Joint Programming Initiative Values

European Member States and associated countries participate in JPIs on a voluntary basis. This allows for an increase in the amount of relevant national and European RDI funding through processes such as joint planning, implementation and evaluation of national research programmes. The European Commission (EC) acts as a facilitator to support JPIs. The progress and results of JPIs are reported to the European Council and the European Parliament. Ten JPIs have been established since 2008, including the Water JPI, which was launched in 2011 **(Figure 1.1)**. The JPI's values are working together, variable geometry, the ability to be flexible and inclusivity. This is reflected by the strong relationships and interactions with other JPIs, partnerships and research and collaboration forums, as well as a willingness to engage in consultation and communication at all levels.

Water Challenges for a Changing World	Global Urban Challenges, Joint European Solutions
Healthy and Productive Seas and Oceans	Agriculture, Food Security and Climate Change
More Years, Better Lives - The Potential and Challenges of Demographic Changes	Cultural Heritage and Global Change: A New Challenge for Europe
Antimicrobial Resistance - The Microbial Challenge - An Emerging Threat to Human Health	A Healthy Diet for a Healthy Life
Connecting Climate Knowledge for Europe	Alzheimer and other Neurodegenerative Diseases

Figure 1.1. The JPIs

1.3 The Water Joint Programming Initiative

Since its approval at the Council of the European Union (EU) in December 2011, the Water JPI has, among other accomplishments, created a common vision and a robust SRIA that is updated in 5-year cycles, and promoted the alignment of national water research and innovation agendas. Membership of the Water JPI has grown since 2011 and now has a high-level operational partnership for implementing joint transnational calls and developing and promoting new partnerships. JPI activities are implemented through a variety of joint actions, such as transnational joint calls, knowledge hubs and task forces.

The fostering of better coordination and cross-border collaboration is at the very core of the Water JPI, which aims to tackle common societal challenges that cannot be addressed by individual European and international countries alone.

The Water JPI's vision until 2030 of **"Together for a Water-secure World"** and shared mission to **"Jointly enable 'smart' water solutions for a changing world"** are presented in the Water JPI Vision 2030 document.

Water is at the heart of all sustainable development (agriculture, food production and security, ecosystem sustainability and biodiversity, and urban area development) and is central to several thematic areas (e.g. climate change adaptation and mitigation measures). The Water JPI strives to produce science-based knowledge to support European and international policies, comprising the identification of problems and their quantification, and the development of feasible technical and managerial solutions. It aims to align water-related RDI in participating countries and provide a powerful tool for international cooperation in the water area.

1.4 The Water JPI Strategic Research and Innovation Agenda (SRIA)

The Water JPI SRIA is an overarching reference base, highlighting the range and direction of all Water JPI activities, which will be delivered through the Water JPI Implementation Plan. Sourcing and developing research-driven solutions to major societal challenges is the main function of the JPIs. The purpose of the SRIA 2025 document is therefore to set out research priorities for the Water JPI under the identified research themes. It outlines background information, such as relevant policy developments and environmental context, as well as the rationale for why research is needed.

The SRIA 2025 has been developed to guide future water-related RDI actions, including but not limited to the Water JPI actions. It sets out specific RDI research themes, sub-themes and research priorities. These research priorities can then be considered by various stakeholders, such as researchers, regulatory agencies, policymakers, industry and the public.

Figure 1.2. Activities of the Water JPI

Research gaps and topics, as well as the means of implementation (e.g. joint actions, via calls or networks.), will be prioritised and further developed as part of the next stage in the Water JPI's activity cycle by developing an agreed implementation plan, detailing joint actions (as illustrated by **Figure 1.2**).

These include exploratory and scoping workshops, to refine the research needs that are being addressed by the proposed joint action. Joint actions encompass RDI mapping, knowledge hubs and the alignment of national programmes.

The Water Joint Programming Initiative Vision 2030

Vision 2030

10 Year Roadmap

- Responding to water issues faced by Europe and globally
- Aimed primarily at policymakers and funding organisations

KEY WATER CHALLENGES

- Water crises are one of the most important risks to the economy and society in the coming years
- By 2025, two thirds of the global population could be facing water stress
- Global water requirements are projected to push beyond sustainable water supplies by 40% by 2030, with global use doubling by 2060
- Around 80% of wastewater is discharged untreated
- Agricultural use accounts for 70% of water use worldwide
- Energy production will lead to an 85% increase in water demands by 2035

Sources: World Economic Forum, the Global Risks Report 2020; UN Water, SDG 6 Interlinkages

ADDRESSING THESE CHALLENGES THROUGH THE WATER JPI'S...

Shared Vision...

Together for a water-secure world

&

Shared Mission...

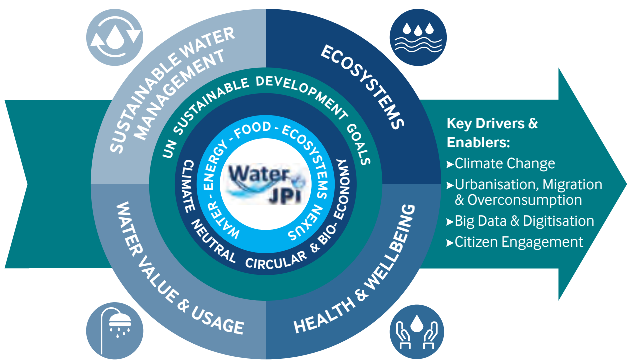
Jointly enabling 'smart' water solutions for a changing world

WATER RESEARCH & INNOVATION

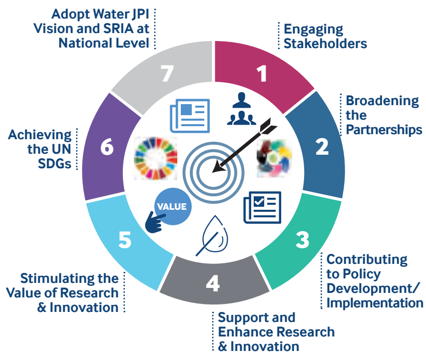
The key water challenges facing society:

- Deteriorating water quality and quantity
- Sustainable use and management of water resources
- Coordinated effort need to tackle these issues through research and innovation

CORE RESEARCH THEMES & CROSS-CUTTING ISSUES



WATER JPI OBJECTIVES



WATER JPI IMPLEMENTATION

10-Year Duration	**VISION 2030** ‣ High level document ‣ Key water challenges and research areas
Revised on a 5-Year Basis	**STRATEGIC RESEARCH AND INNOVATION AGENDA 2025** ‣ Core research themes ‣ Provides key research priorities
Every 3 Years	**JOINT IMPLEMENTATION PLANS** ‣ Work programme defining the Water JPI actions to address key research priorities
Joint Actions	‣ Research & Innovation calls ‣ Knowledge hubs ‣ Alignment of national programmes etc.

Chapter 2

Process to Update the SRIA 2025

2 Process to Update the SRIA 2025

The SRIA is a "living" document that is updated every 5 years. The development of the SRIA 2025 was a multi-faceted process and has involved several consultation steps, during which contributions to the Water JPI SRIA were sought from many sectors of society. The SRIA covers a broad range of RDI, from academic research to innovation activities. Its development has resulted from a collective, forward-looking revision exercise that identifies and sets out an integrated vision of water RDI priorities at regional, EU and global levels.

The SRIA 2025 has resulted from a comprehensive and extensive consultative process, which built on the three previous iterations of the SRIA (versions 0.5 in 2013, 1.0 in 2014 and 2.0 in 2016). Both the vision and the SRIA have been revised to take account of the changes in key policies that have occurred since 2011, such as the ongoing water trends and challenges in both a European and a global context, expansion of the Water JPI membership and increased collaboration agreements and partnerships.

With the launch of the new European Research and Innovation Framework Programme, Horizon Europe, cooperation with the new "partnerships" is being taken into account.

A critical review of the Water JPI research themes identified in Vision 2011 **(Table 2.1)** throughout the update process during the period 2018–2019 resulted in confirmation that these research themes are still valid.

Table 2.1. Core research themes from Water JPI Vision 2020.

SRIA 2.0 Research Themes and Sub-themes	
Theme 1: Improving Ecosystem Sustainability and Human Well-being	
Sub-theme 1.1	Developing approaches for assessing and optimising the value of ecosystem services.
Sub-theme 1.2	Integrated approaches: developing and applying ecological engineering and ecohydrology.
Sub-theme 1.3	Managing the effects of hydro-climatic extreme events.
Theme 2: Developing Safe Water Systems for Citizens	
Sub-theme 2.1	Emerging pollutants and emerging risks of established pollutants: assessing their effects on nature and humans and their behaviour and opportunities for their treatment.
Sub-theme 2.2	Minimising risks associated with water infrastructures and natural hazards.
Theme 3: Promoting Competitiveness in the Water Industry	
Sub-theme 3.1	Developing market-oriented solutions for the water industry.
Sub-theme 3.2	Enhancing the regulatory framework.
Theme 4: Implementing a Water-wise Bio-based Economy	
Sub-theme 4.1	Improving the efficiency of water use for a sustainable bio-economy sector.
Sub-theme 4.2	Reducing soil and water pollution.
Theme 5: Closing the Water Cycle Gap – Improving Sustainable Water Resources Management	
Sub-theme 5.1	Enabling sustainable management of water resources.
Sub-theme 5.2	Strengthening socio-economic approaches to water management.

It has been recommended that the 11 sub-themes are revised, to be more representative, relevant and succinct. To achieve its Vision 2030 and address its grand challenge, the Water JPI has now restructured its SRIA under the following four core research themes:

A. Ecosystems

B. Health and Wellbeing

C. Water Value and Usage

D. Sustainable Water Management

The revision and consultation steps leading to the development of the SRIA 2025 are outlined in detail in **Table 2.2** and **Figure 2.1**, which summarises the process. Information sources used are provided in Section 10 (selected bibliographies).

Table 2.2. Vision 2030 and SRIA 2025 revision and consultation steps.

Vision 2030 and SRIA 2025 Revision and Consultation Steps
Stage 1: Strategic and foresight document and literature review
This literature review was compiled to advise the Water JPI of key research themes and knowledge gaps/needs identified from the literature (both strategic and foresight documents), online sources and stakeholder workshops. Key outcomes following the review include the identification of relevant research gaps/needs that are aligned to the appropriate policy and categorised by the appropriate theme. The review also served to shape and inform Vision 2030, by identifying trends, drivers and challenges in water. It identified expected EU water policy developments for the period 2020–2030 and provided a summary of recommendations regarding priority research areas to be developed.
Stage 2: Public consultation
Inviting the public to participate in identifying future RDI and knowledge gaps/needs is a fundamental component of the Water JPI strategy. An online survey was developed by the Irish Environmental Protection Agency via SurveyMonkey® between December 2018 and February 2019. The aims were to identify key trends and recommendations in RDI to assist in defining the new vision and to inform the revised themes for the updated SRIA.
Stage 3: National consultation workshops
A total of eight countries held national consultation workshops to identify the national perspectives on changes that needed to be made to Vision 2030 and SRIA 2025. These were Finland, Flanders (Belgium), France, Germany, Ireland, Italy, the Netherlands and Turkey. In addition, one European research network, Aqua Research Collaboration (ARC), also held a workshop with its members. The summary reports of the findings and recommendations from each of these workshops were reviewed. The feedback has helped to align the partner countries with the revised Water JPI vision and SRIA.
Stage 4: Semi-structured interviews
Individuals were selected based on the suggestions made at the Water JPI Advisory Boards (ABs) and Governing Board (GB) workshop held in Berlin in May 2019; representatives from organisations in the Water JPI Stakeholders Advisory Group (SAG); and other suggested stakeholders. The aim was to contact stakeholders from other organisations, besides the research community. A shortlist of stakeholders was compiled in agreement with the WaterWorks2014 partners, from a cross-section of water activities. A summary of the main findings and recommendations was provided, and the feedback was incorporated.
Stage 5: Consultative workshop with the Water JPI ABs and GB
Berlin, Germany, May 2019: this consultative workshop collated feedback about the Vision 2030 document, devised Water JPI objectives, SMART (specific, measurable, achievable, relevant and time bound) monitoring indicators and amended RDI themes for the SRIA. Cross-cutting issues and key drivers/enablers for the Water JPI that are applicable across research themes were also compiled. Paris, France, September 2019: this consultative workshop provided feedback on the “Summary Notes” prepared in advance for the Experts Workshop (Stage 6). The vision indicators, targets and the expected impacts of the research themes were all discussed, as were ideas on how best to organise the 2019 Experts Workshop.
Stage 6: Experts Stakeholder Workshop
The Water JPI Experts Stakeholder Workshop was held in Dublin, Ireland, over 2 days in October 2019, with 88 attendees participating in a range of breakout and plenary sessions. The main aim of the workshop was to inform the structure and drafting of SRIA 2025 and the expected impacts. It also looked at the Vision 2030 performance indicators and proposed implementation models. Representatives from the Water JPI GB and ABs, governmental departments, ministries, policymakers, numerous EU initiatives, the research community, enterprises and NGOs non-governmental organisations were in attendance.

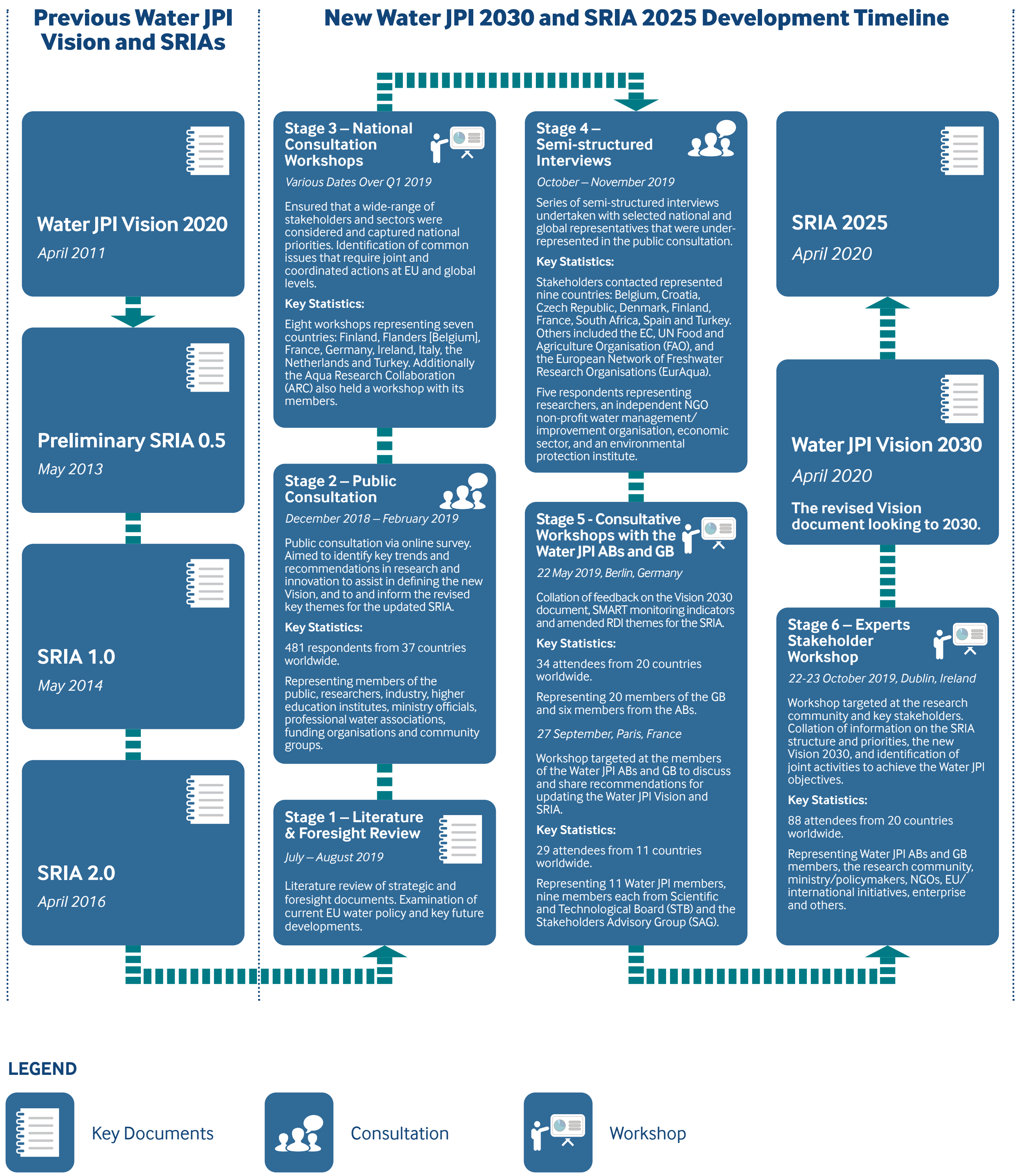


Figure 2.1. Water JPI Vision 2030 and SRIA 2025 preparation and updated timeline.

Chapter 3

Setting the Scene

3 Setting the Scene

3.1 Global and Water Challenges

In 2010, the UN acknowledged the right of all human beings to have access to safe, affordable and accessible water and sanitation (UN SDG6). Transboundary cooperation is essential when there are shared water basins and catchments, and more effort is required in this area.

On a global scale, water crises were identified in 2020 by the World Economic Forum as one of the most important risks to the economy and society in the coming years. Water crises, which are associated with the failure of climate change adaptation/mitigation, water as a factor in major conflicts and natural disasters are perceived to be more likely to occur in the future and have greater global impacts. Global water requirements are projected to be pushed beyond sustainable water supplies by 40% by 2030, with global use doubling by 2060.

Furthermore, water quality is expected to deteriorate substantially over the next decade, leading to impacts on human health, the environment and sustainable development. Key drivers of these issues are an increasing population, migration and climate change, which all lead to greater water demands.

The European Environment Agency's (EEA) The European Environment – State and Outlook 2020 report states that the key pressures on freshwater resources are pollution from diffuse sources, hydro-morphological changes and abstraction **(Figure 3.1)**.

Thematic summary assessment *Source: © European Environment Agency, 2019*

Theme	Past trends and outlook		Prospects of meeting policy objectives/targets
	Past trends (10-15 years)	Outlook to 2030	2020
Water ecosystems and wetlands	Trends show a mixed picture	Developments show a mixed picture	☒ Not on track
Hydromorphological pressures	Deteriorating trends dominate	Developments show a mixed picture	☒ Not on track
Pollution pressures on water and links to human health	Trends show a mixed picture	Developments show a mixed picture	☒ Not on track
Water abstraction and its pressures on surface and groundwater	Improving trends dominate	Developments show a mixed picture	☒ Not on track

Figure 3.1. The European Environment – State and Outlook 2020 – Summary of the freshwater thematic assessment (source: EEA, 2019).

Biodiversity has a functional role in the nature-based solutions that underpin the ecosystem processes and functions that deliver services. There is a direct link between these services and human health and wellbeing (e.g. availability of freshwater, food and fuel). Over 60% of ecosystem services are being degraded or used unsustainably and this affects water supply, and quality, recreational use and flood protection. Habitat degradation, climate change, pollution and invasive or alien species threaten an average of 25% of animals and plants worldwide and up to 1 million species face extinction as a result according to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

The main challenges up to 2030 are protecting and restoring water as a valuable resource, protecting ecosystems and halting biodiversity loss. This can be achieved through the implementation and integration of water measures, such as aligning with the international UN SDGs, the 2015 Paris Agreement and the Convention on Biological Diversity as well as through EU policies.

The UN SDGs have set many targets to be met by 2030. Water is relevant and critical to most of the SDGS. SDG 6, "Ensure availability and sustainable management of water and sanitation for all", is particularly relevant to the Water JPI **(see Figure 3.2)**.

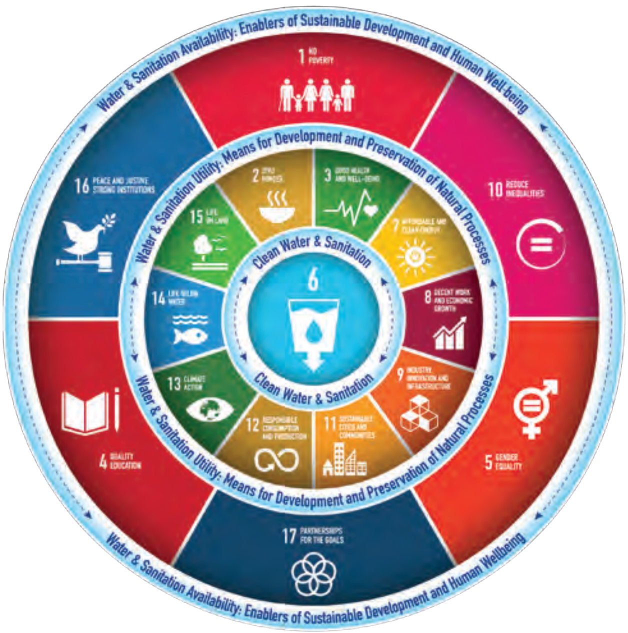


Figure 3.2. UN SDG6 and interlinkages (source: UN 2019).

Source: Integrated Approaches for Sustainable Development Goals Planning: The case of Goal 6 on Water and Sanitation. United Nations publication. Copyright © United Nations 2017. May 2017, Bangkok, Thailand.

Progress towards and current challenges in meeting the SDG6 indicators are outlined in **Table 3.1**. The UN report on the progress towards meeting the SDGs[1] states that a key challenge globally is **access to a basic drinking water service**, as 785 million people still lacked this in 2017. As the **demand for water** continues to increase, and as **population** and **industrial production increase**, research, innovation and technology need to be developed to deal with this demand. This must be considered in the context of energy sources and efficiencies in line with climate change adaptation policies and include societal transformational change.

Table 3.1. Progress towards meeting the UN SDG6 targets

SDG 6 Target	SDG 6 Indicator	Improvements Seen or Critical Challenge/Needs
Target 6.1 *Drinking Water*	6.1.1 Proportion of population using safely managed drinking water services	Cost recovery; solutions for off-grid water collection, household water purification
Target 6.2 *Sanitation and hygiene*	6.2.1 Proportion of population using safely managed sanitation services	Behavioural changes, overcoming taboos
		Dry sanitation; separation of faeces and urine; reuse of nutrients; understand interlinkages between water, sanitation and hygiene (WASH) and water quality
Target 6.3 *Water quality and wastewater*	6.3.1 Proportion of wastewater safely treated	Understand new pollutants, impacts, fate in the environment; integrate water quality in hydrological models; nature based solutions; product replacement; incentives, cost recovery, feedback from down- to up-stream
	6.3.2 Proportion of bodies of water with good ambient water quality	
Target 6.4 *Water use and scarcity*	6.4.1 Change in water use efficiency over time	Implementation: water pricing/ valuation
	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Technologies for irrigation, industry and households; water footprinting and virtual water; scarcity in relation to the hydrological cycle and climate change/ variability
Target 6.5 *Water resources management*	6.5.1 Degree of integrated water resources management implementation	Integrated Water Resource Management (IWRM): understand “integrated”; solutions: e-governance, water information systems; implementation: basin versus admin boundaries
	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	
Target 6.6 *Water related ecosystems*	6.6.1 Change in the extent of water related ecosystems over time	Understand multiple stresses, tolerance limits, tipping points and fragmentation; valuation of ecosystem services
		Nature-based solutions; ecosystem restoration; payment for ecosystem services

Key: ***Adequate*** ***Improvement*** ***Critical***

Source: *UNEP Presentation at the Water JPI Experts Workshop, 22 October 2019, Dublin, Ireland.*

[1] *United Nations Economic and Social Council, 2019. Special Edition: Progress Towards the Sustainable Development Goals. Report of the Secretary-General. Available online:* ***https://undocs.org/E/2019/68***

3.2 Key Policy Developments

Key policy developments (see **Figure 3.3**) have occurred since the Water JPI Vision 2020 was published in 2011. The 17 UN SDGs are intended to frame countries' national agendas and policies until 2030. The EU's report on SDG implementation[2] notes that progress needs to accelerate, and, while the EU has demonstrated leadership, achieving the goals remains a challenging ambition. Member States' development cooperation needs to align more fully with the SDGs. Better engagement throughout society and support are needed, such as joint programmes and results frameworks. Better use of limited resources is needed to tackle related SDG issues, such as mainstreaming environment and climate action into trade policies.

Key water policies within the EU have changed in recent years and continue to evolve **(see Figure 3.3)**. The Water Framework Directive (WFD) (2000/60/EC) has underpinned the EU's water policy since 2000. A fitness check of the WFD was completed in December 2019[3], along with its associated directives (Groundwater Directive and Environmental Quality Standards Directive) and the Floods Directive (2007/60/EC)[4]. Key findings of the fitness check show that the directives are still as relevant as when they were adopted and have led to a high level of protection for water bodies and flood management. However, a delay in the implementation of the directives by Member States has resulted in less than half of the EU's water bodies receiving good status. Pressures such as biodiversity loss, pollution, degradation of freshwater ecosystems, floodplain disconnection and climate change are having a major impact on our water resource. Tackling these issues through the WFD and related directives remain relevant going forward.

The European Commission (EC) adopted a proposal for a revised Drinking Water Directive (98/83/EC) in 2017, updating the quality standards and approach to water quality monitoring[5]. Between 2017 and 2018, an evaluation of the Bathing Water Directive (2006/7/EC) was conducted and recommendations were made by the World Health Organization (WHO) to include additional parameters in the directive[6]. In 2018, the EC proposed new rules to encourage and facilitate water reuse in the EU[7]; however, enacting such policy on waste water reuse in the EU is proving to be challenging.

In response to the challenges facing Europe, the European Green Deal[8] was adopted for the EU in December 2019. Termed a new growth strategy based on clean products and technologies, the European Green Deal is committed to working towards a climate-neutral society by 2050. The 8th Environment Action Plan Framework is also being delivered by the end of 2020.

It is crucial that RDI programmes prioritise synergistic actions that can address and meet multiple targets being set out by current and new policies and frameworks. This, of course, has to be in the context of the Water–Energy–Food–Ecosystems (WEFE) Nexus paradigm, which has been described by UN Water as central to sustainable development[9]. The Nexus encompasses several of the SDGs that will be essential in managing water demand, usage and scarcity, all of which are more challenging in the face of climate change. The 2015 Paris Agreement marked the date that a legally binding global agreement on climate change was made. After 2020, countries must show how targets are being met, with stricter targets to be set thereafter. At the EU level, the 2021–2030 Climate and Energy Policy Framework sets the context for Europe's continued progress towards a carbon-neutral circular economy, complimenting the European Green Deal.

[2] *EU (European Union), 2019. Joint Synthesis Report of the European Union and Its Member States. Available online:*
https://ec.europa.eu/europeaid/sites/devco/files/jsr-report-20190717_en.pdf

[3] *European Commission, EU water legislation – fitness check. Available online:*
https://ec.europa.eu/environment/water/fitness_check_of_the_eu_water_legislation/

[4] *European Commission, 2017. Fitness check of the WFD and the Floods Directive. Available online:*
https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-5128184_en

[5] *European Commission, 2017. Proposal for a Directive of the European Parliament and of the Council on the quality of water intended for human consumption (recast). COM(2017) 0753 final, 2017/0332(COD), 1.2.2018, Brussels. Available online:*
https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1519210589057&uri=CELEX:52017PC0753

[6] *European Environment Agency, 2019. European Bathing Water Quality in 2018. Available online:*
https://www.eea.europa.eu/publications/european-bathing-water-quality-in-2018

[7] *European Commission. Proposal for a regulation on minimum requirements for water reuse. Available online:*
https://ec.europa.eu/environment/water/reuse.htm

[8] *European Commission. A European Green Deal: striving to be the first climate-neutral continent. Available online:*
https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

[9] *UN (United Nations) Water. Water, food and energy. Available online:*
https://www.unwater.org/water-facts/water-food-and-energy/

1991
- Espoo Convention on Environmental Impact Assessment in a Transboundary Context, Espoo
- Urban Wastewater Treatment Directive (91/271/EEC)

1992
- Convention on the Protection and Use of Transboundary Watercourses and International Lakes (ECE Water Convention), Helsinki

1998
- Council Directive 98/83/EC (Quality of water intended for human consumption)

2000
- Implementation of the Water Framework Directive (WFD) (2000/60/EC)
- Millenium Objectives for Development
- European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways (AND), Geneva

2001
- Stockholm Convention on Persistent Organic Pollutants Stockholm

2008
- Environmental Quality Standards Directive (2008/105/EC) (amended 2013)

2008
- Launch of the JPI concept

2010
- Water JPI by 2011 (approval at European Competitiveness Council in December 2011)

2011
- The EU Biodiversity Strategy to 2020
- Water JPI Vision Document

2012
- "FIRST Fitness check of WFD-Blueprint to safe guard Europe's water resources" EU Freshwater policy
- 2012-EU 2020 Strategy: supporting analysis is expected to drive EU water policy up to 2050
- The Blueprint timeline is aligned to the EU's 2020 strategy
- Bioeconomy Strategy

2013
- The Seventh European Action programme to 2020
- EU Strategy for adapting to Climate Change
- SRIA 0.5
- The 7th Environment Action Progamme
- Minamata Convention on Mercury, Minamata
- Common Agricultural Policy (CAP) Reform

2014
- The first phase of implementation of the Marine Strategy Framework Directive (2008/56/EC)
- 2021- 2030 Climate and Energy Policy Framework
- SRIA 1.0

2015
- Action Plan for the Circular Economy
- The General Assembly adopted the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs)
- Food 2030

2016
- SRIA 2.0
- General Data Protection Regulation (GDPR) (EU) 2016/679

2017
- Fitness check of the WFD and the Floods Directive (FD); includes review of the "daughter directives" (the GD (2006/118/EC) and the EQSD (2008/105/EC)). Includes the Second RBMP cycle (2015-2021) and the first FRMPs & UWWTD
- World Health Organization: 'One Health' Approach 2017

2017-2018
- EU "reality check" of the implementation of the Bathing Water Directive (2006/7/EC)

2018
- The European Commission adopted a proposal for a revised Drinking Water Directive (98/83/EC)
- Evaluation of Strategy for adapting to Climate Change
- Updated Bioeconomy Strategy
- Updating the Bathing Water Directive 2006/7/EC
- Drinking Water Proposal of Commission adopted
- 2030 Climate and Energy Framework
- 2018 EU Circular Economy Package

2019
- A new strategic agenda 2019-2024
- EC's Horizon Europe Research and Innovation Framework (2021-2027)
- Completion of the Fitness check of the WFD and the FD
- Regulation (EU) 2019/1009 laying down rules on the making available on the market of EU fertilising products
- Europe's Green New Deal 2019

2019-2024
- EU Strategic Agenda 2019-2024

2020
- Update of the EU Biodiversity Strategy
- The post-2020 Common Agricultural Policy

2021
- European Council restrictions on single use plastic straws, plates and cutlery
- 3rd Cycle River Basin Management Plan 2021-2027

2021-2030
- Europe's 8th Environment Action Programme 2021-2030

2022-2027
- Common Agricultural Policy Programme 2022-2027

2025
- Update of the SRIA beyond 2025

2027
- 4th Cycle River Basin Management Plan 2027

2030
- Review of the UN Sustainable Development Goals (SDGs)
- Next update of the Water JPI Vision beyond 2030

Figure 3.3. Key Relevant Policy Developments to 2030.

Chapter 4

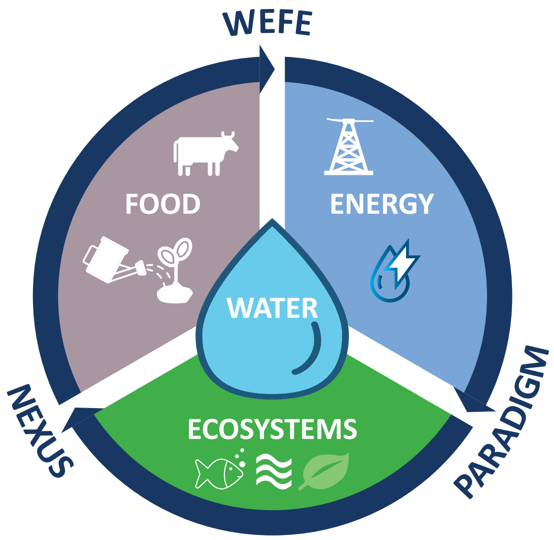
Cross-cutting Issues

4 Cross-cutting Issues

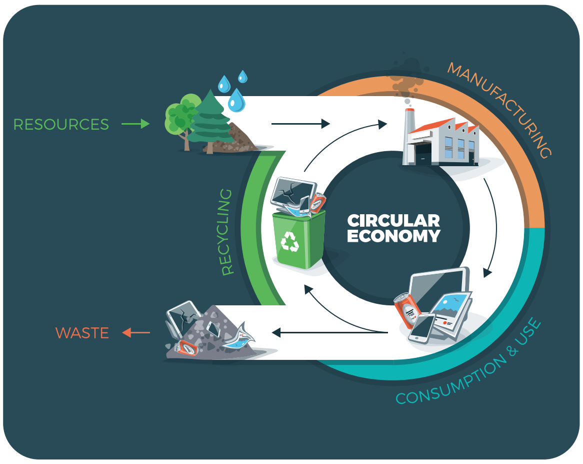
Considering the scope and complexities of the four core research themes of the Water JPI, three key cross-cutting issues have been identified (see below); these illustrate the need to ensure that a more integrated and holistic approach is taken. Considering the scope and complexities of the four core research themes of the Water JPI, three key cross-cutting issues have been identified **(see Figure 6.1)**.

1. **UN SDGs.** Sustainability is at the heart of long-term planning, and the 2030 Agenda for Sustainable Development encourages countries to develop national responses to the SDGs and incorporate them into policy.

2. **WEFE Nexus paradigm** (encompassing water, energy, food and ecosystems). This is central to enabling sustainable development. The Nexus covers several of the SDGs, demand for food, energy and water is rapidly increasing across sectors so the scope of water challenges must widen to include food security, water management and efficiency, sanitation, ecosystem services and resource depletion.



3. **Climate-neutral circular economy and bio-economy**. This aims to eliminate waste and promote the reuse products without compromising the environment. Establishing a climate-neutral economy is challenging, as it requires major changes and transitions, such as the EU's commitment to transition to carbon neutrality by 2050.



Chapter 5

Drivers and Enablers

5 Drivers and Enablers

Our society and our world are subject to global changes. Drivers are those overarching aspects that push change forward, both positively and negatively. They are global trends that affect us all. Enablers act as complements to drivers. They are specific elements that foster change or act to facilitate change. The main drivers and enablers include:

- **Climate change**

Climate change is a clear driver of global trends. Mitigating climate change places an onus on society to act on shifting behaviours in response. Adaptation measures requires society to identify risks and develop strategies to manage them.

- **Urbanisation, migration and overconsumption**

Water management and the sustainable use of resources are critical for adapting to and mitigating climate change. As with climate change, many of the challenges and issues related to water quality/ quantity and water stress are driven by human factors, namely urbanisation and migration. The rate of consumption is increasing because of population growth and increasing globalisation. This puts pressure on both natural and anthropogenic-made systems.

- **Big data and digitisation.**

These are fast becoming important tools for evaluating and contributing to studies in water-related topics. A large number of data is being generated from a vast array of sources. Water utilities are starting to utilise big data and the "internet of things" (IoT). These can be utilised to generate baseline information and risk mapping. Digitisation enables the generation and storage of information that can be leveraged by researchers and other stakeholders. It can also reduce barriers to accessing water data.

- **Citizen engagement.**

This is being driven and enabled by social media. Digital access to information also enables research and allows for knowledge transfer across all levels of society, from the public to policymakers; everyone can have a part to play in contributing to the research knowledge base and knowledge transfer. Social media can act as a catalyst for policy, social and behavioural changes (such as societal sustainable transformation).

Table 5.1 provides examples of other drivers and enablers that have been identified.

Table 5.1. Examples of other drivers and enablers

Enablers	Drivers
• Multiple helix approach (i.e. academia, industry, government and society interactions) • Data acquisition and sharing – open knowledge, open data and open access • Citizen science • Research infrastructures • Bio-technology development • Scientific evidence-based legislation and use of the precautionary principle to effect positive change and behavioural practices • Better communication at all levels of society, and empowering stakeholders	• Global changes and risks (both natural and anthropogenic) • Current global economic models based around increasing growth and increasing consumption of resources (i.e. exceeding planetary boundaries of sustainability) • Increased speed of changes requiring an increased delivery of research outputs • Citizen engagement/pressure groups/influencers • Migration and shifting demographics • Ecosystem degradation • Urbanisation and changes in land

Research infrastructures[10] (RIs) are an essential part of any scientific ecosystem at national, European and international levels. They support and facilitate the advancement of fundamental and complex research, provide access to new research consortia, promote the transfer of knowledge and support capacity building. It forms a critical aspect of the Water JPI's objectives around effective coordination of European RDI needs, mobilising research and innovation funding in water research. RIs are also needed by the SRIAs to contribute to a more strategic alignment and allow for cross-sectoral and transdisciplinary approaches and cooperation with other JPIs and relevant stakeholders[11].

Since water resources and environmental processes are affected by global, regional and local drivers and experience a variety of challenges, national and/or European RI plays an important role in addressing the complexity of necessary knowledge exchange, transfer, innovation and multi-disciplinary approaches for water research.

The majority of the Water JPI member countries have local to national water-relevant RI already in existence. It may not be linked to others, owing to a lack of national or European roadmaps for this type of RI, and can therefore lead to a very fragmented landscape. On a European level, the European Strategy Forum on Research Infrastructures[12] (ESFRI) contributes to the development of pan-European RI and boosts Europe's research and innovation potential. The Water JPI has identified the following RIs as being relevant: Danubius-RI[13], European Long-Term Ecosystem and Socio-Ecological Research Infrastructure[14] (eLTER), Analysis and Experimentation on Ecosystems (AnaEE)[15], Integrated Carbon Observation System (ICOS)[16] European Research Infrastructure Consortium (ERIC) and LifeWatch ERI[17].

[10]The definition of the European Commission Directorate-General for Research and Innovation: "'Research infrastructure' (RI) means facilities, resources and related services that are used by the scientific community to conduct top-level research in their respective fields and covers major scientific equipment or sets of instruments; knowledge-based resources such as collections, archives or structures for scientific information; enabling Information and Communications Technology (ICT)-based infrastructures such as Grid, computing, software and communication, or any other entity of a unique nature essential to achieve excellence in research". Available online: https://ec.europa.eu/research/infrastructures/index.cfm?pg=about

[11]WATER-3-2015: Stepping up EU research and innovation cooperation in the water area. WaterWorks2015 – 1st Water JPI Mobility and Infrastructures Workshop – Proceedings (WP7, Task 7.2), June 2018. Available online: ***http://www.waterjpi.eu/images/documents/mobility-and-infrastructures-workshop-proceedings.pdf***

[12]https://www.esfri.eu/

[13]http://www.danubius-ri.eu/

[14]http://www.lter-europe.net/elter

[15]https://www.anaee.com/

[16]https://www.icos-ri.eu/

[17]https://www.lifewatch.eu/

The Water JPI is looking to reduce this fragmentation by facilitating connections among existing and upcoming facilities (from local and national levels to European level) in the water sector. The Water JPI will strengthen the community, with the aim of building and expanding competences within water-relevant RI landscape. Better access to RI services requires fostering capacity development in the equipment and services that are provided to research projects and programmes. The Water JPI is developing its own Mobility and Research Infrastructure Platform[18], aiming to support the mobility of researchers and experts and create a RI network and synergies within the water community.

Priorities/expected impacts of the Water JPI for RI:

- Encourage pan-European collaboration among national to European RIs to address global challenges.
- Enhance efficiency of water-relevant RIs and the reduction of fragmented RIs.
- Increase innovation potential, develop new services, and create added value.
- Harmonise methods and protocols.
- Strengthen water-relevant RIs within the scientific and European research landscape

[18] *http://www.waterjpi.eu/*

Chapter 6

SRIA 2025 Research Themes

6 SRIA 2025 Research Themes

Achieving the objectives of the Water JPI and its SRIA **(see Figure 6.1)** requires a multi-disciplinary approach for each research theme to contribute to expected impacts under policy, environmental, economic, technological and societal aspects. Society needs a sustainable and holistic vision, as well as an integrated sustainable water resource management approach to adapt to water needs and new challenges. SRIA 2025 has been structured by the four research theme areas and according to the cross-cutting issues, key drivers and enablers. This structure enables the reader to follow the state of the art in each theme while also appreciating the challenge of integrating the four themes, i.e. integrating the complex interactions between water resource use, ecosystems and socio-economic systems.

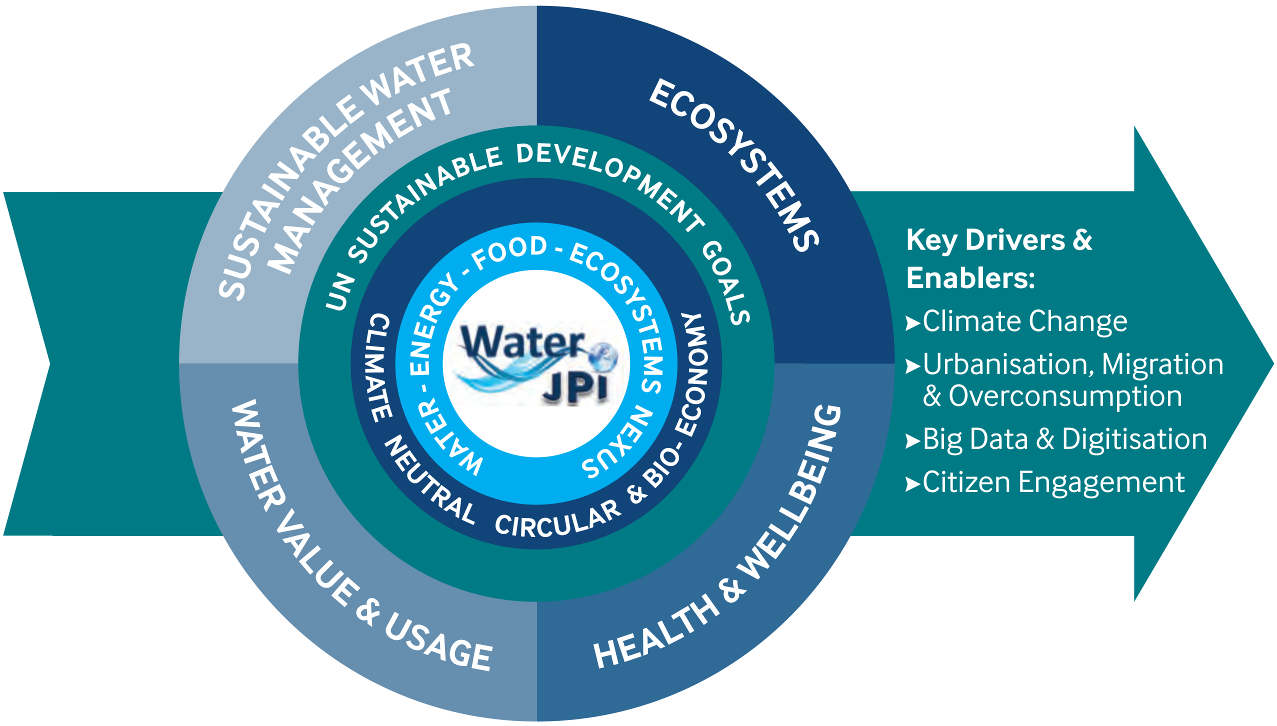


Figure 6.1. Structure of the SRIA 2025.

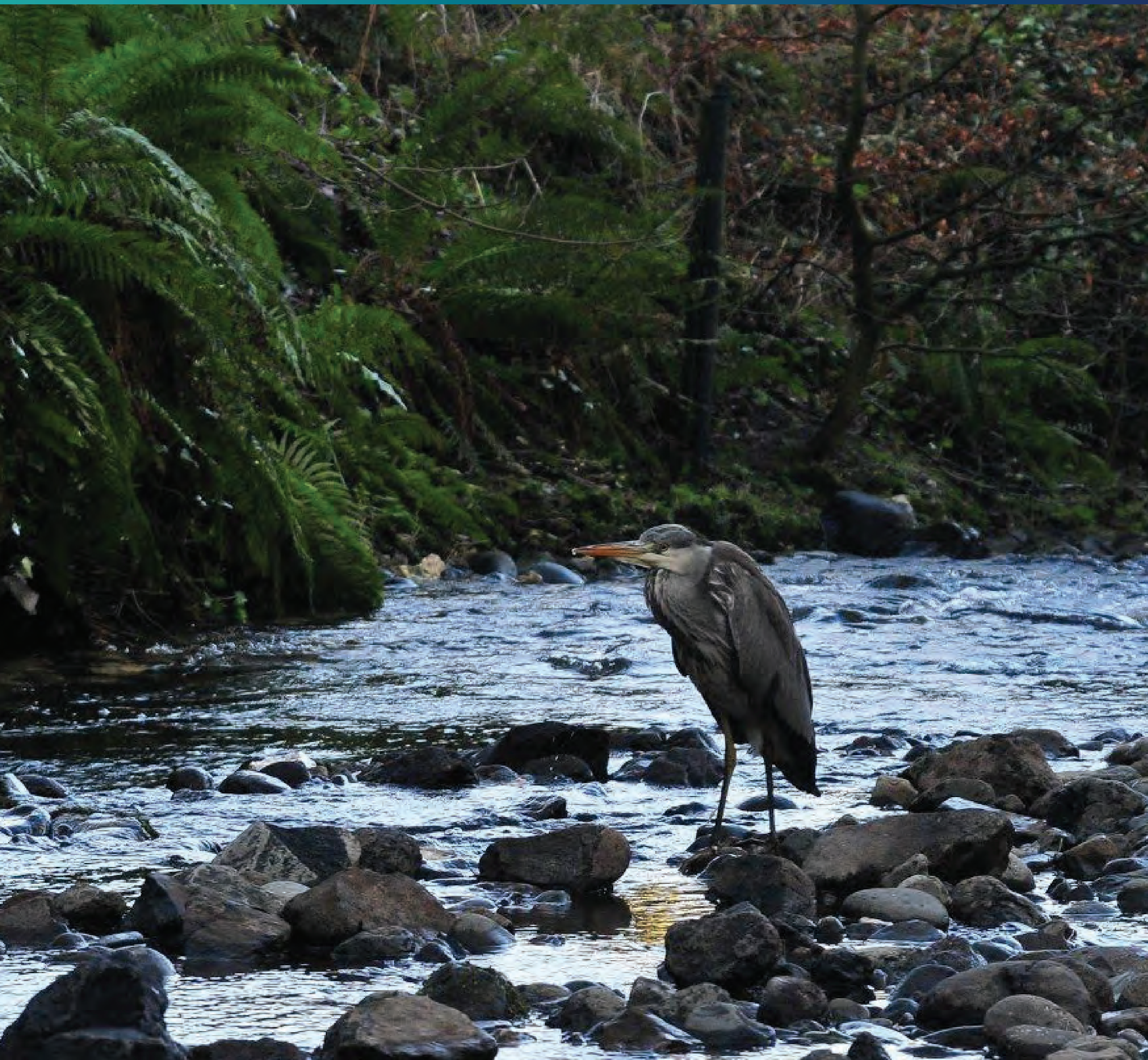
The Water JPI SRIA 2025 is composed of four themes and their sub-themes, as listed in **Table 6.1**. For each sub-theme, specific RDI priorities, expected impacts and key policy drivers have been identified and are detailed under **sections 6.1 to 6.4**.

Table 6.1. SRIA 2025 research themes and sub-themes.

SRIA 2025 Research Themes and Sub-themes	
Theme A: Ecosystems	
Sub-theme A.1	Developing approaches for assessing and optimising the structure and function of ecosystem services.
Sub-theme A.2	Developing and applying an approach to ecological engineering and ecohydrology.
Sub-theme A.3	Managing and adapting ecosystem services to the effects of hydro-climatic extreme events.
Theme B: Health and Wellbeing	
Sub-theme B.1	Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans.
Sub-theme B.2	Water dimension of antimicrobial resistance; "one health approach".
Sub-theme B.3	Understanding and minimising the risks associated with water infrastructures and climate change effects.
Sub-theme B.4	Assessing and evaluating the sustainable interactions between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy.
Theme C: Water Value and Usage	
Sub-theme C.1	Future-proof water technologies, infrastructures and systems for developing climate change resilience.
Sub-theme C.2	Water-smart circular economy and societies.
Sub-theme C.3	Empowering the public, water users and stakeholders in valuing water.
Theme D: Sustainable Water Management	
Sub-theme D.1	Optimising the Nexus approach.
Sub-theme D.2	Adapting water resources management to deal with increased uncertainty.
Sub-theme D.3	Enabling sustainable management of water resources.

Theme A

Ecosystems



6.1 Theme A. Ecosystems

Ecosystems and ecosystem services play an important role in terms of their biodiversity, mitigating the effects of flood and drought and absorbing and detoxifying pollutants. Ecosystems, which encompass the marine, freshwater and terrestrial environments, provide vital services to humankind, for instance food, timber, flood control, water regulation and purification, pollination, recreation and cultural benefits, and habitats for plants and animals. All ecosystems are linked and maintained by water, providing plants and habitats and breeding grounds for the various species that depend on them. Furthermore, ecosystems serve humans in terms of purification and filtration of water, recreationally and economically. They are a finely tuned process and are susceptible to pressures such as climate change, pollution, water abstraction and the spread of alien species.

A related aspect of ecosystems is the concept of ecosystem "disservices." These arise in cases in which the interaction between natural systems and humans is negative or has adverse effects; this can negatively affect economic production and human life. Examples include excessive primary productivity (supporting disservice), the proliferation of non-native species (provisioning disservice), offensive-smelling decomposing organic matter (cultural disservice), carbon sinks turning to carbon sources (regulating disservice) and water quality deterioration following landslides or bog bursts[19].

Rapid population growth and urbanisation have significantly affected ecosystem services in terms of land use change (i.e. agriculture and

[19]*Rolston, A., Jennings. E., Linnane, S. and Getty, D., 2015. Developing the Concept of Catchment Services for Progress Towards Integrated Water Management (Extra TIMe). Environmental Protection Agency Research Programme, The Centre for Freshwater and Environmental Studies and the Department of Humanities, Dundalk Institute of Technology, Dundalk, Ireland.*

urbanisation). Intensive farming practices have contributed to excess nutrients, sediment and chemicals (agri-chemicals) in the environment. Following extreme weather events, excesses of these substances can be washed from farmland into waterways and cause major environmental damage. These factors have contributed to biodiversity loss. Research has also shown that there is a direct correlation between biodiversity and ecosystem services. The IPBES Regional Assessment Report for Europe and Central Asia states that there is a trend towards a decline in biodiversity. This will have consequences for resilient ecosystem services, impacting on, for example, the formation of habitats, the regulation of freshwater quality and quantity, soil formation and flood regulation. According to the report, land use change, climate change and economic growth are considered the key drivers for the loss of both biodiversity and ecosystem services, not only in Europe and Central Asia, but also on a global level. Nonetheless, initiatives such as the SDGs and IPBES highlight not only the deficits regarding biodiversity and ecosystem services but also the achievements in knowledge transfer and policy regulation associated with environmental stewardship. Greater engagement of people with water issues would also lead to an increased awareness of the need to protect water resources and of the value of ecosystem services, as well as including them in national environmental policies and land use planning.

There are significant knowledge gaps regarding the value of ecosystem services, such as understanding the intrinsic value of ecosystems and their functioning, and approaches to accounting for this value. Further research is required to assess and evaluate the links between biodiversity and ecosystem change, and a deeper understanding of ecological tipping points, which is becoming more critical in the face of global changes. Ways of embedding ecosystem services in policymaking, (spatial or land use) planning and river basin management processes is another key linking area. Research outcomes under this theme will contribute to the evidence base, which is critical for informing robust policy actions. It will also support the implementation of European directives and international policy. **New knowledge, evidence and innovative solutions are required in the context of:**

- developing approaches for assessing and optimising the structure and function of ecosystem services;
- developing and applying an approach to ecological engineering and ecohydrology;
- managing and adapting ecosystem services to the effects of hydro-climatic extreme events;
- including ecosystem services in national environmental policies and land use planning.

Sub-theme A.1: Developing approaches for assessing and optimising the structure and function of ecosystem services.

Rationale

One of the main priorities of the 8th Environmental Action Programme of the EU is to protect biodiversity and aquatic ecosystems, which provide goods and services that society relies on. This includes fertile and productive land and seas, freshwater, and clean air. It places ecosystem services at the very core of its objectives, with an urgent need to protect and restore biodiversity (contributing to increased resilience), as well as implement a Europe-wide strategy for a non-toxic environment. It is generally considered that ecosystems are more resilient to changes when there is greater biodiversity potential. The impacts of nutrients and eutrophication in aquatic ecosystems remains a significant pressure. Nutrient run-off and atmospheric deposition of airborne pollutants are key transboundary issues. Further research is important in terms of understanding aquatic ecosystems and their associated ecosystem services. A comprehensive understanding of the benefits and distribution of ecosystem services, and robust indicators to measure this, is required. Ecological forecasting tools can help predict short- and long-range ecological changes. Solutions can then be developed for remediation, mitigation and governance of aquatic ecosystem services. In the face of the challenges facing ecosystems and biodiversity, developing sustainable and environmentally friendly water infrastructures to firstly preserve aquatic ecosystems in the context of other environmental systems present in catchments (geosystems or an underground environment, which provides services such as aggregates, minerals and drinking water, and atmospheric systems, which provide services such as wind and solar energy), both visible and invisible, such as within the hyporheic zone and underground within aquifers, and secondly avoid overexploitation of natural resources is paramount.

Research priorities

The priorities identified for sub-theme **A.1** are summarised in **Table 6.2**.

Table 6.2. Research priorities under sub-theme A.1

	Research priorities under sub-theme A.1
A.1.1	Assessing the functioning of ecosystems, ecosystem goods and services, and human wellbeing associated with ecosystems. This may include reinforcing the knowledge on causal links (including synergies and trade-offs) between biodiversity and ecosystem functioning, and the other systems present in catchments (geosystems and atmospheric systems).
A.1.2	Understanding and predicting multiple pressure–impact–response relationships in all types of aquatic ecosystems (surface waters – rivers, from springs to transitional waters – wetlands and lakes/lagoons, as well as groundwater) in the global biogeochemical (and sediment and rock interaction) cycle. This may include risk assessments and linking these relationships to the ecological and social resilience of ecosystems.
A.1.3	Developing evaluation and prediction methodologies to assess the economic and social value of ecosystem services and biodiversity, considering all aspects of ecosystems in a context that includes geosystems and atmospheric systems (from the visible to the unseen, i.e. groundwater features/flows).
A.1.4	Adapting and integrating aquatic and artificial (e.g. designer ecosystems, such as rain gardens and ponds) ecosystem services into management of water resources, including analysing trade-offs and synergies between water quality objectives, targets and land use planning and governance systems, by utilising better environmental data and information.

Synergies and links

Examples of synergies and links with other themes and sub-themes include the following:

- Sub-theme **A.2** and particularly priority **A.2.1** [Understanding, managing and restoring hydro-morphological alterations, to restore the ecological and sediment flows (E- and S-flows) and thus restore hydrological connectivity and continuity] are relevant to **A.1.2**.
- Theme **B** (Health and Wellbeing), particularly research priorities **A.1.1**, owing to the impact on human health, and the human impacts on ecosystem services and their functioning.
- Sub-theme **D.1** (Optimising the Nexus approach), particularly priority **D.1.1** [Investigating and imagining new approaches to address the Nexus, namely on sustainability and efficiency (environment, health, economy) under multi-disciplinary concepts], and **D.1.4** (Developing, optimising and testing innovative solutions for achieving water, sediment, energy resources sustainability and food security and safety linked to environment, namely in a holistic approach).
- Sub-theme **D.3**, particularly priority **D.3.3** (Develop integration models of high-resolution data in time and space on the water cycle, ecosystems and economic systems to address water resource management. This includes the impacts of climate and global changes to geochemical fluxes on water ecosystems from the critical zone). These models should take account of ecosystems in the context of projected climate changes, economic sustainability and the connections with other related environmental systems – geosystems and atmospheric systems.

- Sub-theme **B.1** (Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans) is linked to research priority **A.1.1**.
- Priority **B.4.1** (Understanding the links between water, nature-based solutions and ecosystem services to assess and evaluate ecosystem change on human wellbeing) is linked to sub-theme **A.1**.
- Priority **C.3.4** (Developing participatory foresight approaches to raise stakeholders' awareness of the long-term value of water resource protection) is linked to **A.1.3**.
- Priority **D.3.3** (Developing integration models of high-resolution temporal and spatial data on the water cycle, ecosystems and economic systems to address water resource management – this includes the impacts of climate and global changes to geochemical fluxes on water ecosystems from the critical zone).

Sub-theme A.2: Developing and applying an approach to ecological engineering and ecohydrology

Rationale

A sustainable use of nature is required to solve societal challenges. Ecological engineering can be utilised to restore, create and design sustainable ecosystems that will integrate the natural environment with the needs of society. The role of NBS in ecological engineering focuses on the benefits to people and the environment. NBS also allow for sustainable solutions that can respond to long-term environmental changes and integrate societal factors (i.e. poverty, socio-economic development and governance principles)[20]. Ecohydrology can be considered an interdisciplinary science between ecology and hydrology and can be used to solve a suite of environmental issues[21]. Research that focuses on machine learning in hydrology, hydro-geology, catchment science, hydro-ecology and hydro-economics may reduce uncertainties with respect to understanding and/or modifying the aquatic environment.

Addressing water resource management as well as the impact of drivers such as climate and global changes on, for example, geochemical fluxes on water ecosystems would help develop an understanding of the ever-changing water supply and demand. Developing a better understanding of ecological/sediment flows and the quantity of water resources used is vital for sustainable ecosystem functioning. These can then be related to social phenomena (e.g. large migratory movement flows towards urban centres), economical aspects (e.g. overexploitation of water resources) and environmental factors (e.g. climate change, run-off). Further knowledge on ecosystem functions and ecosystem "tipping points" is also needed, as they can lead to a collapse and a change in state, as well as further knowledge on their interaction with geosystems and atmospheric systems in catchments. Degraded habitats and ecosystems have limited resilience to both natural and anthropogenic influences, especially in the face of intensification of land use and use of natural capital. This also has implications for the circular economy, the carrying capacity of the environment and ecosystem restoration efforts.

Research priorities

The priorities identified for sub-theme **A.2** are summarised in **Table 6.3**.

Table 6.3. Research priorities under sub-theme A.2.

Research priorities under sub-theme A.2	
A.2.1	Understanding, managing improving and restoring hydro-morphological alterations, to restore the ecological and sediment flows (E- and S-flows), and thus restore hydrological connectivity and continuity, to satisfactory conditions.
A.2.2	Developing NBS for the scaling-up of restoration and improvement actions and mitigation of degraded water bodies and aquatic ecosystems (from local to landscape, across gradients such as upstream and downstream effects and degrees of degradation).
A.2.3	Developing NBS and linking measures to their effects and their societal impacts in terms of risks reduction, climate change mitigation, and water and associated ecosystems preservation.

Synergies and links

Examples of synergies and links with other themes and sub-themes include the following:

- Sub-theme **A.1** (Developing approaches for assessing and optimising the structure and function of ecosystem services), a particular priority, and the other systems present in catchments – geosystems and atmospheric systems – and **A.1.2** [Understanding and predicting multiple pressure–impact–response relationships in all type of aquatic ecosystems (surface waters – rivers, from springs to transitional waters– wetlands and lakes/lagoons, as well as groundwater) in the global biogeochemical (and sediment and rock interaction) cycle, which may include risk assessments and linking these relationships to the ecological and social resilience of ecosystems] are relevant to **A.2.1**.
- Sub-theme **A.3.1** (Determine the pressures on biodiversity and ecosystem services, and genetic resources, in a global change context) is linked to **A.2.1**.
- Sub-theme **D.1.2** [Developing methodologies to assess how water resources, ecosystems and human actions in a complex interconnected system (Nexus) will respond to a changing climate and global changes through participatory scenario development and integrated modelling approaches] is linked to both **A.2.2** and **A.2.3**.

Sub-theme A.3: Managing and adapting ecosystem services to the effects of hydro-climatic extreme events

Rationale

Climate change is predicted to increase seasonal variations in precipitation and surface water availability. Extreme weather conditions, such as droughts and floods, are expected to become more frequent. Coupled with these changes, farmers in many regions will face increasing competition from non-agricultural users because of rising urban population density and water demands from the energy and industrial sectors. Therefore, agricultural production will have to rely on reduced freshwater resources. Considering these factors and in the context of extreme events, knowledge gaps in terms of the direct and indirect effects of land use changes and consumption/increasing requirements on the structure and functioning of aquatic and riparian ecosystems as a function of extreme events need to be improved. This should include the pressures on biodiversity and the genetic resources of ecosystem services. Bridging the knowledge gap between meteorological and climatic forecasts (such as weekly versus longer term forecasts) would serve to accurately predict climatic variations that cause severe drought and floods.

A greater understanding is required of the processes of catchments (climatic or otherwise) causing hydrological extreme events on small to large scales (such as run-off generation and snow melt), as well as analysing the water storage capacity following flood events in dry regions (e.g. managed aquifer recharge). Climate change, urbanisation and agricultural practices can all contribute to major shifts in ecosystem functions. While ecosystems can play a role in coping with extreme events (e.g. in terms of limiting run-off, blue–green solutions for flood control), the ability of ecosystems themselves to cope with extreme events is also an issue. Considering the drivers of climate change, urbanisation, land use changes/intensification, etc., it is vital to quantify and balance the impacts of droughts for different water users (such as households, agriculture, industry and environmental flows). Invasive or alien species, and species that negatively have an impact on biodiversity (which can be tied to impacts from hydro-climatic effects) should be considered. Developing innovative (or improved) tools/design solutions for adaptation to hydro-climatic extreme events, especially flood and drought risk is required. Tackling these issues requires a multi-disciplinary approach.

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[20] *Eggermont, H., Balian, E., Azevedo, J.M.N., Beumer, V., Brodin, T., Claudet, J., Fady, B., Grube, M., Keune, H., Lamarque, P. and Reuter, K., 2015. Nature-based solutions: new influence for environmental management and research in Europe. GAIA-Ecological Perspectives for Science and Society 24: 243–248.*

[21] *Li, X., Yang, D., Zheng, C., Li, X., Zhao, W., Huang, M., Yaning, C. and Yu, P., 2017. Ecohydrology. In The Geographical Sciences During 1986–2015. Springer Geography. Springer, Singapore, pp. 407–417.*

Research priorities

The priorities identified for sub-theme **A.3** are summarised **Table 6.4**.

Table 6.4. Research priorities under sub-theme A.3.

Research priorities under sub-theme A.3	
A.3.1	Determine the pressures on biodiversity and ecosystem services, and genetic resources, in a global change context.
A.3.2	Developing innovative (or improved) tools for adaptation to hydro-climatic extreme events, especially floods and drought in a catchment context.
A.3.3	Developing of prediction models of ecosystem "tipping points" to categorise hydro-climatic extreme events and their system-specific effects on different ecosystems considering the various parameters (physical and bio-geochemical, as well as sociological and economical).
A.3.4	Developing methodologies for managing the risks caused by invasive or alien species and options for remediation.

Synergies and links

Examples of synergies and links with other themes and sub-themes include the following:

- Priority **B.4.2** [Developing an integrated water exposure model which considers social impacts (such as on air, sediment, water, food, social and psychological effects and stressors)] is relevant to **A.3.3**.
- Sub-theme **D.2** (Adapting water resources management to deal with increased uncertainty) has relevance for sub-theme **A.3**, particularly priority **D.2.3** (Building a better understanding of socio-hydrological processes at different scales, i.e. critical zone observatories, including watersheds and catchments, to understand changes with time, considering anthropic activities and solutions, while promoting the use of existing and new water RDI infrastructures).
- Sub-theme **B.4** [Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands, to promote a coordinated resource management strategy] is linked to sub-theme **A.3**, particularly priority **A.3.3**.
- Sub-theme **A.2.1** [Understanding, managing and restoring hydro-morphological alterations, to restore the ecological and sediment flows (E- and S-flows), and thus restore hydrological connectivity and continuity], is linked to **A.3.1**.

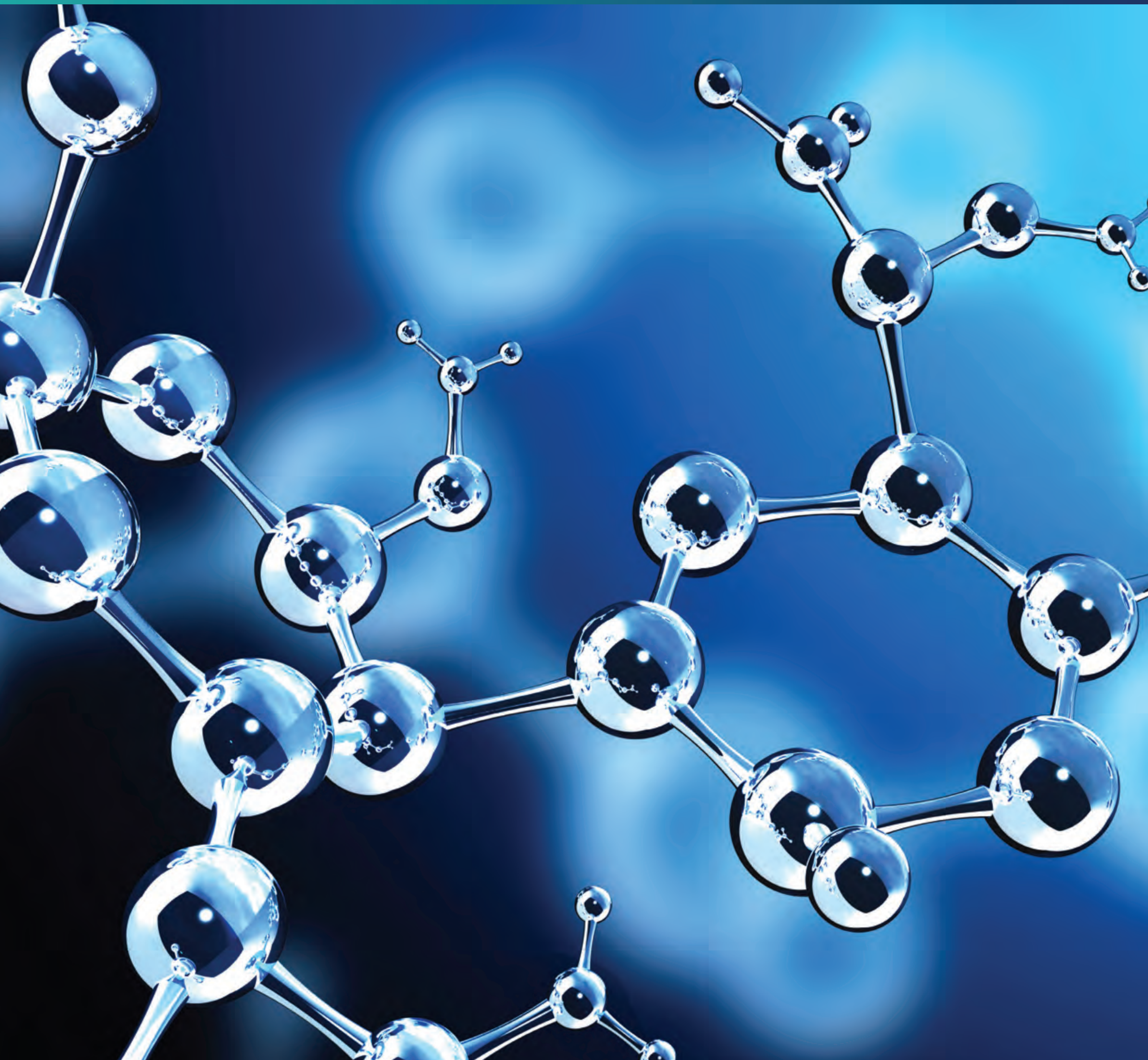
Expected impacts of theme A

Area	Expected impacts
Policy	**Relevant to:** • **EU regulations and policies, in particular** the 7th and 8th Environment Action Programmes; Europe's Green New Deal; the EU Water Blueprint; the WFD; the Marine Strategy Framework Directive; the Floods Directive; the Water Scarcity and Drought Strategy; EC Guidance on Ecological Flows (E--flow); WFD Guidance on sediment management (in prep.); the EU Climate Change Adaptation Strategy; the Habitats and Birds Directive (Natura2000 network); the EU Biodiversity Strategy; the International Convention on Biodiversity; Groundwater and Drinking Water Directives[22] EU Regulation 143/2014 on Invasive Species; and Proposal for a regulation on minimum requirements for water reuse (May 2018); • **the UN SDGs, especially** SDGs 6 (clean water and sanitation), 2 (zero hunger), 14 (life below water), 15 (life on land), 3 (good health and wellbeing), 11 (sustainable cities and communities), 12 (responsible consumption and production) and 13 (climate action).
Environmental	**Contribute to:** • better assessment and evaluation approaches of the ecosystem services concept, as well as multi-stressor effects in the context of climate change; • a better understanding of aquatic ecosystems, particularly in a catchment context in which other potentially interacting geosystems and atmospheric systems and their services are present; • achieving sustainable resource uses; • improved water management and availability of good water quality, in particular in the case of extreme weather events; • using NBS to contribution to services (e.g. water quality, filtering sediment capture and climate change mitigation/adaptation); • assessing the effectiveness of mitigation measures; • a restored flow of sediments from rivers to seas and thus provision of habitats and food for ecology for maintenance of biodiversity; • improved input and consideration of ecosystem services in land use planning and catchment management.
Economic	**Contribute to:** • addressing market failures (integration of externalities in policymaking), by assessing and comparing the preservation, adaptation and restoration costs; • better decision-making and policymaking processes, as well as economic impacts, by developing monetary and non-monetary (e.g. managerial) methods of valuation. • better definition and valuation of the value and benefits of ecosystems and their services, leading to a better understanding and communication of the costs and benefits of maintaining, improving, restoring and protecting ecosystems and ecosystem services – this should then contribute to encouraging investment in ecosystem services now, which will have positive future benefits for society and cost-saving (e.g. flood attenuation, filtering); • a more sustainable exploitation of (water, soil and sediment related) natural resources.
Technological	**Contribute to:** • the development of physical and digital technologies that allow the remediation and treatment of water resources in the case of contamination derived from extreme climate events as well as coordination of water treatment infrastructure to better manage the events with minimal impact on water services and water bodies. • the development of new tools in ecological engineering and early warning systems, including sensors, web services, numerical codes, and ecological and hydro-morphological restoration technologies. • increased availability and relevance of data and decision-making products, in particular for extreme weather events; • the development of new technology related to biodiversity and derived products and services (this also links to economic aspects); • leveraging earth observation technologies to better understand the value structure and function of ecosystems (this also links to big data and digitisation as enablers of research and understanding); • the development of new biological indicators (e.g. microbial, DNA and genetics), which can be applied to all water bodies (particularly groundwater) to better understand water quality; • the use of technology for better assessment – this can include existing and developing data analytical tools and techniques that can contribute to better forecasting (of impacts and events); • new and improved models and decision support systems that help in transforming data into information and information into knowledge.
Societal	**Contribute to:** • a more sustainable use of natural resources, thereby safeguarding them for future generations; • better protection of public health and the environment from effects of extreme weather events (as well as impacts from longer term changes); • identifying, proposing and prioritising measures to help societies adapt and react to current and future pressures; • better communication for the public, to provide a better understanding of the value of ecosystems and their services, biodiversity and restoration efforts, and how these contribute to benefits for society (both human and biological health); • preservation of ecosystem services, which has societal benefits (including but not limited to sustainable tourism, recreation and heritage).

[22] *Note, these are particularly relevant to priorities A.1.2, A.1.4 and A.3.1.*

Theme B

Health and Wellbeing



6.2 Theme B. Health and Wellbeing

Rationale

The current global population is 7.6 billion and it is set to rise to 8.6 billion by 2030. Coupled with climate change, urbanisation and migration, water demand pressures will significantly increase. Intensive agriculture, over-abstraction of ground and surface waters, the persistence of contaminants of emerging concern in water bodies and the subsequent adverse health effects on humans, animals and the environment continue to rise. The global health crisis in the form of antimicrobial resistance (AMR) is estimated to contribute to 10 million deaths by 2050.

The main challenges under this theme are ensuring safe and clean water, for both people and the natural environment. Further research is required not only on the underlying issues but also on human, animal and environmental impacts – the "one health approach". This approach seeks to implement programmes, research and policies to understand and evaluate the links between global human practices (including waste water treatments), ecosystems and human health. There is a requirement to develop methodologies on how to prevent adverse health effects of substances both known and not yet known, to have a direct or cumulative impact on public health and ecosystems. There are direct relationships or correlations between environmental aspects (such as agriculture, forestry, water, soil and climate change) and social science and epidemiological aspects (such as opportunistic pathogens in water due to more favourable climate conditions). Higher temperatures, especially in more temperate regions, will see greater transmission rates of waterborne pathogens, such as species of Legionella, Cryptosporidium and Giardia, leading to increased transmission rates of such pathogens. There are knowledge gaps regarding the evaluation of potential risks of transmission on account of extreme climatic events and mitigation measures, such as improvements in sanitation. Furthermore, evidence-based research can serve to inform policy. Research outcomes in this theme can help to inform policy by providing epidemiology in addition to environmental evidence.

Research under this theme also aims to contribute to key policies, such as the EU Strategy on Adaption to Climate Change and the WFD and related directives, which directly contribute to safeguarding and slowing down the deterioration of water resources. The Waste Framework Directive and the Common Agricultural Policy are relevant to this theme and research should highlight the need for the implementation of stricter controls on the use of antibiotics (relevant to farming and aquaculture). Improving the health and wellbeing of all EU citizens is one of the main objectives of the European Green Deal. Furthermore, one of the objectives of the EU One Health Action Plan on Antimicrobial Resistance, adopted in 2017, is to boost research, development and innovation in AMR. The WHO works closely with similar organisations (such as the Food and Agricultural Organisation of the United Nations and the World Organisation for Animal Health) to promote and foster cross-sectoral cooperation to respond to associated hazards (food safety and zoonoses) at the human–animal interface and offer guidance on how to reduce risks. Research outcomes within this theme can support and contribute to achieving this aim.

New knowledge, evidence and innovative solutions are required in the context of:

- emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans;
- water dimension of AMR; "one health approach";
- understanding and minimising the risks associated with water infrastructures and climate change effects;
- assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy.

Sub-theme B.1: Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans

Rationale

The health and wellbeing of individuals and clean safe water are inextricably linked. The continuous detection of both non-point and point sources of CECs in the environment and their potential to cause adverse health effects with regard to humans, animals and the environment is of major concern. Climate change, urbanisation and migration have greatly influenced how people are affected by the quality and quantity of water. Given the increasing levels of human consumption and waste generation to and from water, research must focus more on CECs and human/animal exposure. Allied to this is the need for further research on how to prevent adverse health effects from substances that have (un)known direct/indirect and/or cumulative impacts on public health and aquatic ecosystems. Similarly, it will be essential for research to understand the impacts of the circular bio-economy in terms of the health implications/environmental consequences associated with the recycling and reuse of materials (e.g. chemicals from electronic waste).

In the context of growing populations and the associated increased demand on waste water treatment capacity, an evaluation of the direct links between agricultural practices, waste water treatment practices and human health is essential. This will contribute to the knowledge base on the risks between global human practices, ecosystems and human health. To develop better solutions and treatment methods requires robust detection of contaminant sources caused by various sectors (i.e. industry waste water treatment, dredged sediments and agriculture) and long-term impact projections on ecosystems and human health. Opportunistic pathogens in water are also arising as a result of more favourable climate change conditions and are set to become more problematic in the future. Research is required to evaluate the potential risk of transmission as a result of extreme climatic events and mitigation measures, such as improvements in sanitation.

Research priorities

The priorities identified for sub-theme **B.1** are summarised in **Table 6.5**.

Table 6.5. Research priorities under sub-theme B.1

Research priorities under sub-theme B.1	
B.1.1	Developing analytical techniques and appropriate matrices (human and animal) with a focus on substances of emerging concern.
B.1.2	Developing new tools to measure and evaluate chemical mixtures, transformation products and environmental exposure effects (the “cocktail effect”).
B.1.3	Understanding and predicting the environmental occurrence (in soil, sediment and water), behaviour and effects of transformation products, contaminants and pathogens.
B.1.4	Develop methodologies and strategies to remediate and reduce contaminants of concern [e.g. disinfection by-products, micro- and nano-plastics and pathogens] at point (e.g. waste water treatment plants, farmyards, domestic waste water treatment systems) and non-point sources [e.g. land spreading of biosolids, fertiliser (organic and inorganic) applications, run-off from agricultural lands, pollution from transport, run-off from agricultural lands], including their environmental effects in water, soil, sediment and sludge.
B.1.5	Understanding and predicting opportunistic pathogens in water due to more favourable climate change conditions.
B.1.6	Multi-disciplinary studies on the effect of land use (taking into account irrigation and fertilisers, as well as the possible remediation of nitrate contamination *in situ*) on the maintenance of healthy groundwater resources (aquifers) and links to climate change.

Synergies and links

Example of synergies and links with other themes and sub-themes include the following:

- Sub-theme **C.1** (future-proof water technologies, infrastructures and systems for developing climate change resilience) is particularly relevant to priority **B.1.4**.
- Sub-theme **A.1** (Developing approaches for assessing and optimising the structure and function of ecosystem services), particularly sub-theme **A1.1**.
- Sub theme **B.2** (Water dimension of AMR; "one health approach") is particularly linked to sub-theme **B.1**.

Sub-theme B.2: Water dimension of anti-microbial resistance; "one health approach"

Rationale

One of the greatest challenges for society today is the prevalence of AMR. It 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. Although there are measures in place, such as the WHO Global Action Plan on AMR and the EU's Action Plan on AMR, there are still knowledge gaps regarding human and animal exposure impacts. Stricter controls on the use of antibiotics should be reinforced and enforced more through the WFD, the Waste Framework Directive and CAP. The interdependent human, animal and environmental dimensions of AMR require the "one health approach" to address this issue.

Further research is required to understand the risks of antibiotics, particularly in aquaculture. Inappropriate overuse of antibiotics in various areas, such as livestock and fish farming, is the main source of AMR in the environment and in this sector. This is relevant in terms of increasing the consumption of seafood and meat and the expansion of these sectors, which are driving this issue. Increased run-off from agriculture (a sector that also heavily utilises antibiotics) can also end up in the aquatic environment and in the food chain for humans. The benefits of reducing AMR in the environment are two-fold: it would reduce the cost of treatment and ultimately the loss of health/life for humans and animals. The development of novel tools for surveillance, such as genomic sequencing and other technologies, that can eliminate AMR at the waste water treatment source are required. There are knowledge gaps on the impact of AMR on human health, such as their effects in bathing and recreational waters and private wells. Further research is required on the implementation of stricter controls on the use of antibiotics, particularly in farming and aquaculture.

Research priorities

The priorities identified for sub-theme **B.2** are summarised in **Table 6.6**.

Table 6.6. Research priorities under sub-theme B.2

Research priorities under sub-theme B.2	
B.2.1	Understanding the role of the environment in the selection and spread of AMR genes; transmission mechanisms.
B.2.2	Developing new tools for monitoring AMR genes and the use of surveillance of AMR data in aquatic environments.
B.2.3	Developing technologies and innovative interventions that rapidly reduce and control AMR in waste water treatment to reduce the introduction to the environment.
B.2.4	Quantifying risk in a "one health" conceptual model – AMR and genes.

Synergies and links

Example of synergies and links with other themes and sub-themes include the following:

- Sub-theme **B.1** (Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans) is particularly relevant to sub-theme **B.2**.
- Priority **D.1.4** (Developing, optimising and testing innovative solutions for achieving water, sediment, energy resources sustainability and food security and safety linked to environment using a holistic approach) is linked to **B.2.3.**

Sub-theme B.3: Understanding and minimising the risks associated with water infrastructures and climate change effects

Rationale

The increasing frequency of climate change impacts (such as intense precipitation, floods, drought, hurricanes and storm surges) can affect poorly planned/constructed infrastructure. This can result in severe consequences for human beings in terms of water security and supply. A research focus on resilient infrastructures is required to reduce vulnerability to natural disasters. Old and ageing infrastructure is problematic in many countries, causing risks to water security. Further research is required to assess and evaluate the human health aspect of non-resilient infrastructure. Risk assessments are paramount in identifying adverse risks and vulnerabilities. This should allow for a greater understanding and evaluation of the subsequent impacts on infrastructure and those that depend on it. The probability of occurrence should also be considered. Developing countries are particularly vulnerable to the effects of extreme climatic events and experience severe consequences as a result of poor infrastructure, increased population density and a lack of adequate governance. Initiatives such as the United Nations Children's Fund (UNICEF) Water, Sanitation and Hygiene (WASH) Programme demonstrate the inequalities in gaining access to water for basic needs. Following extreme climatic events, water supplies can be washed away, such as dams, putting the lives of millions of people at risk.

Research and development in innovative solutions are vital to providing robust technologies, such as point-of-use technologies, which are low-cost on-site water treatment systems and would significantly help those who are economically marginalised. Water reuse technologies that reduce the number of pathogens in water sources prior to consumption would significantly decrease cases of typhoid, cholera, etc., in developing countries. Owing to human interference in the environment, most extreme climatic events cause even more catastrophic consequences. Examples include building on floodplains that are subject to flooding and unsustainable/over-extraction of groundwater, which causes subsidence. Research is therefore required on the entire disaster management cycle: mitigation of, preparedness for, response to and recovery from flood and drought hazards. Research into developing low-cost, low-energy sensors in the environment (for instance, embedded on drones or mobile devices) would contribute to better monitoring and understanding of aquatic ecosystems, water supply systems and infrastructures. This would enable information gathering, prior to and after extreme climatic events. Comprehending the behaviour of water dynamics in NBS is vital for understanding water availability and quality. Research in this area requires developing the knowledge base in relation to the links between the quality of human health and the quality of the natural environment.

Research priorities

The priorities identified for sub-theme **B.3** are summarised in **Table 6.7**. (overleaf).

Table 6.7. Research priorities under sub-theme B.3

	Research priorities under sub-theme B.3
B.3.1	Progressing towards more water-resilient cities and communities in the face of climate change and increasing natural hazards and the issues associated with older and ageing infrastructure.
B.3.2	Studying the effects of mass migration due to climate change on existing water infrastructure and water resources knowledge (currently and in the future) by developing sociological and anthropological long-term approaches and measures, to be resilient and ensure security of water supply.
B.3.3	Developing *in situ* biosensor/monitoring network systems with a low environmental impact that can complement current biological effects-based monitoring infrastructures and early warning systems for water sustainability and water quality.
B.3.4	Understanding the disaster management cycle in the face of climate change, effects on society and mitigation measures.

Synergies and links

Example of synergies and links with other themes and sub-themes include the following:

- Sub-theme **C.1** (Future-proof water technologies, infrastructure and systems for developing climate change resilience) links particularly to priority **B.3.3.**
- Priority **C.1.4** [Developing innovative approaches to assets management (including replacement/ renewal of ageing infrastructure, dealing with leakages) to improve its performance and security. This also includes the security of critical infrastructure (in the context of climate change and cybersecurity)] is particularly relevant to **B.3.2.**

Sub-theme B.4: Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy

Rationale

Humans interact with water on many levels, with devastating consequences for water resources in certain circumstances. Whether it is for industrial or domestic use or for recreation, the quality and quantity of water is important. An understanding of the linkages between water, including water abstraction, and human activities, such as food production and energy generation, is essential. For example, the building of dams can displace people. This can change the ecological landscape and lead to loss of food production and clean water; decrease the flow of sediments; and thus influence the hydro-morphology of rivers. The 8th Environmental Action Programme of the EU therefore strives to safeguard EU citizens from environmental pressures and risks to human health while aiming for a non-toxic environment[23]. There have been a limited number of longitudinal studies on the impacts on human health and wellbeing, and how this relates to water. “Blue prescription” is the term used to describe regular physical activity in water, such as swimming. Having access to “blue spaces” can confer specific health benefits, and so it is an area for which it is worth increasing the knowledge base[24]. Given this, the social and health benefits and enhanced public awareness of water quality issues that can be sought through the application of citizen science and its principles is needed (i.e. actively involve citizens in scientific endeavours at multiple stages).

[23] *The 8th Environment Action Programme. Available online:* ***https://www.consilium.europa.eu/media/40927/st12795-2019.pdf***

[24] *Dempsey, S., Devine, M.T., Gillespie, T., Lyons, S. and Nolan, A., 2018. Coastal blue space and depression in older adults. Economic and Social Research Institute (ESRI) Bulletin. ESRI, Dublin. Available at:* ***https://www.esri.ie/system/files/media/file-uploads/2018-12/RB201826.pdf***

Research priorities

The priorities identified for sub-theme **B.4** are summarised in **Table 6.8**.

Table 6.8. Research priorities under sub-theme B.4

Research priorities under sub-theme B.4	
B.4.1	Understanding of the links between water, NBS and ecosystem services to assess and evaluate ecosystem change on human wellbeing.
B.4.2	Developing an integrated water exposure model which considers social impacts (such as on air, sediment, water, food, social and psychological effects and stressors).
B.4.3	Advancing a holistic approach in the WEFE Nexus to also include health.

Synergies and links

Examples of synergies and links with other themes and sub-themes include the following:

- Sub-theme **A.1** (Developing approaches for assessing and optimising the structure and function of ecosystem services) is particularly relevant to priority **B.4.1**.
- Sub-theme **A.3** (Managing and adapting ecosystem services to the effects of hydro-climatic extreme events), in particular priority **A.3.3**.
- Sub-theme **C.2** (Water-smart circular economy and societies) is particularly relevant to priority **B.4.3**.
- Theme **D** (Sustainable Water Management) is relevant to sub-theme **B.4**.
- Priority **C.3.2** (Understanding and assessing the values of water for the public and stakeholders, in order to guarantee sustainability of water and limit use conflicts) is relevant to priority **B.4.1**.
- Priority **D.1.4** (Developing, optimising and testing innovative solutions for achieving water, sediment, energy resources sustainability and food security and safety linked to environment using a holistic approach) is linked to **B.4**, particularly **B.4.3**.

Expected impacts of theme B

Area	Expected impacts
Policy	**Relevant to:** • **EU regulations and policies** – in particular, contribute to informing species of pathogens and pollutants to be incorporated into regulations (e.g. EU Watch List contaminants of emerging concern). These would need to be reviewed and potentially changed in line with the categories of pollutants that are currently not regulated for. The WFD, the Waste Framework Directive and CAP are relevant to this theme. • **the UN SDGs**, especially SDGs 2 (zero hunger), 3 (good health and wellbeing), 5 (gender equality), 8 (decent work and economic growth), 9 (industry, innovation and infrastructure), 11 (sustainable cities and communities), 12 (responsible consumption and production), 13 (climate action), 14 (life below water) and 15 (life on land).
Environmental	**Contribute to:** • understanding the risks and impacts of antibiotic use in the aquaculture sector; • a reduction in AMR in the environment and subsequent impacts on human, animal and biodiversity/ecosystem health; • understanding the health risks of sludge to allow for evidence-based decision-making regarding national recycling, reuse and land-spreading; • maintaining and restoring ecosystems and biodiversity to build resilience; • better implementation with respect to the “Three R’s” (Reduce, Reuse and Recycle) to effect improvements in the environment for human health; • improvement in water and sediment quality and quantity, and therefore the sustainable use of water and sediments.
Economic	**Contribute to:** • creating new tourism opportunities; • a reduction in the cost of water and waste water treatment (i.e. due to a reduction in AMR in the environment); • A better understanding and evaluation of the cost of removing lead pipes and upgrading aged infrastructure.
Technological	**Contribute to:** • the identification of new technologies, to contribute to a healthier society and the identification of new problems – this can include novel tools for surveillance and new materials or uses of materials; • developing removal technologies for contaminants; • improvements in water resources infrastructure to help achieve SDG 6.
Societal	**Contribute to:** • understanding the health risk from sludge and manure, which will allow evidence-based decisions for nutrient cycling – society would benefit as there would be improved options for the treatment of disease and enabling better health for all; • improved knowledge transfer and communication of “one health” concepts (better health and wellbeing for all). • increased water supply and security for all; • better communication for the public and more awareness of the implications of improper use/disposal of prescription medications (e.g. antibiotics); • moving away from the current “business as usual” approach (i.e. the over-consumption of water for agriculture, industry and recreation), which puts pressure on global water resources, and acting collaboratively to make changes.

Theme C

Water Value and Usage

6.3 Theme C. Water Value and Usage

Rationale

The sustainable use and preservation of natural water resources is becoming more and more relevant in the face of population growth, climate change and urbanisation. As the population expands, demands on water, energy, food and ecosystems and geosystems are all set to significantly increase. Agricultural irrigation accounts for 70% of water use worldwide. Over-abstraction of groundwaters has led to deficits in freshwater, the dropping of water tables and, in coastal areas, the introduction of saltwater intrusion, which degrades groundwater. This is exacerbated by climate change effects (drought and floods) and urbanisation. Ecosystems are also under threat, as many wetlands are in decline in terms of the services they provide. The reuse of water, particularly waste water, has been cited as an option to close the loop in terms of the circular economy. Putting a price on water increases its value. However, it can also exclude marginalised or vulnerable groups in terms of access to water. Research outcomes in this theme can lead to new ways of thinking and technological developments that contribute to improving water and waste water quality and mitigating negative impacts through better processes and better data. This is required to generate a real circular economy market. New concepts to balance conflicting goals are beneficial, for example water as a resource for human needs/infrastructure versus biodiversity and ecosystem functions. This would help create a more water-wise and water-smart society.

There are considerable knowledge gaps in the reuse of treated water and the impact on water quality. Both the Urban Waste Water Treatment Directive and the WFD promote the reuse of treated water whenever appropriate. There is, however, no EU legislation to specify the conditions for water reuse. In 2018, the EC proposed new legislative measures to incentivise the reuse of treated water while maintaining a high level of health (for both humans and the environment). This proposal builds on the 2015 Circular Economy Action Plan. To achieve this vision, improvements in technologies and materials as well as the development of new inclusive governance models and "living laboratory" pilots need to be advanced. Additional research is required to identify conditions under which reuse is not generating new environmental and health risks (greater dispersion in ecosystems of medical contaminants for instance). Governance issues need to be analysed in terms of critical analyses of the potential negative impacts of such technologies.

Research in this theme can contribute to policy development, particularly for the implementation of the Drinking Water Directive, the WFD, the Urban Waste Water Treatment Directive, the EU Scarcity and Droughts Strategy and the EU proposal for regulations on water reuse. Research outcomes should serve to influence and adapt policies, and develop and enforce regulations and directives to enable water reuse technologies and improved associated governance structures. There is also a need to seek better alignment between public preferences and necessary changes (though this does not only imply increased public acceptance).

New knowledge, evidence and innovative solutions are required in the context of:

- future-proof water technologies, infrastructures and systems for developing climate change resilience;
- water-smart circular economy and societies;
- empowering the public, water users and stakeholders in valuing water.

Sub-theme C.1: Future-proof water technologies, infrastructures and systems for developing climate change resilience

Rationale

As global temperatures continue to rise, scientists predict that the effects of climate change will invariably affect different regions unevenly over time, as well as the ability of different social/environmental systems to adapt and mitigate the effect[25]. Extreme climatic events can render drinking water and waste water treatment facilities redundant. These events can trigger overflows in treatment systems and lead to potential health hazards. Mitigating and adapting to these events requires the future-proofing of existing and new water infrastructures. New technologies and systems should contribute to assets and networks that are climate change resilient. Innovative economic instruments (e.g. pricing structures, option contracts) are also required to cope with, for instance, drought events. The development and deployment of monitoring and early warning systems can help to mitigate and reduce potential impacts. Given this, the development of demand management approaches using innovative communication technologies, as well as measuring and sensor technologies (e.g. real time demand monitoring and management), will be beneficial.

Innovative developments in artificial intelligence applications and decision support systems to manage, monitor and control the urban water cycle can revolutionise how to plan for and manage hydrological risks. Developing methodologies to improve biological effects-based monitoring infrastructures and alert systems for water quality would significantly identify and reduce associated risks in real time. Optimising water treatment processes that separate effluents in a selective manner and manage pollutant load peaks requires the development of system models and a process that keeps them up to date. NBS can be a solution to mitigate climatic events. There is a general societal lack of awareness of the severity and irreversibility of degrading natural resources and water infrastructure. These issues are often difficult to communicate or are "invisible", for example groundwater resources and underground infrastructure. Strategies/technologies for incorporating artificial recharge/underground storage into integrated water resources management (IWRM) approaches are also required.

Research priorities

The priorities identified for sub-theme **C.1** are summarised in **Table 6.9**.

Table 6.9. Research priorities under sub-theme C.1

Research priorities under sub-theme C.1	
C.1.1	Developing more efficient, cost-effective and easier-to-implement technological solutions, including drinking water and waste water treatment and water catchments, with a particular focus on solutions for emerging contaminants and emerging risks of established contaminants.
C.1.2	Optimising risk-based solutions by combining conventional and innovative solutions, and technological and NBS approaches to develop resilient water territories (in urban, rural and coastal areas).
C.1.3	Developing circular economy approaches to waste water treatment plants (e.g. production of energy and nutrients, molecules); zero greenhouse gas emissions from new generation treatment plants.
C.1.4	Developing innovative approaches to assets management (including replacement/renewal of ageing infrastructure, dealing with leakages) to improve its performance and security. This also includes the security of critical infrastructure (in the context of climate change and cybersecurity).
C.1.5	Developing smart monitoring and control systems, from assets to water supply, and reclaimed water networks, from catchment to water production sites, and developing methodologies for extending the technological and functional lifespan of water infrastructures.
C.1.6	Developing methodologies to organise effectively the replacement and large-scale renovation of water infrastructure, and how to implement these in a cost-effective and energy-neutral manner while safeguarding the continuation of the water network and water system.

[25] *NASA (National Aeronautics and Space Administration), 2019. The effects of climate change. Available online:* ***https://climate.nasa.gov/effects/***

Synergies and links

Example of synergies and links with other themes and sub-themes include the following:

- Priority **B.1.4** [Developing methodologies and strategies to remediate and reduce contaminants of concern (i.e. disinfection by-products, micro- and nano-plastics and pathogens) at point (i.e. wastewater treatment plants, land spreading of biosolids, fertiliser applications) and non-point sources (i.e. pollution from transport, run-off from agricultural lands), including their environmental effects in water, soil, sediment and sludge] links to sub-theme **C.1**.
- Sub-theme **B.3** (Understanding and minimising the risks associated with water infrastructures and climate change effects), particularly priority **B.3.2.** [Studying the effects of mass migration due to climate change on existing water infrastructures and water resources knowledge (currently and in the future) by developing sociological and anthropological long-term approaches and measures, to be more agile and ready to cope with an increase in demand], which links to priority **C.1.4.**
- Priority **B.3.3** (Developing in situ biosensor/monitoring network systems with a low environmental impact that can complement current biological effects-based monitoring infrastructures and early warning systems for water sustainability and water quality) is linked to **C.1.**
- Sub-theme **C.2** (Water-smart circular economy and societies), particularly priority **C.1.5.**
- Priority **D.2.2** [Innovations on practical, low-cost technologies treating waste water to produce resources that are safe (for the environment and health) for direct and indirect (i.e. management aquifer recharge) reuse] is linked to sub-theme **C.1**, particularly **C.1.1.**
- Priority **D.2.4** (Developing new tools and mechanisms for continuous monitoring, accurate data collection and analyses in order to attain reliable outcomes from modelling studies) is linked to **C.1.5.**

Sub-theme C.2: Water-smart circular economy and societies

Rationale

Various economic sectors and activities increase stress on valuable water resources (i.e. agriculture and industry). Agricultural practices have had to adapt to water shortages, floods and competition from non-agricultural users as urbanisation has continued to increase. A water-smart society recognises the true value of water resources and endeavours to use them sustainably. Leveraging society to effectively manage water resources is crucial to avoid scarcity and pollution and to build climate change resilience.

A move to a more circular economy and resource-efficient Europe has been strongly advocated in the EU's 8th Environmental Action Plan and through the European Green Deal. Research should incorporate circular economy data into policy structures (such as water accounting in industrial operations and supply chains), considering the market potential of water in the industry-use cycle. A contribution to the circular bio-economy must also consider trade-offs, such as the introduction of heavy metals to soil from land-spreading of sewage sludge. Education in water-related resource management practices with regard to climate change would serve to enhance the transition to a carbon-neutral circular bio-economy and encourage greater water recycling and reuse. Water reuse, reuse of dredged material and recycling technologies, and the recovery of products and energy from treatment plants, all add to a water-smart circular economy. However, barriers such as public perception, as well as political and economic barriers, have hindered progress globally. Technological developments to allow the recovery of valuable resources from different waste streams are required to generate a real circular economy market and the acceptance of recovered products and substitutes. In addition, developing digital tools and innovative technologies could help optimise circular economy opportunities, especially in different geographical territories. This would allow for appropriate management of supply chains of recovered products and energy, improve assessments of water availability/demands in real time and optimise allocation. Involving citizens and the public in the development of these strategies would encourage acceptability. Research to address water conservation to cope with scarcity and drought risk would provide solutions to mitigate, adapt and manage water more efficiently. This can include new metering and communication technologies, with innovative economic instruments, and could potentially achieve significant demand reduction.

Research priorities

The priorities identified for sub-theme **C.2** are summarised in Table **6.10.**

Table 6.10. Research priorities under Sub-theme C.2

Research priorities under sub-theme C.2	
C.2.1	Advancing water resources efficiency and allocation across sectors for increasing climate change resilience.
C.2.2	Developing a water quality fit-for-use concept for water-dependant sectors, to allow resources recovery and water reuse in different sectors (development of the circular economy), including risk assessment, acceptance, holistic costs analysis and decision support systems.
C.2.3	Developing and testing scalable and affordable solutions for cities and rural/decentralised areas to allow the prioritisation of investments and increasing climate change resilience.
C.2.4	The development and optimisation of technologies to recover and valorise products from waste water, brines and sludges.
C.2.5	Developing a new water demand management approach, targeting water conservation.
C.2.6	Developing innovative water allocation policies and management practices that ensure increased water use, economic efficiency, social justice and environmental sustainability.

Synergies and links

Example of synergies and links with other themes and sub-themes include the following:

- Sub-theme **B.4.3** (Advancing a holistic approach in the WEFE Nexus to also include health) is linked to sub-theme **C.2.**
- Priority **C.1.5** (Developing smart monitoring and control systems, from assets to water supply, and reclaimed water networks, from catchment to water production sites, and developing methodologies for extending the technological and functional lifespan of water infrastructures) is relevant to sub-theme **C.2.**
- Links to sub-theme **D.1** (Optimising the Nexus approach).
- Priority **D.1.3** (Identifying and investigating not only drivers and pathways, but also nature and types of barriers of such complex systems) is linked to sub-theme **C.2.**

Sub-theme C.3: Empowering the public, water users and stakeholders in valuing water

Rationale

The Organisation for Economic Co-operation and Development projects that, by 2050, over 40% of the world's population will be living in a water-stressed area, with over 240 million people lacking access to an improved water source. Many people take for granted the supply of safe clean water that is consistently available. In addition to this, there can be a lack of appreciation for the value of water and therefore the vital need to protect and ensure sustainable use of water for all. This is a crucial point given the global water challenges that face humanity, such as drought and scarcity, contamination, and the wasteful use of resources. There is a pressing need to discuss long-term values regarding water to ensure its availability and use for future generations. For this reason, research that engages and empowers all water users (i.e. both the public and managers/producers) is particularly relevant. Similarly, it should confer the responsibility to protect and conserve the planet's limited water resources as a joint effort.

[26]*OECD (Organisation for Economic Co-operation and Development), 2015. OECD Studies on Water: Stakeholder Engagement for Inclusive Water Governance. OECD Publishing, Paris. Available online:* ***https://www.oecd.org/gov/stakeholder-engagement-for-inclusive-water-governance-9789264231122-en.htm***

Defining the value of water for different areas of society is a difficult task as the value differs depending on the circumstances, whether they be financial or for basic survival. Water governance should move from the traditional stakeholders (water supply and sanitation business) to new actors, such as business owners, agricultural representatives and citizens. Another facet is the differentiation of values between different forms of water and their end use. This can be an aspect of overall social innovation and citizen engagement, such as how users can contribute financially to the evolution towards robust water systems. As the world's population continues to expand, innovative water pricing structures, communication tools and technological solutions that can be used to reduce water demand and cope with increasing scarcity/ drought events are becoming increasingly important. These solutions should consider and reconcile the long-term financial sustainability of water supply infrastructure while ensuring affordability and social justice (equity/affordability). The economic value of water and "the polluter pays" principle is valid in this context. There is often a lack of political willingness to put a value of the environment on par with that of the economy. To put value on nature, a monetary value must be applied (linking with the principles of ecological economics). However, this can exacerbate inequalities as it can marginalise those who cannot afford to pay for it. In addition to valuation, there is a need for an accounting process to help ensure that nature is not depleted but instead replenished. Consumers want an affordable and fair price for water and waste water services. To treat and supply clean safe water, utility companies need to maintain tariffs that sustain treatment infrastructure and maintain a continuous supply. Research on stakeholder responsibilities, generating new ways of thinking and considering ways of raising stakeholders' knowledge would raise awareness of the long-term value of water resource protection.

Research priorities

The priorities identified for sub-theme **C.3** are summarised in **Table 6.11**.

Table 6.11. Research priorities under sub-theme C.3

Research priorities under sub-theme C.3	
C.3.1	Developing a bottom-up approach for co-design and co-construction of solutions for water users, in a framework of a shared water stewardship of catchments.
C.3.2	Understanding and assessing the values of water for the public and stakeholders in order to guarantee sustainability of water and limit use conflicts.
C.3.3	Developing methodologies to assess stakeholder responsibilities in setting the right prices so that they reflect the marginal value of water.
C.3.4	Developing participatory foresight approaches to raise stakeholders' awareness of the long-term value of water resource protection.
C.3.5	Exploring possible routes to conduct paradigm changes, and understanding brakes and levers, in order to be innovative for water governance.
C.3.6	Developing holistic and sustainable water footprint production and consumption systems.
C.3.7	Developing methodologies of accounting for natural capital as a way of helping to ensure that ecosystems and the services they provide are not diminished by human activities.

Synergies and links

Example of synergies and links with other themes and sub-themes include the following:

- Priority **A.1.3** [Developing evaluation and prediction methodologies to assess the economic and social value of ecosystem services and biodiversity, considering all aspects of ecosystems (from the visible to the unseen, i.e. groundwater features/flows)] is linked to priority **C.3.4.**
- Priority **B.4.1** (Understanding of the links between water, NBS and ecosystem services to assess and evaluate ecosystem change on human wellbeing) is linked to priority **C.3.2.**
- Sub-theme **D.3** (Enabling sustainable management of water resources) is linked to priority **C.3.3.**

Expected impacts of theme C

Area	Expected impacts
Policy	**Relevant to:** • **EU regulations and policies, in particular** the Drinking Water Directive, the WFD and the Urban Waste Water Treatment Directive, Europe's Green New Deal, the EU Scarcity and Droughts Strategy, and the EU proposal for regulations on water reuse; • **the UN SDGs, especially** SDGs 2 (zero hunger), 6 (clean water and sanitation), 7(affordable and clean energy), 9 (industry, innovation and infrastructure), 10 (reduced inequalities), 13 (climate action), 14 (life below water) and 15 (life on land).
Environmental	**Contribute to:** • reduced impacts of water use on the environment (contribute to a zero-pollution environment as enshrined in the Europe's Green Deal). • improved water quality; • a reduction in significant stress on water resources (e.g. by increasing water reuse).
Economic	**Contribute to:** • minimised damage costs, as a result of increased risks of droughts and scarcity or as a result of deteriorating or non-adapted infrastructures; • the resilience of the water systems (i.e. from sources to users); • better allocation of water.
Technological	**Contribute to:** • preserving and improving groundwater quantity and quality by controlling and managing over-extraction and agricultural activities; • water and resources reuse; • promoting more efficient technologies for water treatment, conditioning and the prevention of pollutant discharges; • the development and understanding of NBS. • optimising water treatment with state-of-the-art technologies; • changes in water use efficiency over time (particularly related to SDG 6, target 6.4); • affordable, reliable and modern energy services (particularly related to SDG 7, target 7.1).
Societal	**Contribute to:** • increased societal awareness of water values; • safe and uninterrupted water services for all; • empowering stakeholders, by involving them in the development of solutions and societal transformations.

Theme D

Sustainable Water Management

6.4 Theme D. Sustainable Water Management

Rationale

Climate change has led to an unpredictability in the water cycle in recent years. Unprecedented levels of flooding and drought in recent times have added to a water infrastructure that is already challenged. Globally, drivers such as climate change, population growth and economic development have placed significant pressure on water resources. Agriculture accounts for 44% of all total water abstracted in the EU and reaches even higher proportions in southern regions. Crop adaptation to water shortages, as well as in aquifers in coastal areas on account of groundwater abstraction and in groundwaters as a result of tidal fluctuations, require further monitoring and research. Adapting water resources management to deal with increased uncertainty (in terms of drivers such as climate change, demands/supply) will therefore require developing innovative and robust decision-making approaches. Sustainable water resources management considers all components of the water cycle, particularly with respect to climate and global change and devising appropriate solutions. There is a requirement to develop knowledge of sustainable water resource management, such as management at a catchment scale for different users.

Ensuring the sustainability of water supplies for increasing water demand requires holistic optimisation of the WEFE Nexus approach and it has been suggested that the definition should be broadened to include resource use and health. Food security will be more challenging as resources (water, nutrients, land, energy) become limited, urbanisation/migration/consumption increases and water quality is compromised. The Nexus approach also considers the synergies and trade-offs associated with the management of all resources. Understanding those can help to mitigate and prioritise interventions. In terms of governance, a global management system for water is needed, specifically a negotiation mechanism, as well as a global water strategy.

Research outcomes in this theme can lead to new innovative solutions, a better understanding of the interlinkages and interdependencies of the Nexus approach and a better integration of EU and international policies, as well as across sectors, such as agriculture, water, waste, energy and climate. Research should also contribute to the lessening of political conflicts in relation to water policies, which in turn have an impact on migrant and seasonal workers.

New knowledge, evidence and innovative solutions are required in the context of:

- optimising the Nexus approach;
- adapting water resources management to deal with increased uncertainty;
- enabling sustainable management of water resources.

Sub-theme D.1: Optimising the Nexus approach

Rationale

It is estimated that, by 2050, 9 billion people will populate the planet, thereby increasing pressures on agricultural activities. The key drivers of WEFE deterioration are therefore related to climate change impacts, urbanisation, migration and over-consumption. There are many interlinkages and interdependences between the WEFE Nexus, and all are crucial for human health and wellbeing, as well as environmental health. Furthermore, the WEFE Nexus touches on all the SDG goals. Therefore, it is paramount to understand the interlinkages/dependencies so that the solutions and measures generated can be leveraged to provide the best payoff in the face of these global challenges while attempting to minimise the trade-offs. A holistic optimisation of the Nexus must account for both human needs and the protection of the environment as "inextricably dependent factors"[27]. An example is the overuse of one resource and its impact on other resources.

[27] *Momblanch, A., Papadimitriou L., Jain, S.K., Kulkarni, A., Ojha, C.S.P., Adeloye, A.J. and Holman I.P., 2019. Untangling the water-food-energy-environment nexus for global change adaptation in a complex Himalayan water resource system. Science of the Total Environment 655: 35-47.* **https://doi.org/10.1016/j.scitotenv.2018.11.045**

As part of understanding the Nexus as an interconnected entity, this should include consideration of how changes in one area can affect others. This also relates to enabling a climate neutral circular economy and bio-economy. Opportunistic synergies within the linkages should be explored more. For instance, the utilisation potential of waste water treatment plants to produce energy in the form of biogas. Assessing and evaluating the supply–quality–cost aspect of water in the Nexus in the context of climate change scenarios as well as the circular economy will be key for sustainable water management. End users' perception and governance should also be considered as knowledge gaps to be addressed.

Research priorities

The priorities identified for sub-theme **D.1** are summarised in **Table 6.12**.

Table 6.12. Research priorities under sub-theme D.1

Research priorities under sub-theme D.1	
D.1.1	Investigating and devising new approaches to address the Nexus, namely on sustainability and efficiency (environment, health, economy) using a multi-disciplinary approach.
D.1.2	Developing methodologies to assess how water resources, ecosystems and human actions in a complex interconnected system (Nexus) will respond to a changing climate and global changes through participatory scenario development and integrated modelling approaches.
D.1.3	Identifying and investigating not only drivers and pathways, but also nature and types of barriers of such complex systems.
D.1.4	Developing, optimising and testing innovative solutions for achieving water, sediment, energy resources sustainability and food security and safety linked to environment using a holistic approach.

Synergies and links

Examples of synergies and links with other themes and sub-themes include the following:

- Sub-theme **A.1** (Developing approaches for assessing and optimising the structure and function of ecosystem services), which links to priorities **D.1.1** and **D.1.4.**
- Priority **A.2.2** [Developing NBS for the scaling-up of restoration actions and mitigation of degraded water bodies and aquatic ecosystems (from local to landscape, across gradients such as upstream and downstream effects and degrees of degradation] and **A.2.3** (Developing NBS and linking measures to their effects and their societal impacts in terms of risk reduction, climate change mitigation, and water and associated ecosystems preservation) are linked to **D.1.2.**
- Priority **B.2.3** (Developing technologies and innovative interventions that rapidly reduce and control AMR in waste water treatment to reduce the introduction to the environment) is linked to **D.1.4.**
- Sub-theme **B.4** [Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy], in particular priority **B.4.3** (Advancing a holistic approach in the WEFE Nexus to also include health), which links to priority **D.1.2.**
- Links to sub-theme **C.2** (Water-smart circular economy and societies).
- Sub-theme **C.2** (Water-smart circular economy and societies), which links to priority **D.1.3.**

Sub-theme D.2: Adapting water resources management to deal with increased uncertainty

Rationale

Developing and promoting the RDI infrastructure required for understanding the water cycle and catchments needs further research. It is acknowledged that, while there are ongoing initiatives in this area, there are still major research knowledge gaps that need to be addressed, particularly in relation to hydrological extremes and water quantity and quality.

Developing demonstration sites in order to address the knowledge gaps relating to water harvesting, water recycling and aquifer recharge (including managed aquifer recharge and reuse of dredged material), and at the interface of hydrological, meteorological and climatic research, can help to maximise water resource potential. Water resources adaptation techniques and innovations to effectively treat waste water, as well as the integration of decision support systems into modelling and data collection approaches, are key to effective water management and adapting to uncertainty. Solutions and actions should be more easily devised, deployed and targeted at manageable scales (temporal and spatial), contributing to the development of a robust evidence base and decision support systems/tools.

Research priorities

The priorities identified for sub-theme **D.2** are summarised in **Table 6.13**.

Table 6.13. Research priorities under sub-theme D.2

Research priorities under sub-theme D.2	
D.2.1	Develop and test robust decision-making and adaptative management approaches.
D.2.2	Innovations on practical, low-cost technologies treating waste water to produce resources that are safe (for the environment and health) for direct and indirect (i.e. management aquifer recharge) reuse.
D.2.3	Building a better understanding of socio-hydrological processes at different scales, i.e. critical zone observatories, including watersheds and catchments, to understand changes with time, considering anthropic activities and solutions while promoting the use of existing and new water RDI infrastructures.
D.2.4	Developing new tools and mechanisms for continuous monitoring, accurate data collection and analyses in order to attain reliable outcomes from modelling studies.
D.2.5	Integrating decision-support systems into various types of models of hydro-ecosystems and monitoring networks in order to strengthen the study outcomes and better define the measures and actions to be taken. Developing new strategies for water capture and storage (in surface and subsurface), including socio-economic and environmental aspects.

Synergies and links

Examples of synergies and links with other themes and sub-themes include the following:

- Sub-theme **A.3** (Managing and adapting ecosystem services to the effects of hydro-climatic extreme events) links to **D.2.3.**
- Sub-theme **C.1** (Future-proof water technologies, infrastructures and systems for developing climate change resilience), particularly priority **C.1.1** (Developing more efficient, cost-effective and easier-to-implement technological solutions, including drinking water and waste water treatment, water catchment characterisation, with a particular focus on solutions for emerging contaminants and emerging risks of established contaminants), which links to priority **D.2.2**.
- Priority **C.1.5** (Developing smart monitoring and control systems, from assets to water supply, and reclaimed water networks, from catchment to water production sites, and developing methodologies for extending the technological and functional lifespan of water infrastructures), which is relevant to priority **D.2.4.**

Sub-theme D.3: Enabling sustainable management of water resources

Rationale

Increasing urbanisation, migration, population growth and climate change events are putting extreme pressure on water resources. It is estimated that by 2040, 600 million children will live in areas of extremely high water stress[28]. It is therefore critical to manage and invest in the water resources available now, to ensure a sustainable supply for future generations. There is a strong connection between water and energy, with energy production accounting for 15% of global water withdrawals[29]. Fossil fuel production remains largely water intensive. Research on this sub-theme focuses on enabling the sustainable management of water resources and strengthening the socio-economic approaches to water management. Sustainable and integrated water resources management should be based on an understanding of the functioning and evolvement of the water cycle in a catchment context. In addition, a key factor in achieving sustainability is consideration and application of appropriate strategies and measures to protect existing satisfactory water resources and mitigate impacts where it is unsatisfactory. It is estimated that, by 2035, water withdrawals for energy consumption will increase by 20% and consumption by 85%[30]. Greener technologies (e.g. hydro-power, wind) are other alternatives. Both water and energy resources are, however, being compromised by factors such as climate change, population growth and increasing resource consumption. Research can contribute to linking these drivers with public perceptions and citizen engagement. This is important for enabling action and positive behavioural changes at all levels of society. A global governance system for water is needed. Water management in urban environments and cities is particularly complex, given the density of water uses. New sensors and data processing technologies (such as leveraging big data and machine learning) offer new opportunities for improving water resource management systems. Systems and mechanisms for water governance require the development of digital technologies to enable and support them. This will also provide transparency to different stakeholders and decision-makers.

Research priorities

The priorities identified for sub-theme **D.3** are summarised in **Table 6.14**.

Table 6.14. Research priorities under sub-theme D.3

Research priorities under sub-theme D.3	
D.3.1	Developing integrated transboundary and adaptive water resource management systems for the economic sectors, in particular the agriculture, forestry, aquaculture and energy production sectors, that are currently the largest water consumers.
D.3.2	Enhancing practical solutions for water and integrating social acceptance (working in living laboratories and with demonstration sites).
D.3.3	Developing integration models of high-resolution temporal and spatial data on the water cycle, ecosystems and economic systems to address water resource management. This includes the impacts of climate and global changes to geochemical fluxes (due to climate and global changes) on water ecosystems from the critical zone.
D.3.4	Integrating and connecting economic aspects, ecological issues and social analyses into decision-making processes. Promoting new governance, knowledge and cross-sectoral management approaches.
D.3.5	Developing methods for more efficient citizen and wider stakeholder engagement (improved communication, public perception and responsibility and awareness) for sustainable management of water resources, and developing the sensors and digital solutions that will enable integrated water management in an optimal and transparent manner.
D.3.6	Improving the understanding of the water–energy nexus, particularly developing a better awareness of the role of water in energy production. This should include understanding the influence of climate change on the water–energy nexus.

[28]*UNICEF (2017) Thirsting for a Future: Water and children in a changing climate. Available online:* ***https://www.unicef.org/publications/index_95074.html***

[29]*UN Water (United Nations Water). Water for life 2005–2015. Available online:* ***https://www.un.org/waterforlifedecade/water_and_energy.shtml***

30IEA (2012) World Energy Outlook 2012. Available online: ***https://webstore.iea.org/world-energy-outlook-2012-2***

Synergies and links

Examples of synergies and links with other themes and sub-themes include the following:

- Sub-theme **A.1** (Developing approaches for assessing and optimising the structure and function of ecosystem services), particularly priority **D.3.3.**
- Priority **A.1** (Developing approaches for assessing and optimising the structure and function of ecosystem services) is linked to priority **D.3.3.**
- Priority **C.3.3** (Developing methodologies to assess stakeholder responsibilities in setting the right prices so that they reflect the marginal value of water) links to sub-theme **D.3.**
- Priority **D.2.4** (Developing new tools and mechanisms for continuous monitoring, accurate data collection and analyses in order to attain reliable outcomes from modelling studies) is linked to priority **D.3.3.**

Expected impacts of theme D

Area	Expected impacts
Policy	**Relevant to:** • **EU regulations and policies, in particular** the WFD, the Marine Strategy Framework Directive, the Drinking Water Directive, the Urban Waste Water Treatment Directive and the Floods Directive, and Europe's Green New Deal; • **the UN SDGs, especially SDGs** 2 (zero hunger), 6 (clean water and sanitation), 7 (affordable and clean energy), 8 (decent work and economic growth), 9 (industry, innovation and infrastructure), 10 (reduced inequalities), 11 (sustainable cities and communities) and 13 (climate action) – all SDGs should align with EU directives dealing with water.
Environmental	**Contribute to:** • effective restoration of water quality and resources; • increased resilience of environment and ecosystems services; • recognition that water is not a "limitless" resource and ways to live within the planet's boundaries; • a cleaner environment; • resource recovery and reuse; • a decreased carbon footprint; • better sludge management; • better balance between ecosystems and people (users); • better management of environment resources, including groundwater abstraction; • better use of water in the agricultural and energy production sectors.
Economic	**Contribute to:** • innovations that are sound from the environmental and economic points of view; • innovations in water use in energy production; • increases in jobs, business opportunities and direct foreign investments; • decreased costs of water processes and treatments; • ensuring water security; • fair and sustainable pricing of costs for drinking water and waste water treatments, and for sustainable water management in urban areas; • SDGs 2 (zero hunger) and 9 (industry, innovation and infrastructure); • sustainable agriculture production for arid regions; • decoupling water capacity and water savings as a valuable resource; • a new economic paradigm.
Technological	**Contribute to:** • systematic approaches to innovation; • environmentally friendly green technology; • Europe being a leader in positive technology transfer (Centre of Excellence); • improvements in the handling of big data; • the development of approaches to enacting and enabling NBS; • SDGs 6.4 (water use efficiency) and 7.1 (ensuring universal access to affordable, reliable and modern energy services); • technological development for poorly serviced or developing sectors (new technologies in energy production or waste water monitoring for instance); • innovation for water sharing; • increased ability to transfer and take up technology (communication between industry and society).
Societal	**Contribute to:** • wellbeing for all; • healthy and wealthy societies; • improved capacity and resilience of society in the context of global changes and to climate change impacts; • empowering society by transferring knowledge and clear messages in relation to sustainable water management, the value of water, a better understanding of the water cycle and the need to protect water as a resource; • reducing the burden on the underprivileged low-income population, especially women and children; • SDGs 6 (clean water and sanitation), 8 (decent work and economic growth) and 11 (sustainable cities and communities).

Chapter 7

Synergies with Other JPIs and Relevant Initiatives

7 Synergies with Other JPIs and Relevant Initiatives

7.1 Synergies with Other Initiatives

The Water JPI seeks to enhance synergies with other JPIs or European and international initiatives to establish common activities. Table 7.1 identifies the core research areas of the Water JPI SRIA that could contribute to tackling the societal challenges also being addressed by these other initiatives.

Table 7.1. Synergies between the Water JPI, other JPIs and international initiatives

Name of Initiative	Synergies between other SRIAs/SRAs[31] and the Water JPI SRIA 2025 sub-themes
BiodivERsA	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **B.4:** Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy. **C.2**: Water-smart circular economy and societies. **D.3**: Enabling sustainable management of water resources.
JPI Oceans	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.4:** Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.2:** Water-smart circular economy and societies. **D.1:** Optimising the Nexus approach.**D.3**: Enabling sustainable management of water resources.
European Innovation Partnership (EIP) Water	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **D.1:** Optimising the Nexus approach. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3:** Enabling sustainable management of water resources.
Joint Baltic Sea Research and Development Programme (BONUS)	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.4:** Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy.
Partnership for Research and Innovation in the Mediterranean Area (PRIMA)	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **A.2:** Developing and applying an approach to ecological engineering and ecohydrology. **A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.2:** Water-smart circular economy and societies. **D.1:** Optimising the Nexus approach. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3:** Enabling sustainable management of water resources.
JPI for More Years, Better Lives (MYBL)	**B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.2:** Water dimension of AMR; "one health approach". **B.3:** Understanding and minimising the risks associated with water infrastructures and climate change effects
JPI for A healthy diet for a healthy life (HDHL)	**A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **D.1:** Optimising the Nexus approach.
JPI for Agriculture, Food Security and Climate Change (FACCE)	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **D.1:** Optimising the Nexus approach.

[31] *SRA Strategic Research Agenda*

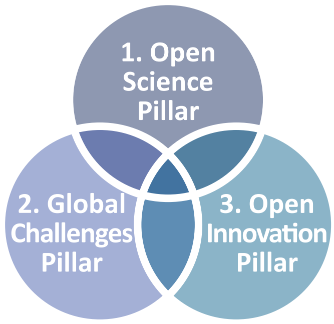
Name of Initiative	Synergies between other SRIAs/SRAs[31] and the Water JPI SRIA 2025 sub-themes
JPI for Antimicrobial Resistance (AMR)	**B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.2:** Water dimension of anti-microbial resistance; "one health approach"
JPI Climate	**A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.2:** Water-smart circular economy and societies. **D.3:** Enabling sustainable management of water resources.
JPI for Urban Europe (UE)	**B.3:** Understanding and minimising the risks associated with water infrastructures and climate change effects
JPI Culture Heritage	**A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.3:** Empowering the public, water users and stakeholders in valuing water.
EurAqua	**A.1**: Developing approaches for assessing and optimising the structure and function of ecosystem services. **A.2**: Developing and applying an approach to ecological engineering and ecohydrology. **A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.2:** Water dimension of anti-microbial resistance; "one health approach". **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.2:** Water-smart circular economy and societies. **D.1**: Optimising the Nexus approach. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3**: Enabling sustainable management of water resources.
Water Europe	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.2:** Water dimension of anti-microbial resistance; "one health approach" **B.3:** Understanding and minimising the risks associated with water infrastructures and climate change effects **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.2:** Water-smart circular economy and societies. **C.3**: Empowering the public, water users and stakeholders in valuing water. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3:** Enabling sustainable management of water resources.
Future Earth	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.2:** Water dimension of Anti-Microbial Resistance; 'One health approach' **B.3:** Understanding and minimising the human health risks associated with water infrastructures deficits, including the effects of climate change effects. **B.4:** Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.2:** Water-smart circular economy and societies. **C.3:** Empowering the public, water users and stakeholders in valuing water. **D.1:** Optimising the Nexus approach between water, energy, food, resource health and ecosystems. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3:** Enabling sustainable management of water resources.
Belmont Forum	**A.1:** Developing approaches for assessing and optimising the structure and function of ecosystem services. **A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.3:** Understanding and minimising the risks associated with water infrastructures and climate change effects. **B.4:** Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.2:** Water-smart circular economy and societies. **D.1:** Optimising the Nexus approach. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3:** Enabling sustainable management of water resources.
Global Water Research Coalition (GWRC)	**B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.2:** Water dimension of anti-microbial resistance; "one health approach". **B.3:** Understanding and minimising the risks associated with water infrastructures and climate change effects. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience.

Name of Initiative	Synergies between other SRIAs/SRAs[31] and the Water JPI SRIA 2025 sub-themes	
	C.2: Water-smart circular economy and societies. **C.3:** Empowering the public, water users and stakeholders in valuing water. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3:** Enabling sustainable management of water resources.	
China Europe Water Platform Partnership (CEWP)	**A.2:** Developing and applying an approach to ecological engineering and ecohydrology. **A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.2:** Water dimension of anti-microbial resistance; "one health approach".	
The Global Framework on Water Scarcity in Agriculture (WASAG)	**Working Group: Water and Migration** **B.3:** Understanding and minimising the risks associated with water infrastructures and climate change effects. **Working Group: Drought Preparedness** **A.3:** Managing and adapting ecosystem services to the effects of hydro-climatic extreme events. **B.3:** Understanding and minimising the risks associated with water infrastructures and climate change effects. **C.1:** Future-proof water technologies, infrastructures and systems for developing climate change resilience. **C.2:** Water-smart circular economy and societies. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3:** Enabling sustainable management of water resources. **Working Group: Water and Nutrition** **B.1:** Emerging contaminants and associated risks: monitoring, remediation and assessing their effects and behaviour on nature and humans. **B.2:** Water dimension of anti-microbial resistance; "one health approach". **B.4:** Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy. **D.1:** Optimising the Nexus approach. **Working Group: Sustainable Agriculture Water Use** **B.4:** Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy. **D.2:** Adapting water resources management to deal with increased uncertainty. **D.3:** Enabling sustainable management of water resources **Working Group: Saline Agriculture** **B.4:** Assessing and evaluating the sustainable interaction between different users (people, agriculture, industry and nature) and their water demands to promote a coordinated resource management strategy. **D.3:** Enabling sustainable management of water resources.	
UN Water	**Theme A. Ecosystems** **SDG 2:** Zero hunger **SDG 3:** Good health and wellbeing **SDG 6:** Clean water and sanitation **SDG 11:** Sustainable cities and communities **SDG 12:** Responsible consumption and production **SDG 13:** Climate action **SDG 14:** Life below water **SDG 15:** Life on land **Theme B. Health and Wellbeing** **SDG 2:** Zero hunger **SDG 3:** Good health and wellbeing **SDG 5:** Gender equality **SDG 6:** Clean water and sanitation **SDG 8:** Decent work and economic growth **SDG 9:** Industry, innovation and infrastructure **SDG 10:** Reduced inequality **SDG 11:** Sustainable cities and communities **SDG 12:** Responsible consumption and production **SDG 13:** Climate action	**SDG 14:** Life below water **SDG 15:** Life on land **Theme C. Water Value and Usage** **SDG 2:** Zero hunger **SDG 6:** Clean water and sanitation **SDG 7:** Affordable and clean energy **SDG 9:** Industry, innovation and infrastructure **SDG 10:** Reduced inequality **SDG 13:** Climate action **SDG 14:** Life below water **SDG 15:** Life on land **Theme D. Sustainable Water Management** **SDG 2:** Zero hunger **SDG 6:** Clean water and sanitation **SDG 7:** Affordable and clean energy **SDG 8:** Decent work and economic growth **SDG 9:** Industry, innovation and infrastructure **SDG 10:** Reduced inequality **SDG 11:** Sustainable cities and communities **SDG 13:** Climate action

7.2 Europe's Water Research Landscape

Horizon Europe[32] forms Europe's forward-looking research and innovation framework (2021–2027), with a proposed budget of over €100 billion. Horizon Europe incorporates research and innovation missions to increase the effectiveness of funding by pursuing clearly defined targets. The framework is built around three pillars (Figure 7.1). Pillar 2, Global Challenges and European Industrial Competitiveness focuses on societal challenges and enabling industrial technologies in line with EU and global policy priorities, all while accelerating industrial transformations. Under this pillar, six clusters with a link to water research will be implemented through usual calls, partnerships and missions **(see Figure 7.1)**.

Three Pillars of Horizon Europe



The six clusters of Pillar 2

- Health
- Culture, creativity and inclusive society
- Civil security for society
- Digital, industry and space
- Climate, energy and mobility
- Food and natural resources

Figure 7.1. The three pillars of Horizon Europe and the six clusters under Pillar 2.

The relevance of the clusters to the Water JPI and key water issues are outlined in **Table 7.2.**

Table 7.2. Linkages to water and the Water JPI across the relevant Horizon Europe clusters

Cluster	Relevant water-related strategic planning, draft orientations and targeted impacts
Cluster 1	• Living and working in a health-promoting environment. • Tackling diseases and reducing disease burden.
Cluster 3	• Improved disaster risk management and societal resilience. • Improved security and resilience of infrastructure and vital societal functions, such as health care, law enforcement, energy, mobility, public services, financial services, communication and logistics infrastructures/networks.
Cluster 4	• Circular industries.
Cluster 5	• Achieving an advanced knowledge base in climate science that can guide the development of required policy measures and low and zero carbon technologies essential to catalyse the transition to a climate neutral emissions economy and society. • Achieve cleaner, more secure and competitive energy supply.
Cluster 6	• Sustainable management of natural resources; prevention and removal of pollution; attractive jobs, enhanced value creation and competitiveness. • Halt of biodiversity decline and restoration of ecosystems. • Reduction in greenhouse gas emissions and successful adaptation of production systems as well as rural, coastal, peri urban and urban areas to climate change. • Establishment of primary production and food systems based on sustainability, inclusiveness, health and safety; ensuring food and nutrition security for all. • Behavioural, socio-economic and demographic change are well understood and drive sustainability; a balanced development of vibrant rural, coastal, peri urban and urban areas. • Establishment of governance models enabling sustainability.

[32] *https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en*

The mission area of “Healthy oceans, seas, coastal and inland waters” acts as a powerful tool for raising awareness of their importance and helping develop solutions on issues such as the supply of freshwater and its sustainable use and management. The second mission area “Adaptation to climate change, including societal transformation” has a strong focus on extreme events, aiming to help maximise the impact of the EU’s support to research and innovation. All mission areas ultimately aim to connect citizens with science and public policy. A third mission “Soil health and food” is also relevant to the water sphere, particularly in terms of nutrient management or water regulation. An evolution in JPI partnerships and memberships with EU countries, private sectors, foundations and stakeholders is supported by Horizon Europe. Value is added through transnational collaboration, exchange and networking, visibility for leading research and innovation and a strengthened European water research landscape. The Water JPI’s Vision 2030, mission and objectives align with the shaping of Horizon Europe.

Water4All[33] is a non-institutionalised candidate partnership for Horizon Europe. It aims to achieve water security in terms of quantity and quality, to protect people as well as natural and economic systems from risks and hazards to water. It aligns with the Water JPI’s aims and objectives. As a research and innovation community engagement initiative, it supports the collaborative values of the Water JPI and reflects the targets of SDG 6 (Clean water and sanitation) and other SDGs in which water has pivotal role, e.g. SDG 2 (Zero hunger) and SDG 14 (Life below water). Building on the achievements of the Water JPI, the Water4All Partnership will provide a unified and shared systematic strategy to secure water for all.

[33]*https://www.era-learn.eu/news-events/news/european-partnerships-under-horizon-europe-results-of-the-structured-consultation-of-member-states-1*

Chapter 8

What the SRIA can be used for

8 What the SRIA can be used for

The Water JPI requires a multi-disciplinary and multi-faceted approach if policy, environmental, technological, economic and societal challenges are to be addressed **(Figure 8.1).**

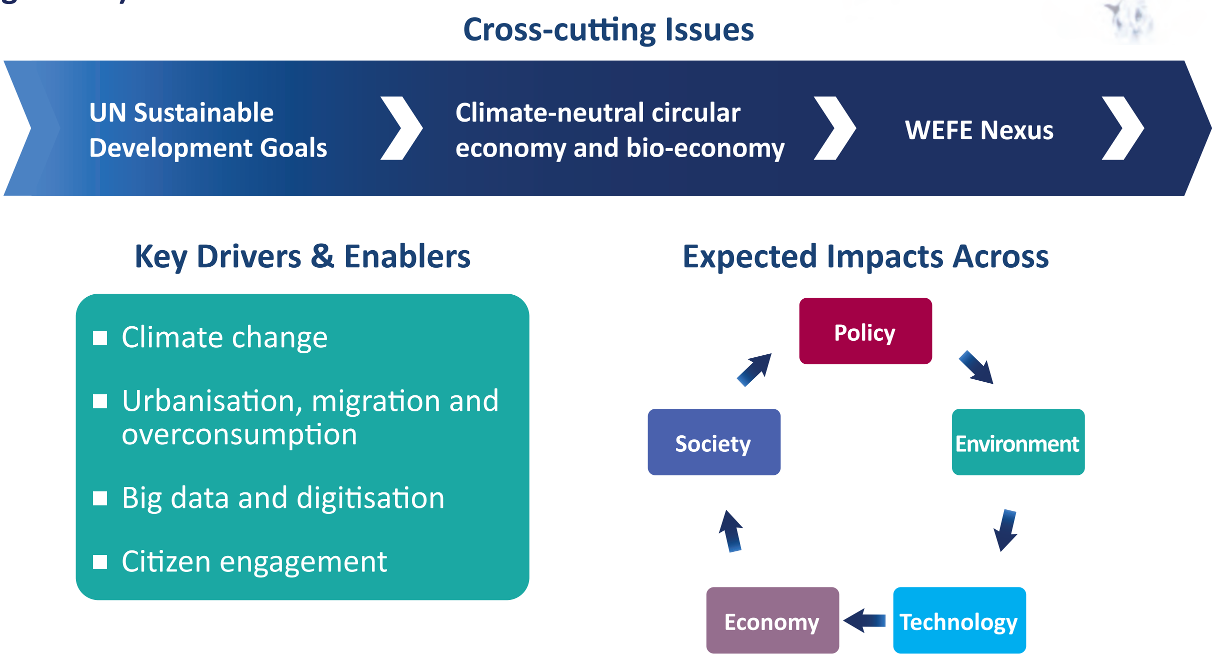


Figure 8.1. Multi-disciplinary challenges to be addressed.

RDI actions can then contribute to the adaptation and/or greater resilience of socio-ecosystems to changes. The SRIA is therefore a document that can be used by a cross-section of actors to help achieve the Water JPI's vision and mission **(Table 8.1)**.

Table 8.1. How the SRIA 2025 can be used

How the SRIA 2025 can be used	
European Commission	It supports the development of the ERA, reduces fragmentation of water RDI efforts across Europe, and will provide underpinning knowledge and evidence to support the implementation of related EU policies.
Researchers	It provides an insight into the focus of future water research funding at EU level, bringing together researchers from multiple disciplines to work together to develop solutions.
RDI funding bodies and programmes	It is a guide to where water-related RDI funding should be focused at EU and national levels. It is a commonly agreed agenda and a reference for all of the Water JPI activities.
Policymakers	It is a reference document for decision-making, which is aligned and responsive to key policy directives and strategies related to water use and management.
Water utilities and river basin management authorities	It will ensure suitable framework conditions (policy, environmental, technological, economic and societal), supporting the development of market-oriented solutions in Europe and beyond.
Enterprises	It acts as an instrument for the co-design and co-development of knowledge and solutions and helps to identify potential research outputs that could support or enable innovation and competitiveness.
General public	It supports the provision security of safe water and provides open access to information.

Chapter 9

Next Steps

9 Next Steps

To date, the Water JPI has been successful in mobilising important national water research and innovation funding. It has encouraged and stimulated the broadening of the JPI to several international cooperation partner countries and focuses on new knowledge and knowledge transfer.

The JPI has engaged in mapping exercises to explore gaps, undertakes joint transnational calls and Thematic Annual Programming (TAP) to generate knowledge, and takes part in two knowledge hubs. Between 2013 and 2018, the Water JPI engaged in five joint calls encompassing 336 research organisations and 70 research and innovation projects **(Figure 9.1)**.

Figure 9.1. Water JPI joint transnational calls (2013–2018).

The first Water JPI Knowledge Hub on CEC started in March 2018 with 25 experts. The Water JPI TAP Action on Ecosystem Services (AQUATAP_ES), which covers six projects from four countries combined, kicked off in June 2019 in Dublin. The second Knowledge Hub on UN SDGs started in December 2019. Future calls comprise of the ERA Networks (ERA-NETs) Cofund 2019:2020 and 2020:2021 Joint Calls. The Water JPI's activities and achievements since 2013, and looking beyond to 2023, are outlined in **Figure 9.2** with regard to the different SRIA themes.

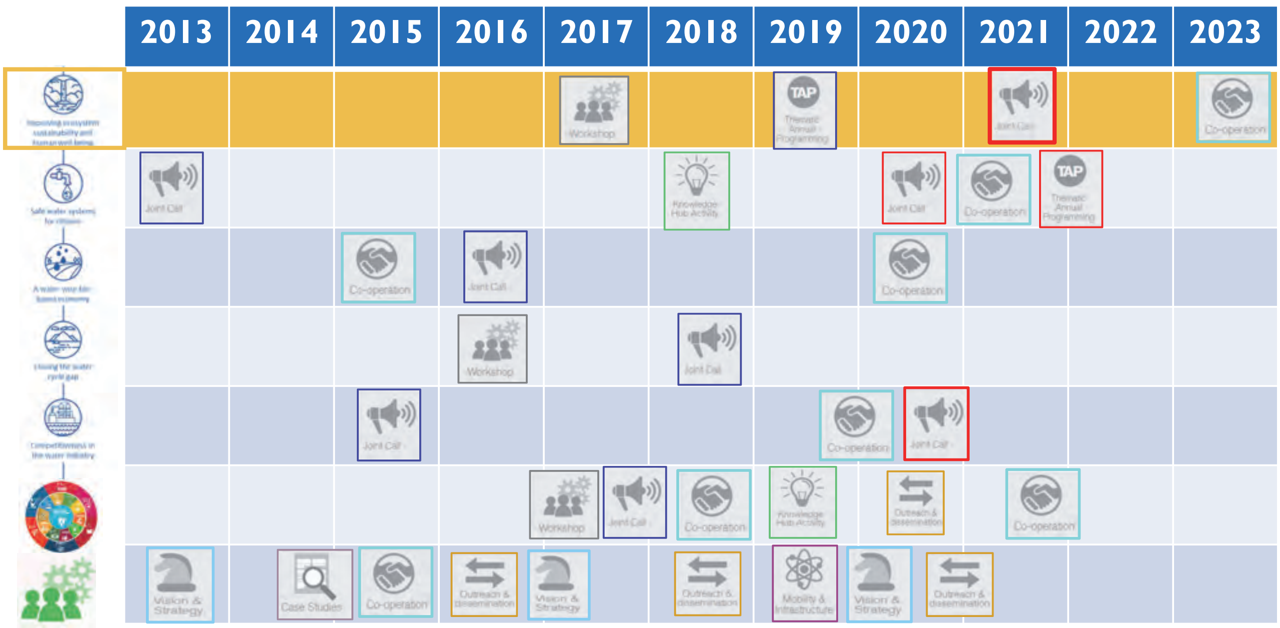


Figure 9.2. The Water JPI's key activities and achievements (2013–2023).

The Water JPI's SRIA 2025 identifies and sets out integrated regional, European and global water RDI priorities. This SRIA will be implemented not only through successive 3-year Implementation Plans by the Water JPI but also via other funding mechanisms, such as Horizon Europe.

Figure 9.3 illustrates the relationships between Water JPI's Vision 2030, the SRIA and the Implementation Plan.

10-Year Duration	**VISION 2030** ► High level document ► Key water challenges and research areas
Revised on a 5-Year Basis	**STRATEGIC RESEARCH AND INNOVATION AGENDA 2025** ► Core research themes ► Provides key research priorities
Every 3 Years	**JOINT IMPLEMENTATION PLANS** ► Work programme defining the Water JPI actions to address key research priorities
Joint Actions	► Research & Innovation calls ► Knowledge hubs ► Alignment of national programmes etc.

Figure 9.3. Key elements of the Water JPI's activities implementation.

Chapter 10

Selected Bibliographies

10 Selected Bibliographies

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