Water Europe

Technology & Innovation

WATER EUROPE CONTRIBUTIONS TO THE EUROPEAN GREEN DEAL AND HORIZON EUROPE

Water Europe
Vision Implementation
2020-2027

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EXECUTIVE SUMMARY

Water Europe (WE) aims at improving the coordination, collaboration, performance and competitiveness of both the water and water-related sectors in the EU and beyond. It seeks to contribute to the addressing of global challenges through research and innovation in order to ensure the true Value of Water and a Water-Smart Society. To this end, between 2016 and 2017 the organisation created the new Water Europe Vision and Strategic Innovation and Research Agenda (SIRA) in close consultation with Water Europe members and key strategic stakeholders.

The WE Vision and SIRA were developed in order to establish a coherent roadmap capable of addressing the most important societal challenges related to water, one of the key resources nurturing human life and permitting economic development, whilst encouraging a more prominent role for water within the agenda of the R&I Framework Programme Horizon 2020.

The more recent political guidelines of the European Commission for the period 2019 to 2024 identify new, challenging priorities and changes for a future, more wealthy Europe. The EC clearly states that Europe must lead the transition to a climate-neutral and healthy planet and a new digital World. The two most important frameworks "The European Green Deal" and "A Europe fit for the digital age" represent the effort that society must make in order to move towards a greener Europe supported by a more integrated approach to the establishment of a digital society. Furthermore, it is now clear that lessons must be learnt as a result of the COVID-19 crisis in order to foster an increased European preparedness and level of resilience to possible future events. In what will be a major transition, water will assume an essential role as both an enabler and engine of the economy, social stability and the sustainable growth of our society.

This document, developed, once again, with contributions from Water Europe members and external stakeholders will outline how the WE Vision and the SIRA address the aforementioned European strategies and policies, as well as considering the future European Horizon Europe Framework Programme for R&I. It clearly demonstrates that the underlying values contained in the Vision and SIRA can accelerate the transition towards a regenerative model of growth that would devolve to the planet far more than what is extracted, as was advocated by the EU Circular Economy Action Plan released in March 2020.

Water Europe proposes the creation and sustainable maintenance of Water oriented Living Labs (WoLLs) as the ideal, functional and proactive mechanism required to support the systemic transition to a green and digital Europe. WoLLs foster the co-designing of innovations and capacity development integrated with effective governance models.

This text is designed to foster collaboration between water stakeholders and to inspire those who are engaged and responsible for developing the content and mechanisms of the European Green Deal and Horizon Europe. It seeks to demonstrate to such stakeholders the necessity of key water-related policy and R&I development if society as a whole is to prosper, if the global competitiveness of our economy is to be enhanced, and if the health of all European citizens is to be protected.

INTRODUCTION

1.1 Introduction

Water security and availability is an integrated part of **all major challenges** we face and is a pervasive enabling element in all sectors of our society. Demographic change, urbanisation, climate change, digitalisation as well as the circular economy are all tightly interconnected with water, offering both challenges and opportunities for Europe to lead the way towards a sustainable future, as targeted by the Commission's new **Green Deal policy**. Water is the "life-blood" of our economy, industries, societal functions, nature as well as health and wellbeing of our citizens. Without water everything else in the 69.8 Trillion Euro global economy would fail. 75% of our jobs depend on water and water crises rank among the top 5 global risks in terms of impact.

Reason why it is essential that the new EU policies and innovation programs consider the real "**Value of Water**" to develop **systemic solutions and changes** towards healthy water bodies, secure and resilient water management infrastructures, and the secure availability of the right water quality for the right use within a sustainably circular society and thus achieving a **Water-Smart Society**.

The **COVID-19 crisis in 2020** showed how the capacity of the EU fundamental systems (water, energy, communication) to be resilient is critical to adequately respond to emergencies and contribute to the overall stability and resilience of our society. A Water-Smart Society is a key element to cope with the emerging challenges of the planet for a sustainable growth, inclusiveness of citizens, and transnational cohesion.

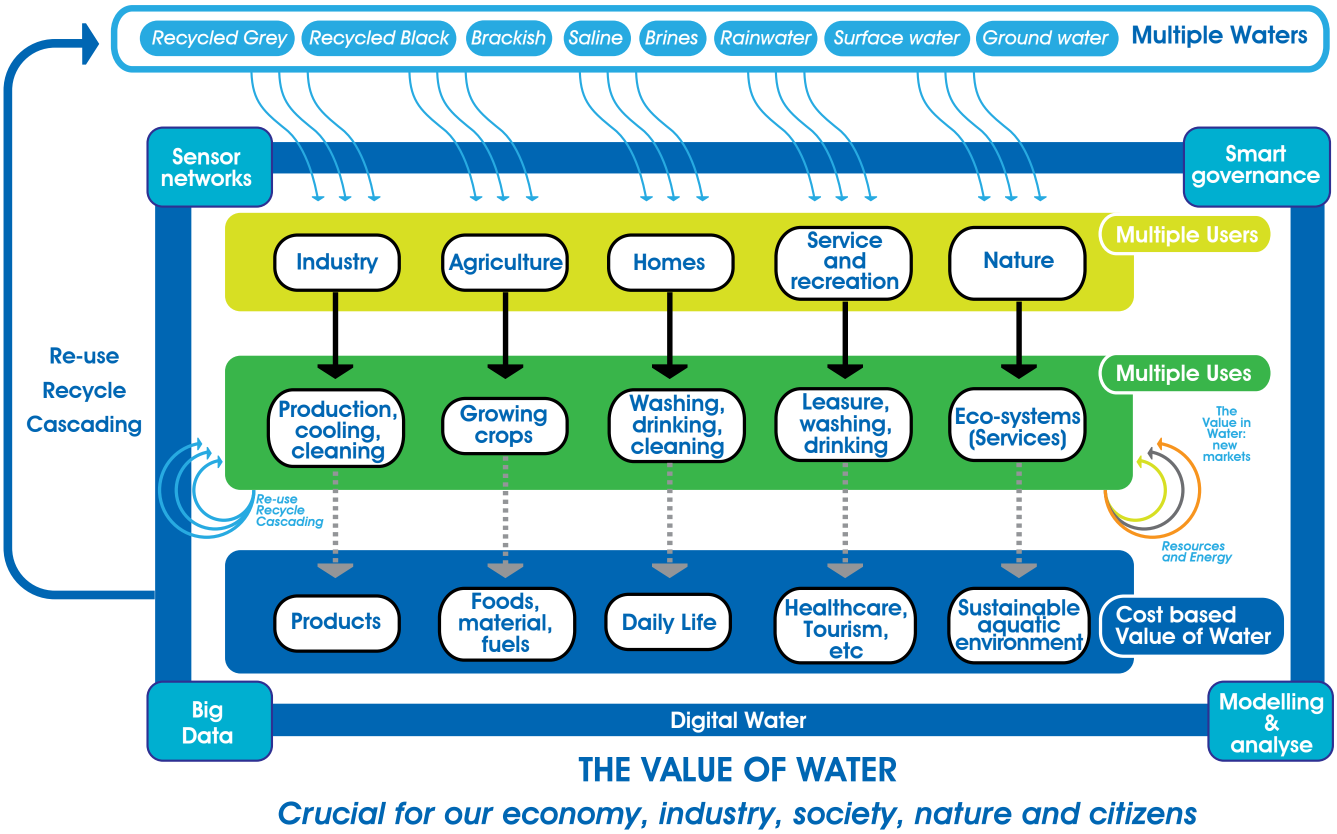


Figure 1.1.Value of Water (Source: Water Europe)

The present document will outline how the **Vision** and the **Strategic Innovation and Research Agenda (SIRA) of Water Europe** relate to the renewed European strategies and policies, with a strong focus on the **European Green Deal**, as well as the **Horizon Europe** Framework Program for Research and Innovation, and how the Vision ad SIRA underlying values can accelerate **the transition towards a regenerative growth model that gives back to the planet more than it takes**, as highlighted in the **EU Circular Economy Action Plan[1] released in March 2020**.

The growth model requires a **twin transition towards a European greener and digital society**, drawing all lessons from the COVID-19 crisis to foster the EU's preparedness and resilience. **In this transition, water plays the essential role of enabler and engine of the economy, of the social stability and sustainable growth of our society**.

This document aims to support those (EC and other EU Institution officers, researchers and innovators from private and public organisations, NGOs and CSOs, MS committees and advisory boards) that are engaged and responsible to develop the contents and mechanisms of the European Green Deal and Horizon Europe, to understand and identify the key water related research and innovation needs, to be integrated in different clusters and intervention areas. It will do so by briefly outlining how water plays an essential role in each cluster and intervention area, and by providing a simple reference tool and Guide to the different Research and Innovation Challenges described in the Water Europe Strategic Innovation and Research Agenda (SIRA), for each Intervention Area.

Water Europe intends to foster the realisation and application of breakthrough, affordable, and practical solutions for our water systems, and make Europe to globally lead the transition to a circular and green planet that can secure water for all. Water, as a crucial and relatively rare resource, plays a key role in the creation and maintenance of human security in relation to the environment.

Achieving and optimising the Water-Smart Society, as the background matrix to realising the objectives of the **Green Deal, will step forward the attainment of the SDGs**, of which, its achievement largely depends on water through the attainment of SDG6.

Water Europe aims to contribute to cross-sectorial and combined research and innovation actions to achieve the Water-Smart Society, by enabling synergies among European Structural application and Investment Funds, R&I FP and other research, innovation and competitiveness-related Union programmes such **LIFE+ and INTERREG** and to coordinate with the strategic plans of the **EIB** and the **EBRD**, and the **EDF** for actions to support international cooperation and international water dialogue.

Figure 1.2. The water-centric 17 Sustainable Development Goals for each sector (Source: UNESCO)

1) COM(2020) 98 final, A New Circular Action Plan for a cleaner and more competitive Europe, 11 March 2020, page 4.

1.2 Structure of the document

SECTION 1 of this document will provide an overview on how water plays a crucial role and needs to be taken into consideration when developing the new **EU policies and programs.** We will especially focus on the **European Green Deal** and **Horizon Europe**, but also taking into consideration their interactions with the multiple policy and funding instruments that Europe, with its member states, make available at European, national, and regional levels. It will recap essential elements of the Water Europe Vision for a **Water-Smart Society** that contribute to transforming the European Union, and beyond. However, for a more detailed account and extensive description including measurable Key Performance Indicators to reach this appealing vision, please visit the Water Europe web site[2] and download our Vision and SIRA[3].

In **SECTION 2**, by fully acknowledging the strategic orientation, expected impact areas, and Research and Innovation (R&I) priorities for each of the **Horizon Europe Program Clusters** and by building on the **Water Europe's Strategic Innovation and Research Agenda (SIRA)**, we depict the complex nature and cross-cutting challenges of **water** and aim to facilitate exploration, thematic positioning, and explicit illustration of **water-related Research** and **Innovation topics** across the elements of the **European Green Deal** (see Figure 1-3.), **Horizon Europe Program Clusters** (see Figure 1-4.) and their intervention areas. As such, as Water Europe, we aim at providing useful support to address the important challenge to design an integrated, **systemic** and effective Research and Innovation program for Europe, that realises the collective goal of **a sustainable world for current and future generations to come. SECTION 2** consists of six (6) sub-sections, each dedicated to one cluster of the Horizon Europe. Each sub-section starts with an easy-to-use figure with references to the Water Europe SIRA R&I topics. As depicted in the Water Europe's SIRA document, there are 177 Water Europe R&I topics that were categorised across four ranges of **Technology Readiness Levels (TRLs)**: fundamental (TRL 1-3), applied (TRL 3-5), close-to-market (TRL 6-8), and non-technical (all TRLs). Following the mapping of 177 Water Europe R&I topics across the six Horizon Europe clusters, TRL figures in the introduction part of each sub-section refers to the grouping of Water Europe R&I topics (**by TRL range**) that are relevant to the intervention areas of the Horizon Europe cluster. Furthermore, each sub-section provides an explanatory description of required water-related Research, Development, and Innovation (RD&I) areas and topics at the intervention area level of each cluster.

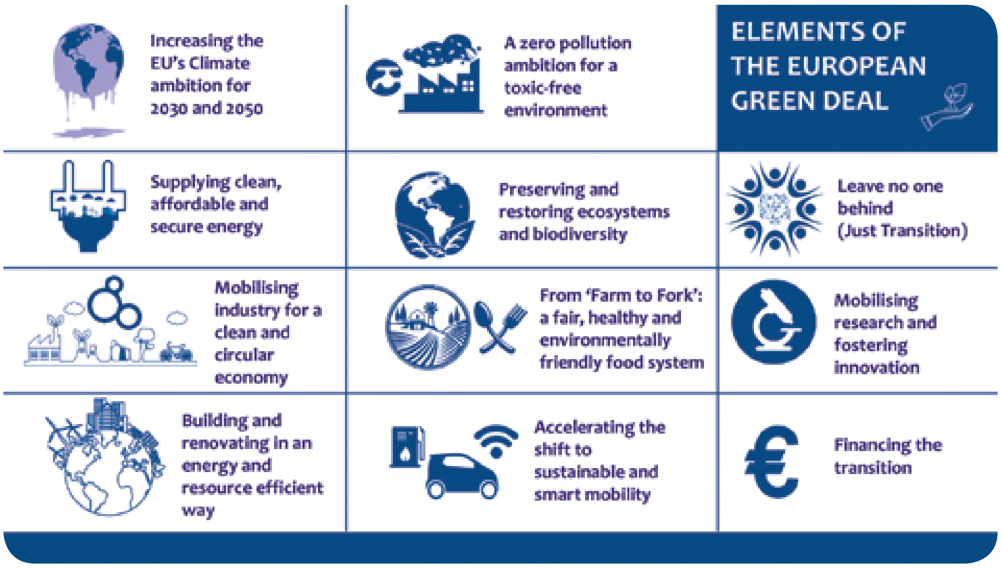


Figure 1.3. Elements of the European Green Deal

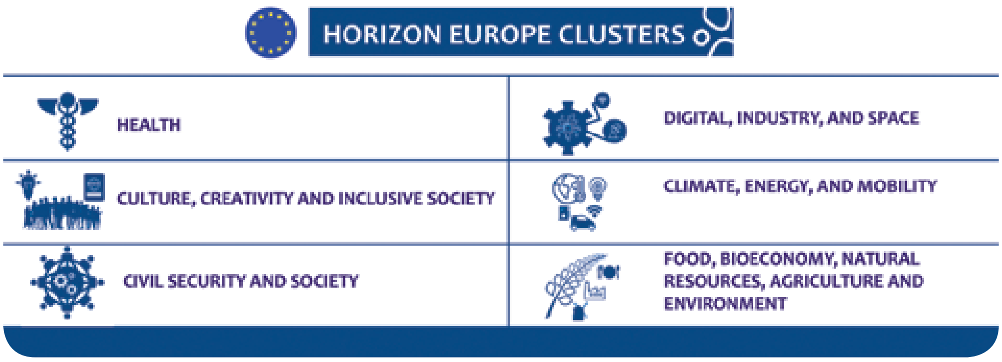


Figure 1.4. Horizon Europe Programme Clusters

2) https://watereurope.eu/
3) https://watereurope.eu/publications/

The second, **ANNEXES** document, support the **SECTION 2**. **ANNEX 1** provides a summary matrix of the cross-references between the Water Europe Vision and SIRA, the European Green Deal and the Horizon Europe Clusters (see Figure 1-5.). **ANNEX 2** displays the consolidated overview of Water Europe Research and Innovation (R&I) topics, as depicted in the Water Europe Strategic Innovation and Research Agenda (SIRA) and referenced in the present guidance document. Whereas, **ANNEX 3** provides the readers with concrete and detailed information on water-related R&I requirements and their strategic relevance as **driver** to the Pillars, Clusters, and Intervention Areas of Horizon Europe and as **enabler** to the elements of the European Green Deal. **ANNEX 3** consists of six (6) sub-parts, each dedicated to one cluster of Horizon Europe. Each part starts with an easy-to-use table with references to the Water Europe SIRA and provides, with granular details, an explanatory description of required water-related Research, Development and Innovation (RD&I) areas and topics at the intervention area level of each cluster.

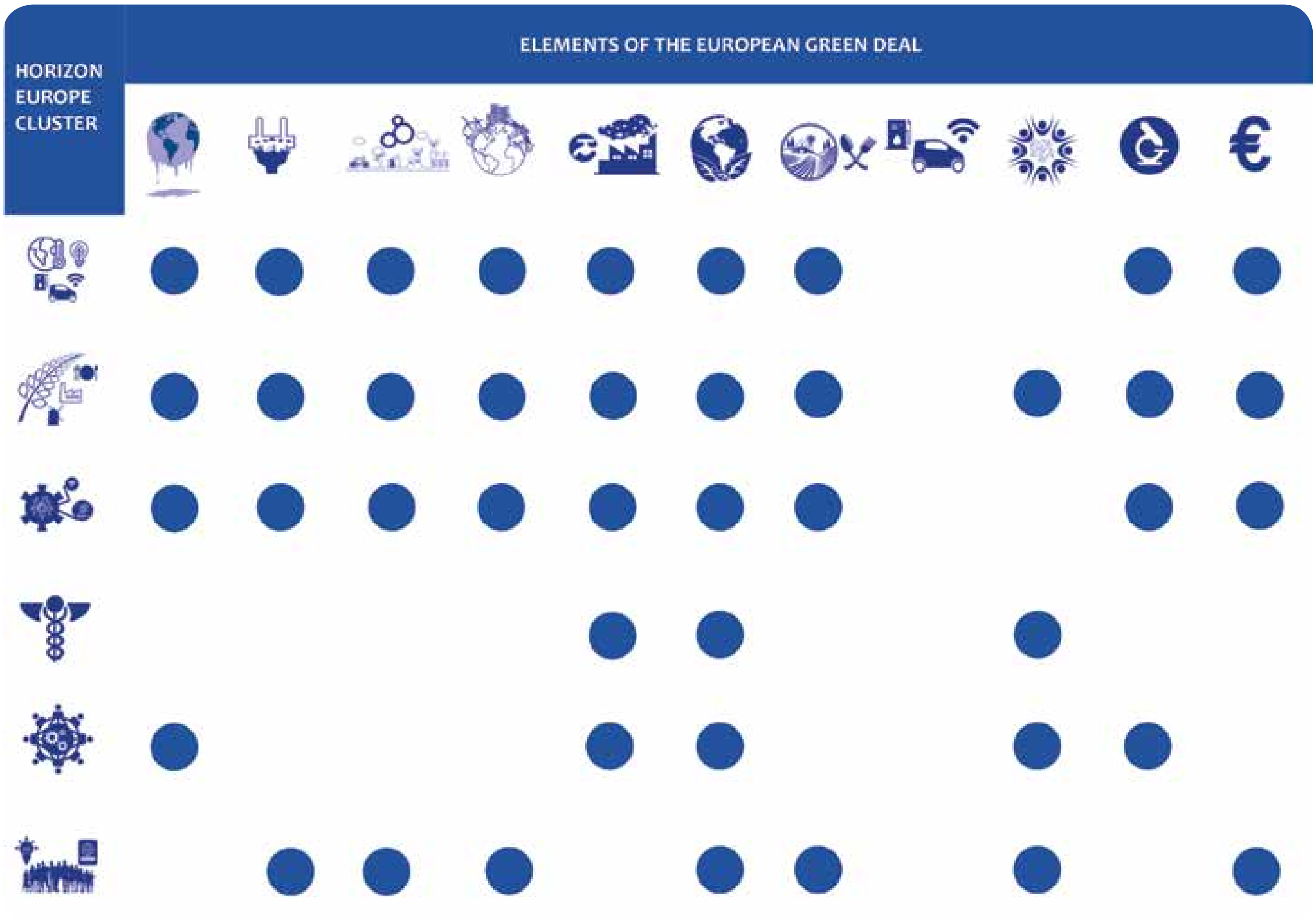


Figure 1.5. Summary Matrix of the Cross-references between the Water Europe Vision and SIRA, the EU Green Deal and the Horizon Europe Clusters

SECTION 1

1.1 THE WATER EUROPE VISION AND RESEARCH STRATEGY IN THE LIGHT OF MAJOR SOCIETAL CHALLENGES

Demographic change will increase the demand of clean and fresh water, while augmenting the pressure on our aquatic eco-system through socio-economic activities and increasing water scarcity, especially in growing geographic areas such as Africa and Asia, and South America but increasingly also in Europe. The impact of **Climate Change** on water availability, especially in these areas is important. **Pollution, droughts, and floods** exacerbate water scarcity, beyond the increasing demand.

Water Scarcity is already a serious challenge in 11% of the EU territory and it is expected that the territory facing water scarcity problems will grow to 30% in 2030[4]. **The escalation of urbanisation, depopulation of rural areas, food production and energy demand in Europe** increases the exposure of large parts of our populations to the risk of water insecurity.

If water demand stays at current usage levels and without significant water saving efforts, the warming climate and reduced precipitation in the Mediterranean will cause extreme increases in water scarcity. The people already exposed to water scarcity in current climate will encounter much more intense water scarcity[5].

Hence, we need to re-think, realise and manage fit for purpose **"multiple-water"** streams and infrastructures, as integrated part of a **sustainable and efficient water management concepts**. In the view of a **"Water-Smart Society"** where access to water by the end-users (city, industry, agriculture, nature) must be secured in the right quality and quantity, at the right time and at a fair price.

Water Europe envisions a European water sector that will be significantly transformed with respect to the current state of play. Concepts such as **"Multiple Waters"**, **"Digital Water"** and **"Hybrid Grey and Green Infrastructures"**, will be driving the transition, decision makers and new water-smart economics. All will be enabled by new technologies fostered within an open innovation environment and a completely r**edesigned water infrastructure that are based on smart Hybrid Grey-Green Infrastructures (HGGI) and Nature Based Solutions (NBS) combinations, based on local and central facilities. This requires a systemic circular economy approach** to minimise the environmental footprint of human activities and ensure water security.

New governance structures, economic mechanisms, and **water stewardship** programs will manage the water market towards smart allocation of water resources.

Water Europe Vision fosters and fully supports the EC priority **"A Europe fit for the digital age"** which aims to make this transformation work for people and businesses, while helping to achieve the EU target of a climate-neutral Europe by 2050. **Water plays a crucial role in the twin transition towards a greener and digital European society**.

Digitalisation of our society will create new opportunities to manage the indicated water challenges with novel, model-based support and management systems, based on a combination of earth observation and capillary proliferation of affordable and reliable sensors from the water infrastructure up to our industries, cities and homes. A capillary sensing, monitoring and management of our multiple-water streams and use, expressed in the concept of **"Digital Water"** is a key example of how digitisation of the water sector will make Europe fit for the Digital Age, enabling fully circular water systems, allocating the right-quality of water to the right users and use, as such tackling both scarcity and environmental impact. Artificial intelligence and new models of data management will encourage businesses to work with, and develop these new technologies, while at the same time making sure that they earn citizens' trust.

A truly inter-operable, intelligent, and data-centric digital ecosystem will provide the framework for a water-driven sustainable growth. It will contribute to reduce energy demands, enhance disaster management and prevention, and improve analysis, modelling, and use of environmental data for addressing climate-related challenges. Standardisation and cybersecurity are also key to secure water and enhance resilience of the water systems. Advanced water systems and digitalisation, which necessarily includes A.I. technology, can generate large amounts of valuable (big) data to achieve innovative and reliable Decision Support Systems (DSSs) and effective governance systems.

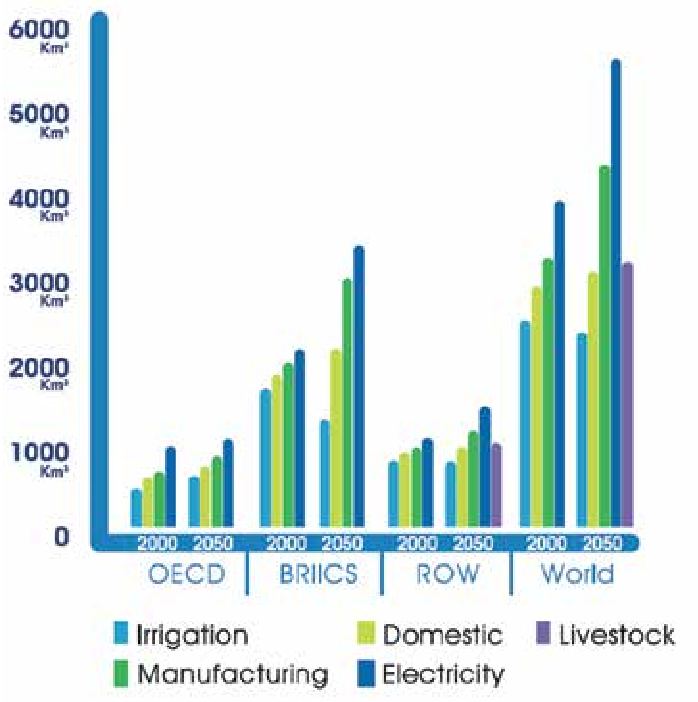


Figure 1.6. Global water demand in 2000 and 2050 (Source: adapted from OECD Environmental Outlook to 2050)

4) EC Factsheet "Water Scarcity and Drought in the European Union"
5) Joint Research Centre (JRC). (2020). Climate change and Europe's water resources

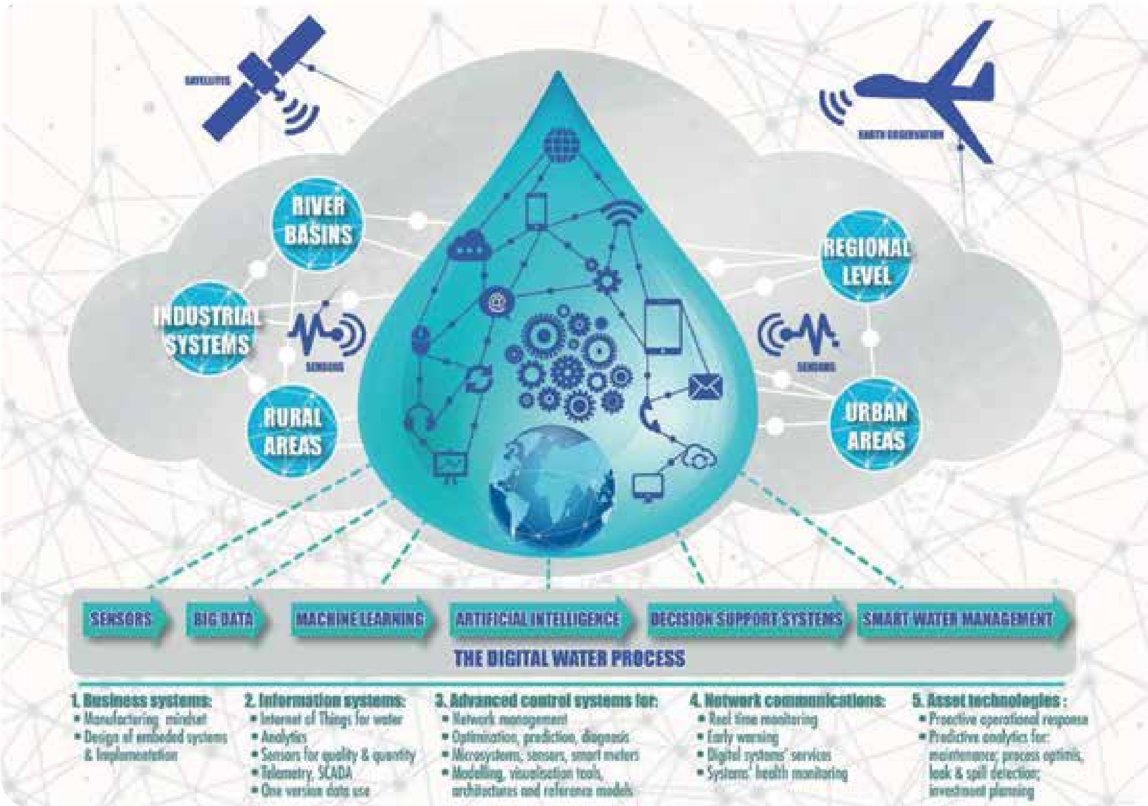


Figure 1.7. Digital Water Concept (Source: Water Europe)

New **scientific developments** will enable **better, cleaner and more sustainable use of water that is crucial for all critical societal functions**, from drastic water savings in food production, a fully circular use of water for energy and industrial production, clean water for health and personal care.

New technologies are needed to reduce the **Contaminants of Emerging Concern (CECs)** that have the potential to enter the environment and cause adverse ecological and human health effects but that are still largely unregulated and whose fate and potential effects are poorly understood. **While many more chemicals are becoming CECs, identification techniques needs to be refined to apply solutions that will create future-proof flexibility that ensures resilience to changing conditions due to demographic development and climate change**.

Further technologies can also valorise and extract the **"valuable pollutants"** by extracting valuable nutrients, materials and energy from urban and industrial (waste) water streams suitable for the creation of a second life circular value chain.

Water security, energy security, and food security are strongly interlinked, meaning that the actions in any one particular area often can have effects in one or both other areas. This right balance within the so-called **water, energy and food security nexus** is necessary for the biodiversity preservation, benefit of human well-being, poverty reduction and sustainable development, and hence will also play a central role in the just transaction of Europe to becoming the world's first climate-neutral continent by 2050, while leaving nobody behind, as expressed within **European Green Deal** policy of the European Commission.

"The European Green Deal sets a path for a transition that is just and socially fair. It is designed in such a way as to leave no individual or region behind in the great transformation ahead."

Europe will have the opportunity to leverage on its leading position in science and technology, to develop **solutions for the world** that contribute to managing critical water challenges in a globe with increasing overpopulation, while driving new markets for European technologies and businesses. Europe is in the unique position to develop and pilot solutions in its home market(s) to speed-up required innovations, as Europe is home to all water related challenges while featuring the best scientific and industrial stakeholders to solve them.

These touch many of the **Sustainable Development Goals** such as Clean Water and Sanitation (SDG6), Climate Action (SDG13), Life Below Water and on land (SDG14 and 15), but also Good Health and Well-Being (SDG3), Sustainable Cities and Communities (SDG11), Affordable and Clean Energy (SDG7), Responsible Consumption and Production (SDG11), No Poverty (SDG1), Zero Hunger (SDG2) and obviously Industry, Innovation and Infrastructure (SDG9).

1.2 Water research and innovation as key enabler for horizon europe

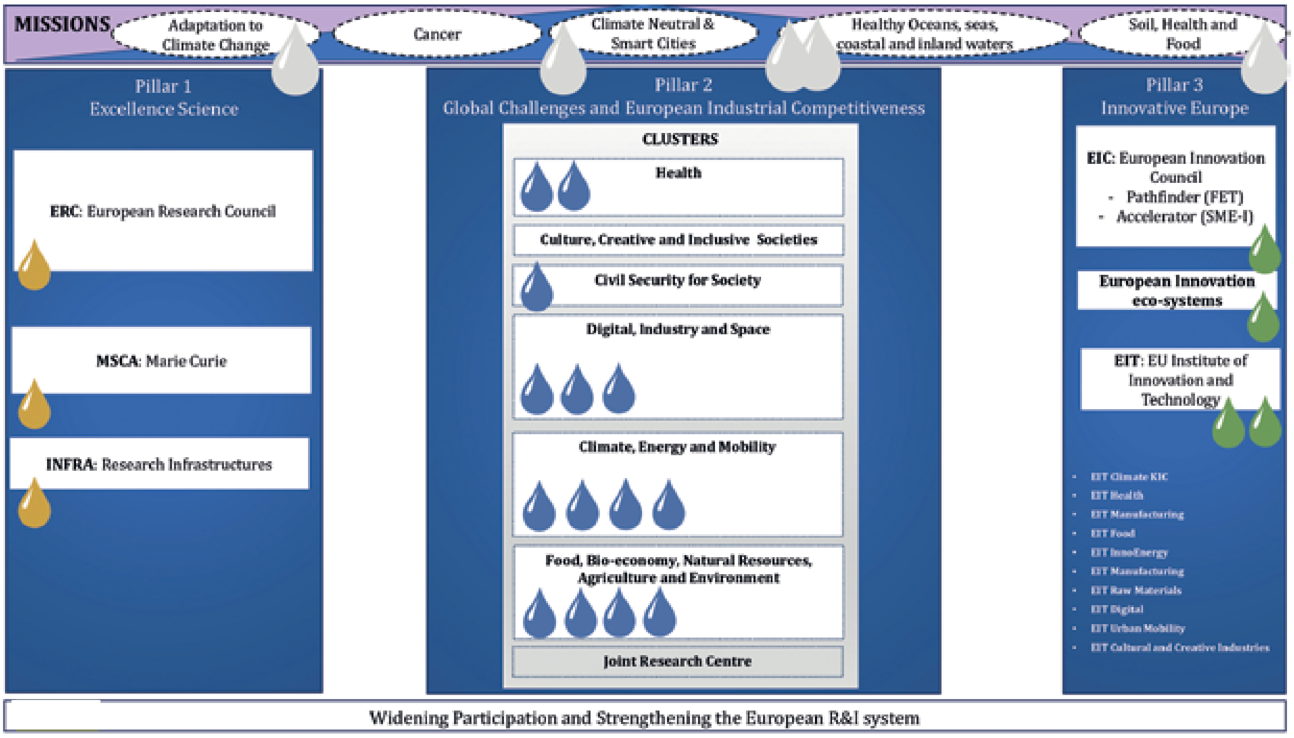


Figure 1.8. The Impact of Water on Horizon Europe Pillars, Clusters and Missions

Water impacts all **HORIZON EUROPE Pillars and almost all Clusters as well as Missions**.

Water research and innovation will be needed to tackle practically all societal challenges, from **Climate, Energy and Mobility**, to **Food, Bioeconomy**, **Natural Resources, Agriculture and Environment up** to **Health and Resilient and Secure Societies**.

Water plays a key enabling role in 4 out of the 5 targeted HORIZON EUROPE missions to: ensure a resilient water infrastructure and management to adapt to Climate Change (e.g. to manage floods and droughts) and for the Climate Neutral and Smart Cities of the future (e.g. to develop fully circular water systems); guarantee adequate water qualities and quantities for our food and health (avoiding pollution and guarantee clean water availability also in periods of scarcity); and, last but not least, safeguard healthy oceans, seas, coastal and inland waters.

To underpin all these developments, new scientific knowledge and better educated cross-disciplinary researchers will be needed to be able to support these RD&I activities, which are explained in detail in SECTION 2 of this document, and even more detail in our Strategic Innovation and Research Agenda (SIRA).

And to make sure, the ambitious transition to a Water-Smart Society and Carbon-neutral society by 2050 will require the development, take-up and integration of novel technologies by industries and societal users with Fast Track to market

Climate, Energy, and Mobility

Water plays a role as better insights in Climate Change in relation to water security, droughts and flooding are key to start curbing its negative effects and start "getting things under control". Beyond getting more and better insights on climate-earth systems, and to better understanding the planetary boundaries, real impact requires adequate management of the water, land, food, energy, and climate nexus.

Food, Bioeconomy, Natural Resources, Agriculture, and Environment

Water, land, food, energy, and climate are interconnected, comprising a coherent system (the 'Nexus'), dominated by complexity and feedback. Putting pressure on one part of the Nexus can create pressures on the others. Scientific insights in these interaction mechanisms in the light of Climate Change and related policy and decision support systems, to improve management of the Nexus is critical to securing the efficient use of our scarce resources and reach emission goals.

Clean and available water is crucial for **Food Production, Industries in the Bioeconomy, as a fundament for our Natural Resources, to enable Agriculture and foster our Environment, through Biodiversity and closing all loops in the circular economy**.

Novel Nature Based Solutions will be a key component for circular water management solutions, while stopping biodiversity decline and enhancing restoration of ecosystems. For example, the restoration of natural wetlands combined with fit-for-purpose treatments, will make it possible to reach near-zero water discharge in industry, re-use water for multiple purposes including precision farming and sustainable food production, while fostering the restoration of original flora and fauna around the wetlands, contributing towards reaching the Global Vision for Biodiversity 2050[6].

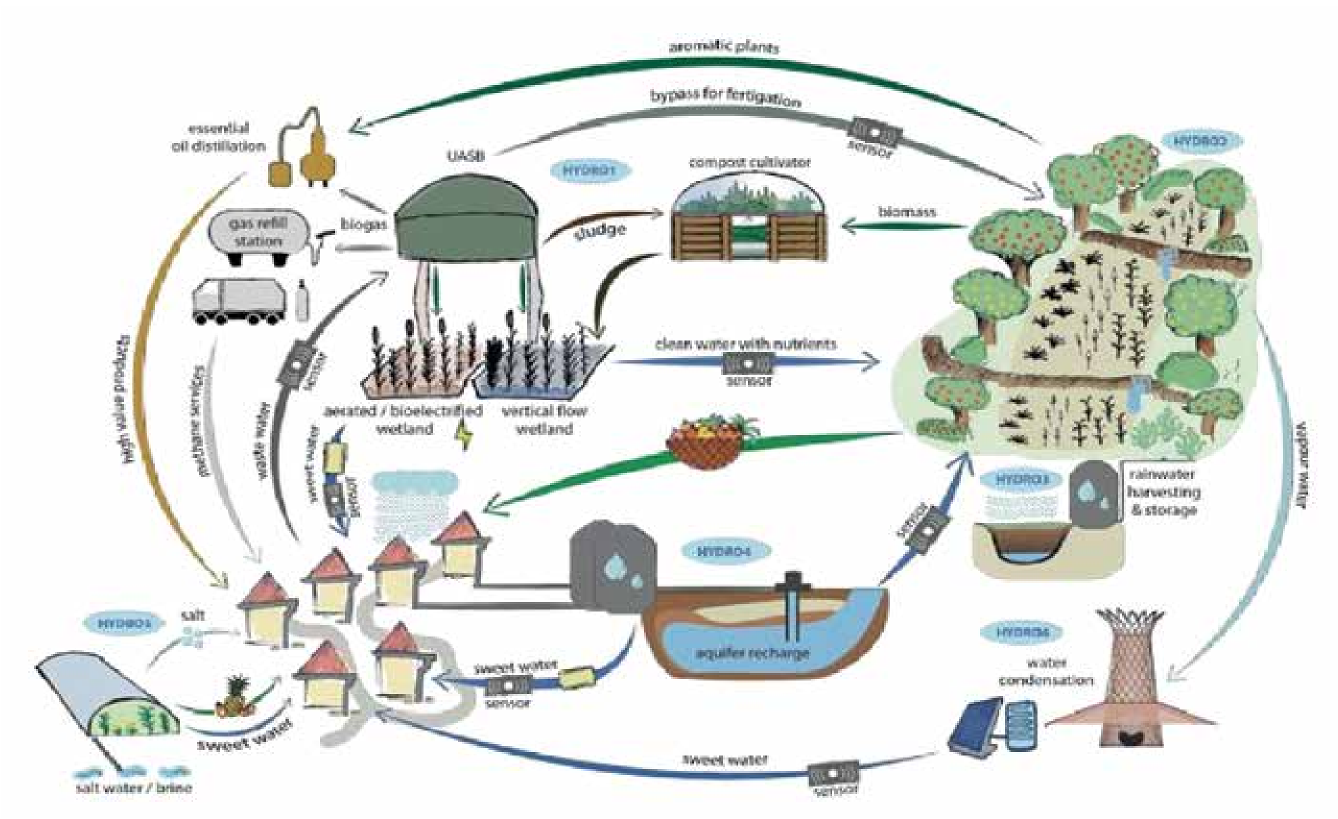


Figure 1.9. Close Water Loop. (Source: Hydrousa project)

Better understanding of behavioural and socio-economic aspects related to the essential **"Value of Water"** for all our societal processes, in combination with new sensor and data-driven water management systems and business models, should lead to novel digital tools and inclusive (self) management to foster innovative approaches that drive sustainability and a balanced development of vibrant rural, coastal, peri-urban and urban areas.

Digital, Industry, and Space

Digital technologies will hence be key to manage a Water-Smart Society, and industries will become 100% circular in their water use while the **Value in Water** will be extracted to create new markets in the circular economy. Moreover, smart, cyber-secure water networks and infrastructure will enable more interaction and better utilisation among producers, consumers, networks, infrastructure, and vectors.

6) Protocols under the Convention: (a) The Cartagena Protocol on Biosafety, (b) The Nagoya – Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety and (c) The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization.

Civil Security for Society

New **"Hybrid Grey and Green infrastructures"** will introduce stability and water security in a mobile world where multiple waters will need to be available and recyclable in urban, peri-urban and agricultural areas. These critical water infrastructures will need to be modernised to be (self) sustainable, and provide input to new (digital) management systems, and they will need to handle cyber-physical attacks, to ensure 100% availability of the right amount and right quality of water for the right purpose, including for health and personal care. Improved disaster risk management for climate-related risks and extreme events is strongly related to resilient, dynamic, and Hybrid Grey and Green urban and peri-urban Infrastructures, that manage our water flows.

Development of innovative and transformative governance: The Water oriented Living Labs

Water Europe proposes the **Water oriented Living Labs (WoLLs)** to support the full pathway of research, development, assessment and market outreach of innovative solutions through participatory, cross-sectoral, cross-learning and capacity development approaches integrated with **effective governance models and decision-support tools** to achieve the Water-Smart Society. **WoLLs are the ideal functioning and proactive frameworks to support the systemic transition to a green and digital Europe**.

Water oriented Living Labs are real-life demo-type and platform-type environments with a cross-sector nexus approach, which have the involvement and commitment of multi-stakeholders (including water authorities) and provide a "field lab" to develop, test, and validate a combination of solutions as defined in the Water Europe SIRA, which include technologies, their integration as well as combination with new business models and innovative policies based on the **Value of Water**. **WoLLs enable the swift implementation of policy mixes** for meeting sustainability, biodiversity, climate challenges and facilitate **citizen engagement** in the **codesign of solutions** and **decision-making process**.

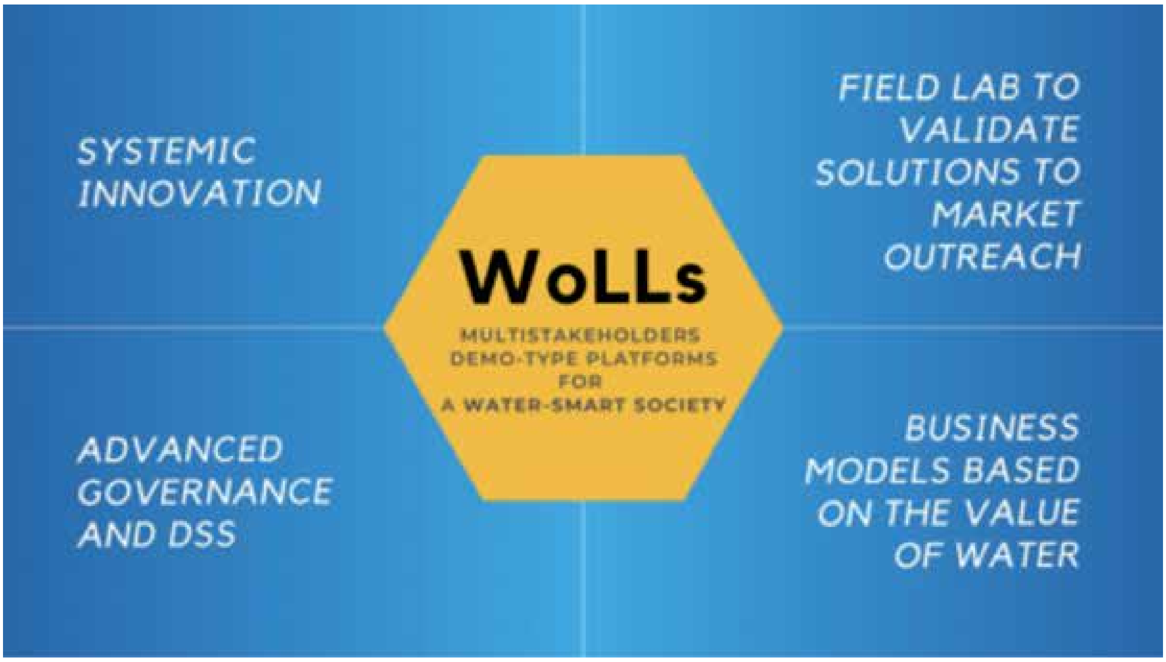


Figure 1.10. WoLLs systemic functioning

Water resources and infrastructure management

When developing innovative solutions for halting pollution and restoring degraded water bodies, advanced circular urban water systems, deployment of alternative waters sources, including water reuse, and new water governance solutions are of vital importance to develop innovative solutions for halting pollution and restoring degraded water bodies.

As described above, **water is a key element in all Horizon Europe clusters and needs to be integrated adequately in the new Framework Programme for Research and Innovation. The rationale is that the right knowledge and solutions to fulfil the necessary systemic changes to achieve a Water-Smart Society will enable with the transition to a Green and Digital Europe**.

1.3. The mission(s) of water

It has become clear that water has a vital role in all societal functions. As such water has a mission to foster a healthy, sustainable, and prosperous world for all citizens. Our water vision and strategy hence offer enabling component for all HORIZON EUROPE's missions:

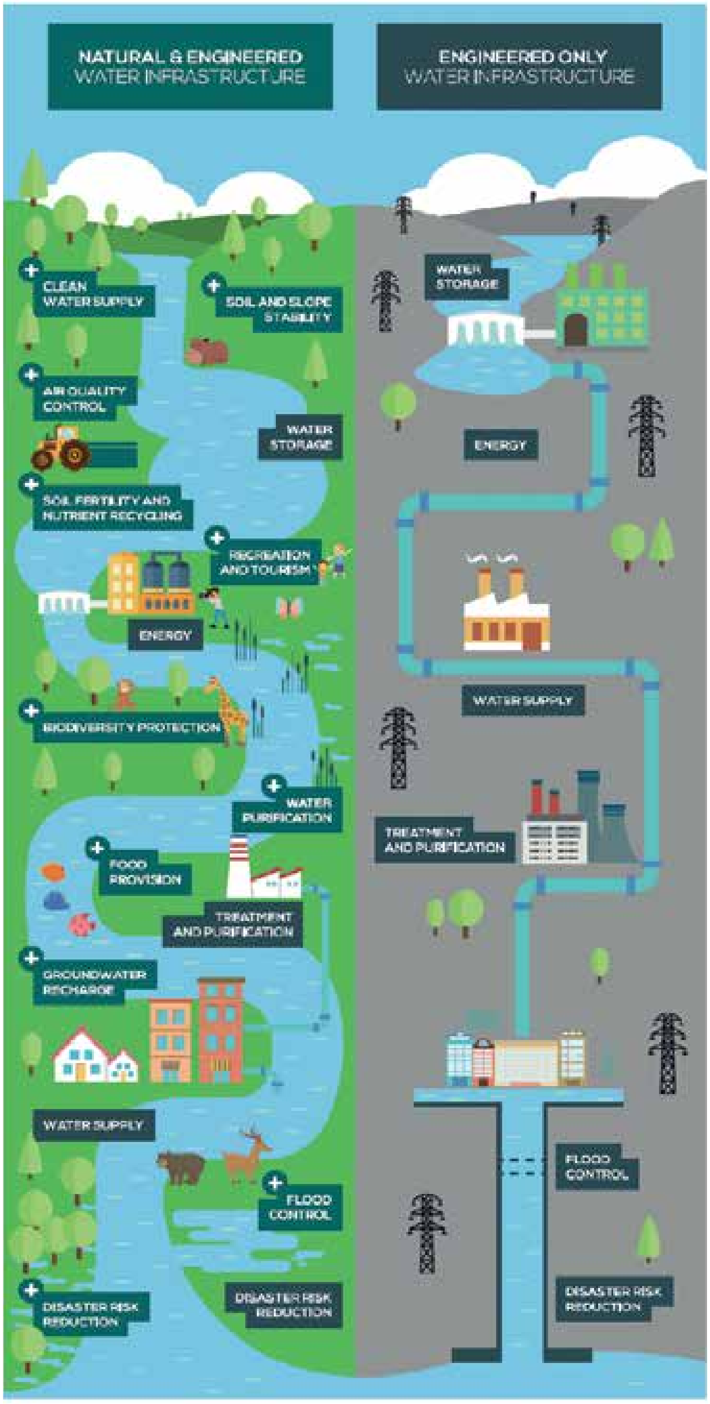


Figure 1.11. Redesign of Water Infrastructure (Source: Water Europe, adapted from IUCN)

Adaptation to Climate Change, including Societal Transformation

Developing new solutions to deal with the impact of Climate Change on draughts and flooding. This requires new smart sensor and bigdata driven predictive technologies, smart Hybrid Grey and Green Infrastructures as well as multi-stakeholder governance and management, including Societal Transformation, to ensure **fit-for-purpose** water availability for all societal functions, to manage the water, land, energy and food nexus.

Public Health

Safe water and eco-systems free of harmful anthropogenically derived pollutants and CECs will be key to guarantee a healthy environment for all citizens, including to reduce the chance of cancer to emerge.

Healthy Oceans, Seas, Coastal and Inland Waters

100% recycling and re-use of wastewater from industries and cities, zero-pollution water solutions, technologies and new business models to extract and valorise the value in water and will need to be developed to ensure that our aqueous environments will be restored to its natural and healthy original state.

Climate-neutral and Smart Cities

Smart Hybrid Grey and Green Infrastructures will be key for the Cities of the future to secure water supply for key urban functions and the other essential services such as energy to avoid cascading effects of failure of the water systems to the functionality of the other sectors. Combined with innovations in the water grid to make the water flows fully circular, digital solutions will be needed to manage the **multiple qualities of water** (ground, surface, rain, brine, salt, brackish, recycled black and grey) through the right incentives and (self) management systems with user involvements in the Water-Smart cities of the future.

Soil Health and Food

Water is the foundation of our soil and food systems. Smart irrigation, including with recycled water, and advanced management of water flows between urban, peri-urban, and agricultural areas, will be fundamental to reach Europe's and the world's missions for a healthy soil and food system within our society.

1.4. Gaps and synergies towards impact

Overall, we believe one of the main challenges for EU research and innovation programming lies in aligning, synergising, and combining the funding, activities, and results of the fragmented EU landscape of support instruments. Taking from the perspective of water as an enabling resource which underlies all societal processes and innovations, we would like to conclude **SECTION 1** with a number of recommendations. They are aimed at highlighting where additional attention may be needed to structure and streamline our upcoming integrated support instruments, towards realising actual impact of a "Water-Smart" and "carbon-neutral society" by 2050.

FUNDING FOR INCLUSIVE AND INTERNATIONAL ACCESS TO SCIENTIFIC EXCELLENCE

Given the limited increase in funds allocated to the Marie Sklodowska Curie Actions, further support research staff exchange opportunities and open up access-to-co-funding and co-funding opportunities for international Research & Innovation R&I within different pillars of the Horizon Europe Program is required. Furthermore, given the fact that private sector funding is still limited in most countries, owing to various factors (e.g. low share of high-tech companies in private R&D, private R&D investment planning and support capacity in Member States), increasing the access of the European water-sector SMEs to scientific excellence would be necessary.

RE-USABLE, ACCESSIBLE, AND TRANSFERABLE WATER-RELATED R&I PROJECTS RESULTS FOR THE FULL ACHIEVEMENT OF THE WFD'S OBJECTIVES

As mentioned in the BOHEMIA Study Final Report (2018) and the Report titled 'Economic and Non-market valuation issues in Water Framework Directive (WFD)' (2010), there has been a disconnection between research projects and practical needs of water policymaking. Furthermore, as described in the interim evaluation report of the H2020 (2017), low success rates (11.6%, comparing to 18.5% in FP7) impacted the programmatic effectiveness of the H2020, creating underfunding problem. By increasing the re-usability, accessibility, and transferability of R&I projects data by the water sector and its broader stakeholders' community, it would be possible to speed up the full achievement of the WFD's objectives.

SYNERGIES BETWEEN FUNDING SOURCES AND STEERING OF WATER-RELATED PROJECTS TOWARDS KEY POLICY PRIORITIES AND GREEN TRANSITION OBJECTIVES

The Horizon Europe program, the European Green Deal, and the Sustainable Europe Investment Plan (2021-2027) introduce a more flexible, overarching, purpose-driven, impact-focused, and long-term funding perspectives, while initiating synergies with different programs and financing instruments, particularly for addressing the investment needs required for meeting the Europe's 2030 green transition ambitions, such as the Cohesion Fund and the European Regional Development Fund (ERDF), Common Agriculture Policy (CAP), LIFE, European Social Fund+, InvestEU Fund, Just Transition Mechanism, European Structural Investment Fund (ESIF), European Maritime and Fisheries Fund, or public sector loan schemes of the European Investment Bank (EIB). In this context, targeted steering of projects towards key policy priorities and green transition objectives is of importance to: i) create coherence across the implementation of various sectoral policies; ii) promote best practices and transfer of knowledge on sustainable water management; and, iii) eliminate potential conflicts in the implementation processes of various water-related measures (e.g. water retention measures, agricultural interests, land-use planning, water efficiency measures) at local or regional levels.

In the 2000-2020, cohesion policy allocations for the water sector amounted to EUR 57.7 bn (Cowi et al., 2019), with the wastewater sector receiving EUR 38.8 bn of the EUR 57.7 bn. Whereas, in the 2000-2021 period, the LIFE program co-financed 421 water projects with an estimated budget of 1.1 BEUR, addressing the WFD objectives. Given the importance of EU-funded subsidies and funding support for the water and wastewater sectors, it is evident that the implementation of the EU's water-related legislation requires not only R&D financing for developing adaptation, mitigation and restoration measures but also initial infrastructure development, operation and maintenance financing. According to the WFD Fitness Check Document (2019) and the Urban Waste Water Treatment Directive (UWWTD) Evaluation Report (2019), insufficient funding for maintenance, Member States' ability to use loans and national co-funding, have been described as some of the factors impeding the full achievement of the WFD's objectives, the implementation of the UWWTD and Floods Directive.

REGIONAL WATER INNOVATION ECOSYSTEMS FOR INTEGRATED, RESOURCE-EFFICIENT REGIONAL DEVELOPMENT

Whilst building on S3 priorities, induce ecosystem thinking into regional water innovation communities to develop integrated, resource-efficient regional development opportunities by: i) amplifying support for integrated demonstration projects, ecosystem accelerators/connectors/multipliers at regional level; ii) allocating substantial proportion of the structural funds for financing water R&I infrastructures and their sustainability; iii) better deploying regional ecosystem actors for tackling transboundary catchment issues; and, iv) effectively mobilising KICs to develop new forms of citizen science engagement opportunities for spotting, probing, and solving water issues at the watershed level.

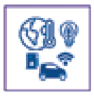
MULTI-STAKEHOLDER, INCLUSIVE, AND SHARED DEVELOPMENT OF WATER R&I AGENDA IN EUROPE

In order to better align national and EU R&I investments, increase citizen engagement in water R&I agenda-setting, and address effectively the transition scenarios of the European Green Deal requiring structural and institutional change process. Co-design and co-development of water policy experimentation opportunities, grounded in new partnership structures (e.g. P4P), is of high importance also to: i) create dynamic interactions between enabling horizontal policies (e.g. R&D policies) and vertical policies (e.g. water policies); diversify R&D options to accelerate market uptake of promising technology applications; iii) create better connection between supply and demand sides of water management innovation to increase resource efficiency (e.g. linking of Green Public Procurement to EU funded projects, green infrastructures promoted by EU funding); and, iv) increase acceptance of new solutions with multiple benefits.

STRATEGIC ALIGNMENT OF DIGITAL AND GREEN ECONOMY NEEDS FOR DRIVING POST-COVID-19 SOCIO-ECONOMIC RECOVERY AT SPEED

The policy necessity for the European Green Deal priorities and for the programmatic development of digital capacities within the EU, has become more evident, particularly for driving at speed socio-economic recovery from the COVID-19 outbreak and leading Europe effectively on the digital and green transitions. The alignment of European digital and green economy ambitions, being also at the core of Europe's new Industrial Strategy Package, the new Circular Economy Action Plan, and SME strategy, requires not only the elimination of demand-side barriers (e.g. market access, access to financing) in the single market but also strengthening the digital and green push, by diversifying sustainable finance mechanisms and opening up new RD&I avenues for unleashing productivity gains from the digital-green convergence, enhancing digital and green competences within industries, capacity development new digital technologies for the transition to sustainability and digitalisation.

SECTION 2

2.1. Climate, energy, and mobility (cluster 5) 

Given the objectives and expected impacts of the intervention areas of the **Cluster 5 'Climate, Energy, and Mobility'**, Water Europe R&I topics contribute to generate the necessary expected impacts of the four (4) intervention areas, namely: **Climate Science and Solutions** (see 2.1.1.), **Energy Supply** (see 2.1.2.), **Energy Systems and Grids** (see 2.1.3.), and **Communities and Cities** (see 2.1.4.). Figure 2.1. displays the distribution and TRL levels of Water Europe R&I topics across the four intervention areas.

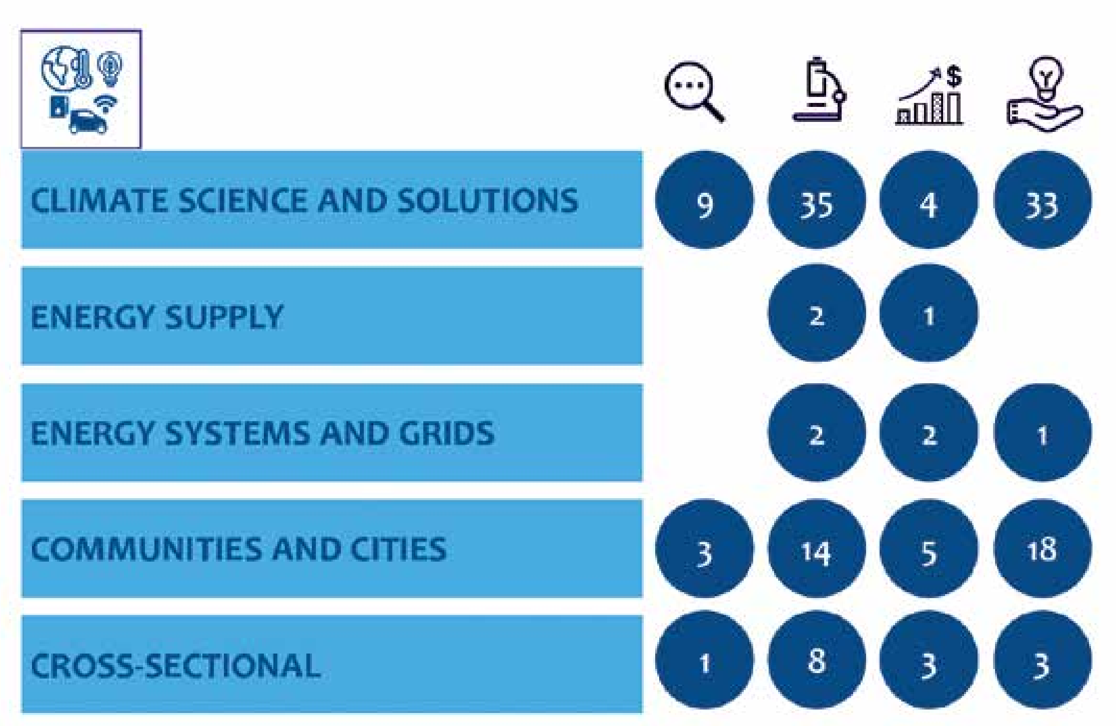


Figure 2.1. Distribution and TRL levels of Water Europe R&I Topics across Intervention Areas

Under **Cluster 5**, as displayed in **Figure 2.2.**, Water Europe R&I topics address nine (9) elements of the European Green Deal.

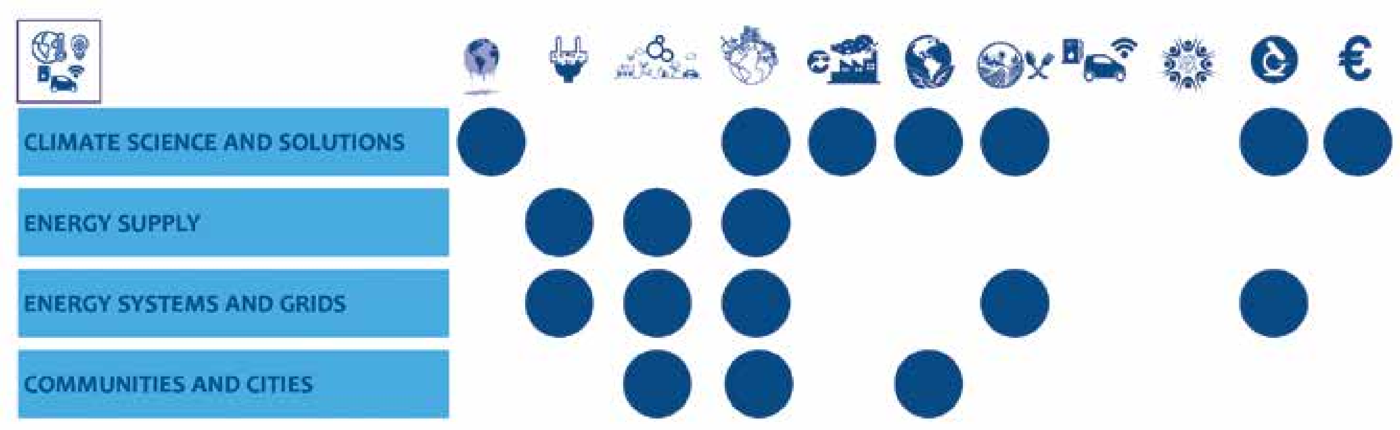


Figure 2.2. Distribution of Water Europe R&I Topics across Intervention Areas of Cluster 5 and the elements of the European Green Deal

2.1.1. Intervention area: climate science and solutions

In many European countries, meteorological, weather, and climate services are organised separately from hydrological services; whilst, the cooperation among these services, together with its users, is of crucial importance to support **water-smart decision-making** and proactive building of local resilience and adaptation capacity. As the ongoing Earth's system changes have implications of **hydro-climatic risks** (e.g. extreme droughts and floods, shortened hydrological cycles, changes in rainfall patterns, variations in water availability from water sources) for current and future societies, climate models need to be integrated into hydrological modelling, taking into account **regional climate hydrology, environmental properties of local biodiversity**, and **multiple water supply sources**. In accordance with the intervention-level objectives defined for the **Cluster 5** of the Horizon Europe and within the cross-disciplinary domain of climate-science, **European research priorities** could further support the broadening of climate science research and technology solutions for solving water issues and complex water disasters (e.g. drought, groundwater depletion, non-availability of safe drinking water) and supporting the cross-scale integration of regional climate measures and ecosystem services at the basin level.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.1.1. in Annex 3.

ACCELERATE CLIMATE ACTION UPTAKE BY IMPROVING KNOWLEDGE OF THE CLIMATE-EARTH SYSTEMS.

- Environmental Internet of Things (IoT) Ecosystems for a Water-Smart Society.
- Improved labeling systems and information-recording of passive and active sampling techniques for lab- and in-field analysis.
- Multi-objective Forecasting Systems in Climate Hydrology.
- Advanced modeling and simulation systems for developing better understanding of micro-pollutants and emerging pollutants in water resources.
- Advanced knowledge base, procedures, and warning tools in climate hydrology and hydroinformatics.
- Climate-related community knowledge network ecosystems and capacity building for water sustainability and management in the face of climate, water and biodiversity challenges.
- Climate resilience and adaptation measures for overcoming seasonal water shortages.

ACCELERATE CLIMATE ACTION UPTAKE BY PROPOSING AND EVALUATING SOLUTIONS FOR SHORT-TO-MEDIUM AND LONG-TERM SYSTEMIC IMPACT.

- Assessment of long-term environmental sustainability of water-related critical infrastructures.
- Development and retrofitting of eco-technological solutions for water pollution detection.
- Climate-smart, green technologies for water efficiency improvements.

CONTRIBUTE SUBSTANTIALLY TO KEY INTERNATIONAL ASSESSMENTS OF BIODIVERSITY, CLIMATE CHANGE, AND ECOSYSTEM SERVICES.

- Public and private decision support-systems for supporting cross-scale integration of climate-water measures and ecosystem services.
- Multi-stakeholder engagement for resources-oriented, environmental water governance and water security strategies in areas with multiple and competing resources and environments with spatial and temporal variability in water supply.

STRENGTHEN THE EUROPEAN AREA ON CLIMATE CHANGE.

- Cross-scale, inclusive collaboration in climate-water matters by channeling climate-smart scientific models in the desired direction of climate change policy targets.
- Role of standardization frameworks, stewardship schemes, and sustainability assessment methods as enablers in Water Sustainability Management and integrated component of Climate-Smart Water Innovation Infrastructure.
- Widening the participatory channels for cross-scale, cross-boundary, climate impact knowledge sharing and transferability to support the international integration of Europe in climate-smart, evidence-based multilateral policy-making.
- Strengthening of the financial sustainability and inclusive growth of the climate-vulnerable, SDG-relevant sectors, such as the water sector, via blended financing mechanisms and investment models.

2.1.2. Intervention area: energy supply

In **2018**, renewable energy represented **18%** of energy consumed in the EU (EEA, 2019). The **Renewable Energy Directive (REDII)** sets a binding target for the EU for **2030** of at least **32%** of **renewable-generated energy**. In this context, broadening and diversifying Europe's renewable energy sector is of importance, particularly to achieve the EU goal of reducing greenhouse gas emissions by **80-95%** by **2050** and meeting the **European Green Deal (COM(2019)640 final)** objectives. While the **EU's Blue Growth Strategy** identifies **ocean energy** (e.g. tide, wave) as a high growth-potential sector and acknowledges Europe's growing installed **hydropower capacity** (251,707 MW, in 2018), more than 25,000 hydropower plants currently produce approximately 10% of electricity in the EU (Vermeulen et al., 2019). With the core objective of achieving intervention-level objectives, under **Cluster 5** of the Horizon Europe, progressing research, development, and demonstration efforts, scaling up clean energy technologies and processes, without creating hydromorphological pressures and alterations on the water ecosystems, and integrating the objectives of renewable energy and water policies, at the nexus of water-energy will help the EU to achieve carbon neutrality in its long-term climate action vision.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.1.2. in Annex 3

INCREASE THE SHARE OF RENEWABLE ENERGY IN EUROPEAN ENERGY MIX.

- Renewable energy production from water sources for low-carbon energy supply, with a joint management of water and energy resources.

2.1.3. Intervention area: energy systems and grids

Given the intrinsic, cross-sectorial interdependencies between **water** and **energy systems**, water availability is affecting drastically the European energy sector, with the use of **74 billion m³/year of freshwater** (JRC, 2018). Without compromising **water availability** for decarbonisation, within the **water-energy nexus**, it is of importance to advance **integrated water-energy modelling systems** and the **clean technologies** supporting **low-carbon**, **water-saving energy systems transformations** (e.g. RES-based desalination) and eliminates the impacts of **critical water scarcity and water pollution** (e.g. chemical, thermal). Acknowledging the intervention-level objectives, stated under **Cluster 5** of the Horizon Europe, advancing research on the techno-economic feasibility of water- and energy-saving sustainability technologies could make significant contributions to the environmental sustainability: reduction of biodiversity losses, optimization of wastewater treatment, improvement of LCIA practices, among others.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult Section 2.1.3. in Annex 3.

ADVANCE EMERGING BREAKTHROUGH TECHNOLOGIES AND CLIMATE SOLUTIONS.

- Advancing the technological and commercial readiness of sustainable technologies at the water-energy nexus.

2.1.4. Intervention area: communities and cities

From an economic standpoint, the total reported **economic losses** caused by **weather** and **climate-related extremes** in the EEA member countries over the period **1980-2015** was around **EUR 433 billion** (EEA, 2017). On top of these **natural hazards, anthropogenic factors, such as increased urbanisation, soil sealing, wetland conversion/degradation**, influence negatively **water quality, water (resources) availability, hydrological regime, inter-connectivity between water bodies, and carbon balance, increasing climate change exposure and vulnerability of communities, particularly in cities.** In this context, **ecosystem-based approaches to climate adaptation**, such as strategically planned network of cost-effective and low-maintenance green, grey, and blue infrastructure solutions have been advocated by many EU policy platforms, e.g. CLIMATE-ADAPT, Covenant of Mayors for Climate and Energy, EIB's Natural Capital Financing Facility 34 (NCFF), while their importance for the European water policy have been promoted in the implementation strategy of the **Water Framework Directive** (WFD) and other EU's policy priorities related to **forest, agri-environment, and regional development. Green, grey, and blue infrastructure systems offer cost-efficient solutions for biodiversity preservation, water treatments (reuse and recycle), water retention, groundwater recharge, and functional connectivity** targeting the synergistic use of natural resources within the Water-Energy-Food-Waste (WEFW) nexus. Therefore, advancing participatory research, development, and innovation at the nexus of regenerative ecosystems solutions, eco-friendly built environments, integrative climate change governance schemes, and digitally transformed, critical infrastructures is of high importance to not only **symbiotic resource efficiency** but also **improved socio-ecological and territorial resilience** against climate and water issues.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.1.4. in Annex 3

INCREASE THE CLIMATE-RESILIENCE OF CITIES AND COMMUNITIES AND THEIR ATTRACTIVENESS TO BUSINESS AND CITIZENS BY TARGETING GREEN INFRASTRUCTURE.

- Nature-based solutions for resilient, healthy, and livable cities.
- Adaptive and integrative climate change governance for urban resilience and circular city transitions.
- Digital water infrastructures and intelligent water ecosystems in urban water futures.
- Sustainable development and retrofitting of green infrastructures into rural, coastal, and city environments.

INCREASE THE CLIMATE-RESILIENCE OF CITIES AND COMMUNITIES AND THEIR ATTRACTIVENESS TO BUSINESSES AND CITIZENS BY TARGETING ENERGY AND RESOURCE EFFICIENCY.

- New, resource-oriented business models for urban smartization.
- Integrated climate-smart policies and sustainable urban planning approaches for resource efficiency in city environments.
- Resilience and resource efficiency solutions for climate-smart urban infrastructure, services and systems.
- Improved industrial sustainability performance for carbon-neutral and European industry at the water-energy nexus.

2.2. Food, bioeconomy, natural resources, agriculture, and environment (cluster 6)

Given the objectives and expected impacts of the intervention areas of the **Cluster 6 'Food, Bioeconomy, Natural Resources, Agriculture and Environment'**, Water Europe R&I topics contribute to generate the necessary expected impacts of the seven (7) intervention areas, namely: **Environmental Observation** (see 2.2.1.), **Biodiversity and Natural Capital** (see 2.2.2.), **Agriculture**, **Forestry**, and **Rural Areas** (see 2.2.3.), **Seas**, **Oceans**, and **Inland Waters** (see 2.2.4.), **Food Systems** (see 2.2.5.), **Bio-based Innovation Systems** (see 2.2.5.), and **Circular Systems** (see 2.2.6.). **Figure 2.3**. displays the distribution and TRL levels of Water Europe R&I topics across the seven intervention areas. Under Cluster 6, as displayed in **Figure 2.4**. Water Europe R&I topics address the ten (10) elements of the European Green Deal.

ENVIRONMENTAL OBSERVATION	5	13	2	5
BIODIVERSITY AND NATURAL CAPITAL	7	18	1	11
AGRICULTURE, FORESTRY, AND RURAL AREAS	3	3	5	25
SEAS, OCEANS, AND INLAND WATERS	2	8	1	1
FOOD SYSTEMS	2	5	4	13
BIO-BASED INNOVATION SYSTEMS	4	6	4	12
CIRCULAR SYSTEMS	3	7	1	7
CROSS-SECTIONAL	6	15	6	18

Figure 2.3. Distribution and TRL levels of Water Europe R&I Topics across Intervention Areas

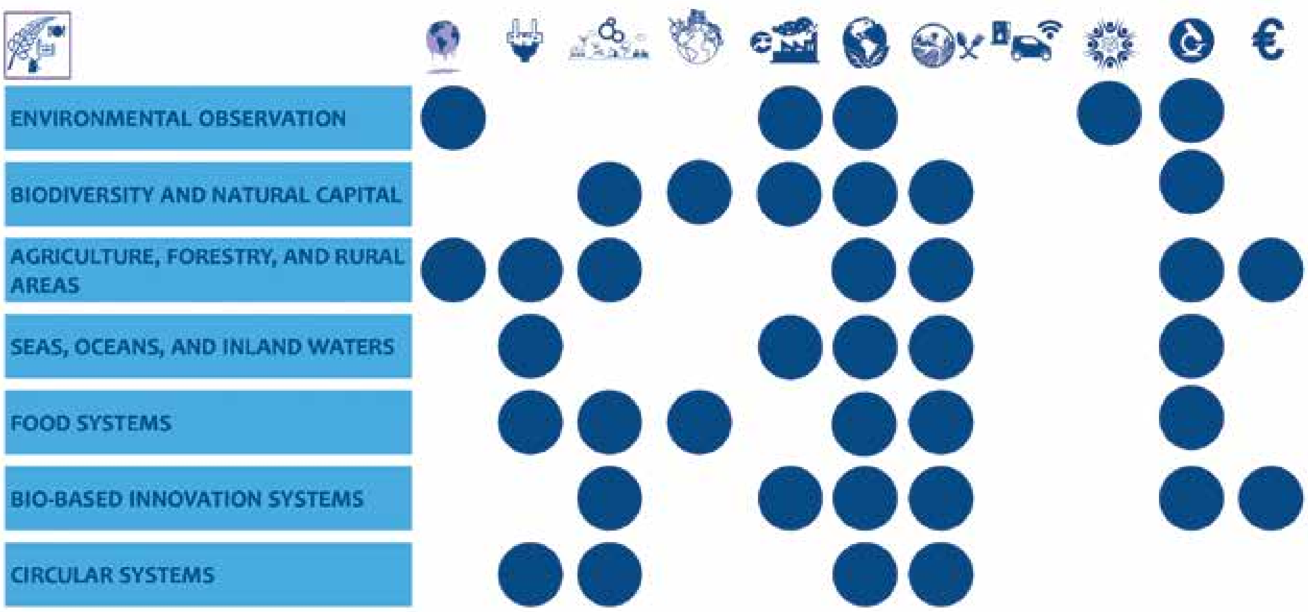


Figure 2.4. Distribution of Water Europe R&I Topics across Intervention Areas of Cluster 6 and the elements of the European Green Deal.

2.2.1. Intervention area: environmental observation

Coupled with **Future Internet** tools and services, **Environmental (earth) observation systems** and **activities** on **land** and **sea** and in the **atmosphere,** largely driven by a number of programmatic, multilateral initiatives and products in EU – **GEO, GEOSS, EuroGEOSS, Copernicus** –, provide forecasting enablers and application technologies for the tangible and systematic collection of **environmental observation data**, while supporting **community-centred biodiversity data** collection and facilitating the implementation of **Climate-Smart Agriculture** in full compliance with **CAP requirements ((EU)2018/746)** and **efficient use of natural resources.** Nevertheless, ecosystems are complex systems, which are not easily defined by a set of specific data types. Therefore, ecosystem data posit **infrastructural, institutional, and computational bottlenecks**, limiting not only the standardisation and usability of **(big) environmental data** but also the programmatic development of **shared, virtual environmental research sharing platforms**. Addressing these bottlenecks by promoting **open science and innovation practices** could bring **multiple societal, ecological, and economic benefits**: improved understanding of **aquatic ecosystem processes, multiple water ecosystems, water safety threats, and biogeochemical cycles affecting water resources; increased efficacy in water saving and wastewater detection; enhanced transparency related to the health and quality of water; optimised environmental compliance capacity of industries; increased efficiency in climate technology transfer, among others**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.2.1. in Annex 3

ADVANCE ENVIRONMENTAL OBSERVATION TECHNOLOGY AND RESEARCH FOR IMPROVING KNOWLEDGE BASE OF CLIMATE SCIENCE AND RESEARCH.

- Environmental Internet of Things (IoT) Ecosystem for a Water-Smart Society.
- Pollution sensing solutions for increasing integrity and resilience in ecosystem services.
- Big (environmental) data analytics and knowledge base.

ENSURE BETTER ACCESS TO EXISTING GROUND ENVIRONMENTAL INFORMATION THROUGH EUROPEAN AND GLOBAL OBSERVATORIES.

- Open Science Practices in Environmental Earth Observation and Climate Technology Transfer.
- Skills Training Programmes in support of improving Climate Technology Transfer.

2.2.2. Intervention area: biodiversity and natural capital

Natural capital, including **biodiversity, productive land, water resources, forests**, is of key importance to the achievement of the **2030 Agenda** as well as the efficient realisation of the **EU's Biodiversity Objectives**. Given the fact that **water** is considered as a key **environmental challenge** cutting across several **sectorial policies** (e.g. Water Framework Directive, Flood Directive, Nature Directives, Marine Strategic Framework Directive), for restoring **aquatic biodiversity** and improving **ecosystem conditions** of water bodies, there has been significant achievements in the development of **regulating ecosystem services** (e.g. water filtration, flood control, soil retention, recreation), **blue and green infrastructure approaches, biodiversity monitoring networks**, and **natural assets accounting mechanisms and standardisation** of sampling and analysis procedures in the context of the **Water Framework Directive (WFD)**. Nevertheless, according to the European Environment Agency (EEA)'s **2020 State of Environment Report (SOER)**, **natural capital** is not yet been protected, conserved and enhanced, in line with the Europe's 7th EAP ambitions. Therefore, it is of significant importance to improve **biosphere integrity** by addressing **biodiversity challenges**, including **local watershed problems** (e.g. water scarcity, water security, groundwater exploitation, local risk problems of micropollutants) and mitigating the depletion and degradation of **natural assets**, via multi-actor, inclusive, and participatory research and innovation infrastructures (e.g. living labs) and collaboration research, development, and innovation projects targeting the challenges related to the regeneration and sustainable conservation of **natural assets**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.2.2. in Annex 3.

BETTER UNDERSTAND BIODIVERSITY AND ECOSYSTEM SERVICES VIA IN-SITU BIODIVERSITY RESEARCH.

- Multi-stakeholder, inclusive, participatory, ecosystem research and long-term ecosystem and biodiversity monitoring infrastructures, in support of regional ecosystem services providers.
- Water-oriented living labs.

ADDRESS DRIVERS OF BIODIVERSITY LOSS.

- New sustainable, alternative water harvesting methods for ecosystem conservation.
- New technological solutions and modeling systems in support of addressing over-exploitation.
- Innovations in nanotechnology for water and wastewater treatment applications to improve biosphere integrity.
- Improved sustainability and flow of ecosystem goods and services through the restoration of ecosystem capital.

SUPPORT THE DEVELOPMENT OF NATURAL CAPITAL TO MONITOR DYNAMICS OF DRIVERS OF CHANGE.

- Integration of methods and frameworks for natural capital to monitor dynamics of drivers of change.

BETTER UNDERSTAND LINKS BETWEEN POLLUTANTS, HUMAN HEALTH, AND ECOSYSTEMS.

- Better understand micro-pollutants and emerging pollutants in water for closing the gap in the knowledge of environmental behavior and ecotoxicological features of chemical compounds.

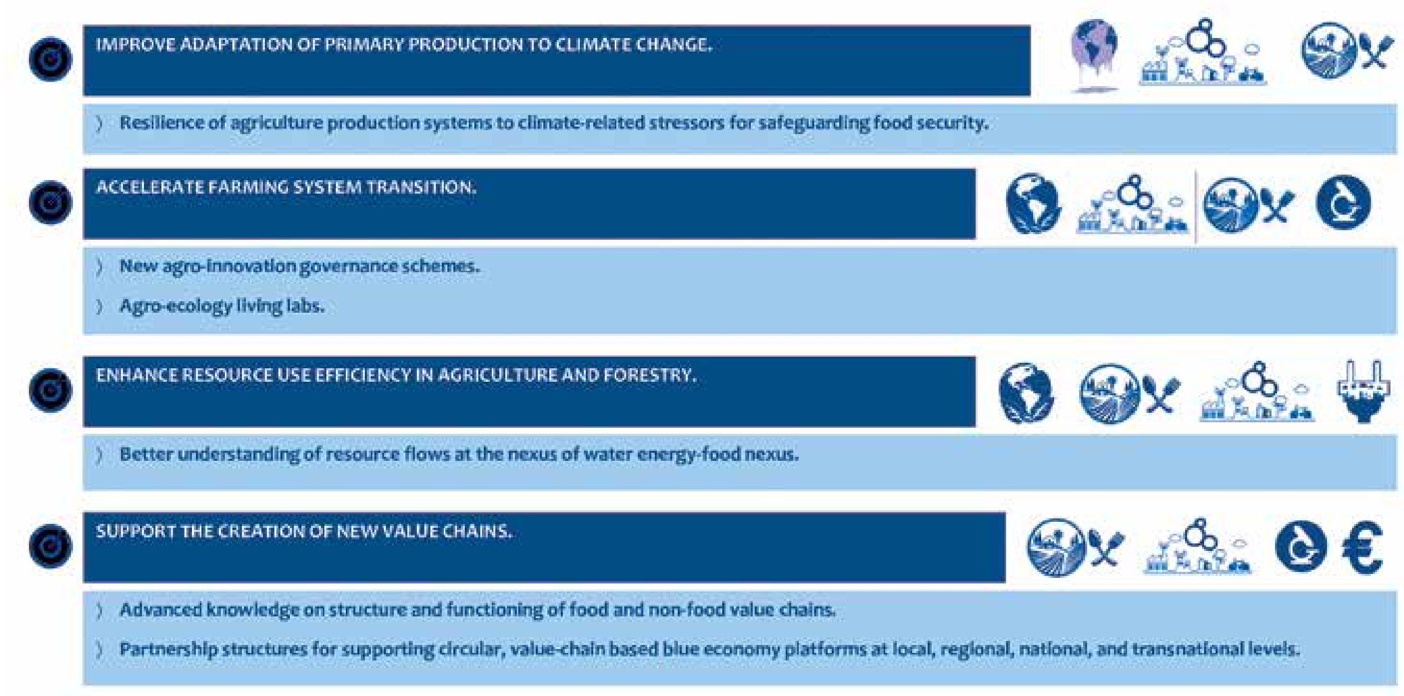
DEVELOP NATURE-BASED SOLUTIONS TO REDUCE POLLUTION AND DEGRADED SYSTEMS.

- Sustainable development and retrofitting of green infrastructures and nature-based solutions to safeguard the environment and mitigate the impacts of climate change-related natural hazards.

2.2.3. Intervention area: agriculture, forestry and rural areas

Considering the EU's low performance against the **SDGs**, particularly **SDG2** and **SDGs 12-15**, in the context of the **European Green Deal**, there are areas of improvements to be considered, particularly when it comes to the **sustainability** and **building blocks** (e.g. sustainable food systems, land use, and oceans) of Europe's **agricultural development model** as well as the development of **integrated strategies** for **productive, efficient, and resilient agriculture and biodiversity restoration**. This is of particular importance for all EU member-states to fuel innovation-led agricultural growth and improve preservation conditions of biophysical ecosystem services in cultivated habitats. Water-efficient **Agricultural Innovation Systems** (AIS) are of crucial importance to cultivate resource-efficient, closed-loop, and climate-smart agro-production and farm management practices. Coupled with open innovation research infrastructures, such as **agro-ecology living labs**, **low-cost, innovative, and digital ICT applications** could contribute greatly to the reorganization of agricultural production systems at the watershed and landscape levels and the development of symbiotic resources management frameworks in cross-sectorial settings

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.2.3. in Annex 3.



2.2.4. Intervention area: seas, oceans, and inland waters

As outlined in the European Commission's **Roadmap to the EU Biodiversity Strategy to 2030** (Ref.Ares(2019)7908307), **biophysical and anthropogenic changes** in land and sea use, such as **ocean acidification, deoxygenation, pollution, sea level, stratification, turbidity,** and **resource scarcity**, constitute some of the main direct drivers of **aquatic biodiversity loss.** According to the European Environment Agency's (EEA) 202o **European Environment State and Outlook Report, 65% of protected seabed habitats** are in unfavourable conservation conditions and **8 million tonnes of plastic waste** ends up in the oceans. As per another EEA assessment titled **'Contaminants in Europe's seas' (2019**), between **75%** and **96%** of Europe's regional seas have a **contamination** problem. Given the evidenced magnitude of **environmental** challenges in **marine** and **coastal environments**, it is of importance to align **policy areas**, e.g. chemicals, eco-design, water use with circular economy and blue growth goals. European research priorities could further contribute to the resilience of **marine capital** at ecosystem and landscape levels, addressing biodiversity challenges (e.g. **groundwater overexploitation, coastal hazards, micropollutants**), and developing new trajectories for **marine renewable energy.**

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.2.4. in Annex 3.

INCREASE INTEGRITY AND RESILIENCE IN MARINE AND COASTAL ENVIRONMENTS.

- Sustainable exploitation of marine ecosystems.

IMPROVE ANALYTICAL TOOLS TO ADDRESS EFFECTS OF CHEMICAL STRESSORS, EMERGING POLLUTANTS.

- Better understanding of micro-pollutants and emerging pollutants in water for closing the gap in the knowledge of environmental behavior and ecotoxicological features of chemical compounds.

2.2.5. Intervention area: food systems

Considering the fact that the **agricultural land** constitutes **48%** of the EU's total land (Rega et al., 2020), **agro-ecological, circular**, and **innovative value chain approaches** and **resource efficiency measures** that are implemented in **local** and **regional contexts** are important for decreasing environmental footprint of **agri-food systems**, tackling implications of climate change for **agricultural productivity** (e.g. diffuse pollution), enhancing food and **nutrition security**, and fostering **sustainable practices** across EU sectorial policies (e.g. agriculture, energy, transport). As highlighted in the President-elect Von der Leyen's political guidelines, such as **'Farm to Fork Strategy'** and 'a **Just Transition for All**', transition to a **Europe-wide** sustainable food system requires the identification of interactions and systems challenges within whole food value chains, analysis of intervention and leverage points, development of **resource-efficient** process intensification approaches**, and testing and scaling of novel eco-innovative technologies** accelerating transformation in food systems and foodsheds, particularly in urban agro-production sites and rural farm settings. Furthermore, such efforts could be complemented by other measures, such as alternative resources planning approaches, farming practices, **agro-ecosystem interventions**, community partnerships, and **agro-governance innovations** addressing institutional barriers to water integrity and food security and leveraging synergies at all levels: **grassland, cropland, livestock.**

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.2.5. in Annex 3

DEVELOP BETTER UNDERSTANDING OF THE FOOD SYSTEMS SUSTAINABILITY.

- Better understanding of resource flows at the nexus of water-energy-food nexus.

IMPROVE RESOURCE EFFICIENCY AND CIRCULARITY BY ADDRESSING ENVIRONMENTAL PRESSURES IMPACTING ON THE FOOD SYSTEMS.

- Resource-efficient use of water in urban-food systems.
- Resource-efficient use of water in agro-food systems.

IMPROVE THE CLIMATE RESILIENCE OF FOOD SYSTEMS INFRASTRUCTURE.

- Institutional capacity-building for climate-resilient development of food systems in urban, peri-urban, and rural contexts.
- Incorporation of climate change adaptation in food systems infrastructure in urban, peri-urban, and rural contexts.

2.2.6. Intervention area: bio-based innovation systems

As highlighted in the EC reflection paper **"Towards a sustainable Europe by 2030"**, bioeconomy contributes to the balancing of **economic, social**, and **environmental objectives** during SDGs fulfilment. Therefore, improvement of **ecosystem integrity** via **scientifically informed resources management practices** at the water-food-energy-waste nexus, decoupling of **economic growth** and **biological resources** use for **ensuring food security**, **ecosystems productivity**, and **local deployment of zero-carbon bioeconomies** within safe ecological limits, can serve to the improvement and **restoration of biodiversity**, s**upporting ecosystem services**, and **natural capital and the future-proofing of inclusive, nutrition-sensitive, sustainable, resilient, and circular bio-based innovation solutions**. New empirical research and innovation avenues and cross-sectorial pilot applications could be further developed for the identification of **bio-compatible business models** (e.g. closed-loop, circular, eco-centric manufacturing), **decreasing of watershed vulnerabilities** (e.g. local water integrity, water scarcity), **recovery**, **reuse**, and (symbiotic and circular) valorisation of scarce resources at the **Water-Energy-Food (WEF) nexus**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.2.6. in Annex 3.

SUPPORT THE ESTABLISHMENT OF NEW BIO-BASED VALUE CHAINS VIA ECOSYSTEMS INTEGRITY.

- Industrial symbiosis for integration of biological resources into models of circular economy.

SUPPORT THE ADVANCEMENT OF RESILIENT AND SUSTAINABLE BIOMASS PRODUCTION SYSTEMS.

- Novel irrigation technologies for climate-resilient crops.
- Advanced climate-smart environmental technologies for resource recovery and reuse and lowering toxicity on the agri-food environment.
- Technologies to optimize the water potential of the consumable feedstock.

2.2.7. Intervention area: circular systems

Development and piloting of **regenerative circular systems** that are integrated well with **new technologies, business models, locally-bounded lifecycles, and system visions**, and that balance **resource flows**, could serve to tackle **resource** and **system challenges** (e.g. material consumption, nutritient losses, waste of products and materials, urbanisation, loss of health and quality of life, system impact of emissions), introduce alternative resource models, **resource benefits and circular business opportunities at scale**. As the **circular economy** encompasses various levels, ranging from product component to cities, **industrial symbiosis contribute** to the achievement of circular economy targets at the **inter-industrial level**; **whereas**, **circular model architectures** for natural resource flows (e.g. water) and decentralised/distributed eco-**technologies optimise circular** and sustainable use of natural resources at the desired **spatial scale and between urban, rural and industry within a watershed**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.2.7. in Annex 3.

OPTIMIZE CIRCULAR AND SUSTAINABLE USE OF NATURAL RESOURCES.

- Sustainable and circular use of water resources for all purposes.

DEVELOP CIRCULAR BUSINESS MODELS AND PRODUCTION PATTERNS.

- Industrial symbiosis.

2.3. Digital, industry and space (cluster 4)

Given the objectives and expected impacts of the intervention areas of the **Cluster 4 'Digital**, **Industry and Space'**, Water Europe R&I topics contribute to generate the necessary expected impacts of the ten (10) intervention areas, namely: **Manufacturing Technologies** (see 2.3.1.), **Key Digital Technologies** (see 2.3.2.), **Advanced Materials** (see 2.3.3.), **Emerging Enabling Technologies** (see 2.3.4.), **AI and Robotics** (see 2.3.5.), **Next Generation Internet** (see 2.3.6.), **Advanced Computing and Big Data** (see 2.3.7.), **Space including Earth Observations** (see 2.3.8.), **Circular Industries** (see 2.3.9.), and **Low-Carbon and Clean Industries** (see 2.3.10.). **Figure 2.5.** displays the distribution and TRL levels of Water Europe R&I topics across the ten intervention areas. Under Cluster 4, as displayed in **Figure 2.6.** Water Europe R&I topics address the nine (9) elements of the European Green Deal.

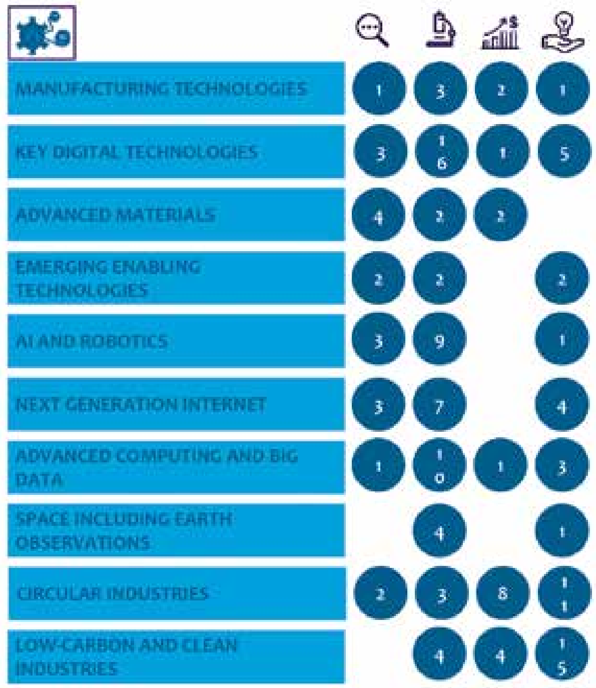


Figure 2.5. Distribution and TRL levels of Water Europe R&I Topics across Intervention Areas

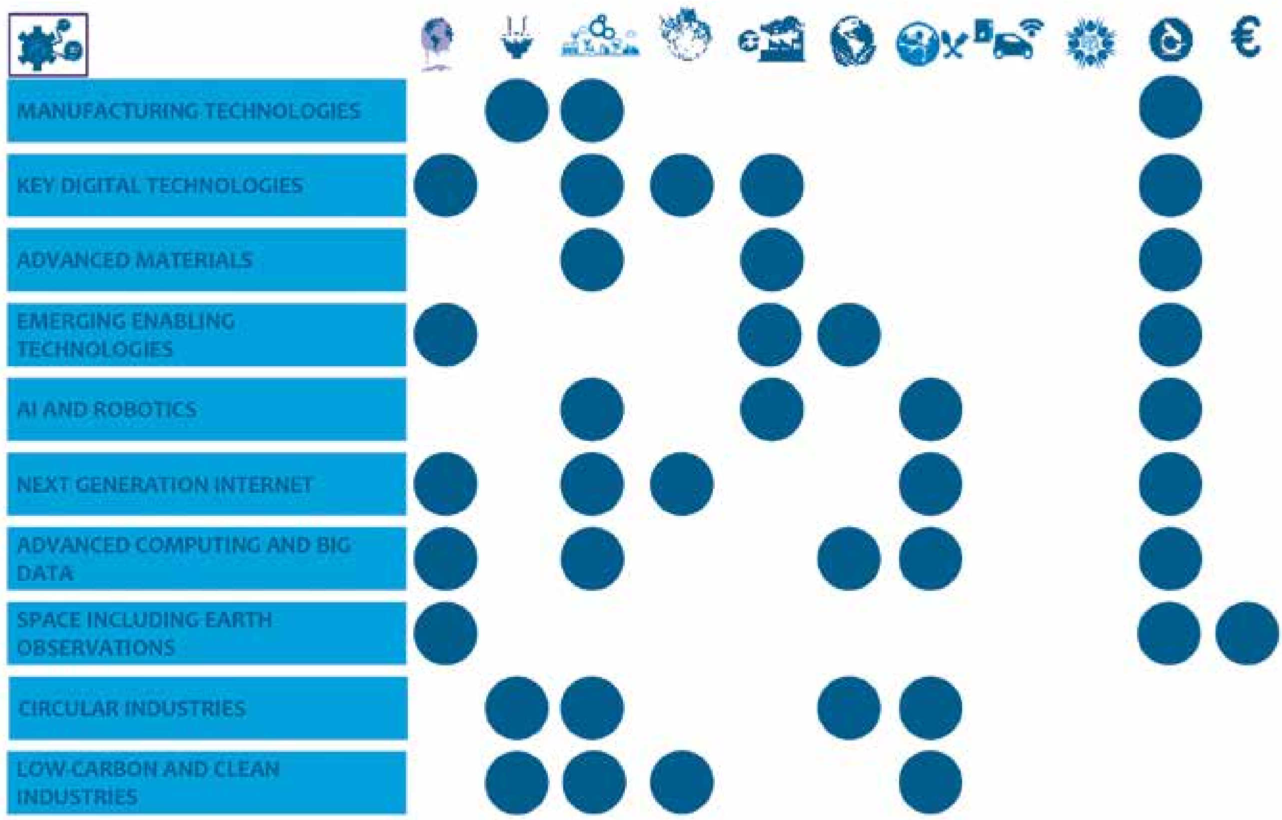


Figure 2.6. Distribution of Water Europe R&I Topics across Intervention Areas of Cluster 4 and the elements of the European Green Deal

2.3.1. Intervention area: manufacturing technologies

Cross-linkages of **biology**, **manufacturing**, and **information technologies** in **industrial manufacturing activities** are changing **industrial value creation processes**, leading to **symbiotic biology-technology interface design**, **implementation of industrial systems** architectures and **systematic applications** of nature and **natural processes** for optimising **industrial manufacturing processes**. Further innovation avenues could be developed in order to enhance **resource circularity** within value chains and diversify the applications of **Nature Based Solutions** at the **water-energy nexus**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.1. in Annex 3.

CAPITALISE ON THE DIGITAL TECHNOLOGIES TO DEVELOP BIO-INTEGRATED MANUFACTURING ECOSYSTEMS.

- Nature-inspired technologies for water applications at the water-energy nexus.

2.3.2. Intervention area: key digital technologies

In the context of the **Digital Europe program**, proposed by the Commission, capacity development and deployment of digital capacities within the EU is of importance for leading Europe effectively and systematically on the twin transition pathway to a **green** and **digital** economy. Design and deployment of **key digital technologies** (e.g. connectivity, big data, cloud computing, artificial intelligence) and **industry 4.0 applications** in the context of **climate change monitoring**, mitigation, and **adaptation** activities brings **efficiency gains** to climate actions, such as reduced **energy demands**, enhanced **disaster management processes**, **improved analysis**, **modelling**, and use of **environmental data**; addressing **climate-related challenges**, such as **food security**, **water security** and supply in various **water environments** (e.g. sedimentary systems, saline environments); **enhancing the identification and characterization of hygienic** (growth of pathogens), **aesthetics** (taste and odour), and **operational** (corrosion and discoloration) problems in **water distribution** networks and other **engineered water systems**; and, **enhancing data-driven operational** performance efficiency and **predictive forecasting capacity** in the **water industry**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.2. in Annex 3.

DEVELOP NEW COMPUTING AND PROGRAMMING CONCEPTS FOR CLIMATE-WATER SOLUTIONS.

- Advanced modeling and simulation systems for developing better understanding of micro-pollutants and emerging pollutants in water resources.
- Further development of (environmental) big data research methods, computational modeling systems, and predictive analytics for optimizing decision-support systems in Integrated Water Resources Management.
- Timely, accurate, multi-objective forecasting systems in climate hydrology.
- Assessment of long-term environmental sustainability of water-related critical infrastructures.

2.3.3. Intervention area: advanced materials

When reinforcing Europe's **sustainable industrial capabilities** and **manufacturing capacities**, **environmentally friendly**, **advanced materials technologies** enable **supply-side benefits**, such as **materials quality**, **materials efficiency**, and **eco-efficiency gains**, within **industrial ecosystems** and at the nexus of **Water-Energy-Waste (WEW) systems**. For the **water** and **wastewater technology applications**, **boosting research** on the **production techniques**, **properties**, **applications**, and **ecotoxicity impacts** of **advanced nanomaterials** is of crucial importance to **provide fit-for-purpose solutions**, **particularly** to the **production**, **public health**, and **ecosystem resilience challenges of climate change**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.3. in Annex 3

SUPPORT THE DEVELOPMENTS OF ADVANCED MATERIALS FOR WATER AND WASTEWATER SOLUTIONS.

- Membrane processes for water and wastewater technology applications.
- Advanced nanomaterials for water and wastewater technology applications.

2.3.4. Intervention area: emerging enabling technologies

The **systems design**, **deployment**, and **integration of emerging enabling technologies** in **cost-effective climate monitoring technologies, such as** (environmental) pollution sensing with **embedded data pre-processing**, **analysis**, and **smart sensor systems**, could enhance evidence-based decision-making when it comes to **global societal problems**, such as **climate change**. With the objective of diversifying **commercial applications of emerging technologies** and realizing **chemical-free water** and **wastewater treatment processes**, scientific and industrial research on the **robustness**, **biocompatibility**, **durability**, **effectivity**, **toxicity, bactericidal effects** and **commercial scalability** of **emerging nanotechnologies** could be further advanced.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.4. in Annex 3

FACILITATE THE EARLY DEVELOPMENT OF WATER TECHNOLOGIES FOR HEALTHIER SYSTEM GOVERNANCE AND WITHIN THE SAFE OPERATING SPACE OF PLANETARY BOUNDARIES

- Emerging enabling technologies in support of lowering toxicological impacts of micro-pollutants on water resources and biodiversity.

2.3.5. Intervention area: AI and robotics

Applications of Artificial Intelligence (AI), Precision Monitoring methods and **Robotics technologies** address various dimensions of **climate challenges**, such as **clean energy**, **smart cities and home**, **sustainable land-use**, and **sustainable production** and **consumption** and **optimise operational** management process of **habitats and resources** (e.g. distribution of off-grid water resources). Given the increasing **data generation capacity** of the **water industry** and expanding portfolio **of Industry 4.0 applications** for **water resources** management purposes, research avenues related to the add-values of **decision intelligence frameworks**, **intelligent control mechanisms**, **environmental asset monitoring**, and **hazard prediction** could be further advanced and expanded.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.5. in Annex 3.

IMPROVE HARDWARE, ALGORITHMS, AND APPLIED RESEARCH FOR WATER APPLICATIONS NEEDS.

- Further development of (environmental) big data research methods, computational modeling systems, and predictive analytics for optimizing decision-support systems in integrated water resources management.
- Pollution sensing solutions for increasing integrity and resilience in ecosystem services.

2.3.6. Intervention area: next generation internet

Coupled with **Artificial Intelligence** and other **Industrial Revolution 4.0 technologies**, such as the **Internet of Things (IoT)**, **smart connectivity and services**, **Next Generation Internet**, optimise **demand forecasting** in **natural resources management**; monitor and maximize **natural resources management practices**; and, improve coordinated development and global use of unstructured climate-related data through distributed, virtual centres and **knowledge networks.** For progressing towards a **Water-Smart Society**, **Next-Generation Internet**, grounded in the circular economy principle of water, could leverage various dedicated **ICT applications** and **connectivity solutions** for solving various **water management bottlenecks**, both in terms of **water safety** and **security**, such as **water saving efficiency**, transparency related to the health and **quality of water**, or **seamless secure integration** of **cyber-physical systems** within the **water networks.**

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.7. in Annex 3.

DEVELOP KEY TECHNOLOGY BUILDING BLOCKS AND INFRASTRUCTURE FOR THE (ENVIRONMENTAL) INTERNET OF THINGS.

- **Environmental Internet of Things Ecosystem for a Water-Smart Society.**

DEVELOP CONNECTIVITY SOLUTIONS FOR CLIMATE-SMART, INTEGRATED WATER RESOURCES MANAGEMENT.

- **Development of adaptive, climate-smart, resilient, and circular water networks systems powered by the ICT solutions.**

2.3.7. Intervention area: advanced computing and big data

In **environmental science,** the collection, seamless storage, on-demand analysis, and re-use of **large-volume**, **high-velocity**, **unstructured**, **observational spatial** and **environmental data streams** require **advanced computing technologies and specialized**, **big data** analysis **systems** and **methods** (e.g. machine learning). Running **spatial** and **environmental data governance pipeline** in **supercomputing environments** or **open science cloud environments** could optimise the **accessibility** and **usability** of on-demand data analysis services by introducing **distributed models for environmental data transfer** and **management** for **various end-users** (e.g. public authorities, private sector, citizens); **alleviate societal** and **economic costs associated** with **climate-related hazards**; and, be **instrumental** when exploiting the **value of data for critical** and **scarce natural resources**, such as **water**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.7. in Annex 3.

IMPROVE COMPUTATIONAL CAPABILITIES IN EARTH OBSERVATION SYSTEMS AND ENVIRONMENTAL SCIENCE.

- Big (environmental) data analytics and knowledge base.
- Further development of (environmental) big data research methods, computational modeling systems, and predictive analytics for optimizing decision-support systems in Integrated Water Resources Management.
- Software-based sustainability management tools for better natural capital monitoring and assessment.

2.3.8. Intervention area: space including earth observation

Today, **earth observation systems** encompass various **services** for information processing and **in situ environmental monitoring tools**, such as **unmanned airborne observing platforms, sensor web modelling**. Given the differences in upstream and downstream market organization of Earth Observation Systems, deployment of an **integrated computational environment**, leveraging on **advanced computation technologies** (e.g. High Processing Computing, Cloud Computing, and Grid Computing) and **IoT**, is needed for analysing georeferenced, environmental big data streams; developing **community-driven, open access, end-to-end data infrastructures**; and, better identifying the **societal value** and benefits of **earth observation systems**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.8. in Annex 3.

PROMOTE SYNERGIES WITH NON-SPACE SECTORS AND DOWNSTREAM EXPLOITATION.

- Public and private decision support-systems for supporting cross-scale integration of climate-water measures and ecosystem services.

2.3.9. Intervention area: circular industries

In the course of a successful transition towards **decarbonised**, **inclusive**, **regenerative** and more **circular value creation** in **European industries**, **systemic**, **symbiotic** and **cross-sectorial solutions,** building on the improved understanding of the **societal**, **environmental**, and **economic value of resources**, should facilitate the transfer and development of **expertise**, **best practices**, **cooperation models**, **technologies**, and **business models** for enhancing further **circular industrial systems**, **resource efficiency**, **industrial sustainability**. In this regard, advancing the understanding on the socio-material connectedness between multiple environmental resources, connectivity of resource flows, and infrastructure operations of resource provisioning is of importance to develop **nexus programs, cross-sectorial trade-offs, and deployment of resource steering and recovery strategies** (e.g. internal recycling and cascading use of process water for increasing industrial water productivity).

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.8. in Annex 3.

ADVANCE SOLUTIONS AND CONDITIONS FOR THE SUSTAINABLE EXPLORATION, EXPLOITATION, EXTRACTION, AND PROCESSING OF WATER RESOURCES IN INDUSTRIAL SYMBIOSIS SETTINGS.

- Advanced knowledge on structure and functioning of food and non-food value chains.
- Better understanding of resource flows at the nexus of water-energy-food nexus.
- Sustainable exploitation of water resources for industrial applications.
- Facilitated and coordinated development and market uptake of sustainable, circular, bio-based processes and products in the European blue economy.

2.3.10. Intervention area: low-carbon and clean industries

For a **just transition to circular economy** and achieving the **zero Greenhouse Gas (GHG) emission objective by 2050**, **environmental sustainability** and **climate performance** of European industries, particularly those with **carbon-intensive production processes** and assets, need to be improved, with the development, deployment, and scale-up of low-carbon industrial processes and **cross-sectorial partnership models** that bring efficiency gains to **industry-resource linkages** and with the integration of bio-intelligent production technologies within existing industrial infrastructures for producing **eco-efficient, circular products with lower carbon content and high circularity**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.3.10. in Annex 3.

SUPPORT COORINDATED INNOVATIONS AND INVESTMENTS IN CLEAN ENERGY SYSTEMS.

- Renewable energy production from water sources for low-carbon energy supply, with a joint management of water and energy resources.
- Advancing the technological readiness of sustainability technologies at the water-energy nexus.
- Improved industrial sustainability performance for carbon-neutral and competitive European industry at the water-energy nexus.
- Partnership structures for supporting circular, value-chain based blue economy platforms at local, regional, national, and transnational levels.

2.4. Health (cluster 1)

Given the objectives and expected impacts of the intervention areas of the **Cluster 1 'Health'**, Water Europe R&I topics contribute to generate the necessary expected impacts of the intervention area **'Living and Working in a Health-Promoting Environment'** (see 2.4.1). **Figure 2.7.** displays the distribution and TRL levels of Water Europe R&I topics.

Figure 2.7. Distribution and TRL levels of Water Europe R&I Topics across Intervention Areas

Under Cluster 1, as displayed in **Figure 2.8**. Water Europe R&I topics address the three (3) elements of the European Green Deal.

Figure 2.8. Distribution of Water Europe R&I Topics across Intervention Areas of Cluster 1 and the elements of the European Green Deal

2.4.1. Intervention area: living and working in a health-promoting environment

According to the WHO's Report titled **'Environmental Health Inequalities in Europe'** (2019), environmental risk factors account for at least **15%** of mortality in the WHO European Region, equivalent to approximately **1.4 million** deaths per year. Given the magnitude of health inequalities, the **Cancer Plan**, by introducing a **transversal "health in all policies" approach** in close integration with other Commission's policy priorities and guidelines, such as the **Farm to Fork, Zero Pollution strategy, and the European Health Data Space**, plans to address **social distribution dynamics of environmental risks, health inequalities, inequalities related to urban environments, such as exposure to environmental risks**, lack of access to **basic drinking water** and **sanitation services**, in a holistic and systemic manner. Given these recent developments in the realms of health policy domain, it is of importance to: (i) develop an evidence-driven, scientifically-informed knowledge base of **integrated exposure to chemicals** or to contaminated sites and **inequalities in environmental risks** at national level; (ii) optimise data collection systems and methods for identifying social distribution of **environmental risks** across sub-groups of societies and across different spatial scales; and, (iii) develop environmental data monitoring, collection, integration and analysis for improving climate-related assessments and eradicating public health effects of climate change.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.4.1. in Annex 3.

IMPROVE RESILIENCE TO CLIMATE-CHANGE RELATED HEALTH RISK FACTORS BY BETTER CHARACTERIZATION OF ENVIRONMENTAL RISK FACTORS.

- Collection, combination, and analysis of environmental risk-related data.
- Identification and characterization of emerging and persistent environmental and climate-change related stressors.

2.5. Civil security for society (cluster 3)

Given the objectives and expected impacts of the intervention areas of the **Cluster 3 'Civil Security for Society',** Water Europe R&I topics contribute to generate the necessary expected impacts of the intervention area **'Disaster-Resilient Societies'** (see 2.5.1). **Figure 2.9**. displays the distribution and TRL levels of Water Europe R&I topics.

Figure 2.9. Distribution and TRL levels of Water Europe R&I Topics across Intervention Areas

Under Cluster 3, as displayed in **Figure2.10**. Water Europe R&I topics address the five (5) elements of the European Green Deal.

Figure 2.10. Distribution of Water Europe R&I Topics across Intervention Areas of Cluster 3 and the elements of the European Green Deal

2.5.1. Intervention area: disaster-resilient societies

Climate change, transboundary phenomenon in nature, affects, directly or indirectly, **various dimensions of human security** (e.g. water security, food security, public health, livelihoods) by increasing situations of **acute insecurity** (e.g. famine, migration), reducing **human capabilities**, and exacerbating the deprivation of **basic needs** and **local livelihood assets.** From **1980** to **2016**, the European Union allocated **EUR 410 billion** for damages derived from **natural disasters** (European Commission, 2018), while some financial instruments, such as the **EU Solidarity Fund** and the **LIFE fund**, position **disaster resilience research and innovation** at the nexus of **climate adaptation**, **risk prevention**, and **mitigation**. In **Europe**, **heat extremes**, **droughts**, **forest fires**, **floods**, **river** and **coastal flooding**, **temperature rise**, **species extinction**, and **heavy rainfalls** constitute the major **climate vulnerabilities**. Across all **spatial scales** and **stages** of **Disaster Risk Management cycle**, **science-based services**, **innovative tools**, **technological solutions**, and **scientifically informed**, **operational partnership**s could serve to **optimise systemic information** flow across stakeholders; improve the effectiveness of **prevention**, **mitigation**, and **response activities**; and, develop **risk-informed policy approaches** towards **natural disasters** and their **associated costs**.

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.5.1. in Annex 3.

IMPROVE THE UNDERSTANDING OF ENVIRONMENTAL RISK FACTORS, RESILIENCE TO CLIMATE-CHANGE RELATED HEALTH RISK FACTORS FOR HEALTH AND WELL-BEING.

- Flexible adaptation to climate change impacts with innovative governance schemes.
- Science-to-practice knowledge exchange in the fields of sustainable climate risk management.
- Use of sustainable, cost-effective, and inclusive nature-based solutions.

2.6. Culture, creativity and inclusive society (cluster 2)

Given the objectives and expected impacts of the intervention areas of the **Cluster 2 'Culture, Creativity and Inclusive Society'**, Water Europe R&I topics contribute to generate the necessary expected impacts of the intervention area **'Management of Social and Economic Transformations'** (see 2.6.1). **Figure 2.11**. displays the distribution and TRL levels of Water Europe R&I topics

Figure 2.11. Distribution and TRL levels of Water Europe R&I Topics across Intervention AreasAreas

Under Cluster 2, as displayed in **Figure 2.12**. Water Europe R&I topics address the seven (7) elements of the European Green Deal.

Figure 2.12. Distribution of Water Europe R&I Topics across Intervention Areas of Cluster 2 and the elements of the European Green Deal

2.6.1. Intervention area: management of social and economic transformations

Considering the cross-cutting ambitions of the transformational **EU policy domains** (e.g. circular economy, bio-economy, and blue growth) and of the **global 2030 Agenda**, management of **social and economic transformations** requires **participatory**, **dialogue-based**, **evolutionary**, and **multi-disciplinary approaches** towards **systems reconfigurations** and **systems solutions** within an enabling policy and governance context as well as diversification of **knowledge-driven**, **community-centred entrepreneurship activities**, **particularly** to secure **socially**, **economically**, and **environmentally sustainable futures**. In this regard, for increasing the s**ocio-economic embeddedness** of **circular economy applications**, **social learning mechanisms** could be factored into **circular economic interventions**, **spatial planning** of **circular resources systems**, and **cross-sectorial circular governance systems**. Furthermore, the **regional development** of **resources synergies** for **industrial applications**, **supply chain integration** of **unused biomass**, and **piloting of nexus solutions** could provide various **co-benefits** for the **society** and **local biodiversity.**

WATER RESEARCH, DEVELOPMENT, AND INNOVATION TRAJECTORIES
Please further consult section 2.6.1. in Annex 3.

ADVANCE ECONOMIC APPLICATIONS OF CIRCULAR ECONOMY FOR SUSTAINABLE RESOURCE MANAGEMENT IN INDUSTRIAL SYSTEMS.

- Design of food systems based on the principles of circular economy.
- Solutions supporting the regional development and integration of unused biomass (e.g. wastewater) for industrial applications.
- Circular governance systems across water cycles.
- Improved industrial sustainability performance for carbon-neutral and competitive European industry at the water-energy nexus.

RAISE AWARENESS ABOUT CIRCULAR ECONOMY PRACTICES IN BLUE ECONOMY.

- Enhanced social and institutional awareness towards the optimal, resource-efficient, and circular use of water resources in all sectors.

List of abbreviations

A	AI	Artificial Intelligence
	AIS	Agricultural Innovation System
B	bn	Billion
C	CAP	Common Agriculture Policy
	CEC	Contaminants of Emerging Concern
	CLIMATE-ADAPT	European Climate Adaptation Platform
	COVID-19	Coronavirus Disease 2019
	CSO	Civil Society Organisation
D	DSS	Decision-Support System
E	EAP	Environmental Action Plan
	EBRD	European Bank for Reconstruction and Development
	EC	European Commission
	EDF	European Development Fund
	EEA	European Economic Area
	EEA	European Environment Agency
	EIB	European Investment Bank
	ERDF	European Regional Development Fund
	ESIF	European Structural Investment Fund
	EU	European Union
	EuroGEOSS	Europe – Global Earth Observation System of Systems
F	FP7	Seventh Framework Programme
	FP	Framework Programme
G	GEO	Group on Earth Observations
	GEOSS	Global Earth Observation System of Systems
	GHG	Greenhouse Gas
H	H2020	Horizon 2020 Programme
	HGGI	Hybrid Grey-Green Infrastructure
I	ICT	Information Communication Technology
	INTERREG	European Territorial Cooperation
	IoT	Internet of Things
J	JRC	Joint Research Centre
K	KIC	Knowledge and Innovation Communities
L	LCIA	Lifecycle Inventory Analysis
	LIFE+	LIFE Plus programme
M	MS	Member State
	MW	Mega-Watt
N	NbS	Nature-based Solutions
	NCFF	Natural Capital Financing Facility
	NGO	Non-governmental Organisation
O	OECD	Organisation for Economic Cooperation and Development
P	P4P	Public-Private-People Partnership
R	RD&I	Research, Development, and Innovation
	REDII	Renewable Energy Directive
	RES	Renewable Energy Source
	R&I	Research and Innovation
S	S3	Smart Specialisation Strategy
	SDG	Sustainable Development Goal
	SIRA	Strategic Innovation and Research Agenda
	SOER	State of Environment Report
T	TRL	Technology Readiness Level
U	UWWTD	Urban Wastewater Treatment Directive
W	WEF	Water-Energy-Food
	WEFW	Water-Energy-Food-Waste
	WFD	Water Framework Directive
	WHO	World Health Organisation
	WoLL	Water-Oriented Living Labs

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Colophon

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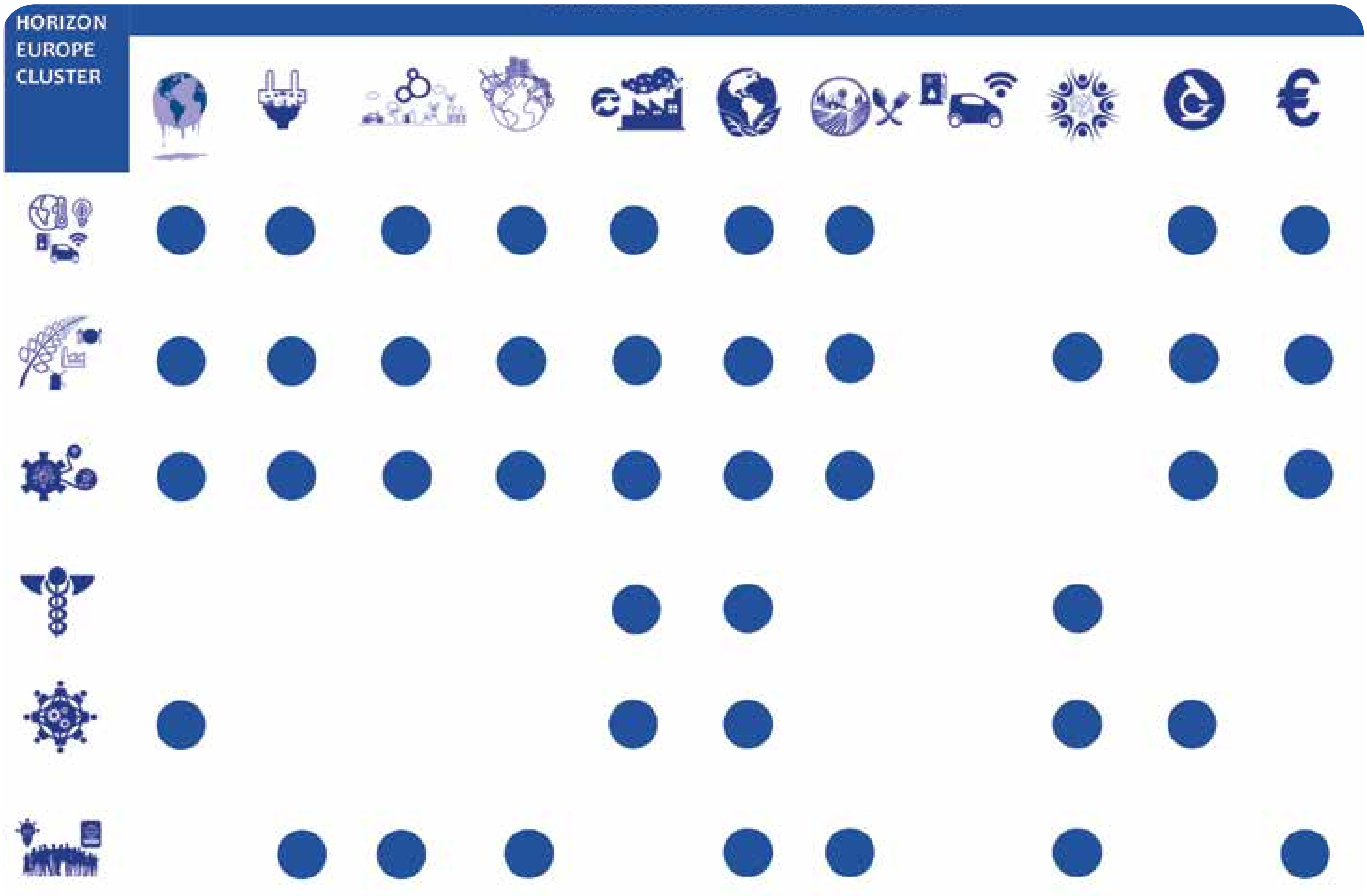


ANNEX 2. Consolidated list of water europe research and innovation topics

KEY COMPONENT	SUB-CHALLENGE	Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL
VALUE OF WATER	1.1. Towards new economic model for the value of water	1.1.1.	New water incentive pricing and pricing water security	Non-technical	All
		1.1.2.	Innovative economic mechanisms	Non-technical	All
		1.1.3.	Innovative business models for the water sector	Non-technical	All
	1.2. Towards multiple waters in a circular economy	1.2.1.	New diversification of water sources	Applied	TRL5-8
		1.2.2.	New cost-effective combinations of salty and brackish water, desalination and (natural) pre-treatment	Applied	TRL5-8
		1.2.3.	Develop structured and certified alternative water resources for irrigation	Applied	TRL5-8
		1.2.4.	New management tools and methodologies, partnerships and business models	Non-technical	All
		1.2.5.	Enlarging the Industrial symbiosis concept to agricultural sector	Non-technical	All
		1.2.6.	New tools to support industrial symbiosis	Applied	TRL5-8
		1.2.7.	Public-private industrial partnerships	Non-technical	All
		1.2.8.	Promotion and rationalisation of (quasi) Zero Liquid Discharge (ZLD) approaches in industrial applications	Close-to-market	TRL 6-9
		1.2.9.	New schemes of water reclamation	Close-to-market	TRL6-9
	1.3. Optimising the use of water in all sectors	1.3.1.	Optimal irrigation strategies	Close-to-market	TRL 6-9
		1.3.2.	Innovative smart irrigation systems	Close-to-market	TRL6-9
		1.3.3.	Agri-environmental measures	Non-technical	All
		1.3.4.	Validate and deploy new digital (ICT) solutions for sustainable agriculture	Close-to-market	TRL 6-9
		1.3.5.	Decoupling the rise of agricultural production from the use of water resources	Non-technical	All
		1.3.6.	Combining water and energy efficiency in the urban context, integrating this nexus with smart urban management and planning solutions	Non-technical	All
		1.3.7.	Increase awareness and improve perception (on direct and indirect reuse – as drinking water or recharge)	Non-technical	All
		1.3.8.	Urban-environmental measures	Non-technical	All
		1.3.9.	Watershed management problem solving	Non-technical	All
		1.3.10.	Smart digital water management systems in cities via nexus and circularity approaches	Non-technical	All
		1.3.11.	Urban/industrial symbiosis	Fundamental	TRL 3-5
		1.3.12.	Sustainable process water production by water recycling at various scales	Close-t0-market	TRL 6-9
		1.3.13.	New solutions for an increased upstream process integration	Close-to-market	TRL 6-9
		1.3.14.	Standardisation of materials, specifications and technical solutions	Non-technical	All
		1.3.15.	Integrated water management technologies	Close-to-market	TRL 6-9
		1.3.16.	Water-energy-waste nexus in industrial environments	Close-to-market	TRL 6-9
		1.3.17.	Development of methodologies and pilot applications of LCA for water	Non-technical	All

KEY COMPONENT	SUB-CHALLENGE	Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL
VALUE OF WATER	1.4. Creating new markets, valorising the value in water	1.4.1.	Nutritients, minerals, and metals	Close-to-market	TRL 6-9
		1.4.2.	Valorisation of industrial brines	Applied	TRL 5-8
		1.4.3.	Boosting the value of membrane and other separation technologies in water	Close-to-market	TRL 6-9
		1.4.4.	Pilots for new nano-membrane technologies applications for water purification and treatment	Close-to-market	TRL 6-9
		1.4.5.	Pilot systems and tools of nano-technologies applications to ensure clean water	Close-to-market	TRL 6-9
		1.4.6.	Promotion of new policy developments, new regulation and incentives	Non-technical	All
		1.4.7.	Fostering a level playing field for the EU water market	Non-technical	All
	1.5. Energy harvesting as integrated valorisation strategy of water	1.5.1.	New technologies for energy-efficient water treatment, including new decentralised systems	Applied	TRL 5-8
		1.5.2.	New energy-efficient measures in water-intensive industries	Applied	TRL 5-8
		1.5.3.	Water-energy nexus in energy sector	Applied	TRL 5-8
		1.5.4.	New ICT solutions for energy and water efficiency	Close-to-market	TRL 6-9
		1.5.5.	Increase energy production from water sources	Close-to-market	TRL 6-9
		1.5.6.	Reduction of energy losses	Close-to-market	TRL 6-9
		1.5.7.	Digital tools and systems for demand forecasting	Close-to-market	TRL 6-9
TECHNOLOGIES – ENABLING INSIGHT AND MANAGEABILITY	2.1. Digital enabling technologies for a water-smart society	2.1.1.	New sensors for detection and chemical measurement of pollutants	Close-to-market	TRL 6-9
		2.1.2.	Passive sampling techniques	Applied	TRL 5-8
		2.1.3.	Active sampling techniques	Close-to-market	TRL 6-9
		2.1.4.	New sensors for biological measurement of micro-organisms	Close-to-market	TRL 6-9
		2.1.5.	New sensors for protection, security and resilience	Close-to-market	TRL 6-9
		2.1.6.	Cost-effective sensors for large scale capillary deployment throughout the water network	Non-technical	All
		2.1.7.	Sensor systems and online monitoring tools for quality assurance of water sources in industrial processes	Non-technical	All
		2.1.8.	Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants	Applied	TRL 5-8
		2.1.9.	Forecasting	Applied	TRL 5-8
		2.1.10.	Improve (big) data collection, fusion, analysis, data-driven process-based models' development, and visualisation techniques	Applied	TRL 5-8 TRL 6-9
		2.1.11.	Advanced modelling, simulation, control and optimisation techniques	Close-to-market	TRL 6-9
		2.1.12.	Cloud computing and real-time monitoring	Close-to-market	
		2.1.13.	High-performance computing systems and applications development	Close-to-market	TRL 6-9
		2.1.14.	Data and metadata standardisation, data security, interoperability, protection and privacy	Close-to-market	TRL 6-9

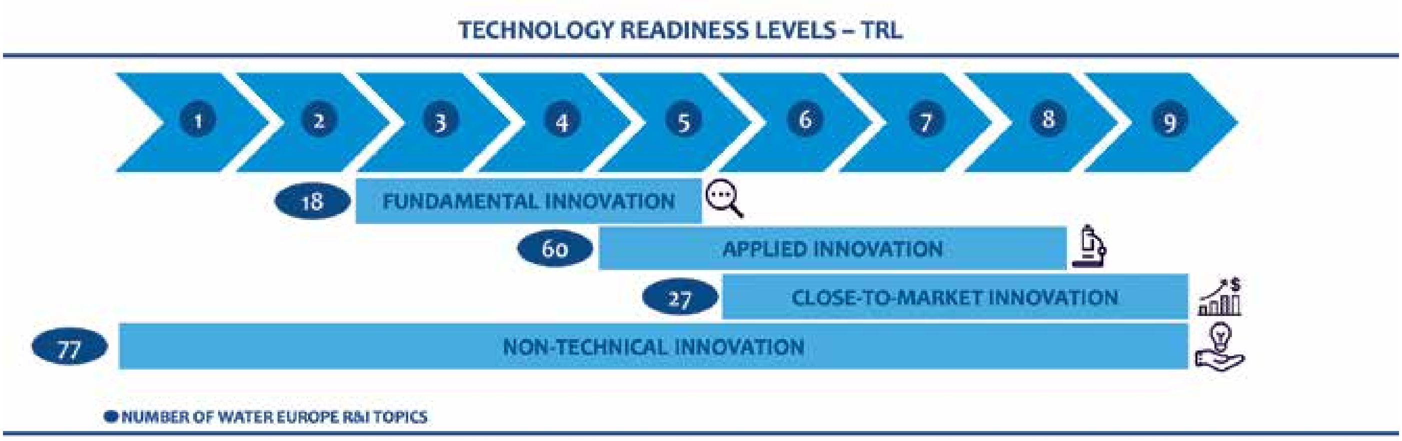
KEY COMPONENT	SUB-CHALLENGE	Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL
TECHNOLOGIES – ENABLING INSIGHT AND MANAGEABILITY	2.2. Technologies for safeguarding surface and drinking water from pollution	2.2.1.	FETs for alternatives for harmful substances and methods to avoid pollutants entering the environment	Fundamental	TRL 3-5
		2.2.2.	Develop solution-oriented strategies and perform surveillance and impact studies to support the prioritisation of emerging pollutants or indicators	Fundamental	TRL 3-5
		2.2.3.	Bioaccumulation in the food chain as well as effects of direct consumption of water containing emerging pollutants	Fundamental	TRL 3-5
		2.2.4.	Hygiene and safety	Fundamental	TRL 3-5
		2.2.5.	New pollution detection and laboratory comprehensive methods	Applied	TRL 5-8
		2.2.6.	Assessment of micro-pollutants breakdown products	Applied	TRL 5-8
		2.2.7.	Emerging nanotechnology approaches	Applied	TRL 5-8
		2.2.8.	Pathways and exposure of nanomaterials to water	Applied	TRL 5-8
		2.2.9.	Bio-diagnostics	Applied	TRL 5-8
		2.2.10.	New models	Applied	TRL 5-8
		2.2.11.	Technologies and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquafiers	Applied	TRL 5-8
		2.2.12.	FETs for removal of micro-pollutants	Fundamental	TRL 3-5
		2.2.13.	Removal of micropollutants (emerging pollutants) from drinking, industrial and domestic wastewaters	Applied	TRL 5-8
		2.2.14.	Smart and intelligent membranes for advanced water	Fundamental	TRL 3-5
		2.2.15.	Technologies for nanomaterials removal	Applied	TRL 5-8
		2.2.16.	Emerging nanotechnologies, nanomaterials, and nano-sciences for water remediation in industrial effluents	Applied	TRL 5-8
		2.2.17.	Technological and managerial solutions reducing the pressures exerted by 'hotspots' of emerging pollutants	Applied	TRL 5-8
	2.3. Enabling cost-efficient water treatment technologies to foster re-use, recycling and cascading	2.3.1.	New solutions for recovery and (re)use of recovered resources	Fundamental	TRL 3-5
		2.3.2.	New biotechnological solutions for resource recovery	Fundamental	TRL 3-5
		2.3.3.	Water purification/filtration concepts	Fundamental	TRL 3-5
		2.3.4.	Smart and intelligent membranes	Applied	TRL 5-8
		2.3.5.	Generation of new treatment technologies, e.g. hybrid membrane systems	Fundamental	TRL 3-5
		2.3.6.	Improvement of advanced oxidation and adsorption/absorption technologies	Applied	TRL 5-8
		2.3.7.	Solutions for storm water overflows	Applied	TRL 5-8
		2.3.8.	New solutions for decentralised treatment	Fundamental	TRL 3-5
		2.3.9.	Membrane nanotechnologies and technologies	Fundamental	TRL 3-5
		2.3.10.	Use of antimicrobial nanomaterials, including nanozymes for biofilm removal	Applied	TRL 5-8
		2.3.11.	New materials for a more sustainable and resilient water infrastructure	Fundamental	TRL 3-5
	2.3. Enabling cost-efficient water treatment technologies to foster re-use, recycling and cascading	2.4.1.	Advanced new generation effect-based monitoring methods based on 'omics' and bioinformatics	Fundamental	TRL 3-5
		2.4.2.	Advanced technologies and sustainable management techniques	Fundamental	TRL 3-5
		2.4.3.	Methods for the rational use of water resources and agrochemicals in precision agriculture	Fundamental	TRL 3-5

KEY COMPONENT	SUB-CHALLENGE	Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL
HYBRID GREY-GREEN INFRASTRUCTURE	3.1. Resilience against Climate and Seasonal Change effects	3.1.1.	Improved big data collection, assessment, data-driven and process-based models' development	Applied	TRL 5-8
		3.1.2.	Novel urban water systems and infrastructures to cope with Climate and Seasonal effects (mitigation and adaptation)	Applied	TRL 5-8
		3.1.3.	Research the causes and significance of microbial growth (including opportunistic pathogens) in water distribution networks and other engineered water systems	Fundamental	TRL 3-5
		3.1.4.	Advancing knowledge base (procedures and warning tools)	Applied	TRL 5-8
		3.1.5.	Strategies and decision support systems	Applied	TRL 5-8
		3.1.6.	New knowledge bases, predictions, smart management and cost-effective solutions, new community and catchment-based business models	Close-to-market	TRL 6-9
		3.1.7.	Inclusive multi-stakeholders, and multi-sectorial technological and non-technological approaches and partnerships incorporating water into urban agendas	Non-technical	All
		3.1.8.	Role and functionality of natural ecosystems functions	Fundamental	TRL 3-5
		3.1.9.	Validating the functionality of Hybrid Grey Green Infrastructure under extreme conditions	Applied	TRL 5-8
		3.1.10.	Nature Basedsolutions to fight extreme precipitation events/flooding	Applied	TRL 5-8
		3.1.11.	Adapt community water management to climate variability	Applied	TRL 5-8
		3.1.12.	Green infrastructure in rural, urban and coastal areas	Applied	TRL 5-8
		3.1.13.	Information basis and technologies to ensure drinking water supply	Applied	TRL 5-8
		3.1.14.	Sustainable storage of aquafier and recovery systems on the regional perspective	Applied	TRL 5-8
		3.1.15.	Technologies and strategies to decrease pollution dispersion during extreme hydro-climatic events	Applied	TRL 5-8
	3.2. Longer term financial sustainability of the water distribution system	3.2.1.	New "value" framework, enabling better balance of benefits vs. costs	Non-technical	All
		3.2.2.	Innovative financing schemes and investment models for the water sector	No-technical	All
		3.2.3.	Asset lifetime prediction tools in managing failure	Applied	TRL 5-8
		3.2.4.	Environmentally effective and optimally/ sustainably managed water installations	Applied	TRL 5-8
		3.2.5.	Assessment of long-term environmental sustainability of water infrastructure	Fundamental	TRL 3-5
		3.2.6.	Integration of advanced, low-cost monitoring systems	Applied	TRL 5-8
		3.2.7.	Decentralised remediation technologies	Applied	TRL 5-8
	3.3. Redesigned integrated Hybrid Grey and Green Infrastructure	3.3.1.	Innovations in the grey infrastructure	Applied	TRL 5-8
		3.3.2.	Restoration methodologies for degraded urban ecosystems	Applied	TRL 5-8
		3.3.3.	Design of Nature Basedor nature-inspired technologies	Fundamental	TRL 3-5
		3.3.4.	Nature Basedwastewater treatment systems and urban storm water treatment	Applied	TRL 5-8
		3.3.5.	Integrated planning and operation of urban drainage and wastewater treatment plants infrastructures	Non-technical	All
		3.3.6.	Cost-effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilisation of multiple water resources	Applied	TRL 5-8
		3.3.7.	Hydropower as a European battery	Non-technical	All

KEY COMPONENT	SUB-CHALLENGE	Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL
HYBRID GREY-GREEN INFRASTRUCTURE	3.3. Redesigned integrated Hybrid Grey and Green Infrastructure	3.3.8.	Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple water supply	Applied	TRL 5-8
		3.3.9.	Improved survey and inspection techniques in sewer networks	Applied	TRL 5-8
		3.3.10.	Validate the performance functionality and stability of green infrastructure	Non-technical	All
		3.3.11.	Strategies for optimising the integration of (new) green and grey functionalities	Non-technical	All
		3.3.12.	Desalination based on green technologies	Applied	TRL 5-8
GOVERNANCE	4.1. Decision Support Systems for multi-stakeholder governance	4.1.1.	Develop digital solutions for competing users of water resources	Applied	TRL 5-8
		4.1.2.	Improvement of the knowledge base and ICT tools of nutritient management and recycling	Applied	TRL 5-8
		4.1.3.	Develop and deploy sensing technologies, decision support systems and communication instruments	Applied	TRL 5-8
		4.1.4.	Decision support systems	Applied	TRL 5-8
		4.1.5.	Integration of new digital technologies and tools	Applied	TRL 5-8
		4.1.6.	Analyse the feasibility, flexibility and governance of water-related infrastructure and technologies	Non-technical	All
		4.1.7.	Integrating climate projections at various levels into adaptive water management planning	Non-technical	All
		4.1.8.	Modelling, monitoring, and communicating measure efficiency for supporting decision-making	Non-technical	All
		4.1.9.	Develop climate services for policy and operational water management	Non-technical	All
	4.2. Stakeholder engagement for good water governance	4.2.1.	Develop and deploy innovative tools and mechanism to support and improve multi-stakeholder engagement	Applied	TRL 5-8
		4.2.2.	Novel ways to involve all relevant stakeholders in the storm water planning process	Non-technical	All
		4.2.3.	Engaged dialogue among diverse stakeholders in water resources management and capacity development on the value of water and water usage	Non-technical	All
		4.2.4.	Harness innovative and evolving ICTs for communication/dissemination campaigns, and public engagement	Non-technical	All
	4.3. Integrated planning and water management at all levels and across sectors	4.3.1.	Develop multi-stakeholder Water Diplomacy approaches and practices at regional levels	Non-technical	All
		4.3.2.	Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measures Design	Non-technical	All
		4.3.3.	Flood risk and drought strategies in urban, industrial and rural context	Non-technical	All
		4.3.4.	Water Diplomacy approaches for climate change response to ensure availability for all purposes of water	Non-technical	All
		4.3.5.	Alignment of policies	Non-technical	All
		4.3.6.	Joint decision frameworks to shift to a more chemical-free society	Non-technical	All
		4.3.7.	Setting-up and strengthening collaborative actions and regional multi-stakeholder partnerships	Non-technical	All
		4.3.8.	Streamlining of multi-stakeholder and multi-sectorial actions and decisions	Non-technical	All
		4.3.9.	Public-private and cross-sectorial partnerships	Non-technical	All
		4.3.10.	Support to reduce the risk perception of "green" versus "grey" infrastructure	Non-technical	All
		4.3.11.	Collaborative actions among stakeholders	Non-technical	All

KEY COMPONENT	SUB-CHALLENGE	Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL
LIVING LABS	5. Living Labs	5.1.1	Water-oriented Living Labs	Non-technical	All
HORIZONTAL	6.1. Create a level playing field for eco-innovative companies	6.1.1.	Green public procurement enhancing innovation in urban water management for the circular economy	Non-technical	All
		6.1.2.	SME platforms to foster easy partnerships for water	Non-technical	All
		6.1.3.	Develop or make a better use of the existing EU-wide financing instruments (e.g. COSME) for water in support to develop business models to bring to the market innovative SMEs solutions on water	Non-technical	All
		6.1.4.	Fast Track Innovation for water-related value chains and lifecycles including the possibility of testing and demonstration at local/regional scales and opening opportunities for the access to the environmental technologies and verification testing	Non-technical	All
	6.2. Standards for Water Footprint Assessment and Stewardship	6.2.1.	Innovation in Green and Water Accounting Systems for the European Water Sector	Non-technical	All
		6.2.2.	Agricultural water stewardship for food security	Non-technical	All
		6.2.3.	Water footprint of (food) products	Non-technical	All
		6.2.4.	Water stewardship approaches in the cities	Non-technical	All
		6.2.5.	Water stewardship certification for large water users in industry and agriculture and water stewardship collection action in the shared catchment	Non-technical	All
		6.2.6.	Methodologies and tools for sustainability assessment of circular economy systems and demonstration for water	Non-technical	All
		6.2.7.	Implementation and demonstration of methodologies to assess water technologies in cross-sectorial business cases in various water cycles	Non-technical	All
		6.2.8.	LCA for water in various domains	Non-technical	All
		6.2.9.	Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture	Non-technical	All
	6.3. Enhanced sharing knowledge and best practices in water: education, awareness, capacity development tools	6.3.1.	New education and training programs for an upskilled workforce in the future digital water sector	Non-technical	All
		6.3.2.	Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes	Non-technical	All
		6.3.3.	Creation of smart skill building tools for water and water-related sectors to facilitate replicability and applicability of water related technologies	Non-technical	All
		6.3.4.	Talent building program on KETs and FETs for water and water in a circular economy	Non-technical	All
		6.3.5.	Education programs (smart people and smart consumers)	Non-technical	All
		6.3.6.	Awareness raising actions on social perception of water reclamation and reuse	Non-technical	All
	6.4. Water advocacy, planning and management capacity	6.4.1.	Support measures to integrate water component into the implementation of roadmaps	Non-technical	All
		6.4.2.	Innovations in regulatory framework, utility pricing systems, transparency of value, price for water, social awareness, lifecycle assessment including water, smart specialization in water reflecting water-economy, markets, and ecosystem services for water	Non-technical	All
		6.4.3.	Open access specific guides, security issues, IPRs for water	Non-technical	All
		6.4.4.	Innovation capacity development tools for the entire innovation process (e.g. supply/demand sides, users of innovation)	Non-technical	All

KEY COMPONENT	SUB-CHALLENGE	Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL
HORIZONTAL	6.5. International cooperation	6.5.1.	Support the promotion of the European model for smart-water abroad through first-of-a-kind demonstration of novel technologies and solutions in extra-European countries and regions	Non-technical	All
		6.5.2.	Strengthen collaborations and synergies with water management and innovation platforms with strategic regions (e.g. Israel, the US, Japan, Middle East)	Non-technical	All
		6.5.3.	Inclusion of SDGs in corporate strategic planning	Non-technical	All
		6.5.4.	Identification of "transformative potentials" for the achievement of SDGs form other KC	Non-technical	All
		6.5.5.	Alignment of policies and financing mechanisms within the EU and beyond the EU around the overarching SDG agenda	Non-technical	All
		6.5.6.	Support international cooperation on Water, as a means to achieve EU priorities in terms of jobs and growth considering the prominent role of Water in jobs creation	Non-technical	All
		6.5.7.	Complementing and upscaling initiatives at EU level with emerging international initiatives in support on the global partnership goal of the SDGs	Non-technical	All
		6.5.8.	Developing capacities in the EU and abroad (or joint capacity) to successful research and co-generation of knowledge and innovation to address real life demands and societal challenges	Non-technical	All



Annex 3. Extended version of Section 2. Water research, development, and innovation trajectories and topics

3.1. Climate, Energy, And Mobility (Cluster 5)

Table 1. Guidance Table for Water Europe R&I Topics

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
1.2.1.	New diversification of water sources	Fundamental	TRL3-5	2.1.1.
1.2.2.	New cost-effective combinations of salty and brackish water, desalination and (natural) pre-treatment	Applied	TRL5-8	2.1.1.
1.2.3.	Develop structured and certified alternative water resources for irrigation	Applied	TRL5-8	2.1.1.
1.2.8.	Promotion of new policy developments, new regulation and incentives	Close-to-market	TRL6-9	2.1.1.
1.5.7.	Digital tools and systems for demand forecasting	Close-to-market	TRL6-9	2.1.1.
2.1.10.	Improved Big Data collection, assessment, data-driven and process-based models' development	Applied	TRL5-8	2.1.1.
2.1.11.	Advanced modelling, simulation, control, and optimisation techniques	Applied	TRL5-8	2.1.1.
2.1.12.	Cloud computing and real-time monitoring	Applied	TRL5-8	2.1.1.
2.1.13.	High-performance computing systems and applications development	Applied	TRL5-8	2.1.1.
2.1.2.	Passive sampling techniques	Applied	TRL5-8	2.1.1.
2.1.3.	Active sampling techniques	Fundamental	TRL3-5	2.1.1.
2.1.5.	New sensors for protection, security and resilience	Fundamental	TRL3-5	2.1.1.
2.1.8.	Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters	Applied	TRL5-8	2.1.1.
2.1.9.	Forecasting	Fundamental	TRL3-5	2.1.1.
2.2.1.	FETs for alternatives for harmful substances and methods to avoid entering the environment	Fundamental	TRL3-5	2.1.1.
2.2.10.	New models	Fundamental	TRL3-5	2.1.1.
2.2.11.	Technologies and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquifer	Applied	TRL5-8	2.1.1.
2.2.2.	Develop solution-oriented strategies and perform surveillance and impact studies to support the prioritization of emerging pollutants or indicators	Fundamental	TRL3-5	2.1.1.
2.2.5.	New pollution detection and laboratory comprehensive methods	Applied	TRL5-8	2.1.1.
2.2.6.	Assessment of micro-pollutants breakdown products	Applied	TRL5-8	2.1.1.
2.2.7.	Emerging nanotechnology approaches	Applied	TRL5-8	2.1.1.
2.2.8.	Pathways and exposure of nanomaterials to water	Applied	TRL5-8	2.1.1.
2.2.9.	Bio-diagnostics	Applied	TRL5-8	2.1.1.
3.1.2.	Novel urban water systems and infrastructures to cope with Climate and Seasonal effects (mitigation and adaptation)	Applied	TRL5-8	2.1.1.
3.1.3.	Research the causes and significance of microbial growth (including opportunistic pathogens) in water distribution networks and other engineered systems	Applied	TRL5-8	2.1.1.
3.1.4.	Advancing knowledge base (procedures and warning tools) in climate hydrology and hydroinformatics	Applied	TRL5-8	2.1.1.
3.1.5.	Strategies and decision support systems	Applied	TRL5-8	2.1.1.
3.1.8.	Role and functionality of natural ecosystem functions	Fundamental	TRL3-5	2.1.1.
3.1.9.	Validating the functionality of Hybrid Grey Green Infrastructure under extreme conditions	Applied	TRL5-8	2.1.1.

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
3.2.2.	Innovative financing schemes and investment models for the water sector	Applied	All	2.1.1.
3.2.3.	Asset lifetime prediction tools in managing failure	Applied	TRL5-8	2.1.1.
3.2.3.	Prediction tools in managing failure	Applied	TRL5-8	2.1.1.
3.2.6.	Integration of advanced, low-cost monitoring systems	Applied	TRL5-8	2.1.1.
3.3.9.	Improved survey and inspection techniques in sewer networks	Applied	TRL5-8	2.1.1.
4.1.2.	Improvement of the knowledge base and ICT tools of nutritient management and recycling	Applied	TRL5-8	2.1.1.
4.1.3.	Develop and deploy sensing technologies, decision support systems and communication instruments	Applied	TRL5-8	2.1.1.
4.1.4.	Predictive decision support systems for systematic and water smart network management	Applied	TRL5-8	2.1.1.
4.1.5.	Integration of new digital technologies and tools	Applied	TRL5-8	2.1.1.
4.1.6.	Analyse the feasibility, flexibility and governance of water-related infrastructure and technologies	Non-technical	All	2.1.1.
4.1.7.	Integrating climate projections at various levels into adaptive water management planning	Non-technical	All	2.1.1.
4.1.9.	Develop climate services for policy and operational water management	Non-technical	All	2.1.1.
4.2.1.	Develop and deploy innovative tools and mechanism to support and improve multi-stakeholder engagement	Applied	TRL5-8	2.1.1.
4.2.2.	Novel ways to involve all relevant stakeholders in the storm water planning process and the development of river basins	Non-technical	All	2.1.1.
4.2.3.	Engaged dialogue among diverse stakeholders in water resources management and capacity development on the value of water and water usage	Non-technical	All	2.1.1.
4.2.4.	Harness innovative and evolving ICTs for communication/dissemination campaigns, and public engagement	Non-technical	All	2.1.1.
4.3.1.	Develop multi-stakeholder Water Diplomacy approaches and practices at regional levels	Non-technical	All	2.1.1.
4.3.2.	Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measures Design	Non-technical	All	2.1.1.
4.3.4.	Water Diplomacy approaches for climate change response to ensure availability for all purposes of water	Non-technical	All	2.1.1.
4.3.5.	Alignment of policies and financing mechanisms within the EU and beyond the EU around the overarching SDG agenda	Non-technical	All	2.1.1.
6.1.2.	SME platforms to foster easy partnerships for water	Non-technical	All	2. 1.1.
6.2.1.	Innovation in Green and Water Accounting Systems for the European Water Sector	Non-technical	All	2.1.1.
6.2.2.	Agricultural water stewardship for food security	Non-technical	All	2.1.1.
6.2.3.	Water footprint of (food) products	Non-technical	All	2.1.1.
6.2.5.	Water stewardship certifications for large water users in industry and agriculture and water stewardship collective action in the shared catchment	Non-technical	All	2.1.1.
6.2.6.	Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water	Non-technical	All	2.1.1.
6.2.8.	LCA for water in various domains	Non-technical	All	2.1.1.
6.3.1.	New education and training programs for an upskilled workforce in the future digital water sector	Non-technical	All	2.1.1.
6.3.2.	Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes	Non-technical	All	2.1.1.
6.3.3.	Creation of smart skill building tools for water and water-related sectors to facilitate replicability and applicability of water related technological solutions and facilitate capacity development	Non-technical	All	2.1.1.
6.3.4.	Talent building program on KETs and FETs for water in a circular economy	Non-technical	All	2.1.1.
6.3.5.	Education programs (smart people and smart consumers)	Non-technical	All	2.1.1.
6.4.1.	Support measures to integrate water component into the implementation of roadmaps	Non-technical	All	2.1.1.

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
6.4.4.	Innovation capacity development tools for the entire innovation process (e.g. supply/demand sides, users of innovation)	Non-technical	All	2.1.1.
6.5.1.	Support the promotion of the European model for smart-water abroad through first-of-a-kind demonstration of novel technologies and solutions in extra-European countries and regions	Non-technical	All	2.1.1.
6.5.2.	Strengthen collaborations and synergies with water management and innovation platforms with strategic regions (e.g. Israel, the US, Japan, Middle East)	Non-technical	All	2.1.1.
6.5.3.	Inclusion of SDGs in corporate strategic planning	Non-technical	All	2.1.1.
6.5.6.	Support international cooperation on Water, as a means to achieve EU priorities in terms of jobs and growth considering the prominent role of Water in jobs creation	Non-technical	All	2.1.1.
6.5.7.	Complementing and upscaling initiatives at EU level with emerging international initiatives in support on the global partnership goal of the SDGs	Non-technical	All	2.1.1.
1.3.1.6.	Water-energy-waste nexus in industrial environments	Close-to-market	TRL6-9	2.1.1., 2.1.4.
3.1.10.	Nature Basedsolutions to fight extreme precipitation events/flooding	Applied	TRL5-8	2.1.1., 2.1.4.
3.1.11.	Adapt community water management to climate variability	Applied	TRL5-8	2.1.1., 2.1.4.
3.1.12.	Green infrastructures in rural, urban, and coastal areas	Applied	TRL5-8	2.1.1., 2.1.4.
3.1.13.	Information basis and technologies to ensure drinking water supply	Applied	TRL5-8	2.1.1., 2.1.4.
3.1.14.	Sustainable storage of aquafier and recovery systems on the regional perspective	Applied	TRL5-8	2.1.1., 2.1.4.
3.1.6.	New knowledge bases, predictions, smart management and cost-effective solutions, new community and catchment-based business models	Close-to-market	TRL6-9	2.1.1., 2.1.4.
3.2.4.	Environmentally effective and optimally/sustainably managed water installations	Applied	TRL5-8	2.1.1., 2.1.4.
3.2.5.	Assessment of long-term environmental sustainability of water infrastructure	Fundamental	TRL3-5	2.1.1., 2.1.4.
4.1.1.	Develop digital solutions for competing users of water resources	Applied	TRL5-8	2.1.1., 2.1.4.
4.3.10.	Support to reduce the risk perception of "green" and "grey" infrastructure	Non-technical	All	2.1.1., 2.1.4.
6.2.4.	Water stewardship approaches in the cities	Non-technical	All	2.1.1., 2.1.4.
6.3.6.	Awareness raising actions on social perception of water reclamation and reuse	Non-technical	All	2.1.1., 2.1.4.
1.5.3.	Water-energy nexus in energy sector	Applied	TRL5-8	2.1.2.
1.5.5.	Increase energy production from water resources	Close-to-market	TRL6-9	2.1.2.
3.3.7.	Hydropower as a European battery	Applied	TRL5-8	2.1.2.
1.5.1.	New technologies for energy-efficient water treatment, including new decentralised systems	Applied	TRL5-8	2.1.3.
1.5.4.	New ICT solutions for energy and water efficiency	Close-to-market	TRL6-9	2.1.3.
6.2.9.	Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including agriculture	Non-technical	All	2.1.3.
1.5.6.	Reduction of energy losses	Close-to-market	TRL6-9	2.1.3., 2.1.4.
2.1.6.	Cost-effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilization of multiple water resources	Applied	TRL5-8	2.1.3., 2.1.4.

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
1.1.1.	New water incentive pricing and pricing water security	Non-technical	All	2.1.4.
1.1.2.	Innovative economic mechanisms	Non-technical	All	2.1.4.
1.2.9.	New schemes of water reclamation	Close-to-market	TRL6-9	2.1.4.
1.3.10.	Smart digital water management systems in cities via nexus and circularity approaches	Fundamental	TRL3-5	2.1.4.
1.3.12.	Sustainable process water production by water recycling at various scales	Close-to-market	TRL6-9	2.1.4.
1.3.6.	Combining water and energy efficiency in the urban context, integrating this nexus with smart urban management and planning solutions	Non-technical	All	2.1.4.
1.3.7.	Increase awareness and improve perception (on direct and indirect reuse - as drinking water or recharge)	Non-technical	All	2.1.4.
1.3.8.	Urban/industrial symbiosis	Non-technical	All	2.1.4.
1.5.2.	New energy-efficient measures in water-intensive industries	Applied	TRL5-8	2.1.4.
2.3.7.	Solutions for storm water overflows	Applied	TRL5-8	2.1.4.
2.3.8.	New solutions for decentralised treatment	Fundamental	TRL3-5	2.1.4.
3.1.7.	Inclusive multi-stakeholder, and multi-sectoral technological and non-technological approaches and partnerships incorporating water into urban agenda	Non-technical	All	2.1.4.
3.2.1.	New "value" frameworks enabling better balance of benefits vs. costs	Non-technical	All	2.1.4.
3.2.7.	Decentralised remediation technologies	Applied	TRL5-8	2.1.4.
3.3.10.	Validate the performance functionality and stability of green infrastructure	Non-technical	All	2.1.4.
3.3.11.	Strategies for optimizing the integration of (new) green and grey functionalities	Non-technical	All	2.1.4.
3.3.2.	Restoration methodologies for degraded urban systems	Applied	TRL5-8	2.1.4.
3.3.4.	Nature Basedwastewater treatment systems and urban storm water treatment	Applied	TRL5-8	2.1.4.
3.3.5.	Integrated planning and operation of urban drainage and wastewater treatment plants infrastructures	Non-technical	All	2.1.4.
3.3.8.	Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple waters	Applied	TRL5-8	2.1.4.
4.3.3.	Flood risk and drought strategies in urban, industrial, and rural context	Non-technical	All	2.1.4.
6.1.1.	Green public procurement enhancing innovation in urban water management for the circular economy	Non-technical	All	2.1.4.
6.1.3.	Develop or make a better use of the existing EU-wide financing instruments (e.g. COSME) for water in support to develop business models to bring to the market innovative SMEs solutions on water	Non-technical	All	2.1.4.
6.2.7.	Implementation and demonstration of methodologies to assess water technologies in cross-sectorial business cases in various water cycles	Non-technical	All	2.1.4.
6.4.2.	Innovations in regulatory framework, utility pricing systems, transparency of value, price for water, social awareness, lifecycle assessment including water, smart specialisation in water reflecting water-economy, markets, and ecosystem services for water	Non-technical	All	2.1.4.

3.1.1. Intervention area: climate science and solutions

ACCELERATE CLIMATE ACTION UPTAKE BY IMPROVING KNOWLEDGE OF THE CLIMATE-EARTH SYSTEMS

Environmental Internet of Things (IoT) Ecosystem for a Water-Smart Society. With the objective of better understanding aquatic ecosystem processes, water safety threats, and multiple waters ecosystems within the Earth's biosphere, **automated, multi-parameter, near real-time or real-time water metering and monitoring solutions**, coupled with the advanced applications of **efficient, heuristic algorithms on centralized cloud computing platforms** or **near-device edge servers**, can increase **efficacy in water saving, wastewater detection; enhance transparency related to the health and quality of water** (e.g. discharges to water) at the point of discharge or in the receiving environments; optimize **environmental compliance capacity** of industrial water-users with environmental licenses; and, provide **cost-effective, scalable, high-performing monitoring, with real-time indications of operational cause and environmental effect**; foster **immediate remedial action** by detecting water events.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New sensors for protection, security and resilience**
- **Cloud computing and real-time monitoring**
- **High Performance Computing systems and applications' development**
- **Integration of advanced, low-cost monitoring systems**

Improved Lab and In-Field Analyses Approaches. In the water sampling locations, labelling systems and information-recording of **passive** and **active sampling techniques for lab and in-field analysis**, improved at the interface of **climate science** and **digital technologie**s, can increase **data reliability in the assessments of water quality**. In the domain of **traditional, manual or in-field water sampling, innovative water monitoring sensor technologies**, with new ranges of water monitoring parameters and the ability of detecting contaminants of concern (e.g. metals, pesticides, per- and polyfluoroalkyl substances [PFAS], perfluorooctane sulfonate [PFOS]), can further increase the **speed in manual analysis and interpretation**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Passive sampling techniques**
- **Active sampling techniques**
- **Improved survey and inspection techniques in sewer networks**

Timely, Accurate, Multi-objective Forecasting Systems in Climate Hydrology. Due to the complicated interactions among climate, hydrology, and humans, multi-model experiments and **multi-objective hydrological forecasting systems, approaches, and models** can improve **seasonal and sub-seasonal forecasting** and **decision-support for agriculture**; increase capacity in **climate prediction, multi- or mono-hazard detection, monitoring, forecasting and warning, food security and climate data management**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Forecasting**
- **Digital tools and systems for demand forecasting**
- **Advanced modelling, simulation, control and optimization techniques**

Advanced modelling and simulation systems for developing better understanding of micro-pollutants and emerging pollutants in water resources. With the co-use of **optimally deployed sensor technologies and supervised machine-learning techniques**, efficacy in **real-time, holistic environmental water-quality monitoring** and **detection of water-borne pathogenic microorganisms**, **effluents**, and **toxic chemicals** as well as statistical model efficiency in prediction of **sanitation-related water quality and spatial/temporal trends of micro-pollutants** in waterways increase. On the other hand, the application of molecular methods, such as **in-vitro, bio-diagnostics and bio-testing techniques**, together with cost-effective and ultra-sensitive multi-sensor systems, to the detection of water pollution improves the pathway of the microbiological analysis of water, characterisation and understanding of **integral toxicity**, **micro-pollutant risk profile**, and **safety in source water reservoirs**. The **nanomaterial-based approaches to waterborne and environmental pathogen sampling and detection schemes** enhance the identification of **hygienic** (growth of pathogens and opportunistic pathogens), **aesthetics** (taste and odour) and **operational problems** (corrosion and discoloration) in water distribution networks and other engineered water systems, enabling better assessment of micro-pollutants. Particularly, in the field of nanomaterials dispersions in the environment, **integrated research instruments based on biosensors contribute better to the characterisation of colloidal properties, suspension stability**, **exposure concentration**, and **adsorption of nanoparticles in various water environments** (e.g. sedimentary systems, saline environments).

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Bio-diagnostics**
- **New models**
- **Assessment of micro-pollutants breakdown products**
- **Emerging nanotechnology approaches**
- **Pathways and exposure of nanomaterials to water**
- **Research the causes and significance of microbial growth (including opportunistic pathogens) in water distribution networks and other engineered water systems**
- **Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters**
- **Improvement of the knowledge base and ICT tools of nutrient management and recycling**
- **New pollution detection and laboratory comprehensive methods**

Advancing knowledge base, procedures, and warning tools in climate hydrology and hydroinformatics. In the cross-disciplinary domain of climate science, scientific knowledge builds over time, owing to **continuous integration of knowledge bases from different scientific disciplines**, including the physical, social, biological, health, and engineering sciences and **across different spatial scales of analysis. Complex network analysis methods, big and multivariate data mining, numerical and agent-based simulations based on artificial neural networks** serve to the optimisation of **water quality model outputs**; the improvement of **decision algorithms for water and catchment modelling excellence**; development of **predictive decision-support systems for systematic and smart water network management**; and, knowledge and capacity building for **targeted climate mitigation strategies related to the water supply security risks**. Particularly in the field of chemical monitoring and hydrogeological studies, **integrated deployment of spatial data-mining methods with modelling approaches** could contribute to the better **tracing of pollutant sources; improved identification of toxic elements in soils and water ecosystems; and, prioritisation of emerging (organic, nutritient, heavy metals) water pollutants in diffuse pollution sources.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improved Big Data collection, assessment, data-driven and process-based models' development**
- **Advancing knowledge base (procedures and warning tools) in climate hydrology and hydroinformatics**
- **Strategies and decision support systems**
- **Information basis and technologies to ensure drinking water supply**
- **Develop solution-oriented strategies and perform surveillance and impact studies to support the prioritization of emerging pollutants or indicators**
- **Prediction tools in managing failure**

Climate-related community knowledge network ecosystems and capacity building for water sustainability and management in the face of climate, water, and biodiversity challenges. With the objective of better translating climate scenarios to adaptation policies and broadening the usability of climate science for solving water issues, **human** and **institutional capacity development efforts**, and **knowledge sharing and transfer of technologies and practical intelligence** shall be improved in **water- and water-related sectors**, by developing **new educational schemes, training programs, and skills building tools** on the futures of water management, including resilience capacity of distributed water systems, water factories, digital water, **KETs** and **FETs** for circular blue economy, among others. Furthermore, in a bottom-up fashion, **perceptive awareness** on the role of **water reuse** and **reclamation** as an **integral component of water management** as well as **business model innovations in water reuse** (e.g. **catchment-based business models**) shall be improved.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New education and training programs for an upskilled workforce in the future digital water sector**
- **Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes**
- **Creation of smart skill building tools for water and water-related sectors to facilitate replicability and applicability of water related technological solutions and facilitate capacity development**
- **Talent building program on KETs and FETs for water in a circular economy**
- **Education programs (smart people and smart consumers)**
- **Awareness raising actions on social perception of water reclamation and reuse**
- **New knowledge bases, predictions, smart management and cost-effective solutions, new community and catchment-based business models**

Climate resilience and adaptation measures for overcoming seasonal water shortages. Given the effects of anthropogenic climate change on seasonal water availability and supply, and climatic water cycling regimes, **cost-effective, Nature Basedsolutions**, such as **multi-functional green infrastructure frameworks in rural, urban, coastal areas, with ecological and social benefits**, can maintain and optimise **ecosystem-based climate adaptation services**, enabling the decrease of **flooding risks**, regulating temperature, maintaining freshwater quality and supply, and enhancing **species resilience** through provision of varied habitats and green corridors. Furthermore, on the regional level, the **community-based aquifer solutions and groundwater recharging processes** shall be considered as climate resilience measures against complex water disasters, e.g. drought, groundwater depletion, and non-availability of safe drinking water.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Novel urban water systems and infrastructures to cope with Climate and Seasonal effects (mitigation and adaptation)**
- **Role and functionality of natural ecosystem functions**
- **Validating the functionality of Hybrid Grey Green Infrastructure under extreme conditions**
- **Nature Basedsolutions to fight extreme precipitation events/flooding**
- **Adapt community water management to climate variability**
- **Green infrastructures in rural, urban, and coastal areas**
- **Sustainable storage of aquafier and recovery systems on the regional perspective**

ACCELERATE CLIMATE ACTION UPTAKE BY PROPOSING AND EVALUATING SOLUTIONS FOR SHORT-TO-MEDIUM AND LONG-TERM SYSTEMIC IMPACT.

Assessment of long-term environmental sustainability of water-related critical infrastructures. For water and wastewater utilities, **effective and comprehensive planning for sustainable, eco-efficient water infrastructure** is an integrated component of sustainable water supply. With the aim of improving baseline assessments of **IWRM**, indicators should be **re-arranged with new aggregation methods** and **computational modelling approaches or new indicators** should be created in the domains of water quality, solid waste treatment, basic water services, wastewater treatment, infrastructure, climate robustness, and governance.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Environmentally effective and optimally/sustainably managed water installations**
- **Analyse the feasibility, flexibility and governance of water-related infrastructure and technologies**
- **Asset lifetime prediction tools in managing failure**
- **Assessment of long-term environmental sustainability of water infrastructure**

Development and retrofitting of eco-technological solutions for water pollution detection. Population growth is leading to an increase of water consumption and pollution. With the objective of achieving "good status" for all water bodies and "good ecological status" for surface water bodies as required by the EU Water Framework Directive (WFD), **new pollution detection technologies** are of crucial importance for decreasing the **diffuse of pollution** and enhancing **control of priority substances** in water bodies. In parallel to the advancements within the disciplines of analytical chemistry, climate hydrology, and environmental sciences, **continuous, multi-parameter, low-cost, and real-time detection systems for water pollution and pollutant concentration** can contribute to sustainable conservation and use of water resources, by enabling **real-time generation of pollution alerts**; modelling and controlling diffuse and point source pollution; and, improving **nutritient monitoring**, including early warning systems for pollution and pathogen detection. Furthermore, the **earth observation technologies**, such as satellite-based remote sensing techniques, could be leveraged for the **high-quality profiling, characterisation, and risk assessment of micro-pollutants**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New pollution detection and laboratory comprehensive methods**
- **FETs for alternatives for harmful substances and methods to avoid pollutants entering the environment**
- **Assessment of micro-pollutant breakdown products**

Climate-smart, green technologies for water efficiency improvements. Through a **climate resilience lens**, the modelling of novel **water harvesting, water-reuse, and water-saving practices** needs to be further stimulated, particularly for **building restorative** and **regenerative sustainability mindset** into the **integrated water resources management** and **accelerating pathways** for water users and service providers to transition towards the **circular economy**. Today, considering the increasing pressure on scarce transitional, coastal, and freshwater resources and water regimes, **innovative, scalable, and climate-smart water efficiency improvements (e.g. water harvesting methods, technologies and structures for multiple water-use purposes; drainage control systems; salinity control mechanisms)** can create novel **opportunities for water saving and re-use** in potential water harvesting catchments (e.g. water from seasonal streams, runoff water, rooftop rainwater, road runoff water) and for **urban, agricultural, and industrial consumptive processes and users of water**. To the **agricultural sector, climate-smart water harvesting methods, coupled with novel agricultural practices** (e.g. **saline agriculture**) and **natural water treatment systems**, can bring the following benefits: **groundwater recharge, soil moisture replenishment, decreased water requirement in irrigation infrastructure, storage for household food and livestock production, among others**. Whereas, to **urban environments** and **urban living**, considering the ever-increasing urban population and rapid depletion of surface and ground water sources, **alternative water harvesting systems**, such as rainwater harvesting, and **cascading of multiple water sources** bring visible economic benefits at household-level: **low cost of installation and maintenance, low energy requirement, convenience in using stand-out systems, less dependency on the local storage and distribution infrastructure of safe drinking water**. Lastly, to the **industrial water supply**, particularly in the traditional industries (e.g. chemical, steel, metallurgy, pulp, paper, food, cooling water), technologically competitive **water harvesting**, **recharge**, and **wastewater treatment** and **re-use solutions** can increase **efficiency in industrial processes and sustainable resource productivity; decrease water abstraction needs** for industrial water use; develop **circular, life-cycle driven markets performance**; and, create **separate supply networks for wastewater reuse for industry**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New diversification of water sources**
- **New cost-effective combinations of salty and brackish water, desalination and (natural) pre-treatment**
- **Develop structured and certified alternative water resources for irrigation**

CONTRIBUTE SUBSTANTIALLY TO KEY INTERNATIONAL ASSESSMENTS OF BIODIVERSITY, CLIMATE CHANGE, AND ECOSYSTEM SERVICES.

Public and private decision support-systems for supporting cross-scale integration of climate-water measures and ecosystem services. **Participatory Climate Change Research**, in principle, is instrumental to advance climate policy decision-making, whilst supporting cross-scale integration of climate measures and ecosystem services. In the context of the **Integrated and Water Resources Management (IWRM)**, participatory stakeholder involvement and participation in water resources processes, coupled with **science and technical tools such as Decision Support Systems (DSSs)**, is of vital importance not only to tackle complex water management and planning challenges but also to make **users of water resources** adaptive and resilient to variability and change. The effective deployment of **prescriptive, functional, holistic, and integrative computer modelling approaches in DSSs** can serve to improve **regional climate modelling** and inform different sets of decisions for **medium- and long-term planning, management, and conservation at the basin scale**. Nevertheless, development of **optimised, analytical DSSs** for water problems largely depends on the availability of **high-performance computing technologies**, highly skilled **human resources**, and digital technology infrastructure. The **collaborative design and model assumptions of DSSs**, resulting from various **institutional drivers and organisational interests**, can also foster social learning and **shared vision planning at basin level**, regarding the impacts and improvements of alternative management scenarios and **predictive climate measures**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Develop and deploy sensing technologies, decision support systems and communication instruments**
- **Decision support systems**
- **Integration of new digital technologies and tools**
- **Develop climate services for policy and operational water management**
- **Develop and deploy innovative tools and mechanism to support and improve multi-stakeholder engagement**
- **Harness innovative and evolving ICTs for communication/dissemination campaigns, and public engagement**

Multi-stakeholder engagement for resources-oriented, environmental water governance and water security strategies in areas with multiple and competing resources and within environments with spatial and temporal variability in water supply. With the objective of overcoming the threatened states of the coupled human and natural water systems and bridging water governance gaps, **multi-stakeholder water governance at local, basin, regional, and national levels**, should promote **inclusive, bottom-up, systemic, informed, sustainable and resources-oriented policy targets** at the least cost to and through fairness for society. Furthermore, **implementation capacity of institutions**, should be supported with strong knowledge base and **decision-support systems (DSSs)**, in order to fashion policy responses not only to various **regional water governance issues in critical areas with competing resources but also the implications of water-energy-food interdependencies. Comparing to surface water resources** that are typically societally managed, **groundwater resources management process in conjunction with surface water and other resource uses can largely benefit from the DSSs models**, **Geographic Information Systems (GISs)**, **simulation-based optimisation methods**, and **analytical tools**. In Europe, **groundwater** supplies 70% of domestic use (OECD, 2012, p.5); hence, mining groundwater affects water quality and relative richness of fresh groundwater resources. To better inspect the problems causing to **overexploitation of groundwater or impacts of global climate change on aquifer storage and depletion trajectory management**, **digital decision-support systems**, **technologies**, and **tools** can optimise the **decisional and shared management capacity of municipalities**, **water authorities**, **utilities**, **local sanitation** service providers, **consumers**, **environmental** and **social organisations**, while enhancing inter-local partnerships to develop resource-oriented, **environmental water governance targets**. On another note, **DSSs**, **sensor technologies**, and **scenario-based optimisation methods** can also support the institutional capacity and knowledge base of **local authorities** in the design of climate adaptive city planning, such as the optimal localisation of **green infrastructures in urban environments** and **integration** of **stormwater planning priorities** into the **land use agendas.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Technologies and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquifer**
- **Develop digital solutions for competing users of water resources**
- **Novel ways to involve all relevant stakeholders in the storm water planning process and the development of river basins**
- **Engaged dialogue among diverse stakeholders in water resources management and capacity development on the value of water and water usage**
- **Support to reduce the risk perception of "green" versus "grey" infrastructure**
- **Develop multi-stakeholder Water Diplomacy approaches and practices at regional levels**

STRENGTHEN THE EUROPEAN AREA ON CLIMATE CHANGE.

Cross-scale, inclusive collaboration in climate-water matters by channelling climate-smart scientific models in the desired direction of climate change policy targets. With the objective of supporting the **joint decision-making for regional IWRM for all purposes of water** and the timely realisation of **WFD policy targets**, purposeful leverage of **climate-smart scientific models, such as advanced, multi-scale, multi-agent modelling systems**, particularly in the context of local and regional policy decision-making, could serve not only to decrease the **uncertainty in regional climate projections** but also to promote t**argeted, legislative or non-legislative IWRM policy directions** more in tune with the societal, environmental, economic, resource, and logistical needs.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measures Design**
- **Integrating climate projections at various levels into adaptive water management planning**
- **Water Diplomacy approaches for climate change response to ensure availability for all purposes of water**
- **Promotion of new policy developments, new regulation and incentives**

Role of standardisation frameworks, stewardship schemes, and sustainability assessment methods as enablers in Water Sustainability Management and as an integrated component of Climate-Smart Water Innovation Infrastructure. From a market standpoint, the integration of **standardisation frameworks, sustainability assessment methods**, and **green accounting systems** into research programs could boost the **market uptake of green innovations and research outcomes**; induce **shared risk management approach** into **corporate decision-making**, considering the **social equity dimension of water sustainability**; and, make **the critical water infrastructure in key vulnerable sectors more resilient**. From a climate policy standpoint, the use of (new or revised) **'climate resilience' or 'climate influenced' standards and sustainability assessment methods can help to close the climate adaptation deficit,** by providing climate impacts information, required level of resilience, labelling, and **climate adaptation** options **into product design changes**; influencing **'corporate water behaviour'** and **'design for circular behaviour'**; and, **increasing water self-reliance security** and awareness on the **value of water** in response to **climate effects on multiple water resources**, whilst taking **stock of the impacts** of **increased competition** for resources on **water systems**. The **implementation of Water Stewardship principles** and **schemes** in **products and supply chains and at industry**, **sector**, and **community scale**s could optimise the **water risk management** performance and practices, whilst further facilitating the exploration of **climate impacts at use**, **acquisition**, **production**, and **end-of-life stages.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Innovation in Green and Water Accounting Systems for the European Water Sector**
- **Agricultural water stewardship for food security**
- **Water footprint of (food) products**
- **Water stewardship approaches in the cities**
- **Water stewardship certification for large water users in industry and agriculture and water stewardship collective action in the shared catchment**
- **Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water**
- **Inclusion of SDGs in corporate strategic planning**
- **LCA for water in various domains**
- **Water-energy-waste nexus in industrial environments**
- **Innovation capacity development tools for the entire innovation process (e.g. supply/demand sides, users of innovation)**

Widening the participatory channels for cross-scale, cross-boundary, climate impact knowledge sharing and transferability to support the international integration of Europe in climate-smart, evidence-based multilateral policymaking. With the objective of translating climate science information into adaptive and mitigative climate policies, European research priorities, in the fields of climate science and solutions, shall effectively support and diversify, in a coordinated and systematic manner, the **channels for innovative knowledge interaction and transfer** between **fields of climate science** and **climate-vulnerable sectors**, whilst taking into account the **conditioning contexts of these sectors** – i.e., sources of learning, patterns of innovation development, sources of technology improvement of firms, level of technological opportunity, entry barriers, as well as the characteristics and disciplinary origins of the knowledge involved in climate science. Particularly, whilst generating and applying new insights into the fields of climate-smart water management, water-smart technology development, and resource-oriented industrial transformations, **democratic pluralisation** and **horizontal exchange of water innovation knowledge** through the use of **participatory, inclusive, creative, and open knowledge translation** mechanisms is of vital importance. The **clustered knowledge transfer channels**, such as **SME platforms**, could serve to make **the influence of industrial Research and Development** proportional for all sizes and scales of **European companies** in the short-to-medium term, whilst increasing the **absorptive capacities of SMEs in innovative water management knowledge** in the medium-to-long term. Moreover, **collaborative, multi-stakeholder, and open research and innovation settings**, such as **living labs**, could foster the **development, testing, and validation of water-oriented solutions with a cross-sector nexus approach**, while better responding to the context-specific climate conditions. Supporting the global development of **collaborative synergies**, **entrepreneurial behaviour and growth aspirations** in the **avenues of water-smart technology solutions** and with the **multi-partite innovation spaces from the extra-European countries** and **strategic regions** can further enable to diversify and scale up, from domestic scale to international level, **European application-focused, translational research initiatives addressing climate-related resources vulnerabilities and effects of climate on water**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Support the promotion of the European model for smart-water abroad through first-of-a-kind demonstration of novel technologies and solutions in extra-European countries and regions**
- **Strengthen collaborations and synergies with water management and innovation platforms with strategic regions (e.g. Israel, the US, Japan, Middle East)**
- **Support international cooperation on Water, as a means to achieve EU priorities in terms of jobs and growth considering the prominent role of Water in jobs creation**
- **Support measures to integrate water component into the implementation of roadmaps**
- **Complementing and upscaling initiatives at EU level with emerging international initiatives in support on the global partnership goal of the SDGs**
- **SME platforms to foster easy partnerships for water**
- **Creation of smart skill building tools for water and water-related sectors to facilitate replicability and applicability of water-related technological solutions and facilitate capacity development**

Strengthening of the financial sustainability and inclusive growth of the climate-vulnerable, SDG-relevant sectors, such as the water sector, via blended financing mechanisms and investment models. The water sector has been traditionally been financed by the public sector, while the private finance flows to the water sector have been limited to date. While tackling the **investment barriers** in the **water sector** and addressing the **infrastructural investment needs** in **other sectors that contribute to water-related SDGs** (e.g. water resources management, bulk water supply, storage and conveyance, water supply services, sanitation, wastewater collection and treatment, irrigation, flood protection, urban drainage, and multipurpose infrastructure), **design of the risk-return profile of the blended finance mechanisms and instruments** should take into consideration sectorial constraints limiting the **mobilisation of commercial finance, effective partnering structures, scale of water-oriented infrastructural solutions within a given spatial area, and development and climate-related risk intensity**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Innovative financing schemes and investment models for the water sector**
- **Assessment of long-term environmental sustainability of water infrastructure**
- **Alignment of policies and financing mechanisms within the EU and beyond the EU around the overarching SDG agenda**

3.1.2. Intervention area: energy supply

INCREASE THE SHARE OF RENEWABLE ENERGY IN EUROPEAN ENERGY MIX.

Renewable energy production from water sources for low-carbon energy supply, with a joint management of water and energy resources. **More than 25,000 hydropower plants** (with or without pumping functions) currently produce approximately **10%** of electricity in the EU (Vermeulen et al., 2019). **Hydropower energy systems** and **technologies** contribute to the stabilisation, improved security, balanced supply, and storage of renewables, such as wind and solar. While considering to increase the **water footprint** of the **energy system**, given the **long-term freshwater needs of the EU energy sector** and **boundary conditions** of **hydropower operations** (e.g. flows, catchments), the integration of **water** and **energy modelling** in **hydropower assessments** is of crucial importance to assess the **impact of hydropower reservoirs** on **water availability** (e.g. altered water flows, sediment transport, loss of connectivity), **water stress** (e.g. blue and green water scarcity), **(chemical) water pollution** in the reservoirs, **biodiversity loss**, and the **management of freshwater resources with other uses**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Hydropower as a European battery**
- **Increase energy production from water sources**
- **Water-energy nexus in energy sector**

3.1.3. Intervention area: energy systems and grids

ADVANCE EMERGING BREAKTHROUGH TECHNOLOGIES AND CLIMATE SOLUTIONS.

Advancing the technological and commercial readiness of sustainability technologies at the water-energy nexus. Advancing research on the **deployment applications** and **techno-economic feasibility** of **water- and energy-saving sustainability technologies** can make a significant contribution to the environment, through the reduction of **biodiversity losses** (e.g. losses and leakages in water networks), the optimisation of wastewater treatments, and valorisation of **unused biomass** for alternative purposes (e.g. municipal use, industrial applications). In terms of water requirements, CO2 emissions, **assessment mediums** could be diversified, with the developments of **computer-aided softwares**, using hybrid modelling methods for **cross-sectorial sustainability** and **integrated environmental assessments** and improving LCIA practices leveraged in the development of technology options for **industrial symbiosis** environments. Furthermore, for advancing **technological and commercial readiness** of water- and energy-saving sustainability technologies, in addition to the importance of politico-engineering efforts, such as **demand-side, catalytic procurement policy mechanisms**, **scale-up industrial research on water- and energy-saving technologies** (e.g. air-based and advanced cooling systems, advanced materials for improved waste-heat recovery, membrane desalinization technologies, smart meters), shall be further supported in the context of industrial, sustainability research and development projects.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New technologies for energy-efficient water treatment, including new decentralised systems**
- **New ICT solutions for energy and water efficiency**
- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including agriculture**
- **Cost effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilisation of multiple water resources**
- **Reduction of energy losses**

3.1.4. Intervention area: communities and cities

INCREASE THE CLIMATE-RESILIENCE OF CITIES AND COMMUNITIES AND THEIR ATTRACTIVENESS TO BUSINESSES AND CITIZENS BY TARGETING GREEN INFRASTRUCTURE.

Nature Basedsolutions for resilient, healthy, and liveable cities. In Europe, **74%** of Europe's population live in **cities** (Statista, 2020). Given the **mass urbanisation** trends at global scale, cities consume **75%** of global energy and emit **80%** of greenhouse gas generated by human activity (Cardone et al., 2013) Henceforth, with the aim of increasing the **territorial resilience of cities** against climate and water issues, regenerating **natural properties of urban ecosystems**, overcoming urban sustainability challenges, and combatting the **natural hazards** (e.g. flooding, drought, heat stress) and their **cascading effects**, the **technology base**, **(co-)benefits**, and **flexibility of nature-inspired configurations**, **socio-techno-economic implementation pathways** and **cost-effectiveness** of **innovative Nature Basedsolutions (NBSs)**, deployed with the support of cohesive **urban policies** and in **synergy with grey infrastructure**, shall be further assessed for **water resource management, disaster risk reduction**, and **climate change adaptation**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Nature Basedsolutions to fight extreme precipitation events/flooding**
- **Nature Basedwastewater treatment systems and urban storm water treatment**
- **Cost effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilization of multiple water resources**

Adaptive and integrative climate change governance for urban resilience and circular city transitions. Within the **(trans)national city networks** focused on **climate governance** (e.g. ICLEI, C40, Cities Alliance) and **urban research networks** (e.g. Urban Climate Change Research Network), **cities** are acknowledged as a **climate solution space**. Nevertheless, **climate mitigation** and **climate adaptation** policies in cities are still not fully integrated, while **adaptation** policies are limited to water management. **Adaptive** and **integrative climate governance**, supported with horizontal, vertical, and multilevel governance modes, can facilitate **more efficient use of urban services** and **natural resources**, while addressing vulnerability and improving quality of life. Moreover, **inclusive**, **multi-stakeholder**, and **multi-sectoral learning networks**, **partnership platforms** could enhance adaptive governing **capacities of local authorities** while realising **climate strategies**; whereas, **innovative environmental governance arrangements**, such as **urban water stewardship approaches**, **water-sensitive urban design schemes** (e.g. new schemes of water reclamation), and **catalytic**, **green procurement mechanisms** in high **climate impact sectors**, could enrich the modes of **urban climate governance** in the realms of **urban policy-making**; introduce cooperative **urban resources management** and **regeneration mechanisms** into the existing **urban resources management** systems; flourish new, circular urban design interventions, by leveraging on the symbiotic relationship of **urban**, **agricultural**, and **industrial resources networks** and **capabilities**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Adapt community water management to climate variability**
- **Water stewardship approaches in the cities**
- **New schemes of water reclamation**
- **Awareness raising actions on social perception of water reclamation and reuse**
- **Green public procurement enhancing innovation in urban water management for the circular economy**
- **Inclusive multi-stakeholders, and multi-sectoral technological and non-technological approaches and partnerships incorporating water into urban agenda**
- **Urban/industrial symbiosis**
- **Innovations in regulatory framework, utility pricing systems, transparency of value, price for water, social awareness, lifecycle assessment including water, smart specialization in water reflecting water-economy, markets, and ecosystem services for water**

Digital water infrastructures and intelligent water ecosystems in urban water futures. The **development** and **deployment of (end-to-end) digital water applications** within **cities** serve to increase **water efficiency** and **water quality** by: optimizing **water resource management**; improving asset management and **customer service excellence** in the water and wastewater industry; optimising water treatment processes in the distribution networks; providing a **data-driven, near-real or real-time understanding of dynamic water systems**, **distribution networks**, **water assets**, and **drivers of biodiversity loss** (e.g. leaks, backflows); and, **producing actionable**, **predictive intelligence** on **water networks** and **natural hazards**. Today, despite the early stage adoption of **digital water solutions** (e.g. smart water metering, cloud-based water software programs) and the digitisation efforts of the (waste-)water utility sector(s), further research is still needed in order to overcome the **externalities affecting the growth of digital water applications**, e.g. **CAPEX/OPEX** associated with the technology development and implementation, lack of **standardisation** in **digital water knowledge systems**, poor, incomplete **water data and analytics**, incompatibilities among **data logging systems**, type of **communication systems** required by the end-use of the data, softwares, **data collection intervals**, among others.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Smart digital water management systems in cities via nexus and circularity approaches**
- **New solutions for decentralized treatment**
- **Information basis and technologies to ensure drinking water supply**
- **Decentralised remediation technologies**
- **Develop digital solutions for competing users of water resources**

Sustainable development and retrofitting of green infrastructures into rural, coastal, and city environments. In **urban** environments, in parallel to the **European Commission's Green Infrastructure Strategy** (2013), for a **decarbonised 2050**, the development and maintenance of **green infrastructures**, among other **urban design solutions** (e.g. indirect reuse, hydrologic restauration, source control), serve to increase not only **resource efficiency** and **performance** (e.g. stormwater reuse, bioretention) but also to **reduce climate vulnerability** (e.g. urban runoff, pollutant loads). In **rural** and **coastal** environments, **green infrastructures** provide s**ocio-ecological resilience benefits** by constructing, restoring wetlands and increasing tree canopy, among others. Nevertheless, for promoting a **coordinated**, **systematic**, **approach towards** the **deployment of green infrastructures in all environments**, research is still needed on the **restoration methodologies**, implementation frameworks, **experimentation approaches, ownership strategies of green infrastructures, performance assessment of green infrastructure systems, and green-grey hybrid systems integration**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Green infrastructures in rural, urban, and coastal areas**
- **Validate the performance functionality and stability of green infrastructure**
- **Validating the functionality of Hybrid Grey Green Infrastructure under extreme conditions**
- **Strategies for optimizing the integration of (new) green and grey functionalities**
- **Restoration methodologies for degraded urban systems**
- **Support to reduce the risk perception of "green" versus "grey" infrastructure**

INCREASE THE CLIMATE-RESILIENCE OF CITIES AND COMMUNITIES AND THEIR ATTRACTIVENESS TO BUSINESSES AND CITIZENS BY TARGETING ENERGY AND RESOURCE EFFICIENCY.



New, resource-oriented business models for urban smartization. With the objective of developing **fit-for-purpose integrative, smart city frameworks, state-of-the-art urban innovation, governance solutions to city management complexity**, development of **new, entrepreneurial business models**, and exploration of **smart city use cases** (e.g. predictive catchment model for supply areas) are of vital importance to: formulate a **co-creation sustainable strategy** building on the right set of value creation, value capture, and revenue models; enhance **resource efficiency and performance**; optimise technological adoption and **exploitation of KETs/FETs** in smart city ecosystems; and, create an **innovative environment for entrepreneurs** to benefit from.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New knowledge bases, predictions, smart management and cost-effective solutions, new community and catchment-based business models**
- **Develop or make a better use of the existing EU-wide financing instruments (e.g. COSME) for water in support to develop business models to bring to the market innovative SMEs solutions on water**
- **Implementation and demonstration of methodologies to assess water technologies in cross-sectorial business cases in various water cycles**

Integrated climate-smart policies and sustainable urban planning approaches for resource efficiency in city environments. With the objective of facilitating the implementation of **sustainable urban water (supply) management**, from a regional scale to individual buildings, the implications of water-related impacts of climate change on **spatial planning interventions** and land planning mechanisms shall receive further research attention, particularly when it comes to: how to reduce **demand for water** in new urban developments within the **food-water-energy-waste nexus**; how to implement **water-sensitive urban design interventions**; how to incorporate **blue-green-grey infrastructure**; and, how to undertake **zoning** and **retrofit actions** for **urban water and wastewater infrastructure in flood zones**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Combining water and energy efficiency in the urban context, integrating this nexus with smart urban management and planning solutions**
- **Assessment of long-term environmental sustainability of water infrastructure**
- **New "value" frameworks enabling better balance of benefits vs. costs**
- **Integrated planning and operation of urban drainage and wastewater treatment plants infrastructures**
- **Environmentally effective and optimally/sustainably managed water installations**

Resilience and resource efficiency solutions for climate-smart urban infrastructure, services and systems. From the perspective of **adaptation** and **resilience** to **climate change**, **resource-efficiency solutions**, combined with **urban planning** that enables beneficial exchange of materials and energy across different industry and infrastructure, yield **economic gains, natural resource conservation, greenhouse gas mitigation**, and **air-pollution reduction**. While setting out the long-term vision for the **new urban developments, resource efficiency solutions**, coupled with **socio-economic** and **ecological resilience solutions**, can increase the **efficiency of water quality**, **use**, **supply** and **sanitation**, or **energy generation** from **water resources**, while addressing **water security challenges** related to **climate change in urban water management**, e.g. **flood risk and damage**, **heatwaves**, **salinisation**, **erosion**. Reinforced coupling of **urban resilience and resource efficiency agendas** in the context of **urban infrastructure** and services could **optimise the resilience of urban systems** while i**ncreasing the efficiency of urban climate adaptation and mitigation plans.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Sustainable process water production by water recycling at various scales**
- **Solutions for storm water overflows**
- **Flood risk and drought strategies in urban, industrial and rural context**
- **Sustainable storage of aquafier and recovery systems on the regional perspective**
- **Restoration methodologies for degraded urban ecosystems**

Improved industrial sustainability performance for carbon-neutral and competitive European industry at the water-energy nexus. With better economies of scale and a systematic application of resource efficiency, harnessing **synergies** of the **water-energy-waste nexus** by leveraging the **state-of-the-art technologies for incineration, energy recovery, waste-to-energy process** and the integration of **used water** and solid **waste treatment processes,** could yield **environmental, economic** and **social benefits** for stakeholders involved in the development of **industrial symbiosis business models,** extension and collaborative governance of **symbiotic resource interdependencies** within the **water-energy-waste nexus** and of **industrial ecology.** With the aim of **diffusing circular**, sustainable **economic models** into **untapped synergies** and improving **industrial sustainability performance**, regions and cities as springboards for industrial symbiosis can accelerate the development of systemic and **symbiotic industrial approaches** for revalorisation and reuse of resources, with the support of **facilitative fiscal, financial, economic and regulatory instruments, schemes, and models.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water-energy-waste nexus in industrial environments**
- **New energy-efficient measures in water-intensive industries**
- **Reduction of energy losses**
- **New water incentive pricing and pricing water security**
- **Innovative economic mechanisms**
- **Technological (including ICT) and management solutions for a sustainable, energy-efficient, and flexible cost-effective and safe multiple waters**
- **Increase awareness and improve perception (on direct and indirect reuse – as drinking water or recharge)**

3.2. Food, bioeconomy, natural resources, agriculture, and environment (cluster 6)

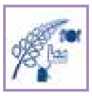


Table 2. Guidance Table for Water Europe R&I Topics

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
1.5.7.	Digital tools and systems for demand forecasting	Close-to-market	TRL6-9	2.2.1.
2.1.1.	New sensors for detection and chemical measurement of pollutants	Fundamental	TRL3-5	2.2.1.
2.1.12.	Cloud computing and real-time monitoring	Applied	TRL5-8	2.2.1.
2.1.13.	High-performance computing systems and applications development	Applied	TRL5-8	2.2.1.
2.1.14.	Data and metadata standardization, data security, interoperability, protection and privacy	Applied	TRL5-8	2.2.1.
2.1.4.	New sensors for biological measurement of micro-organisms	Fundamental	TRL3-5	2.2.1.
2.1.5.	New sensors for protection, security and resilience	Fundamental	TRL3-5	2.2.1.
2.1.9.	Forecasting	Fundamental	TRL3-5	2.2.1.
2.2.10.	New models	Applied	TRL5-8	2.2.1.
2.2.17.	Technologies and managerial solutions for reducing the pressures exerted by 'hot spots' of emerging pollutants	Applied	TRL5-8	2.2.1.
2.2.5.	New pollution detection and laboratory comprehensive methods	Applied	TRL5-8	2.2.1.
2.4.1.	Advanced new generation effect-based monitoring methods based on 'omics' and 'bioinformatics'	Fundamental	TRL3-5	2.2.1.
3.2.3.	Asset lifetime prediction tools in managing failure	Applied	TRL5-8	2.2.1.
4.1.5.	Integration of advanced, low-cost monitoring systems	Applied	TRL5-8	2.2.1.
4.2.1.	Develop and deploy sensing technologies, decision support systems and communication instruments	Applied	TRL5-8	2.2.1.
6.3.3.	Creation of smart skill building tools for water and water-related sectors to facilitate replicability and applicability of water related technological solutions and facilitate capacity development	Non-technical	All	2.2.1.
6.3.4.	Talent building program on KETs and FETs for water in a circular economy	Non-technical	All	2.2.1.
6.3.5.	Education programs (smart people and smart consumers)	Non-technical	All	2.2.1.
6.4.3.	Open access specific guides, security issues, IPR for water	Non-technical	All	2.2.1.
6.4.4.	Innovation capacity development tools for the entire innovation process (e.g. supply/demand sides, users of innovation)	Non-technical	All	2.2.1.

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
1.2.1.	New diversification of water sources	Applied	TRL5-8	2.2.2.
1.2.2.	New cost-effective combinations of salty and brackish water, desalination and (natural) pre-treatment	Applied	TRL5-8	2.2.2.
2.2.1.	FETs for alternatives for harmful substances and methods to avoid pollutants entering the environment	Fundamental	TRL3-5	2.2.2.
2.2.12.	FETs for removal of micro-pollutants	Fundamental	TRL3-5	2.2.2.
2.2.15.	Technologies for nanomaterial removal to avoid persistent and mobile micropollutants in water resources	Applied	TRL5-8	2.2.2.
2.2.16.	Emerging nanotechnologies, nanomaterials, and nano-sciences for water remediation in industrial effluents	Applied	TRL5-8	2.2.2.
2.2.9.	Biodiagnostics: pathways and of microorganisms and viruses – microbial source tracking, pandemic early warning systems by e.g. wastewater monitoring	Applied	TRL5-8	2.2.2.
2.3.10.	Use of antimicrobial nanomaterials, including nanozymes for biofilm removal	Applied	TRL5-8	2.2.2.
2.3.3.	Water purification and filtration concepts	Fundamental	TRL3-5	2.2.2.
2.3.8.	New solutions for decentralised treatment	Fundamental	TRL3-5	2.2.2.
3.1.10.	Nature Basedsolutions to fight extreme precipitation events/flooding	Applied	TRL5-8	2.2.2.
3.1.8.	Role of functionality of natural ecosystems functions	Fundamental	TRL3-5	2.2.2.
3.1.9.	Validating the functionality of Hybrid Grey Green Infrastructure under extreme conditions	Applied	TRL5-8	2.2.2.
3.3.10.	Validate the performance functionality and stability of green infrastructure	Non-technical	All	2.2.2.
3.3.11.	Strategies for optimizing the integration of (new) green and grey functionalities	Non-technical	All	2.2.2.
3.3.6.	Cost effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilization of multiple water resources	Applied	TRL5-8	2.2.2.
4.3.1.	Develop multi-stakeholder Water Diplomacy approaches and practices at regional levels	Non-technical	All	2.2.2.
4.3.2.	Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measure Design	Non-technical	All	2.2.2.
6.2.1.	Innovation in Green and Water Accounting Systems for the European Water Sector	Non-technical	All	2.2.2.
6.3.2.	Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes	Non-technical	All	2.2.2.
5.1.1.	Water-oriented living labs	Non-technical	All	2.2.2., 2.2.3.
1.3.9.	Watershed management problem solving	Non-technical	All	2.2.2., 2.2.3.
6.2.6.	Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water	Non-technical	All	2.2.2., 2.2.3., 2.2.5.
6.2.9.	Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture	Non-technical	All	2.2.2., 2.2.3., 2.2.5.
2.1.8.	Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters	Applied	TRL5-8	2.2.2., 2.2.4.
2.2.2.	Develop solution-oriented strategies and perform surveillance and impact studies to support to prioritisation of emerging pollutants or indicators	Fundamental	TRL3-5	2.2.2., 2.2.4.
2.2.3.	Bioaccumulation in the food chain as well as effects of direct consumption of water containing emerging pollutants	Fundamental	TRL3-5	2.2.2., 2.2.4.
2.2.6.	Assessment of micropollutants breakdown products	Applied	TRL5-8	2.2.2., 2.2.4.
2.2.8.	Pathways and exposure of nanomaterials to water	Applied	TRL5-8	2.2.2., 2.2.4.
3.1.12.	Green infrastructures in rural, urban, and coastal areas	Applied	TRL5-8	2.2.2., 2.2.4., 2.2.5., 2.2.6., 2.2.7.
2.2.13.	Removal of micropollutants (emerging pollutants) from drinking, industrial and domestic wastewaters	Applied	TRL5-8	2.2.2., 2.2.4., 2.2.7.
3.3.2.	Restoration methodologies for degraded urban systems	Applied	TRL5-8	2.2.2., 2.2.5.
3.3.4.	Nature Basedwastewater treatment systems and urban storm water treatment	Applied	TRL5-8	2.2.2., 2.2.5.
1.1.3.	Innovative business models for the water sector	Non-technical	All	2.2.2., 2.2.6., 2.2.7.

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
1.1.1.	New water incentive pricing and pricing water security	Non-technical	All	2.2.3.
1.2.9.	New schemes for water reclamation	Close-to-market	TRL6-9	2.2.3.
1.4.7.	Fostering a level playing field for the EU water market	Non-technical	All	2.2.3.
2.4.2.	Advanced technologies and sustainable management techniques	Fundamental	TRL3-5	2.2.3.
3.1.6.	New knowledge bases, predictions, smart management and cost-effective solutions, new community and catchment-based business models	Close-to-market	TRL6-9	2.2.3.
4.1.7.	Integrating climate projections at various levels into adaptive water management planning	Non-technical	All	2.2.3.
4.3.11.	Collaborative actions among stakeholders	Non-technical	All	2.2.3.
4.3.5.	Alignment of policies	Non-technical	All	2.2.3.
4.3.6.	Joint-decision frameworks to shift to a more chemical-free society	Non-technical	All	2.2.3.
4.3.8.	Streamlining of multi-stakeholder and multi-sectorial actions and decisions	Non-technical	All	2.2.3.
6.5.7.	Complementing and upscaling initiatives at EU level with emerging international initiatives in support on the global partnership goal of the SDGs	Non-technical	All	2.2.3.
6.5.8.	Developing capacities in the EU and abroad (or joint capacity) to successful research and co-generation of knowledge and innovation to address real life demands and societal challenges	Non-technical	All	2.2.3.
1.5.5.	Increase energy production from water resources	Close-to-market	TRL6-9	2.2.3., 2.2.4.
6.2.2.	Agricultural water stewardship for food security	Non-technical	All	2.2.3., 2.2.5.
6.2.5.	Water stewardship certifications for large water users in industry and agriculture and water stewardship collective action in the shared catchment	Non-technical	All	2.2.3., 2.2.5.
1.2.3.	Develop structured and certified alternative water resources for irrigation	Applied	TRL5-8	2.2.3., 2.2.5., 2.2.6.
1.3.4.	Validate and deploy new digital (ICT) solutions for sustainable agriculture	Close-to-market	TRL6-9	2.2.3., 2.2.5., 2.2.6.
2.4.3.	Methods of the rational use of water resources and agrochemicals in precision agriculture	Fundamental	TRL3-5	2.2.3., 2.2.5., 2.2.6.
1.2.5.	Enlarging the Industrial Symbiosis concept to agricultural sector	Non-technical	All	2.2.3., 2.2.5., 2.2.6., 2.2.7.
1.4.1.	Nutritients, minerals and metals	Close-to-market	TRL6-9	2.2.3., 2.2.5., 2.2.6., 2.2.7.
1.3.17.	Development of methodologies and pilot applications of LCA for water	Non-technical	All	2.2.3., 2.2.6.
1.3.5.	Decoupling the rise of agricultural production from the use of water resources	Non-technical	All	2.2.3., 2.2.6.
6.2.8.	LCA for water in various domains	Non-technical	All	2.2.3., 2.2.6.
1.2.4.	New management tools and methodologies, partnerships and business models	Non-technical	All	2.2.3., 2.2.6., 2.2.7.
1.2.7.	Public-private industrial partnerships	Non-technical	All	2.2.3., 2.2.6., 2.2.7.
2.3.2.	New biotechnological solutions for resource recovery	Fundamental	TRL3-5	2.2.3., 2.2.6., 2.2.7.
4.3.7.	Setting-up and strengthening collaborative actions and regional multi-stakeholder partnerships	Non-technical	All	2.2.3., 2.2.6., 2.2.7.
6.1.2.	SME platforms to foster easy partnerships for water	Non-technical	All	2.2.3., 2.2.6., 2.2.7.
6.2.3.	Water footprint of (food) products	Non-technical	All	2.2.3., 2.3.5., 2.3.6.
3.3.7.	Hydropower as a European battery	Non-technical	All	2.2.4.
1.5.3.	Water-energy nexus in energy sector	Applied	TRL5-8	2.2.4., 2.2.7.

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
1.3.3.	Agri-environmental measures	Non-technical	All	2.2.5.
1.3.6.	Combining water and energy efficiency in the urban context, integrating this nexus with smart urban management and planning solutions	Non-technical	All	2.2.5.
1.3.8.	Urban-environmental measures	Non-technical	All	2.2.5.
3.1.2.	Novel urban water systems and infrastructures to cope with Climate Seasonal effects (mitigation and adaptation)	Non-technical	All	2.2.5.
3.1.7.	Inclusive multi-stakeholders, and multi-sectorial technological and non-technological approaches and partnerships incorporating water into urban agendas	Non-technical	All	2.2.5.
3.3.5.	Integrated planning and operation of urban drainage and wastewater treatment plants infrastructure	Non-technical	All	2.2.5.
4.3.3.	Flood risk and drought strategies in urban, industrial and rural context	Non-technical	All	2.2.5.
6.1.1.	Green public procurement enhancing innovation in urban water management for the circular economy	Non-technical	All	2.2.5.
1.3.1.	Optimal irrigation strategies	Close-to-market	TRL6-9	2.2.5., 2.2.6.
1.3.2.	Innovative smart irrigation systems	Close-to-market	TRL6-9	2.2.5., 2.2.6.
1.3.11.	Urban/industrial symbiosis	Fundamental	TRL3-5	2.2.5., 2.2.6., 2.2.7.
6.5.4.	Identification of "transformative potentials" for the achievement of SDGs from other Water Europe SIRA Key Components	Non-technical	All	2.2.6.
4.3.9.	Public-private and cross-sectorial partnerships	Non-technical	All	2.2.6., 2.2.3., 2.2.7.
6.1.4.	Fast Track Innovation for water-related value chains and lifecycles including the possibility of testing and demonstration at local/regional scales and opening opportunities for the access to the environmental technologies and verification testing	Non-technical	All	2.2.6., 2.2.7
1.2.6.	New tools to support industrial symbiosis	Applied	TRL5-8	2.2.6., 2.2.7.
2.3.1.	New solutions for recovery and (re)use of recovered resources	Fundamental	TRL3-5	2.2.6., 2.2.7.
3.3.12.	Desalination based on green technologies	Applied	TRL5-8	2.2.6., 2.2.7.

3.1.2. Intervention area: environmental observation

ADVANCE ENVIRONMENTAL OBSERVATION TECHNOLOGY AND RESEARCH FOR IMPROVING KNOWLEDGE BASE OF CLIMATE SCIENCE AND RESEARCH.

Environmental Internet of Things (IoT) Ecosystem for a Water-Smart Society. With the objective of better understanding aquatic ecosystem processes, water safety threats, and multiple waters ecosystems within the Earth's biosphere, **automated, multi-parameter, near real-time or real-time water metering and monitoring solutions**, coupled with the advanced applications of **efficient, heuristic algorithms** on **centralized cloud computing platforms** or **near-device edge servers**, can increase **efficacy in water saving**, **wastewater detection**; enhance transparency related to the **health and quality of water** (e.g. discharges to water) at the point of discharge or in the receiving environments; optimise environmental **compliance capacity** of industrial water-users with environmental licenses; and, provide cost-effective, scalable, high-performing monitoring, with **real-time indications of operational cause and environmental effect**; foster **immediate remedial action** by detecting water events.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New sensors for protection, security and resilience**
- **Cloud computing and real-time monitoring**
- **High Performance Computing systems and applications development**
- **Integration of advanced, low-cost monitoring systems**

Pollution sensing solutions for increasing integrity and resilience in ecosystem services. It is evident that **anthropogenically-derived** pollutants (e.g. heavy metals, persistent organic pollutants [POP], volatile organic compounds) have increased deterioration of **atmosphere**, **water**, and **soil resources**. Given the growing demand for **accurate** and **spatial technologies and remote sensing solutions and methods**, fundamental and applied research on the development and scale-up of **low-cost pollution** sensing technologies (e.g. sensor arrays, pixel performance), together with the **enabling computing technologies** (e.g. artificial **neural networks**, **environmental intelligence** platforms) should be expanded, particularly for the environmental monitoring of water and **wastewater quality**. Supporting and furthering advancements in pollution sensing solutions and the accessibility to reliable water pollution data could serve to improve **public health protections**, reduce exposures in communities, increase understanding on **biogeochemical cycles affecting water resources**, and accelerate transition to **toxic-free environments** that **protect ecosystems**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Develop and deploy sensing technologies, decision support systems and communication instruments**
- **New sensors for detecting and chemical measurement of pollutants**
- **New sensors for biological measurement of micro-organisms**
- **Technologies and managerial solutions for reducing the pressures exerted by 'hot spots' of emerging pollutants**
- **Advanced new generation effect-based monitoring methods based on 'omics' and 'bioinformatics'**
- **New pollution detection and laboratory comprehensive methods**
- **Pilot systems and tools of nano-technologies applications to ensure clean water**

Big (environmental) data analytics and knowledge base. Ecosystems are complex systems that are not easily defined by a set of **specific data types. Big (environmental) data analytics** builds on a combination of large, multi-faceted datasets generated by **real-time data acquisition technologies** (e.g. real-time sensors, autonomous underwater vehicles) or extracted from **site-collected historical datasets** and other sources (e.g. social media geotagging). Within the context of **environmental data processing, simulation** and prediction, the **environmental science community** have been using or **re-purposing the big data capabilities**, together with **web service technologies**, with the aim of developing shared, **virtual environmental** research sharing and monitoring environments for the fields of climate sciences and increasing efficiency in **environmental decision-making for the policy fields of natural resource recovery and management.** Nevertheless, the infrastructural and **computational bottlenecks**, such as the design of **integrated data accumulation processes**, data **handling procedures,** the **secure** and **consistent access to data**, consideration of **fit-for-purpose analytical methods**, affect the standardisation and usability of **big (environmental) data**. Current **infrastructural bottlenecks** related to the volume, **velocity**, and **variety of environmental data** shall be eliminated, in order to expand the purposive applications of **big data techniques to climate change** and **to environmental monitoring of human-environmental systems**. In the field of water applications, **big (environmental) data** is of crucial importance to the optimal planning of water systems, detection of **ecosystem changes in water cycles**, scheduling of irrigation plans, and mitigation of **environmental pollution**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Cloud computing and real-time monitoring**
- **High-performance computing systems and applications' development**
- **Forecasting**
- **Digital tools and systems for demand forecasting**
- **New models**
- **Develop digital solutions for competing users of water resources**
- **Prediction tools in managing failure**
- **Decision support systems**
- **Improvement of the knowledge base and ICT tools of nutrient management and recycling**
- **Technologies and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquifers**

BETTER ACCESS TO EXISTING GROUND ENVIRONMENTAL INFORMATION THROUGH EUROPEAN AND GLOBAL OBSERVATORIES.

Open Science Practices in Environmental Earth Observation and Climate Technology Transfer. With the objective of increasing efficiency in **climate technology transfer** and advancing the development of **virtual environmental research sharing and monitoring environments, the linked open data platforms, science and technology agreements**, and **environmental metadata initiatives** should be further facilitated on **trans-disciplinary topics of environmental sciences, such as watershed management, biodiversity protection, biotechnology, earth sciences, marine science, and alternative energy**. In the domain of water, development of open science practices and **virtual water knowledge ecosystems** is of high importance to not only enhance the **economics of water technology transfer** (e.g. materials cost, Operations & Maintenance [O&M] costs, technology failures) but also better **understand the societal, ecological, geographical settings of water technology applications**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Open access specific guides, security issues, IPR for water**
- **Data and metadata standardisation, data security, interoperability, protection and privacy**

Skills Training Programs in support of improving Climate Technology Transfer. Climate and ecosystem services cannot function without skilled human capital. In **water- and sanitation-related** sectors, **vocational education** and **training** are considered as **critical success factors** and have been always important for **planning, construction, operation, and maintenance** jobs. In the context of **national** and **transnational technology cooperation frameworks, technical assistance programs**, and **climate technology capacity building programs** at **technology** and **sectoral levels**, **skills challenge**s, **practical training needs, access pathways** for **training and talent programs**, **institutional capacity bottlenecks impeding technology transfer** and **skills application in water- and sanitation-related sectors**, and innovation capacity challenges for the achievement of **SDG6**, shall be further investigated. Improving and diversifying **inclusive skills development pathways**, through the diverse portfolio of **EU funds and programs**, could contribute to the realisation of a **future-oriented**, **climate-smart**, s**ustainable development** of integrated and digitally advanced **water and waste-water management**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Creation of smart skill building tools for water and water-related sectors to facilitate replicability and applicability of water related technological solutions and facilitate capacity development**
- **Talent building program on KETs and FETs for water in a circular economy**
- **Education programs (smart people and smart consumers)**
- **Innovation capacity development tools for the entire innovation process (e.g. supply/demand sides, users of innovation)**

3.2.2. Intervention area: biodiversity and natural capital

BETTER UNDERSTANDING OF BIODIVERSITY AND ECOSYSTEM SERVICES VIA IN-SITU BIODIVERSITY RESEARCH.

Multi-actor, inclusive, participatory, ecosystem research and long-term ecosystem and biodiversity monitoring infrastructures, in support of regional ecosystem services providers. With the aim of identifying, quantifying, and addressing the **localised watershed problems**, in **biodiversity research**, it is of importance to not only develop, co-locate or maintain **long-term, collaborative, integrated, space-based, in-situ biodiversity observation sites and research facilities but also to develop standardised site documentation systems**, **meta-data attributes**, **data integration systems** (for data collected on oceans, atmospheres, terrestrial ecosystems, and solid earth), and **level of aggregation of observed indicators** for these organisational settings. The latter is important for: enhancing connectivity and co-location dynamics between different **in-situ ecosystem research networks; creating problem-oriented processes in environmental science; and, heightening policy awareness at watershed level**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Watershed management problem solving**
- **Role of functionality of natural ecosystems functions**
- **Develop multi-stakeholder Water Diplomacy approaches and practices at regional levels**
- **Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes**

Water-oriented living labs. **Long-term, multi-actor, inclusive, and participatory research and innovation infrastructures and place-based networks**, such as **living labs**, have various societal, political, economic, technological, and ecosystem benefits: promotion of eco-citizenship; entrepreneurial ecosystem research; collaborative solution design for localised watershed management problems; and, development, testing, and validation of technology solutions. In the context of the **Water Europe's Atlas of the EU Water-oriented Living Labs, Water-oriented Living Labs (WoLLs)** are defined as "real-life, water-oriented, demo-type and platform-type environments of a cross-sector nexus approach; 'field-labs' where a combination of solutions can be developed, tested, and validated; and, open and local multi-stakeholder governance structures with democratic control systems."

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water-oriented living labs**
- **Watershed management problem solving**

ADDRESS DRIVERS OF BIODIVERSITY LOSS.

New, sustainable, alternative water harvesting methods for ecosystem conservation. With the objective of overcoming **water poverty**, maintaining ecosystems for **continued service provision**, and improving **livelihood, community**, and **ecosystem resilience**, **green infrastructures**, such as **alternative water harvesting methods** and **practices brings both water management benefits** (e.g. groundwater recharge, water supply/quality regulation) and **co-benefits** (e.g. recovery of natural connectivity, climate change adaptation, increased food security, and protection and valuation of traditional knowledge). While developing the planning, installation, and implementation schemes of **water harvesting systems** (e.g. rainwater harvesting), development of location-specific business models, in accordance with **market demands** and grounded in **Water Diplomacy principles**, could serve to mitigate business **sustainability risks** and increase the **societal** and ecosystem value of these practices.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Innovative business models for the water sector**
- **Develop multi-stakeholder Water Diplomacy approaches and practices at regional levels**
- **New diversification of water sources**
- **New cost-effective combinations of salty and brackish water, desalination and (natural) pre-treatment**

New technological solutions and modelling systems in support of addressing over-exploitation. **Groundwater overexploitation and excess withdrawal of water from aquifers** in coastal zones causes to various **water scarcity** and **security problems** in aquatic ecosystems (e.g. depletion of **water level, contamination of aquifers**, shortages of **water for various uses**, among others) and **coupled human-nature systems** (e.g. inter-relationships between land use changes and water cycles). With the aim of better identifying the **impact pathways of overexploitation on** (fund and stock) **freshwater availability**, **human health**, **water cycles**, **land use related to production systems**, and direct **water use**, the downscaling methods and tools used for **impact characterisation**, **hazard risk assessment**, and **system dynamics methodology of modelling**, can be **further optimised**, in **support of modern tools**, such as **new databases**, **computer softwares**, **mathematical modelling**, and **remote sensing**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Technologies and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquifers**

Innovations in nanotechnology for water and wastewater treatment applications to improve biosphere integrity. Given the global importance of sustaining **drinking water supply** and reducing **water pollution**, **innovations in reliable, automated**, **nano-engineered membrane separation processes**, **membrane filtration techniques,** **self-assembling membranes**, and **biomimetic membranes** (e.g. aquaporin-based membranes) have been only some of the **technological advancement areas** in various **research avenues**. Further research work is necessary for the **stabilisation**, **properties**, and **efficient applications of nanoengineered membrane processes and materials**, together with their **ecotoxicity potentials** and **mobility of nanomaterials on water bodies**. On the **other hand**, **nano-based materials**, such as **adsorption materials**, **nano-catalysts**, **functionalised surfaces**, **coatings and reagents**, bring process efficiency to **water and wastewater treatment processes**, particularly to decentralised applications and point-of-use **water disinfection systems** in various ways: **increasing resistance to fouling**; **increasing rate of adsorption** for organic compounds; **fastening decontamination processes**; and, enhancing the **oxidative elimination of micropollutants** and **microbial pathogens**. Nevertheless, with the overarching goal of improving **biosphere integrity**, furthering research on the **production techniques**, **properties**, **applications**, and **ecotoxicity impacts** of advanced **nanomaterials and nano-engineered membrane** processes is of importance to develop **fit-for-purpose solutions**, **particularly to the production**, **public health**, and **ecosystem resilience challenges** of **climate change**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water purification and filtration concepts**
- **New solutions for decentralised treatment**
- **Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters**
- **Biodiagnostics**
- **FETs for removal of micro-pollutants**
- **FETs for alternatives for harmful substances and methods to avoid pollutants entering the environment**
- **Technologies for nanomaterial removal**
- **Emerging nanotechnologies, nanomaterials, and nano-sciences for water remediation in industrial effluents**
- **Use of antimicrobial nanomaterials, including nanozymes for biofilm removal**
- **Pilot systems and tools of nano-technologies applications to ensure clean water**

Improved sustainability and flow of ecosystem goods and services through the restoration of ecosystem capital. In **densely populated human settlements**, such as **cities**, **spatially engineered urban ecosystems** could affect the **flow of ecosystem goods and services**, such as **air**, **water, living organisms**, and **modified formation**s of **biosphere** as well as the (monetary and non-monetary) maintenance and restauration costs of **ecosystem functions in urban systems.** With the aim of **mitigating the depletion** and **degradation** of **natural assets** available in **urban systems** and **climate change** related impacts on the **capacity of environmental assets** (e.g. rivers, lakes, and woodlands in urban areas), **restoration** and **rehabilitation cases** for degraded **urban areas** should be further defined and **mapped in empirical terms**. This is of importance not only to measure the **benefits of urban ecosystem** assets on urban life quality but also to better identify how **green infrastructure systems** or practices could help to reduce physical stresses caused by **climate risks and hazards** (e.g. flooding).

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Restoration methodologies for degraded urban systems**

SUPPORT THE DEVELOPMENT OF NATURAL CAPITAL TO MONITOR DYNAMICS OF DRIVERS OF CHANGE.

Integration of methods and frameworks for natural capital monitoring and assessment. There are various **accounting approaches** and **methods** that are used for measuring **natural (ecosystem) capitals**, e.g. ENCA, SEEA-EEA, ENCA-QSP, which lead to the development of **siloed opinions** on the **capital capabilities of natural (and ecosystem) assets**. The development of **robust, coherent, multi-scale frameworks and modelling methodologies for natural resource (consumption) accounting** is not only important for finding the most optimal options at system, process, or inter-process levels, while designing circular production-consumptions systems but also for instigating further **climate-adaptive** and **multi-disciplinary collaboration environments for integrated water management systems** at watershed level.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measure Design**
- **Innovation in Green and Water Accounting Systems for the European Water Sector**
- **Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water**
- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture**

BETTER UNDERSTAND LINKS BETWEEN POLLUTANTS, HUMAN HEALTH, AND ECOSYSTEMS.

Better understanding of micro-pollutants and emerging pollutants in water for closing the gap in the knowledge of environmental behaviour and ecotoxicological features of chemical compounds. Anthropogenic, trace **micropollutants**, generated from **diverse sources**, are contaminants present in source and finished water. The **physicochemical properties of micropollutants, local risk factors, human exposure, and water treatment infrastructures affect the movement, mobility, retention, bioaccumulation and transformation of micropollutants** in water cycles. From the public health standpoint, it's been widely acknowledged that **(residual) pharmaceuticals, nanomaterials, endocrine disrupting chemicals (EDCs)**, among various types of micropollutants, cause severe health effects. Given the scarcity of epidemiological data for **micropollutants**, new **solution-oriented, risk mitigation strategies, chemical exposure monitoring technologies**, detection and control mechanisms, enabling better **biochemical assessments** and **wastewater reuse risk evaluations**, should be developed with the aim of better **understanding ecotoxicity profiles**, **chronic health risks**, **chemical degradation** and **biotransformation** capabilities of **micropollutants** in **water cycles** and the **sectorial implications of contamination**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Develop solution-oriented strategies and perform surveillance and impact studies to support to prioritization of emerging pollutants or indicators**
- **Improvement of the knowledge base and ICT tools of nutrient management and recycling**
- **Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters**
- **Bioaccumulation in the food chain as well as effects of direct consumption of water containing emerging pollutants**
- **Removal of micropollutants (emerging pollutants) from drinking, industrial and domestic waste waters**
- **Pathways and exposure of nanomaterials to water**
- **Assessment of micro-pollutants breakdown products**

NATURE BASEDSOLUTIONS TO REDUCE POLLUTION AND DEGRADED SYSTEMS.

Sustainable development and retrofitting of green infrastructures and Nature Basedsolutions to safeguard the environment and mitigate the impacts of climate change-related natural hazards. For maintaining **spatio-ecological sustainability**, increasing **territorial resilience of human settlements and enhancing ecosystem** resilience against **environmental hazard drivers**, restoring and **regenerating natural properties** and **ecological systems** of **human settlements is of importance.** Given the effects of **anthropogenic climate change** on **seasonal water availabilit**y and **supply**, and **climatic water cycling regimes**, the **water-shed scale implementation** of **cost-effective, Nature Basedsolutions (NBSs)**, such as multi-functional **green infrastructure frameworks** in rural, **urban**, **coastal areas**, with **ecological** and **social benefits**, can maintain and **optimise ecosystem-based** climate adaptation services, by enabling the decrease of **flooding risks**, **regulating temperature**, **maintaining freshwater quality** and **supply**, and **enhancing species resilience** through provision of **varied habitats** and **green corridors**. In order to develop successful water-shed scale implementation cases of **green infrastructures and NBSs**, technology base, **(co-)benefits**, **flexibility** of **nature-inspired configurations** and **socio-techno-economic implementation pathways** and **cost-effectiveness of innovative NBS**, deployed with the **support of cohesive urban policies** and in **synergy** with **grey infrastructure**, shall be further developed.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Green infrastructures in rural, urban, and coastal areas**
- **Validate the performance functionality and stability of green infrastructure**
- **Validating the functionality of Hybrid Grey Green Infrastructure under extreme conditions**
- **Strategies for optimizing the integration of (new) green and grey functionalities**
- **Nature Basedsolutions to fight extreme precipitation events/flooding**
- **Nature Basedwastewater treatment systems and urban storm water treatment**
- **Cost effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilization of multiple water resources**

3.2.3. Intervention area: agriculture, forestry and rural areas

IMPROVE ADAPTATION OF PRIMARY PRODUCTION TO CLIMATE CHANGE.

Resilience of agricultural production systems to climate-related stressors for safeguarding food security. **Agriculture**, being the biggest sectorial user of water, requires large quantities of **water** for **irrigation** and of **good quality** for **various production processes** (i.e. food production, processing, transport, and preparation), **across agricultural chains**. While **low-cost**, **innovative, digital ICT solutions** (e.g. global positioning systems [GPS], sensor networks, flood monitoring systems, web applications) have undeniable potentials for **irrigation management**, **contingency planning**, and **rural livelihood maintenance**; deployment of **low-carbon agricultural** processing **practices**, **on-site generation of alternative** (renewable) **energy**, and **bio-tech-based** processing **solutions valorising various types of secondary agriculture** and **forestry wastes contribute** to the decrease of **energy-intensity** and to the **optimisation of processes**. With the aim of **increasing the efficient**, **closed-loop water use**, **crop water productivity, regional water balance**, and **climate-smart agro-production resilience** with less water use, **various cross-domain**, **water-oriented**, **agricultural** production solutions need further research attention. Given the **importance of achieving a climate-neutral agricultural productivity growth**, this is of **importance to address** the **challenges emerged** from the **interdependency** of **water**, **energy**, and **food**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Decoupling the rise of agricultural production from the use of water resources**
- **Validate and deploy new digital (ICT) solutions for sustainable agriculture**
- **Methods of the rational use of water resources and agrochemicals in precision agriculture**
- **Innovative smart irrigation systems**
- **Increase energy production from water sources**
- **Develop structured and certified alternative water resources for irrigation**
- **New biotechnological solutions for resource recovery**
- **Development of methodologies and pilot applications of LCA for water**
- **LCA for water in various domains**

ACCELERATE FARMING SYSTEM TRANSITION.

New agro-innovation governance schemes. Agricultural Innovation Systems (AIS) are of crucial to cultivate **resource-efficient agro-production** practices and optimise the **sustainability of natural** resource use within the agri-food sector. While the long-term impact of **agricultural R&D** on **carbon-neutral agricultural productivity growth is well acknowledged**; **institutional settings** (e.g. governance structures, modes) and **framework conditions** (e.g. national agricultural innovation strategies, policy coherence within the agriculture and agri-food sectors) **affect the solution effectiveness**, **adoption rate** and **watershed implementation** scale of **climate-smart**, **resource-efficient**, and **closed-loop agro-production solutions.** For enhancing the adaptive **capacity of agricultural innovation ecosystems** and **developing climate-smart**, **resource-efficient**, **inclusive**, and **climate-smart agricultural innovation governance**, **issue-**, **process-**, **location-** or **technology-domain** specific cases for sustainable resource management practices, **agricultural production** and **process-control techniques**, farm decision **support systems** (e.g. application of LCA for cropping system analysis, environmental assessment of farms) **should receive further research focus.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Agricultural water stewardship for food security**
- **Water stewardship certification for large water users in industry and agriculture and water stewardship collective action in the shared catchment**
- **Decision support systems**
- **Advanced technologies and sustainable management techniques**
- **Agri-environmental measures**
- **New schemes for water reclamation**
- **New water incentive pricing and pricing water security**
- **Streamlining of multi-stakeholder and multi-sectorial actions and decisions**
- **Integrating climate projections at various levels into adaptive water management planning**

Agro-ecology living labs. Within the **agriculture** and **agro-food sectors**, the spatial application of **living lab concept**, as an **open-innovation research infrastructure**, in the forms of **piloting area**, **self-organised social farming system**, or **agro-innovation knowledge network**, could have **various implications** on the reorganisation of agricultural production systems at the **watershed** and **landscape levels**, whilst **leveraging synergies** among **agro-ecological communities**, improving **adaptive capacity of agricultural policy interventions**, structuring **agro-ecological data** gathering, and **facilitating** the transition towards **carbon-neutral agricultural production systems** and sustainable farming practices.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water-oriented living labs**
- **Watershed management problem solving**
- **New knowledge bases, predictions, smart management and cost-effective solutions, new community and catchment-based business models**

ENHANCE RESOURCE USE EFFICIENCY IN AGRICULTURE AND FORESTRY.

Better understanding of resource flows at the nexus of water-energy-food nexus. Understanding, in empirical and systemic terms, the **socio-material interconnectedness** between **multiple environmental resources**, **connectivity** of **resource flows**, **cross-sectorial systems**, and **infrastructure operation** of resource **provisioning**, is of crucial importance to advance in the development of **nexus programs**, **cross-sectorial trade-offs**, **technical solutions** and **deployment** of **resource steering** and **recovery strategies**. In order to enhance understanding on the material conditions and capability limitations of water-energy-food **nexus constellations** and optimize **alternative**, cross-sectorial resource **management planning**, **nexus-oriented**, **transdisciplinary**, **ICT-enhanced decision support systems** (e.g. systems analytics, advanced visualisation, nexus assessment) need to be further developed, in a coordinated manner.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water footprint of (food) products**
- **Enlarging the Industrial symbiosis concept to agricultural sector**
- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture**
- **Nutritients, minerals, and metals**
- **Improvement of the knowledge base and ICT tools of nutritient management and recycling**
- **Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water**

SUPPORT THE CREATION OF NEW VALUE CHAINS.

Advanced knowledge on structure and functioning of food and non-food value chains. It is evident that investment in **sustainable food** and **non-food production systems** and processes leads to the entrepreneurial creation of **new, bio-circular value chains** for both **sectors supplying biomass** and **sectors using biomass**, implementation of **symbiotic resources management frameworks** in cross-sectorial settings, valorisation of **unused biomasses, value-added utilisation** of **by-products** and **recovered resources** for **cost-effective industrial process**. In order to foster scale-up **innovations** at the **nexus of physical**, **digital,** and **biological systems**, deploy **bio-circular solutions** and **optimise product** value in **new value chains**, further research on how to **optimise the systematics** of **value chain** data gathering and foster **decision model innovation** for resource optimisation purposes could be undertaken, both for the food and non-food value chains. For the **food value chains**, although markets conditions and **distribution systems affect** impact pathways for **food value chains**, some of the **major bottlenecks** impeding efficient value chain data gathering still remain: **difficult-to-control** and **difficult-to-measure** processes (e.g. nutritient leaching, erosion, emissions); complexity of **environmental mechanisms**; **high variability** of **production processes**; lack of **agro-ecological** data models; lack of **efficient LCA databases** and calculation procedures applicable for **agricultural ecosystems**; and, lack of systemic knowledge on **nutrient recycling**, **recovery and reuse (RRR) value chains**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water footprint of (food) products**
- **Development of methodologies and pilot applications of LCA for water**
- **LCA for water in various domains**
- **Enlarging the Industrial symbiosis concept to agricultural sector**
- **Nutritients, minerals, and metals**
- **Improvement of the knowledge base and ICT tools of nutritient management and recycling**

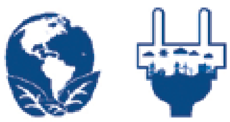
Partnership structures for supporting circular, value-chain based blue economy platforms at local, regional, national, and transnational levels. In full alignment with the Europe's **bioeconomy** and **circular economy** policy priorities, sustaining the **European blue economy growth** is of crucial importance while addressing **global challenges**, such as **energy security**, **environment**, **climate change**, and **food security**. In this context, the creation of **well-functioning** and **sustainable partnership** structures could facilitate not **only effective**, **systematic**, and c**ollaborative innovation** in the **European blue economy** but also increase **synergies for gathering reliable**, **sector-related information**, by **embracing multiple sectors** and **polices related to the blue economy**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New management tools and methodologies, partnerships and business models**
- **Public-private industrial partnerships**
- **Public-private and cross-sectorial partnerships**
- **Streamlining of multi-stakeholder and multi-sectorial actions and decisions**
- **Setting-up and strengthening collaborative actions and regional multi-stakeholder partnerships**
- **Joint-decision frameworks to shift to a more chemical-free society**
- **Alignment of policies**
- **Collaborative actions among stakeholders**
- **Fostering a level playing field for the EU water market**
- **SME platforms to foster easy partnerships for water**
- **Complementing and upscaling initiatives at EU level with emerging international initiatives in support on the global partnership goal of the SDGs**
- **Developing capacities in the EU and abroad (or joint capacity) to successful research and co-generation of knowledge and innovation to address real life demands and societal challenges**

3.2.4. Intervention area: seas, oceans, and inland waters

INCREASE INTEGRITY AND RESILIENCE IN MARINE AND COASTAL ENVIRONMENTS.



Sustainable exploitation of marine ecosystems. While reinforcing the resilience of **marine ecosystems** and their **biodiversity** and addressing **challenges** related to the marine capital (e.g. increase of sea temperatures, rise of sea levels, ocean acidification), **better understanding** and **sustainable exploitation** of **marine renewable biomass** sources at ecosystem and landscape levels is important. From the **renewable energy standpoint**, for curtailing **greenhouse gas emissions** and responding to **increased energy demands**, trajectories for **marine renewable energy (MRE) development**, installation and maintenance aspects of **MRE systems**, **MRE device testing locations**, technologies enabling **MRE production** from tidal streams, **waves**, and so forth should be **further explored** in **research** and **innovation activities**. Furthermore, in order to decrease **excessive groundwater exploitation** in **coastal zones** and to decrease **coastal hazards** (e.g. wind-driven coastal waves, shoreline erosion), **innovative**, **integrated modelling tools** for exploring the interactions between different **water masses** (e.g. groundwater, surface water) and **habitats can enable better spatial** planning on land and sea use **management.** Lastly, given the complexity of **marine ecosystems**, **knowledge base**, **ecological value** and **mapping practices** related to **marine green infrastructures** are still limited.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Increase energy production from water resources**
- **Hydropower as a European battery**
- **Water-energy nexus in energy sector**
- **Technologies and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquifers**
- **Green infrastructures in rural, urban and coastal areas**

IMPROVE ANALYTICAL TOOLS TO ADDRESS EFFECTS OF CHEMICAL STRESSORS, EMERGING POLLUTANTS.

Better understanding of micro-pollutants and emerging pollutants in water for closing the gap in the knowledge of environmental behaviour and ecotoxicological features of chemical compoundss. Anthropogenic, trace **micropollutants**, generated from **diverse sources**, are contaminants present in source and finished water. The **physicochemical properties of micropollutants**, **local risk factors**, **human exposure**, and **water treatment infrastructures** affect the **movement**, **mobility**, **retention**, **bioaccumulation** and **transformation of micropollutants** in water cycles. From the public health standpoint, it has been widely acknowledged that **(residual) pharmaceuticals, nanomaterials, endocrine disrupting chemicals (EDCs)**, among various types of **micropollutants**, cause severe health effects. Given the scarcity of **epidemiological data** for micropollutants, new **solution-oriented**, **risk mitigation strategies**, **chemical exposure monitoring technologies**, **detection and control mechanisms**, enabling better **biochemical assessments** and **wastewater reuse risk evaluations**, should be developed with the aim of better understanding **ecotoxicity profiles, chronic health risks, chemical degradation** and **biotransformation capabilities** of micropollutants in water cycles and the **sectorial implications of contamination.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Develop solution-oriented strategies and perform surveillance and impact studies to support to prioritization of emerging pollutants or indicators**
- **Improvement of the knowledge base and ICT tools of nutrient management and recycling**
- **Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters**
- **Bioaccumulation in the food chain as well as effects of direct consumption of water containing emerging pollutants**
- **Removal of micropollutants (emerging pollutants) from drinking, industrial and domestic waste waters**
- **Pathways and exposure of nanomaterials to water**
- **Assessment of micro-pollutants breakdown products**

3.2.5. Intervention area: food systems

BETTER UNDERSTANDING OF THE COMPONENTS OF THE FOOD SYSTEMS SUSTAINABILITY.

Better understanding of resource flows at the water-energy-food nexus. Understanding, in empirical and systemic terms, the **socio-material interconnectedness** between **multiple environmental resources**, **connectivity** of **resource flows**, **cross-sectorial systems**, and **infrastructure operation** of resource **provisioning**, is of crucial importance to advance in the development of **nexus programs**, **cross-sectorial trade-offs**, **technical solutions** and **deployment** of **resource steering** and **recovery strategies**. In order to enhance understanding on the material conditions and capability limitations of water-energy-food **nexus constellations** and optimize **alternative**, cross-sectorial resource **management planning**, **nexus-oriented**, **transdisciplinary**, **ICT-enhanced decision support systems** (e.g. systems analytics, advanced visualisation, nexus assessment) need to be further developed, in a coordinated manner.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water footprint of (food) products**
- **Enlarging the Industrial symbiosis concept to agricultural sector**
- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture**
- **Nutrients, minerals, and metals**
- **Improvement of the knowledge base and ICT tools of nutrients management and recycling**
- **Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water**

IMPROVE RESOURCE EFFICIENCY AND CIRCULARITY BY ADDRESSING ENVIRONMENTAL PRESSURES IMPACTING ON THE FOOD SYSTEMS.

Resource-efficient use of water in urban-food systems. **Circularity, low-carbon resource efficiency, and sustainability of food systems and urban foodsheds** has been implicated in various urban policy arenas. Although urban settings differ in terms of **land use**, **scale of urbanisation**, **demographics**, and **level of food system sustainability**, the sustainability of **urban food systems** and **water efficiency in urban food production processes** are directly linked to the effective management of **urban land**, **watersheds**, **water treatment** and **distribution infrastructures** within **urban areas as well** as s**uccessful integration of green infrastructures** (e.g. grey water collection and filtration systems decreasing the use of drinking water for irrigation in urban farms, precision drip-irrigation systems, drought resistant plants, food producing rooftops), and **implementation of alternative cultivation techniques in urban farms** (e.g. aeroponics, hydroponics), among others. Adoption of **collaborative**, **multi-sector**, and **multi-stakeholder** approaches is also crucial, particularly when it comes to the **sustainable managemen**t, use and **rehabilitation of urban resource base** (e.g. land, water, energy). Henceforth, more research attention should be given to the **discovery of novel pathways** for resource-efficient use of water in urban-food systems.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Urban/industrial symbiosis**
- **Urban-environmental measures**
- **Combining water and energy efficiency in the urban context, integrating this nexus with smart urban management and planning solutions**
- **Novel urban water systems and infrastructures to cope with Climate and Seasonal effects (mitigation and adaptation)**
- **Green public procurement enhancing innovation in urban water management for the circular economy**

Resource-efficient use of water in agro-food systems. Large amounts of **water** are needed for **agro-food production**. While **water resource-use efficiency** can be realised in **multiple ways** (e.g. decoupling, reduction of leakages from irrigation systems) in **agro-food systems**, in the effort to develop and **maintain sustainable**, **carbon-neutral, productive**, **resource-efficient** and **resilient agro-food systems**, the key **drivers** of **water efficiency** and **nutrient uptake efficiency in rural farm** settings, such as adoption of **eco-innovative**, **water-saving technologies** for **irrigation, cultivation, and farm-management applications**, **alternative resource** planning approaches, **integrated investment** in **food systems**, **community partnerships**, **farming practices**, **agro-ecosystem interventions** (e.g. damming of rivers, changing flow regimes), shall be further mapped, identified, assessed and analysed.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Develop structured and certified alternative water resources for irrigation**
- **Optimal irrigation strategies**
- **Innovative smart irrigation systems**
- **Validate and deploy new digital (ICT) solutions for sustainable agriculture**
- **Methods of the rational use of water resources and agrochemicals in precision agriculture**

IMPROVE THE CLIMATE RESILIENCE OF FOOD SYSTEMS INFRASTRUCTURE.

Institutional capacity building for climate resilient development of food systems infrastructure in urban, peri-urban, and rural contexts. In **urban**, **peri-urban**, and **rural contexts**, there are still **institutional** and **policy barriers** to the **water integrity**, **climate-resilient development** of sustainable **food systems infrastructure** and **food security**, such as the lack of **push-and-pull incentives** (e.g. benefits sharing mechanisms, know-how tools, water distribution planning, water-saving irrigation measures, water productivity measures in sourcing policies), inappropriate **land uses** (e.g. land tenure issues), **crowded stakeholders' space** in the **Water-Food-Energy nexus** (WEF), **lack of systemic**, **trans-sectorial**, **vertical** and **horizontal coordination** and **cooperation** between key **institutions in WEF nexus domains**. The **systemic institutional** capacity building efforts and **service design** of **local utilities** for **water supply and sanitation** could serve to increase **water productivity** in food systems as well as the **contribution** of **integrated water management practices** at the **WEF nexus** to **water integrity**, **resource development**, **biodiversity protection**, and **environmental conservation**, among others.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Integrated planning and operation of urban drainage and wastewater treatment plants infrastructure**
- **Agricultural water stewardship for food security**
- **Water stewardship certification for large water users in industry and agriculture and water stewardship collective action in the shared catchment**
- **Inclusive multi-stakeholders, and multi-sectorial technological and non-technological approaches and partnerships incorporating water into urban agendas**

Incorporation of climate change adaptation in food systems infrastructure in urban, peri-urban and rural contexts. Given the fact that **climate change** (e.g. variability in seasonality, extreme weather events, changing rainfall patterns) reduces **yield growth** by increasing **pressure** on **land** and **water**, **high dependence of agricultural production** on climatic conditions puts **long-term agricultural productivity** is at stake. On the other hand, the agriculture sector accounts for approximately **10 % of the EU's total greenhouse gas (GHG) emissions (European Environment Agency, 2015)**. In this context, it is of vital importance to instigate and develop **climate-adaptive**, **multi-functional**, and **resilient practices**, **technologies**, and **tools** which improve not only the systems components (e.g. water, soil, energy, crop diversity and production, livestock) of **food systems** in **urban**, **peri-urban**, and **rural settings** but also **facilitates the achievement** of **food security**. With the objective of developing **climate-smart** and **future-proof food systems**, **synergies between mitigative** and **adaptive measures** should be further leveraged at all levels: **grassland (use) management**, **cropland (use) management**, **livestock management**, **energy use**, and **water use**, among others.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Urban/industrial symbiosis**
- **Enlarging the Industrial Symbiosis concept to agricultural sector**
- **Urban-environmental measures**
- **Agri-environmental measures**
- **Novel urban water systems and infrastructures to cope with Climate and Seasonal effects (mitigation and adaptation)**
- **Combining water and energy efficiency in the urban context, integrating this nexus with smart urban management and planning solutions**
- **Restoration methodologies for degraded urban ecosystems**
- **Flood risk and drought strategies in urban, industrial, and rural context**
- **Nature Basedwastewater treatment systems and urban storm water treatment**
- **Green infrastructures in rural, urban, and coastal areas**

3.2.6. Intervention area: bio-based innovation systems

SUPPORT THE ESTABLISHMENT OF NEW BIO-BASED VALUE CHAINS VIA ECOSYSTEMS INTEGRITY.

Industrial symbiosis for integration of biological resources into models of circular economy. Industrial symbiosis, applying the **principles of sustainable ecosystem integrity**, **resource economics**, and **multi-industrial ecology**, contributes to **recovery** and **re-use** of **scarce resources** while maintaining the **market value of products**, enhancing the **adoption** of **ecological design requirements** in industrial processes, instigating **bio-compatible** business models (e.g. closed-loop, circular, eco-centric manufacturing), and extending or modifying resource base of **industrial organisations**. From this **definitional standpoint**, as the expansion of this **transformative economic** thinking into **sectors require** a crowded, **trans-sectorial stakeholder** base, it is of importance to develop **right structures**, decision support mechanisms and models for developing and managing symbiotic partnerships across all sizes and scales of stakeholders and enabling the **harmonisation** of industrial activities with the **environment, biodiversity, energy, and carbon reduction.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Innovative business models for the water sector**
- **New management tools and methodologies, partnerships and business models**
- **Enlarging the industrial symbiosis concept to agricultural sector**
- **New tools to support industrial symbiosis**
- **Urban/industrial symbiosis**
- **Public-private and cross-sectorial partnerships**
- **Public-private industrial partnerships**
- **Setting up and strengthening collaborative actions and regional multi-stakeholder partnerships**
- **SME platforms to foster easy partnerships for water**
- **Fast Track Innovation for water-related value chains and lifecycles including the possibility of testing and demonstration at local/ regional scales and opening opportunities for the access to the environmental technologies' verification testing**
- **Identification of "transformative potentials" for the achievement of SDGs from other Water Europe SIRA Key Components**

SUPPORT THE ADVANCEMENT OF RESILIENT AND SUSTAINABLE BIOMASS PRODUCTION SYSTEMS.

Novel irrigation technologies for climate-resilient crops. **Innovative**, **cost-effective**, **water-efficient irrigation technologies**, **water harvesting** and **storage techniques**, coupled with **climate-resilient** and **adaptive crop production methods**, serve to sustain f**reshwater supply** and **retention**; decrease **watershed vulnerabilities** at **agricultural community level**; optimise **agricultural productivity at the Water-Food-Energy (WEF) nexus** and local **water integrity**, in support of **water and food security;** and, **improve sanitation**.

While it is important to find and field-test the **water-efficient irrigation schemes and technologies** that meet the needs of local context, territorial and **biophysical opportunities** for **wastewater reuse** pathways, **alternative water** harvesting structures, **smart agriculture applications** (e.g. IoT-enabled, automatic irrigation systems) barriers to the **technology adoption** can be further explored through the successful development of new, empirical research and development avenues.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Develop structured and certified alternative water resources for irrigation**
- **Optimal irrigation strategies**
- **Innovative smart irrigation systems**
- **Decoupling the rise of agricultural production from the use of water resources**
- **Methods of the rational use of water resources and agro-chemicals in precision agriculture**
- **Validate and deploy new (ICT) solutions for sustainable agriculture**

Advanced climate-smart environmental technologies for resource recovery and re-use and lowering toxicity in the agri-food environments. **Innovation approaches**, supporting the **climate co-benefits** through resource **recovery** and **re-use**, **improving sanitation**, and lowering **toxicity of products** used or found in **natural resource components of food systems** (e.g. water, soil), **could facilitate** the **watershed scale** implementation of climate **smart agriculture practices**, through various **optimisation pathways** for resource use (e.g. onsite/offsite resource recovery, onsite energy generation, nutrient recycling, water reuse) at the **Water-Energy-Food (WEF) nexus** as well as **the benefits generated from the co-implementation of resource recovery and reuse strategies** and **pollution prevention mechanisms** for smart, **zero-carbon**, **zero-waste agro-production environments**. In addition to the fact that it is important to assess the appropriateness, benefits and trade-offs of such **environmental innovation approaches**, **techniques**, and **technologies**, it is important to generate **advances in climate-smart**, **resource-efficient** environmental technologies for **future-proof food systems** and **agro-production environments**, by supporting trans-disciplinary research and development ventures at the **water-energy-food nexus**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improvement of the knowledge base and ICT tools of nutritient management and recycling**
- **Nutritients, minerals and metals**
- **Desalination based on green technologies**
- **New solutions for recovery and (re)use of recovered resources**
- **New biotechnological solutions for resource recovery**
- **Develop digital solutions for competing users of water resources**
- **Green infrastructures in rural, urban, and coastal areas**

Technologies to optimize the water potential of the consumable feedstock. The reinforcement of the **adaptive, water-saving agricultural production capacity and mitigation measures for freshwater water scarcity** can be further supported and evidence-based by showing advancements in **computational environmental research** and **pilot applications** that enable to develop new scales of problem solution for tackling resource scarcity at the **Water-Energy-Food (WEF) nexus** and quantify uncertainties of climate science and w**ater scarcity footprint**. While the **computational methods**, such **water footprint assessments** can quantify and **localise the blue**, **green**, and **grey water footprint at various scales** (e.g. supply chain, organization, product, consumer), advancing the **statistical methods** and pilot applications of **Life-Cycle Assessments (LCA)**, building upon **aggregated metric systems** and **impact categories**, help to generate insights on factors affecting **water abstraction** and **consumption**. Such advanced, computational methods and their real-life pilot applications facilitate the robust planning of **integrated resource optimization strategies and circular use of resources**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water footprint of (food) products**
- **Development of methodologies and pilot applications of LCA for water**
- **LCA for water in various domains**

3.2.7. Intervention area: circular systems

OPTIMISE CIRCULAR AND SUSTAINABLE USE OF NATURAL RESOURCES.

Sustainable and circular use of water resources for all purposes. **Sustainable** and **circular use of water resources across industrial sectors** contribute greatly to the improvement of the **water systems resilience** and **water availability**. There are various **model-architectures** for **circular water systems** at different spatial scales, leveraging on the **integrated systems designs** that combine decentralised or **distributed technologies**, acknowledging **multiple water cycle** domains, externalities, and **policy priority areas** (e.g. water treatment, wastewater treatment, recovery of resources, water reuse and recycling). Nevertheless, generating research efforts in the further development of **transdisciplinary knowledge base** on the **benefits associated** with the circular water systems, **ICT-enabled computational tools**, and **advancement of cross-sectorial pilot applications** is highly important in order to conceptualise, design, and apply sustainable, circular water systems at the desired **spatial scale** and **watershed** level and develop business models supporting circular **water systems**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improvement of the knowledge base and ICT tools of nutritient management and recycling**
- **Nutritients, minerals and metals**
- **Desalination based on green technologies**
- **New solutions for recovery and (re)use of recovered resources**
- **New biotechnological solutions for resource recovery**
- **Develop digital solutions for competing users of water resources**
- **Green infrastructures in rural, urban, and coastal areas**
- **Water-energy-waste nexus in industrial environments**
- **Removal of micropollutants (emerging pollutants) from drinking, industrial and domestic waste waters**

DEVELOP CIRCULAR BUSINESS MODELS AND PRODUCTION PATTERNS.

Industrial symbiosis. **Industrial symbiosis is a process-oriented**, **collaborative**, **territorial**, **industrial re-organization approach** towards the **recovery**, **reuse**, **optimal**, and **synergistic valorisation** of scarce resources, which can be, oftentimes, framed as a **circular business modelling framework.** Given the fact that circular economy encompasses various levels, ranging from product component to cities, **industrial symbiosis**, by opening up **alternative paths for eco-friendly profitability**, advancing **flows of trans-sectorial information**, and instigating **partnership opportunities** built into **circular business models**, impacts positively the achievement of **circular economy targets** at the **inter-industrial level**, and across different **spatial scales** (e.g. urban, peri-urban, rural, regional).

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Innovative business models for the water sector**
- **New management tools and methodologies, partnerships and business models**
- **Enlarging the industrial symbiosis concept to agricultural sector**
- **New tools to support industrial symbiosis**
- **Urban/industrial symbiosis**
- **Public-private and cross-sectorial partnerships**
- **Public-private industrial partnerships**
- **Setting up and strengthening collaborative actions and regional multi-stakeholder partnerships**
- **SME platforms to foster easy partnerships for water**
- **Fast Track Innovation for water-related value chains and lifecycles including the possibility of testing and demonstration at local/ regional scales and opening opportunities for the access to the environmental technologies' verification testing**

3.3. Digital, industry and space (cluster 4)

Table 3. Guidance Table for Water Europe R&I Topics

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
2.1.6.	Cost-effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilisation of multiple water resources	Applied	TRL5-8	2.3.1.
3.3.3.	Design of Nature Basedor nature-inspired technologies	Fundamental	TRL3-5	2.3.1.
1.5.2.	New energy-efficient measures in water-intensive industries	Applied	TRL5-8	2.3.1., 2.3.10.
1.5.6.	Reduction of energy losses	Close-to-market	TRL6-9	2.3.1., 2.3.10.
3.3.8.	Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple waters	Applied	TRL5-8	2.3.1., 2.3.10.
6.1.4.	Fast Track Innovation for water-related value chains and lifecycles including the possibility of testing and demonstration at local/regional scales and opening opportunities for the access to the environmental technologies and verification testing	Non-technical	All	2.3.1., 2.3.4.
1.3.16.	Water-energy-waste nexus in industrial environments	Close-to-market	TRL6-9	2.3.1., 2.3.9., 2.3.10.
1.2.4.	New management tools and methodologies, partnerships and business models	Non-technical	All	2.3.10.
1.2.7.	Public-private industrial partnerships	Non-technical	All	2.3.10.
1.4.6.	Promotion of new policy developments, new regulation and incentives	Non-technical	All	2.3.10.
1.4.7.	Fostering a level playing field for the EU water market	Non-technical	All	2.3.10.
1.5.1.	New technologies for energy-efficient water treatment, including new decentralized systems	Applied	TRL5-8	2.3.10.
1.5.3.	Water-energy nexus in energy sector	Applied	TRL5-8	2.3.10.
1.5.4.	New ICT solutions for energy and water efficiency	Close-to-market	TRL6-9	2.3.10.
4.3.11.	Collaborative actions among stakeholders	Non-technical	All	2.3.10.
4.3.5.	Alignment of policies	Non-technical	All	2.3.10.
4.3.6.	Joint-decision frameworks to shift to a more chemical-free society	Non-technical	All	2.3.10.
4.3.7.	Setting up and strengthening collaborative actions and regional multi-stakeholder partnerships	Non-technical	All	2.3.10.
4.3.8.	Streamlining of multi-stakeholder and multi-sectorial actions and decisions	Non-technical	All	2.3.10.
4.3.9.	Public-private and cross-sectorial partnerships	Non-technical	All	2.3.10.
6.5.8.	Developing capacities in the EU and abroad (or joint capacity) to successful research and co-generation of knowledge and innovation to address real-life demands and societal challenges	Non-technical	All	2.3.10.
2.1.11.	Advanced modelling, simulation, control and optimization techniques	Applied	TRL5-8	2.3.2.
2.1.8.	Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters	Applied	TRL5-8	2.3.2.
2.2.26.	Assessment of micro-pollutants breakdown products	Applied	TRL5-8	2.3.2.
2.2.8.	Pathways and exposure of nanomaterials to water	Applied	TRL5-8	2.3.2.
2.2.9.	Bio-diagnostics	Applied	TRL5-8	2.3.2.
3.1.3.	Research the causes and significance of microbial growth (including opportunistic pathogens) in water distribution networks and other engineered water systems	Fundamental	TRL3-5	2.3.2.
3.2.4.	Environmentally effective and optimally/sustainably managed water installations	Applied	TRL5-8	2.3.2.
3.2.5.	Assessment of long-term environmental sustainability of water infrastructure	Fundamental	TRL3-5	2.3.2.
4.1.6.	Analyse the feasibility, flexibility and governance of water-related infrastructure and technologies	Non-technical	All	2.3.2.

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
2.2.7.	Emerging nanotechnology approaches	Applied	TRL5-8	2.3.2., 2.3.4.
2.1.12.	Cloud computing and real-time monitoring	Applied	TRL5-8	2.3.2., 2.3.5, 2.3.6.,
2.2.5.	New pollution detection and laboratory comprehensive methods	Applied	TRL5-8	2.3.7.
4.3.2.	Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measure Design	Non-technical	All	2.3.2., 2.3.5.
2.1.13.	High-performance computing systems and applications' development	Applied	TRL5-8	2.3.2., 2.3.5.
2.1.10.	Improve (big) data collection, fusion, analysis, data-driven process-based models' development, and visualisation techniques	Applied	TRL5-8	2.3.2., 2.3.5., 2.3.6., 2.3.7. 2.3.2., 2.3.5., 2.3.7.
2.1.14.	Data and metadata standardisation, data security, interoperability, protection and privacy	Applied	TRL5-8	2.3.2., 2.3.5., 2.3.7.
2.2.10.	New models	Applied	TRL5-8	2.3.2., 2.3.5., 2.3.7.
3.2.3.	Asset lifetime prediction tools in managing failure	Applied	TRL5-8	2.3.2., 2.3.5., 2.3.7.
4.1.4.	Predictive decision support systems for systematic and water smart network management	Applied	TRL5-8	2.3.2., 2.3.5., 2.3.7., 2.3.8.
6.2.9.	Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture	Non-technical	All	2.3.2., 2.3.6., 2.3.7., 2.3.9., 2.3.10.
1.5.7.	Digital tools and systems for demand forecasting	Close-to-market	TRL6-9	2.3.2., 2.3.7.
2.1.9.	Forecasting	Fundamental	TRL3-5	2.3.2., 2.3.7.
6.2.1.	Innovation in Green and Water Accounting Systems for the European Water Sector	Non-technical	All	2.3.2., 2.3.7.
4.1.2.	Improvement of the knowledge base and ICT tools of nutritient management and recycling	Applied	TRL5-8	2.3.2., 2.3.7., 2.3.9.
6.2.6.	Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water	Non-technical	All	2.3.2., 2.3.7., 2.3.9.
1.4.3.	Boosting the value of membrane and other separation technologies in water	Close-to-market	TRL6-9	2.3.3.
1.4.4.	Pilots for new nano-membrane technologies and applications for water purification and treatment	Close-to-market	TRL6-9	2.3.3.
2.2.14.	Smart and intelligent membranes for advanced water treatment	Fundamental	TRL3-5	2.3.3.
2.3.10.	Use of antimicrobial nanomaterials, including nanozymes for biofilm removal	Applied	TRL5-8	2.3.3.
2.3.11.	New materials for a more sustainable and resilient water infrastructure	Fundamental	TRL3-5	2.3.3.
2.3.5.	Generation of new treatment technologies, e.g. hybrid membrane systems	Fundamental	TRL3-5	2.3.3.
2.3.6.	Improvement of advanced oxidation and adsorption technologies	Applied	TRL5-8	2.3.3.
2.3.9.	Membrane nanotechnologies and technologies	Fundamental	TRL3-5	2.3.3.
2.2.1.	FETs for alternatives for harmful substances and methods to avoid pollutants entering the environment	Fundamental	TRL3-5	2.3.4.
2.2.12.	FETs for removal of micro-pollutants	Fundamental	TRL3-5	2.3.4.
2.2.16.	Emerging nanotechnologies, nanomaterials, and nano-sciences for water remediation in industrial effluents	Applied	TRL5-8	2.3.4.
6.5.7.	Complementing and upscaling initiatives at EU level with emerging international initiatives in support of the global partnership goal of SDGs	Non-technical	All	2.3.4., 2.3.10.
6.3.4.	Talent building program on KETs for water and water in a circular economy	Non-technical	All	2.3.4., 2.3.9.

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
2.1.1.	New sensors for detecting and chemical measurement of pollutants	Fundamental	TRL3-5	2.3.5.
2.1.4.	New sensors for biological measurement and micro-organisms	Fundamental	TRL3-5	2.3.5.
2.2.17.	Technologies and managerial solutions for reducing the pressures exerted by 'hot spots' of emerging pollutants	Applied	TRL5-8	2.3.5.
2.4.1.	Advanced new generation effect-based monitoring methods based on 'omics' and 'bioinformatics'	Fundamental	TRL3-5	2.3.5.
4.1.3.	Develop and deploy new sensing technologies, decision support systems and communication instruments	Applied	TRL5-8	2.3.5., 2.3.8.
1.3.10.	Smart digital water management systems in cities via nexus and circularity approaches	Fundamental	TRL3-5	2.3.6.
1.3.6.	Combining water and energy efficiency in the urban context, integrating this nexus with smart urban management and planning solutions	Non-technical	All	2.3.6.
2.1.5.	New sensors for protection, security and resilience	Fundamental	TRL3-5	2.3.6.
2.3.8.	New solutions for decentralised treatment	Fundamental	TRL3-5	2.3.6.
3.1.13.	Information basis and technologies to ensure drinking water supply	Applied	TRL5-8	2.3.6.
3.1.2.	Novel urban water systems and infrastructures to cope with Climate and Seasonal effects (mitigation and adaptation)	Applied	TRL5-8	2.3.6.
3.1.7.	Inclusive multi-stakeholders, and multi-sectorial technological and non-technological approaches and partnerships incorporating water into urban agendas	Non-technical	All	2.3.6.
3.2.6.	Integration of advanced, low-cost monitoring systems	Applied	TRL5-8	2.3.6.
3.2.7.	Decentralised remediation technologies	Applied	TRL5-8	2.3.6.
6.1.1.	Green public procurement enhancing innovation in urban water management for the circular economy	Non-technical	All	2.3.6.
4.1.1.	Develop digital solutions for competing users of water resources	Applied	TRL5-8	2.3.6., 2.3.7.
2.2.11.	Technological and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquifers	Applied	TRL5-8	2.3.7., 2.3.9.
4.1.5.	Integration of new digital technologies and tools	Applied	TRL5-8	2.3.8.
4.1.9.	Develop climate services for policy and operational water management	Non-technical	All	2.3.8.
4.2.1.	Develop and deploy innovative tools and mechanisms to support and improve multi-stakeholder engagement	Applied	TRL5-8	2.3.8.
1.1.3.	Innovative business models for the water sector	Non-technical	All	2.3.9.
1.2.5.	Enlarging the Industrial Symbiosis concepts to agricultural sector	Non-technical	All	2.3.9.
1.2.6.	New tools to support industrial symbiosis	Applied	TRL5-8	2.3.9.
1.2.8.	Promotion and rationalisation of (quasi) Zero Liquid Discharge (ZLD) approaches in industrial approaches	Close-to-market	TRL6-9	2.3.9.
1.2.9.	New schemes for water reclamation	Close-to-market	TRL6-9	2.3.9.
1.3.11.	Urban/industrial symbiosis	Fundamental	TRL3-5	2.3.9.
1.3.12.	Sustainable processes for water production by water recycling at various scales	Close-to-market	TRL6-9	2.3.9.
1.3.13.	New solutions for an increased upstream process integration	Close-to-market	TRL6-9	2.3.9.
1.3.15.	Integrated water management technologies	Close-to-market	TRL6-9	2.3.9.
1.3.17.	Development of methodologies and pilot applications of LCA for water	Non-technical	All	2.3.9.
1.4.1.	Nutritients, minerals, and metals	Close-to-market	TRL6-9	2.3.9.
2.3.2.	New biotechnological solutions for resource recovery	Fundamental	TRL3-5	2.3.9.
6.1.3.	Develop or make a better use of the existing EU-wide financing instruments (e.g. COSME) for water in support to develop business models to bring to the market innovative SMEs solutions on water	Non-technical	All	2.3.9.
6.2.3.	Water footprint of (food) products	Non-technical	All	2.3.9.
6.2.8.	LCA for water in various domains	Non-technical	All	2.3.9.
3.3.7.	Hydropower as a European battery	Non-technical	All	2.3.9., 2.3.10
1.5.5.	Increase energy production from water resources	Close-to-market	TRL6-9	2.3.9., 2.3.10.
6.1.2.	SME platform to foster easy partnerships for water	Non-technical	All	2.3.9., 2.3.10.

3.3.1. Intervention area: manufacturing technologies

CAPITALISE ON THE DIGITAL TECHNOLOGIES TO DEVELOP BIO-INTEGRATED MANUFACTURING ECOSYSTEMS.

Nature-inspired technologies for water applications at the water-energy nexus. In the context of **future-oriented manufacturing technologies**, the **bio-intelligent industrial revolution paradigm** leverages **biomimicry** as a **systemic design thinking approach** to develop **manufacturing solutions** imitating **natural processes**, **forms, systems** and to introduce **resource circularity** into **value chains**. In the field of **water applications** at the **water-energy nexus**, **nature-inspired solutions** have been used in the solution design of **membranes**, **cooling applications** for buildings, **water or wastewater filtration/filtering/treatment systems,** new diversification of **water sources**, **energy capture** from **sea waves**, **water distribution networks** (allowing efficient movement of water and flow of nutrients), **self-powered pumps for irrigation**, **desalination plants**, **among others**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Cost-effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilization of multiple water resources**
- **Design of Nature Basedor nature-inspired technologies**
- **Fast Track Innovation for water-related value chains and lifecycles including the possibility of testing and demonstration at local/ regional scales and opening opportunities for the access to the environmental technologies and verification testing**
- **Water-energy-waste nexus in industrial environments**
- **New energy-efficient measures in water-intensive industries**
- **Reduction of energy losses**
- **Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple waters**

3.3.2. Intervention area: key digital technologies

DEVELOP NEW COMPUTING AND PROGRAMMING CONCEPTS FOR CLIMATE-WATER SOLUTIONS.

Advanced modelling and simulation systems for developing better understanding of micro-pollutants and emerging pollutants in water resources. With the co-use of **optimally deployed sensor technologies and supervised machine-learning techniques**, efficacy in **real-time, holistic environmental water-quality monitoring** and detection of **water-borne pathogenic microorganisms, effluents**, and **toxic chemicals** as well as statistical model efficiency in prediction of **sanitation-related water quality and spatial/temporal trends of micro-pollutants** in waterways increase. On the other hand, the application of molecular methods, such as **in-vitro, biodiagnostics and bio-testing techniques**, together with **cost-effective ultra-sensitive multi-sensor systems**, to **water pollution detection** improves the **microbiological analysis of water, characterisation** and **understanding** of integral **toxicity, micro-pollutant risk profile**, and **safety** in source **water reservoirs**. Through **microbial source** tracking, **pandemic early** warning systems by e.g. **wastewater monitoring** can be settled. The **nanomaterial-based** approaches to **waterborne and environmental pathogen** sampling and detection schemes enhance the i**dentification of hygienic** (growth of pathogens and opportunistic pathogens), **aesthetics** (taste and odour) and **operational problems** (corrosion and discoloration) in **water distribution networks** and other **engineered water systems**, enabling better assessment of **micro-pollutants**. Particularly, in the field of **nanomaterials dispersions** in the environment, **integrated research instruments** based on **biosensors contribute** better to the characterisation of **colloidal properties**, **suspension stability**, **exposure concentration**, and a**dsorption of nanoparticles in various water environments** (e.g. sedimentary systems, saline environments).

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- Bio-diagnostics
- New models
- Assessment of micro-pollutants breakdown products
- Emerging nanotechnology approaches
- Pathways and exposure of nanomaterials to water
- Research the causes and significance of microbial growth (including opportunistic pathogens) in water distribution networks and other engineered water systems
- Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters
- Improvement of the knowledge base and ICT tools of nutrient management and recycling
- New pollution detection and laboratory comprehensive methods

Further development of (environmental) big data research methods, computational modelling systems, and predictive analytics for optimizing decision-support systems in Integrated Water Resources Management. Given the day-by-day expanding portfolio of **Industry 4.0 applications for resource-efficient, flexible, competitive, secure, and integrated water resources (and supply) management** and considering the increasing **data generation capacity of water industry, data-driven performance efficiency** in the **cyber-physical systems integration** of the **water industry** becomes more and more important, in parallel to the developments occurring in **digital water innovation.** Hence, it is of importance to increase data utilisation when evaluating and using water-related data in the decision-making context of water governance arrangements, such as **Integrated Water Resources Management (IWRM)**. In this regard, the add-value of decision intelligence frameworks, such as **Artificial Intelligence (AI) systems** and **its subset domains** (e.g. machine learning) for the **water value chain** can be further explored, particularly when exploring the novel pathways for **intelligent control mechanisms, process, optimisation, asset monitoring, proactive environmental management, hazard detection and prediction, and infrastructure planning**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measure Design
- Improve (big) data collection, fusion, analysis, data-driven process-based models' development, and visualisation techniques
- Data and metadata standardisation, data security, interoperability, protection and privacy
- Cloud computing and real-time monitoring
- High-performance computing systems and applications' development
- Prediction tools in managing failure
- Decision support systems
- New models

Timely, Accurate, Multi-objective Forecasting Systems in Climate Hydrology. Due to the complicated interactions among climate, hydrology, and humans, **multi-model experiments and multi-objective hydrological forecasting systems, approaches, and models** can improve **seasonal and sub-seasonal** forecasting and **decision-support for agriculture**; increase capacity in **climate prediction**, **multi- or mono-hazard detection, monitoring, forecasting and warning, food security and climate data management**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- Forecasting
- Digital tools and systems for demand forecasting
- Advanced modelling, simulation, control and optimization techniques

Assessment of long-term environmental sustainability of water-related critical infrastructures. For water and wastewater utilities, **effective and comprehensive planning for sustainable, eco-efficient water infrastructure** is an integrated component of sustainable water supply. With the aim of improving baseline assessments of **IWRM**, indicators should be **re-arranged with new aggregation methods** and **computational modelling approaches or new indicators** should be created in the domains of water quality, solid waste treatment, basic water services, wastewater treatment, infrastructure, climate robustness, and governance.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Environmentally effective and optimally/sustainably managed water installations**
- **Analyse the feasibility, flexibility and governance of water-related infrastructure and technologies**
- **Asset lifetime prediction tools in managing failure**
- **Assessment of long-term environmental sustainability of water infrastructure**
- **Innovation in Green and Water Accounting Systems for the European Water Sector**
- **Methodologies and tools for sustainability for sustainability assessment of circular economy systems and demonstrations for water**
- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture**

3.3.3. Intervention area: advanced materials

SUPPORT THE DEVELOPMENTS OF ADVANCED MATERIALS FOR WATER SOLUTIONS.

Membrane processes for water and wastewater technology applications. Amongst the **types** of **nanomaterials applied for water** and **wastewater technologies**, **reliable**, **automated**, **membrane separation processes** are applicable for all fields of **water** and **wastewater treatment processes** (e.g. removal of micropollutants, reduction of odour, hardness, heavy metals, and colour, water filtration, desalination). Nanoengineered **membrane filtration techniques**, nanocomposite **membranes with superhydraulic materials** (e.g. hydrophobic nanofiber materials), **self-assembling membranes**, and **biomimetic membranes** (e.g. aquaporin-based membranes) have been only some of the technological advancement areas in various research avenues. Nevertheless, further research work is necessary for the **stabilisation**, **properties**, and **efficient applications** of **nanoengineered membrane processes** and **materials**, together with their **ecotoxicity potentials** and **mobility** of **nanomaterials** on water bodies.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Boosting the value of membrane and other separation technologies in water**
- **Pilots for new nano-membrane technologies and applications for water purification and treatment**
- **Smart and intelligent membranes for advanced water treatment**
- **Generation of new treatment technologies, e.g. hybrid membrane systems**
- **Membrane nanotechnologies and technologies**

Advanced nanomaterials for water and wastewater technology applications. Novel **nano-based materials**, such as **adsorption materials**, **nano-catalysts**, **functionalised surfaces**, **coatings**, and **reagents**, bring process efficiency to **water and wastewater treatment** processes. While **antimicrobial nanoparticles** (e.g. nan-silver, CNTs) and **photocatalytic nanomaterials** (e.g. bimetallic nanoparticles) **increase resistance** to fouling; whereas, **nano-adsorbents** and **advanced oxidation processes** increase the rate of **adsorption for organic compounds**, enabling **faster decontamination processes** and enhance the oxidative **elimination of micropollutants** and **microbial pathogens**. On the other hand, **nanostructures**, such as **carbon nanotubes (CNTs)** and **nano-silver**, which exhibit **antimicrobial properties**, are preferred for point-of-use water **disinfection systems.** For the **water** and **wastewater technology applications**, boosting research on the **production** techniques, **properties**, **applications**, and **ecotoxicity impacts** of advanced **nanomaterials** is of crucial importance to provide **fit-for-purpose solutions**, **particularly to the production**, **public health**, and **ecosystem resilience challenges of climate change**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improvement of advanced oxidation and adsorption/absorption technologies**
- **Use of antimicrobial nanomaterials, including nanozymes for biofilm removal**
- **New materials for a more sustainable and resilient water infrastructure**

3.3.4. Intervention area: emerging enabling technologies

FACILITATE THE EARLY DEVELOPMENT OF WATER TECHNOLOGIES FOR HEALTHIER EARTH SYSTEM GOVERNANCE AND WITHIN THE SAFE OPERARING SPACE OF PLANETARY BOUNDARIES.

Emerging enabling technologies in support of lowering toxicological impacts of micro-pollutants on water resources and biodiversity. In **conventional decontamination processes** (e.g. chlorination, ozonation), the use of **chemical agents** produces **toxic by-products**. Novel, nano-engineered **adsorption materials**, **nanoscale metal oxides, and advanced oxidation processes** enable to remove **organic** and **inorganic pollutants** (e.g. micropollutants, heavy metals) efficiently and faster, particularly in **decentralised applications** and **point-of-use systems.** In complementary to the ongoing technological developments and research advancements and with the objective of diversifying commercial applications of emerging technologies, advancing research on the **robustness, biocompatibility, durability, effectivity, toxicity, bactericidal effects, and commercial scalability of emerging nano-technologies for water and wastewater treatment processes is of importance for realising chemical-free water and wastewater treatment processes**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **FETs for alternatives for harmful substances and methods to avoid pollutants entering the environment**
- **FETs for removal of micro-pollutants**
- **Talent building program on KETs for water and water in a circular economy**
- **Emerging nanotechnology approaches**
- **Emerging nanotechnologies, nanomaterials, and nano-sciences for water remediation in industrial effluents**
- **Complementing and upscaling initiatives at EU level with emerging international initiatives in support of the global partnership goal of SDGs**
- **Fast Track Innovation for water-related value chains and lifecycles including the possibility of testing and demonstration at local/ regional scales and opening opportunities for the access to the environmental technologies' verification testing**

3.3.5. Intervention area: AI and robotics

IMPROVE HARDWARE, ALGORITHMS, AND APPLIED RESEARCH FOR WATER APPLICATIONS NEEDS.

Further development of (environmental) big data research methods, computational modelling systems, and predictive analytics for optimising decision-support systems in Integrated Water Resources Management. Given the day-by-day expanding portfolio of **Industry 4.0 applications** for **resource-efficient**, **flexible**, **competitive**, **secure**, and **integrated water resources (and supply) management** and considering the increasing **data generation capacity** of water industry, **data-driven performance efficiency** in the **cyber-physical systems integration** of the **water industry** becomes more and more important, in parallel to the developments occurring in **digital water innovation**. Hence, it is of importance to increase **data utilisation** when evaluating and using **water-related data** in the decision-making context of water governance arrangements, such as **Integrated Water Resources Management (IWRM)**. In this regard, the add-value of decision intelligence frameworks, such as **Artificial Intelligence (AI)** systems and **its subset domains** (e.g. machine learning) for the **water value chain** can be further explored, particularly when exploring the novel pathways for **intelligent control mechanisms, process, optimisation, asset monitoring, proactive environmental management, hazard detection and prediction, and infrastructure planning**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measure Design**
- **Improve (big) data collection, fusion, analysis, data-driven process-based models' development, and visualisation techniques**
- **Data and metadata standardization, data security, interoperability, protection and privacy**
- **Cloud computing and real-time monitoring**
- **High-performance computing systems and applications' development**
- **Prediction tools in managing failure**
- **Decision support systems**
- **New models**

Pollution sensing solutions for increasing integrity and resilience in ecosystem services. It is evident that **anthropogenically-derived pollutants** (e.g. heavy metals, persistent organic pollutants [POP], volatile organic compounds) have increased deterioration of **atmosphere**, **water**, and **soil resources**. Given the growing demand for **accurate** and **spatial technologies and remote sensing solutions and methods**, fundamental and applied research on the development and scale-up of **low-cost pollution sensing technologies** (e.g. sensor arrays, pixel performance), together with the **enabling computing technologies** (e.g. artificial neural networks, environmental intelligence platforms) should be expanded, particularly for the **environmental monitoring** of **water** and **wastewater quality**. Supporting and furthering advancements in **pollution sensing solutions** and the accessibility to **reliable water pollution data** could serve to improve **public health protections**, reduce **exposures** in communities, increase understanding on **biogeochemical cycles affecting water resources**, and accelerate transition to **toxic-free environments** that **protect ecosystems**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improvement of WFD implementation through advanced multiscale modelling, better River Basin Management and Program of Measure Design**
- **Improve (big) data collection, fusion, analysis, data-driven process-based models' development, and visualisation techniques**
- **Data and metadata standardization, data security, interoperability, protection and privacy**
- **Cloud computing and real-time monitoring**
- **High-performance computing systems and applications development**
- **Prediction tools in managing failure**
- **Decision support systems**
- **New models**

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3.3.6. Intervention area: next generation internet

DEVELOP KEY TECHNOLOGY BUILDING BLOCKS AND INFRASTRUCTURE FOR THE (ENVIRONMENTAL) INTERNET OF THINGS.

Environmental Internet of Things (IoT) Ecosystem for a Water-Smart Society. With the objective of better understanding aquatic ecosystem processes, water safety threats, and multiple waters ecosystems within the Earth's biosphere, **automated**, **multi-parameter**, **near real-time or real-time water metering and monitoring solutions**, coupled with the advanced applications of **efficient**, **heuristic algorithms** on **centralised cloud computing platforms** or **near-device edge servers**, can increase **efficacy in water saving**, **wastewater detection**; enhance **transparency related to the health and quality of water** (e.g. discharges to water) at the point of discharge or in the receiving environments; optimise environmental compliance **capacity of industrial water-users** with **environmental licenses**; **provide cost-effective**, **scalable**, **high-performing monitoring**, with **real-time indications** of **operational cause** and **environmental effect**; and, foster **immediate remedial action** by **detecting water events**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New sensors for protection, security and resilience**
- **Cloud computing and real-time monitoring**
- **High Performance Computing systems and applications' development**
- **Integration of advanced, low-cost monitoring systems**

DEVELOP CONNECTIVITY SOLUTIONS FOR CLIMATE-SMART, INTEGRATED WATER RESOURCES MANAGEMENT.

Development of adaptive, climate-smart, resilient, and circular water networks systems powered by ICT solutions. **Next-generation water networks systems**, grounded in the **circular economy principle** of **water**, leverage various **dedicated ICT applications** and **prospective technologies** to solve **water resources management bottlenecks**. While there's a wide range of research and development advances in the **digitisation of water**, given the **increasing data volume** and velocity and the crowded stakeholder space of the water industry, there are still remaining challenges impeding the development of **adaptive**, **climate-smart**, **resilient**, and **circular water networks**, such as: lack of **seamless integration** and **inter-operability** among the components of **cyber-physical systems** for **real-time**, **integrated water resources management**; **network resilience problems**; lack of **connectivity standards** and **dynamic asset management know-how**, **developed** by **trans-sectorial utility communications networks**, **improved coordination** for **infrastructure investments**, among others.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Novel urban water systems and infrastructures to cope with Climate and Seasonal effects (mitigation and adaptation)**
- **Green public procurement enhancing innovation in urban water management for the circular economy**
- **Combining water and energy efficiency in the urban context, integrating this nexus with smart urban management and planning solutions**
- **Inclusive multi-stakeholders, and multi-sectorial technological and non-technological approaches and partnerships incorporating water into urban agendas**
- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture**

Digital water infrastructures in urban environments. In **urban** and **peri-urban settings**, **applications of** the **Information and Communications Technologies (ICT)** to the **water domain** contributes to the mitigation of **Green House Emissions (GHG)**, increase of water efficiency, and improvement of sanitation, owing to the better modelling of the spatial **design interventions in urban areas**, facilitation of **continuous and efficient reporting for integrated water resources management** (e.g. early warning systems for water control, smart watering infrastructure), decrease of **Operations and Maintenance (O&M) costs**, **distributed and decentralised water governance schemes and technologies**, among others. Nevertheless, given the various contexts of **urban water management** and **water networks control** (e.g. treatment, supply, distribution, wastewater treatment, reclamation and reuse) advancing the current state-of-the-art in the **applications of ICT** to the urban **water domain** is of **importance**, particularly in order to improve **water-related data readability**, **usability**, **interoperability**, **registry interfaces**, and **scalability for enabling integrated**, real-time **water networks control**, **monitoring**, and **management**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Smart digital water management systems in cities via nexus and circularity approaches**
- **New solutions for decentralised treatment**
- **Information basis and technologies to ensure drinking water supply**
- **Decentralised remediation technologies**
- **Develop digital solutions for competing users of water resources**

3.3.7. Intervention area: advanced computing and big data

IMPROVE COMPUTATIONAL CAPABILITIES IN EARTH OBSERVATION SYSTEMS AND ENVIRONMENTAL SCIENCE.

Big (environmental) data analytics and knowledge base. **Ecosystems** are complex systems that are not easily defined by a set of **specific data types**. **Big (environmental) data analytics** builds on a combination of large, multi-faceted datasets generated by **real-time data acquisition technologies** (e.g. real-time sensors, autonomous underwater vehicles) or extracted from **site-collected historical datasets** and **other sources** (e.g. social media geotagging). Within the context of **environmental data processing**, **simulation and prediction**, the **environmental science community** have been **using** or **re-purposing the big data capabilities**, together with **web service technologies**, with the aim of developing **virtual environmental research** and **monitoring environments** for the **fields of climate sciences and of increasing efficiency** in **environmental decision-making** for the **policy fields** of **natural resource recovery and management.** Nevertheless, the **infrastructural** and **computational bottlenecks**, such as the **design of integrated data accumulation processes**, **data handling procedures**, the **secure and consistent access to data**, consideration of **fit-for-purpose analytical methods**, affect the **standardisation and usability of big** (environmental) data. Current **infrastructural bottlenecks** related to the **volume**, **velocity**, and **variety of environmental data** shall be eliminated in the effort to expand the **purposive applications** of **big data techniques to climate change** and **environmental monitoring of human-environmental systems.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Cloud computing and real-time monitoring**
- **High-performance computing systems and applications' development**
- **Forecasting**
- **Digital tools and systems for demand forecasting**
- **New models**
- **Develop digital solutions for competing users of water resources**
- **Prediction tools in managing failure**
- **Decision support systems**
- **Improvement of the knowledge base and ICT tools of nutrient management and recycling**
- **Technologies and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquifers**

Further development of (environmental) big data research methods, computational modelling systems, and predictive analytics for optimising decision-support systems in Integrated Water Resources Management. Given the day-by-day expanding portfolio of **Industry 4.0 applications** for **resource-efficient**, **flexible**, **competitive**, **secure**, and **integrated water resources (and supply) management** and considering the increasing **data generation capacity** of **water industry**, **data-driven performance efficiency** in the **cyber-physical systems integration** of the **water industry** becomes more and more important, in parallel to the developments occurring in digital water innovation. Hence, it is of importance to increase **data utilisation** when evaluating and using **water-related data** in the decision-making context of water governance arrangements, such as **Integrated Water Resources Management (IWRM)**. In this regard, the add-value of **decision intelligence frameworks**, such as **Artificial Intelligence (AI) systems** and **its subset domains** (e.g. machine learning) for the **water value chain** can be further explored, particularly when exploring the novel pathways for **intelligent control mechanisms**, **process**, **optimisation**, **asset monitoring**, **proactive environmental management**, **hazard detection and prediction**, and **infrastructure planning**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Improve (big) data collection, fusion, analysis, data-driven process-based models' development, and visualisation techniques**
- **Data and metadata standardization, data security, interoperability, protection and privacy**
- **Cloud computing and real-time monitoring**
- **High-performance computing systems and applications' development**
- **Prediction tools in managing failure**
- **Decision support systems**
- **New models**

Software-based sustainability management tools for better natural capital monitoring and assessment. There are various **accounting approaches** and **methods** that are used for measuring **natural (ecosystem) capitals**, e.g. ENCA, SEEA-EEA, ENCA-QSP, which lead to the development of **siloed opinions** on the **capital capabilities of natural (and ecosystem) assets**. The development of **robust**, **coherent**, **multi-scale frameworks** and **modelling methodologies** for **natural resource (consumption)** accounting is not only important for finding the most optimal options at system, process, or inter-process levels, while designing circular production-consumptions systems but also for instigating further climate-adaptive and **multi-disciplinary collaboration environments** for **integrated water management systems** at **watershed level**. In this context, adopting environmental **Software-as-a-Service (SaaS)** approach in the **end-to-end production**, **management**, and **dissemination processes** of **natural capital data** is of **importance** in order to make **the natural (ecosystem) capitals data accessible**, **optimised**, **scalable**, and **usable** in all scales and sizes of organizations.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture**
- **Innovation in Green and Water Accounting Systems for the European Water Sector**
- **Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water**

3.3.8. Intervention area: space including earth observation

PROMOTE SYNERGIES WITH NON-SPACE SECTORS AND DOWNSTREAM EXPLOITATION.

Public and private decision support-systems for supporting cross-scale integration of climate-water measures and ecosystem services. **Participatory Climate Change Research**, in principle, is instrumental to advance climate policy decision-making, whilst supporting cross-scale integration of climate measures and ecosystem services. In the context of the **Integrated and Water Resources Management (IWRM)**, participatory stakeholder involvement and participation in water resources processes, coupled with **science and technical tools such as Decision Support Systems (DSSs)**, is of vital importance not only to tackle complex water management and planning challenges but also to make **users of water resources** adaptive and resilient to variability and change. The effective deployment of **prescriptive**, **functional**, **holistic**, and **integrative computer modelling approaches in systems dynamics DSSs** can serve to improve **regional climate modelling** and inform different sets of decisions for **medium- and long-term planning, management, and conservation at the basin scale**. Nevertheless, development of **optimised**, **analytical DSSs systems** for water problems largely depends on the availability of **high-performance computing technologies**, **highly skilled human resources**, and **digital technology infrastructure**. The **collaborative design** and **model assumptions of DSSs**, resulting from various institutional drivers and organisational interests, can also foster **social learning and shared vision planning at basin level**, regarding the impacts and improvements of **alternative management scenarios, predictive climate measures.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Develop and deploy sensing technologies, decision support systems and communication instruments**
- **Decision support systems**
- **Integration of new digital technologies and tools**
- **Develop climate services for policy and operational water management**
- **Develop and deploy innovative tools and mechanism to support and improve multi-stakeholder engagement**

3.3.9. Intervention area: circular industries

ADVANCE SOLUTIONS AND CONDITIONS FOR THE SUSTAINABLE EXPLORATION, EXPLOITATION, EXTRACTION, AND PROCESSING OF WATER RESOURCES IN INDUSTRIAL SYMBIOSIS SETTINGS.

Advanced knowledge on structure and functioning of food and non-food value chains. It is evident that investment in **sustainable food** and **non-food production systems** and **processes** leads to the entrepreneurial creation of **new, bio-circular value chains** for both **sectors supplying biomass** and **sectors using biomass**, implementation of **symbiotic resources management** frameworks in cross-sectorial settings, valorisation of **unused biomasses**, **value-added utilisation** of **by-products and recovered resources** for cost-effective industrial process. In order to foster **scale-up innovations** at the nexus of **physical**, **digital**, and **biological systems**, deployment of **bio-circular solutions** and optimisation of product value in new value chains, further research on how to optimise the **systematics of value chain data gathering** and foster **decision model innovation** for resource optimisation purposes could be undertaken, both for the **food** and **non-food value chains**. For the **food value chains**, some of the **major bottlenecks** impeding efficient value chain data gathering are as follows: **difficult-to-control** and **difficult-to-measure processes** (e.g. nutritient leaching, erosion, emissions); **complexity of environmental mechanisms**; **high variability of production processes**; lack of **agro-ecological data models**; lack of **efficient LCA databases** and **calculation procedures applicable for agricultural ecosystems**; and, lack of systemic knowledge on **nutrient recycling, recovery and reuse** (RRR) **value chains**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water footprint of (food) products**
- **Development of methodologies and pilot applications of LCA for water**
- **LCA for water in various domains**
- **Enlarging the Industrial symbiosis concept to agricultural sector**
- **Nutritients, minerals, and metals**
- **Improvement of the knowledge base and ICT tools of nutritient management and recycling**

Better understanding of resource flows at the nexus of water-energy-food nexus. Understanding, in empirical and systemic terms, the **socio-material** interconnectedness **between multiple environmental resources,** connectivity of **resource flows**, **cross-sectorial systems**, and **infrastructure operation** of **resource provisioning**, is of crucial importance to advance in the development of **nexus programs**, **cross-sectorial trade-offs**, **technical solutions** and deployment of **resource steering** and **recovery strategies.** In order to enhance understanding on the **material conditions** and **capability limitations** of **water-energy-food nexus constellations** and optimise **alternative**, **cross-sectorial resource management planning**, **nexus-oriented**, **transdisciplinary**, **ICT-enhanced decision support systems** (e.g. systems analytics, advanced visualisation, nexus assessment) need to be further developed, in a coordinated and applied fashion.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water footprint of (food) products**
- **Enlarging the Industrial symbiosis concept to agricultural sector**
- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including the agriculture**
- **Nutritients, minerals, and metals**
- **Improvement of the knowledge base and ICT tools of nutritient management and recycling**
- **Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water**

Sustainable exploitation of water resources for industrial applications. Industry is the **second largest user of freshwater**, particularly for the following industrial applications: **water for energy**, **cooling water**, **process water**, **water for products**, **water for waste disposal**, among others. With the objective of increasing **industrial water productivity** at the **Water-Energy-Waste (WEW) nexus**, industrial practices, coupled with supporting **push-and-pull policies and clean manufacturing technologies**, can be modified by adopting **process intensification solutions** as well as **wastewater recycling** and **reuse approaches** in **industrial applications**, such as **reuse of municipal wastewater**, **internal recycling and cascading use of process water**, and **non-industrial use of effluents**. Although in each country or industrial ecosystem, **organisation structure** and **technology base** of **industries** could affect **industrial water withdrawal patterns** and **intensity**, it is of importance to develop new avenues of research on the **alternative pathways** for increasing **industrial water productivity**, as its **direct benefits** (e.g. heat recovery, reduction of production and waste disposal costs) for industries are non-negligible.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Increase energy production from water resources**
- **Hydropower as a European battery**
- **Water-energy-waste nexus in industrial environments**
- **Technologies and management scenarios addressing groundwater over-exploitation in coastal zones and shallow aquifers**
- **Sustainable processes for water production by water recycling at various scales**
- **Integrated water management technologies**
- **New solutions for an increased upstream process integration**
- **Development of methodologies and pilot applications of LCA for water**
- **Promotion and rationalization of (quasi) Zero Liquid Discharge (ZLD) approaches in industrial applications**
- **New schemes of water reclamation**

Facilitated and coordinated development and market uptake of sustainable, circular bio-based processes and products in the European blue economy. While creating new markets and value chains that support the bio-circular economic growth in Europe, in addition to the **industrial policy instruments** available for **market uptake** of **bio-circular processes and products** in the **European blue economy**, **innovation** and **talent programs**, **cluster-based SME development approaches**, effective **demand-side**, **market pull mechanisms** both for **downstream** and upstream industry players, **partnership platforms** opening new avenues for **trans-sectorial market access opportunities**, and **differentiated**, **coordinated actions** increasing the awareness of **value chain actors** are important to speed up the **market uptake** and **penetration** of **bio-circular processes and products.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Talent building program on KETs and FETs for water and water in a circular economy**
- **New tools to support industrial symbiosis**
- **Urban/industrial symbiosis**
- **Enlarging the industrial symbiosis concept to agricultural sector**
- **New biotechnological solutions for resource recovery**
- **Innovative business models for the water sector**
- **SME platforms to foster easy partnerships for water**
- **Develop or make a better use of the existing EU-wide financing instruments (e.g. COSME) for water in support to develop business models to bring to the market innovative SMEs solutions on water**

3.3.10. Intervention area: low-carbon and clean industries

SUPPORT COORDINATED INNOVATIONS AND INVESTMENTS IN CLEAN ENERGY SYSTEMS.

Renewable energy production from water sources for low-carbon energy supply, with a joint management of water and energy resources. More than **25,000 hydropower plants** (with or without pumping functions) currently produce approximately 10% of electricity in the EU (JRC, 2019). **Hydropower energy systems** and **technologies** contributes to the stabilisation, improved security, balanced supply, and storage of renewables, such as wind and solar. While considering to increase the **water footprint** of the **energy system**, given the **long-term freshwater needs of the EU energy sector** and **boundary conditions of hydropower operations** (e.g. flows, catchments), the integration of **water** and energy modelling in **hydropower assessments** is of crucial importance to assess the impact of **hydropower reservoirs** on water availability (e.g. altered water flows, sediment transport, loss of connectivity), **water stress** (e.g. blue and green water scarcity), and (chemical) **water pollution in the reservoirs**, **biodiversity loss**, and on the **management of freshwater resources with other uses**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Hydropower as a European battery**
- **Increase energy production from water sources**
- **Water-energy nexus in energy sector**
- **Promotion of new policy developments, new regulation and incentives**

Advancing the technological readiness of sustainability technologies at the water-energy nexus. Analysing and tracking the advancements in **technological** and **green innovation capabilities** within the **central fields of sustainability technologies** (i.e. energy efficiency, green energy supply technologies, material efficiency, waste management, and water technologies), with **composite innovation indicators and dimensions**, is of significance to not only understand the **green technology development, diffusio**n, and **transfer pathways** and efficacy of **green innovation capabilities** but also to induce **innovation effects** towards **new sustainability technologies**. Given the fact that **sustainability technologies** are directly related to many environment-related **Sustainable Development Goals (SDGs)**, such as **SDG7**, **SDG8**, **SDG13**, **SDG14**, and **SDG15** and that they are leveraged at **various scales** (e.g. product, sector, city), generating **continuous advancements** and optimising **green innovation outcomes** in the fields of **ICT intelligent systems** for the **nexus applications** (e.g. Water-Waste-Energy, Water-Energy-Food, Water-Energy-Carbon, Water-Energy-Waste-Food) could advance the achievement of **environment-related Sustainable Development Goals (SDGs).**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New technologies for energy-efficient water treatment, including new decentralised systems**
- **New ICT solutions for energy and water efficiency**
- **Software-based sustainability (water and energy) rating tools for assessment of water and energy performance in water and water-dependent economic sectors, including agriculture**

Improved industrial sustainability performance for carbon-neutral and competitive European industry at the water-energy nexus. With better economies of scale and a systematic application of resource efficiency, harnessing **synergies** of the **water-energy-waste nexus** by leveraging the **state-of-the-art technologies** for **incineration**, **energy recovery**, **waste-to-energy process** and the integration of **used water** and s**olid waste treatment process**, could yield **environmental**, **economic and social benefits** for stakeholders involved in the development of **industrial symbiosis business models**, extension and collaborative governance of **symbiotic resource interdependencies** within the water-energy-waste nexus and of **industrial ecology**. With the aim of diffusing **circular**, **sustainable economic models** into **untapped synergies** and improving **industrial sustainability performance**, **regions** and **cities** as springboards for **industrial symbiosis** can accelerate the development of **systemic** and **symbiotic**, **industrial approaches** for revalorisation and reuse of resources, with the support of **facilitative fiscal**, **financial**, **economic** and **regulatory instruments, schemes**, and **models**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water-energy-waste nexus in industrial environments**
- **New energy-efficient measures in water-intensive industries**
- **Reduction of energy losses**
- **Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple waters**

Partnership structures for supporting circular, value-chain based blue economy platforms at local, regional, national, and transnational levels. In full alignment with the Europe's **bioeconomy** and **circular economy** policy priorities, sustaining the **European blue economy growth** is of crucial importance while addressing **global challenges**, such as energy security, environment, climate change, and food security. In this context, the creation of **well-functioning** and **sustainable partnership structures** could facilitate not only **effective**, **systematic**, and **collaborative innovation** in the **European blue economy** but also increase synergies for gathering **reliable**, **sector-related information**, by embracing **multiple sectors** and polices related to the blue economy.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New management tools and methodologies, partnerships and business models**
- **Public-private industrial partnerships**
- **Public-private and cross-sectorial partnerships**
- **Streamlining of multi-stakeholder and multi-sectorial actions and decisions**
- **Setting-up and strengthening collaborative actions and regional multi-stakeholder partnerships**
- **Joint-decision frameworks to shift to a more chemical-free society**
- **Alignment of policies**
- **Collaborative actions among stakeholders**
- **Fostering a level playing field for the EU water market**
- **SME platforms to foster easy partnerships for water**
- **Complementing and upscaling initiatives at EU level with emerging international initiatives in support on the global partnership goal of the SDGs**
- **Developing capacities in the EU and abroad (or joint capacity) to successful research and co-generation of knowledge and innovation to address real life demands and societal challenges**

3.4. Health (cluster 1)

Table 4. Guidance Table for Water Europe R&I Topics

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
2.1.2.	Passive sampling techniques	Applied	TRL 5-8	2.4.1.
2.1.3.	Active sampling techniques	Fundamental	TRL 3-5	2.4.1.
2.2.4.	Hygiene and safety	Fundamental	TRL 3-5	2.4.1.
2.2.5.	New pollution detection and laboratory comprehensive methods	Applied	TRL 5-8	2.4.1.
3.1.3.	Research the causes and significance of microbial growth (including opportunistic pathogens) in water distribution networks and other engineered water systems	Fundamental	TRL 3-5	2.4.1.
3.1.4.	Advancing knowledge base (procedures and warning tools) in climate hydrology and hydroinformatics	Applied	TRL 5-8	2.4.1.
3.3.9.	Improved survey and inspection in sewer networks	Applied	TRL 5-8	2.4.1.

3.4.1. Intervention area: living and working in a health-promoting environment

IMPROVE RESILIENCE TO CLIMATE-CHANGE RELATED HEALTH RISKS FACTORS BY BETTER CHARACTERISATION OF ENVIRONMENTAL RISK FACTORS.

Collection, combination, and analysis of environmental risk-related data. In order to ensure **accuracy**, **integrity**, and **authenticity of environmental risk-related data**, it is important to strengthen research and development efforts on **environmental data monitoring**, **collection**, **integration**, and **analysis**, through the use of **Information Communications Technologies** (**ICTs**), such as **big data**, **next generation internet**, **remote sensing**, **Geographic Information System** (**GIS**), **Global Positioning System** (**GPS**), **and cloud computing**. Owing to the **imprecise nature of environmental data** and the **deficiencies occurring** in the disclosure and **sharing of environmental risk data** across **various information systems**, it is still challenging to develop **unified environmental risk data accounting systems**. Therefore, with the aim of developing a **unified environmental risk information system**, improving climate-related assessment chains (e.g. pollution detection, water quality assessment) for eradicating negative **public health effects** of climate change, and dealing, in an integrated manner, with **whole system problems** (e.g. engineered systems, natural ecosystems), continuously expanding current environmental risk research into new research avenues is of importance.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **New pollution detection and laboratory comprehensive methods**
- **Research the causes and significance of microbial growth (including opportunistic pathogens) in water distribution networks and other engineered water systems**
- **Active sampling techniques**
- **Passive sampling techniques**
- **Improved survey and inspection in sewer networks**
- **Advancing knowledge base (procedures and warning tools) in climate hydrology and hydroinformatics**
- **Hygiene and safety**

Identification and characterisation of emerging and persistent environmental and climate-change related stressors. The **omnipresence**, **concentration**, and **diversity of anthropogenically-derived pollutants** (e.g. persistent organic pollutants [POPs], volatile organic compounds) have increased not only **natural ecosystem deterioration** but also emerged a variety of **public health issues** (e.g. public health issues). Particularly, the concentration and diversity of and exposure to **Persistent Organic Pollutants [POPs]** is considered as one of the biggest threats to **human health**. With the co-use of **optimally deployed sensor technologies**, and **supervised machine-learning techniques**, efficacy in **real-time, holistic environmental water-quality monitoring** and detection of **water-borne pathogenic microorganisms, effluents, and toxic chemicals** as well as statistical model efficiency in prediction of **sanitation-related water quality and spatial/temporal trends of micro-pollutants** in waterways increase. On the other hand, the application of molecular methods, such as **in-vitro, biodiagnostics and bio-testing techniques**, together with cost-effective ultra-sensitive multi-sensor systems, to water pollution detection improves the pathway of the microbiological analysis of water, characterisation and understanding of **integral toxicity**, **micro-pollutant risk profile**, and **safety** in source water reservoirs. The **nanomaterial-based approaches to waterborne and environmental pathogen sampling and detection schemes** enhance the identification of **hygienic** (growth of pathogens and opportunistic pathogens), **aesthetics** (taste and odour) and **operational problems** (corrosion and discoloration) in water distribution networks and other engineered water systems, enabling **better assessment of micro-pollutants**. Particularly, in the field of nanomaterials dispersions in the environment, **integrated research instruments based on biosensors** contribute better to the **characterisation of colloidal properties, suspension stability, exposure concentration**, and **adsorption of nanoparticles** in various water environments (e.g. sedimentary systems, saline environments).

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Continuous online measurement, sensor systems and (big) data generation and assessment tools of micro-, nano-, and other pollutants in various types of waters**
- **Bioaccumulation in the food chain as well as effects of direct consumption of water containing emerging pollutants**
- **Removal of micropollutants (emerging pollutants) from drinking, industrial and domestic waste waters**
- **Pathways and exposure of nanomaterials to water**
- **Assessment of micro-pollutants breakdown products**
- **Hygiene and safety**

3.5. Civil security for society (cluster 3)

Table 5. Guidance Table for Water Europe R&I Topics

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
1.3.9.	Watershed management problem solving	Non-technical	All	2.5.1.
2.4.2.	Advanced technologies and sustainable management techniques	Fundamental	TRL 3-5	2.5.1.
3.1.10.	Nature Basedsolutions to fight extreme precipitation events flooding	Applied	TRL 5-8	2.5.1.
3.1.11.	Adapt community water management to climate variability	Applied	TRL 5-8	2.5.1.
3.1.7.	Inclusive multi-stakeholders, and multi-sectorial technological and non-technological approaches and partnerships incorporating water into urban agendas	Non-technical	All	2.5.1.
3.3.4.	Nature Basedwastewater treatment systems and urban storm water treatment	Applied	TRL 5-8	2.5.1.
3.3.6.	Cost-effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilisation of multiple water resources	Applied	TRL 5-8	2.5.1.
3.3.8.	Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple waters supply	Applied	TRL 5-8	2.5.1.
4.1.6.	Analyse the feasibility, flexibility, and governance of water-related infrastructure and technologies	Non-technical	All	2.5.1.
4.1.7.	Integrating climate projections at various levels into adaptive water management planning	Non-technical	All	2.5.1.
4.1.9.	Develop climate services for policy and operational water management	Non-technical	All	2.5.1.
6.3.2.	Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes	Non-technical	All	2.5.1.
6.3.3.	Creation of smart skill building tools for water and water-related sectors to facilitate replicability and applicability of water related technological solutions and facilitate capacity development	Non-technical	All	2.5.1.
6.3.4.	Talent building program on KETs and FETs for water in a circular economy	Non-technical	All	2.5.1.
6.3.5.	Education programs (smart people and smart consumers)	Non-technical	All	2.5.1.
6.4.4.	Innovation capacity development tools for the entire innovation process (e.g. supply/demand sides, users of innovation)	Non-technical	All	2.5.1.

3.5.1. Intervention area: disaster-resilient societies

IMPROVE THE UNDERSTANDING OF ENVIRONMENTAL RISK FACTORS, RESILIENCE TO CLIMATE-CHANGE RELATED HEALTH RISK FACTORS FOR HEALTH AND WELL-BEING.

Flexible adaptation to climate change impacts with innovative governance schemes. Climate change, transboundary phenomenon in nature, affects, directly or indirectly, various dimensions of **human security** (e.g. water security, food security, public health, livelihoods), as **climate-related risks** and **hazards** continuously increase **situations of acute insecurity** (e.g. famine, migration, displacement), while exacerbating the deprivation of basic needs (e.g. water availability, food shortage) and **local livelihood assets** (e.g. loss of agricultural land) and reducing **human capabilities**.

In the evolving area of **polycentric**, **multi-level climate risk governance landscape**, where more **than 50 (out of 200) Inter-Governmental Organisations (IGOs)** engage, systemic development of **innovative**, **integrated**, **multi-level**, and **multi-stakeholder climate risk management** and **governance mechanisms** and factoring **robust climate risk data** into **policy allocations** could serve to institute flexible, adaptive policy responses to the **biophysical**, **economic**, **social**, **cultural**, and **human security dimensions of climate change risks**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Inclusive multi-stakeholders, and multi-sectorial technological and non-technological approaches and partnerships incorporating water into urban agendas**
- **Adapt community water management to climate variability**
- **Watershed management problem solving**
- **Integrated water management technologies**
- **Advanced technologies and sustainable management techniques**
- **Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple waters supply**
- **Integrating climate projections at various levels into adaptive water management planning**
- **Develop climate services for policy and operational water management**
- **Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes**
- **Analyse the feasibility, flexibility and governance of water-related infrastructure and technologies**

Science-to-practice knowledge exchange in the fields of sustainable climate risk management. Given the fact that **climate risk management** spans across various levels of governance and spatial scales, advancing the applied utilisation of **transdisciplinary climate-science fields** (e.g. water science) for **system-oriented discovery of climate change solutions** through building **institutional innovation** and **research uptake capacity building activities**, developing new **focus areas for smart green skills development**, and could increase **evidence-based responsiveness, operational agility, policy communication efficiency in climate risk management**, while contributing to the development of **climate mitigation and adaptation policy coherence** across sectors. When it comes to **climate-related water risks** and **hazards**, which is a cross-cutting policy domain spanning across **disaster reduction**, **water management**, and **climate change adaptation**, leveraging on science-to-practice exchange networks and capabilities becomes highly important, particularly to increase **factual**, **stakeholder value** of **water science** and **innovation** in the **policy design processes** and pull **stakeholder orientations**, in an evidence-based manner, towards the right direction.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Creation of smart skill building tools for water and water-related sectors to facilitate replicability and applicability of water related technological solutions and facilitate capacity development**
- **Talent building program on KETs and FETs for water in a circular economy**
- **Education programs (smart people and smart consumers)**
- **Innovation capacity development tools for the entire innovation process (e.g. supply/demand sides, users of innovation)**

Use of sustainable, cost-effective, and inclusive Nature Basedsolutions. **Nature Based Solutions (NBS), to Societal Challenges** as per the definition of the **International Union for Conservation of Nature (IUCN)**, informed by the **joint** and **cross-sectorial use of different forms of knowledge** (e.g. scientific, local, traditional) and **domains of skills** (e.g. ecology, hazard risk modelling, disaster risk governance, climate science), provides co-benefits for **biodiversity**, **human well-being**, and **environmental public health**. Building upon the **community ownership of problem-solution definition**, the **Nature Based Solutions (NBS)**, to **Societal Challenges** with different scales of implementation, are **sustainable**, **cost-effective**, and **community-led**, taking into account **complexities**, **uncertainties**, **dynamism** of the **coupled human-ecosystem interactions and vulnerabilities of human settlements to climate change.** Therefore, advancing research, development, and social learning efforts in **sustainable**, **cost-effective**, **inclusive**, **and locally relevant Nature Basedsolutions** can help to reduce **climate change induced disaster risks**, as they address the challenges related to various **dimensions of human security** (e.g. water security, food security, human health, disaster risk reduction, climate change). In the domain of **water security, Nature Basedsolutions** become important while managing **climate-related water issues**, such as **water stress**, **flood risks**, **drought**, **storm water runoff**, and **soil erosion**, among others.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Nature Basedsolutions to fight extreme precipitation events/flooding**
- **Nature Basedwastewater treatment systems and urban storm water treatment**
- **Cost effective Nature Basedor nature-inspired technologies for decreasing the carbon footprint associated to the mobilization of multiple water resources**

3.6. Culture, creativity and inclusive society (cluster 2)

Table 6. Guidance Table for Water Europe R&I Topics

Nº	RESEARCH AND INNOVATION TOPIC	INNOVATION TYPE	TRL LEVEL	INTERVENTION AREA Nº
1.1.1.	New water incentive pricing and pricing water security	Non-technical	All	2.6.1.
1.1.2.	Innovative economic mechanisms	Non-technical	All	2.6.1.
1.2.2.	New cost-effective combinations of salty and brackish water, desalination and (natural) pre-treatment	Applied	TRL 5-8	2.6.1.
1.2.5.	Enlarging the industrial symbiosis concept to agricultural sector	Non-technical	All	2.6.1.
1.3.11.	Urban/industrial symbiosis	Non-technical	All	2.6.1.
1.3.12.	Sustainable processes for water production by water recycling at various scales	Close-to-market	TRL 6-9	2.6.1.
1.3.16.	Water-energy-waste nexus in industrial environments	Close-to-market	TRL 6-9	2.6.1.
1.3.2.	Innovative smart irrigation systems	Close-to-market	TRL 6-9	2.6.1.
1.3.4.	Validate and deploy new digital (ICT) solutions for sustainable agriculture	Close-to-market	TRL 6-9	2.6.1.
1.3.7.	Increase awareness and improve perception (on direct and indirect reuse – as drinking water or recharge)	Non-technical	All	2.6.1.
1.4.1.	Nutritients, minerals and metals	Close-to-market	TRL 6-9	2.6.1.
1.4.2.	Valorisation of industrial brines	Applied	TRL 5-8	2.6.1.
1.5.1.	New diversification of water sources	Applied	TRL 5-8	2.6.1.
1.5.2.	New energy-efficient measures in water-intensive industries	Applied	TRL 5-8	2.6.1.
1.5.6.	Reduction of energy losses	Close-to-market	TRL 6-9	2.6.1.
2.3.1.	New solution for recovery and (re)use of recovered resources	Fundamental	TRL 3-5	2.6.1.
3.3.12.	Desalination based on green technologies	Applied	TRL 5-8	2.6.1.
3.3.8.	Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple waters	Applied	TRL 5-8	2.6.1.
4.1.2.	Improvement of the knowledge base and ICT tools of nutritient management and recycling	Applied	TRL 5-8	2.6.1.
4.1.6.	Analyse the feasibility, flexibility and governance of water-related infrastructure and technologies	Non-technical	All	2.6.1.
4.2.4.	Harness innovative and evolving ICTs for communication/dissemination campaigns and public engagement	Non-technical	All	2.6.1.
4.3.10.	Support to reduce the risk perception of "green" versus "grey" infrastructure	Non-technical	All	2.6.1.
6.2.2.	Agricultural water stewardship for food security	Non-technical	All	2.6.1.
6.2.3.	Water footprint of (food) products	Non-technical	All	2.6.1.
6.2.6.	Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water	Non-technical	All	2.6.1.
6.3.2.	Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes	Non-technical	All	2.6.1.
6.3.6.	Awareness raising actions on social perception of water reclamation and reuse	Non-technical	All	2.6.1.
6.4.2.	Innovations in regulatory framework, utility pricing systems, transparency of value, price for water, social awareness, lifecycle assessment including water, smart specialization in water reflecting water-economy, markets, and ecosystem services for water	Non-technical	All	2.6.1.

3.6.1. Intervention area: management of social and economic transformations

ADVANCE ECONOMIC APPLICATIONS OF CIRCULAR ECONOMY FOR SUSTAINABLE RESOURCE MANAGEMENT IN INDUSTRIAL SYSTEMS.

Design of food systems based on the principles of circular economy. Locally produced, **restorative**, and **regenerative food systems** could enhance **efficient** and **responsible use** of **natural resources** and support **biodiversity**. When addressing climate-related societal challenges, such as **food security** and malnutrition, **circular food systems** build on the nexus thinking of **Food-Water-Waste-Energy (FWWE)**. Developing and piloting **nexus solutions** have various co-benefits for the society and local biodiversity: increased **energy productivity** by the use of less water-intensive, renewable energy; optimised **economic water** by the use of **water-saving technologies**, **harvesting methods**, and **provisions systems**; and, improved **efficiency** in **agri-food chains**, owing to the use of **smart agriculture solutions**. Nevertheless, when designing **future-proof circular food systems**, there are a wide array of complementary action areas that should be taken into account: improvement of **socially inclusive** and **responsible production** and **consumption practices**; better **agricultural education schemes**; adoption of **food production techniques** improving ecosystem health at all agro-food production scales (e.g. farm, urban garden); advancement of **research**, **development**, **piloting**, and **social learning opportunities** at the nexus of **Food-Water-Waste-Energy (FWWE)**; and, inclusive development of **rural-urban linkages within the food systems**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water footprint of (food) products**
- **Enlarging the Industrial symbiosis concept to agricultural sector**
- **Improvement of the knowledge base and ICT tools of nutritient management and recycling**
- **Methodologies and tools for sustainability assessment of circular economy systems and demonstrations for water**
- **Sustainable processes for water production by water recycling at various scales**
- **Urban/industrial symbiosis**
- **Innovative smart irrigation systems**
- **Validate and deploy new digital (ICT) solutions for sustainable agriculture**
- **Agricultural water stewardship for food security**
- **New solutions for recovery and (re)use of recovered resources**

Solutions supporting the regional development and integration of unused biomass (e.g. wastewater) for industrial applications. The **regional development**, **supply chain integration**, **recovery**, and **reuse** of **viable**, **unused**, and **non-edible biomass**, such as oils from separators in municipal waste and water treatment or sewage sludge, nitrogen compounds, from in-house or public wastewater treatment, for industrial applications, could serve to re-orient **local material flows** into a **circular path**, reduce **waste production**, deliver **energy savings** through **distributed bioenergy supply systems**, and decrease production costs (e.g. use of wastewater for low-cost microalgae production). Therefore, advancing research, development, and piloting efforts on the **supply chain design** and **development** of **viable**, **unused**, and **non-edible biomass** of sufficient quality for **industrial applications** is of importance to increase not only **industrial water** and **energy productivity** but also to create **climate-resilient, closed-loop circular production systems**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Desalination based on green technologies**
- **New cost-effective combinations of salty and brackish water, desalination and (natural) pre-treatment**
- **New diversification of water sources**
- **Valorisation of industrial brines**
- **Nutrients, minerals and metals**

Circular governance systems across water cycles. **Locally adaptive**, **cross-sectorial**, **(centralised or decentralised) circular governance systems facilitate the recycle**, **reuse**, **valorisation** of **unused** or **abandoned biomass**, and close the **resource loops** by introducing **coordinated use practices** of natural capital assets (e.g. water, land, energy) to the local ecosystems of stakeholders. Design and implementation of such **integrated**, **closed-loop water governance systems** could reduce **chance of contamination**, enhance better monitoring of **water levels** and **water chemistry**, and introduce **efficiency gains** in **industrial applications** (e.g. circular water pumping, circular water purification, closed-loop cooling systems, enabling continuous heat removal and decreasing operations and maintenance costs [O&M]). From the scenario planning to pilot spatial design interventions, there is a need to advance research, development, and innovation efforts on the **spatial**, **ecosystem**, and **socio-economic consequences** of **circular water systems**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Analyse the feasibility, flexibility and governance of water-related infrastructure and technologies**
- **Innovations in regulatory framework, utility pricing systems, transparency of value, price for water, social awareness, lifecycle assessment including water, smart specialization in water reflecting water-economy, markets, and ecosystem services for water**

Improved industrial sustainability performance for carbon-neutral and competitive European industry at the water-energy nexus. With better economies of scale and a systematic application of resource efficiency, harnessing **synergies** of the **water-energy-waste nexus** by leveraging the **state-of-the-art technologies** for **incineration** and **energy recovery**, **waste-to-energy process**, the integration of **used water** and **solid waste treatment process**, could yield **environmental**, **economic and social benefits** for stakeholders involved in the development of **industrial symbiosis business models**, extension and collaborative governance of symbiotic resource interdependencies within the water-energy-waste nexus and of **industrial ecology**. With the aim of diffusing **circular**, **sustainable economic models** into **untapped synergies** and improving **industrial sustainability performance**, **regions** and **cities** as springboards for **industrial symbiosis** can accelerate the development of **systemic** and **symbiotic**, **industrial approaches** for revalorisation and reuse of resources, with the support of **facilitative fiscal**, **financial**, **economic and regulatory instruments, schemes**, and **models**.

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Water-energy-waste nexus in industrial environments**
- **New energy-efficient measures in water-intensive industries**
- **Reduction of energy losses**
- **New water incentive pricing and pricing water security**
- **Innovative economic mechanisms**
- **Technological (including ICT) and management solutions for a sustainable, energy-efficient and flexible cost-effective and safe multiple waters**
- **Increase awareness and improve perception (on direct and indirect reuse – as drinking water or recharge)**

RAISE AWARENESS ABOUT CIRCULAR ECONOMY PRACTICES IN BLUE ECONOMY.

Enhanced social and institutional awareness towards the optimal, resource-efficient, and circular use of water resources in all sectors. In **circular economic interventions** and **spatial planning** of **circular resources systems**, design and piloting of **social learning mechanisms**, as part of **knowledge**, **awareness**, and **capacity building activities**, is of significance to increase the **socio-economic embeddedness of circular economy applications** and eliminate the **risk perceptions** emerged from **circular economy**. Particularly, in the domain of **circular water systems**, for developing **sustainable policy instruments** and enhancing **participatory**, **joint planning** for **Integrated Water Resources Management (IWRM)**, **risk attitudes**, **power differentials** in the crowded stakeholders space of water, **deficiencies** between real and perceived risks of water reuse, hazards (e.g. stormwater issues) should be overcome with the **design** and **deployment** of **social awareness** and **learning mechanisms** and **opportunities** factored into **institutional**, **community-based**, and **industrial capacity building activities.**

WATER EUROPE RESEARCH AND INNOVATION TOPICS

- **Increase awareness and improve perception (on direct and indirect reuse – as drinking water or recharge).**
- **Awareness actions towards water managing authorities on new economic mechanisms and joint governance processes**
- **Awareness raising actions on social perception of water reclamation and reuse**
- **Innovations in regulatory framework, utility pricing systems, transparency of value, price for water, social awareness, lifecycle assessment including water, smart specialisation in water reflecting water-economy, markets, and ecosystem services for water**
- **Support to reduce the risk perception of "green" versus "grey" infrastructure**
- **Harness innovative and evolving ICTs for communication/dissemination campaigns, and public engagement**

List of abbreviations

A	AI	Artificial Intelligence
	AIS	Agricultural Innovation System
C	C40	C40 Cities Climate Leadership Group
	CAPEX	Capital Expenses
	CNT	Carbon nanotube
	CO2	Carbon Dioxide
	COSME	EU Programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (SMEs)
D	DSS	Decision Support System
E	EDC	Endocrine Disrupting Chemicals
	ENCA	Ecosystem Natural Capital Accounting
	ENCA-QSP	Ecosystem Natural Capital Accounting – Quick Start Package
	EU	European Union
F	FET	Future Emerging Technology
	FWWE	Food-Water-Waste-Energy
G	GHG	Greenhouse Gas Emission
	GIS	Geographic Information System
	GPS	Global Positioning System
I	ICLEI	Local Governments for Sustainability
	ICT	Information Communications Technology
	IGO	Intergovernmental Organisation
	IoT	Internet of Things
	IPR	Intellectual Property Rights
	IUCN	International Union for Conservation of Nature
	IWRM	Integrated Water Resources Management
J	JRC	Joint Research Centre
K	KET	Key Enabling Technology
L	LCA	Life Cycle Analysis
	LCIA	Life Cycle Inventory Analysis
M	MRE	Marine Renewable Energy
N	NBS	Nature Based Solution
O	O&M	Operation and Maintenance
	OECD	Organisation for Economic Cooperation and Development
	OPEX	Operational Expense
P	PFAS	Per- and polyfluoroalkyl substances
	PFOS	Perfluorooctane sulfonate
	POP	Persistent Organic Pollutants
R	R&D	Research and Development
	R&I	Research and Innovation
	RRR	Recycling, Recovery, and Reuse
S	SAAS	Software-as-a-Service
	SDG	Sustainable Development Goal
	SEEA-EEA	System of Environmental Economic Accounting – Experimental Ecosystem Accounting
	SME	Small and Medium-sized Entreprise
	SIRA	Strategic Innovation and Research Agenda
U	US	United States
	UWWTD	Urban Waste Water Treatment Directive
W	WE	Water Europe
	WEF	Water-Energy-Food
	WEW	Water-Energy-Waste
	WFD	Water Framework Directive
	WOLL	Water-oriented Living Labs
Z	ZLD	Zero Liquid Discharge

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Colophon

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