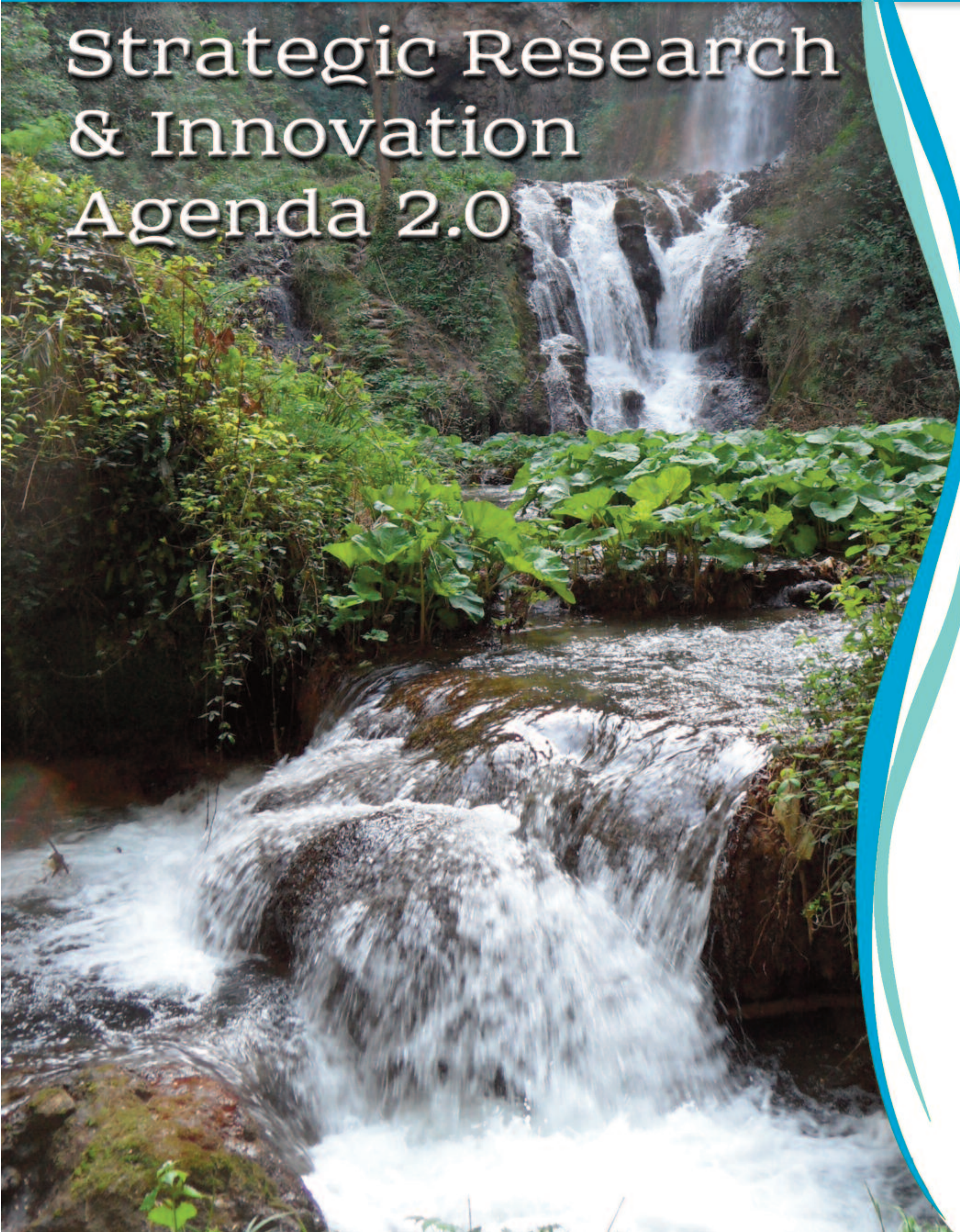
Water JPI

Strategic Research & Innovation Agenda 2.0



Adopted on 15 April 2016

Table of Contents

List of Abbreviations

ACQUEAU	Eureka Cluster for Water
AMR	Antimicrobial resistance
ARC	Aqua Research Collaboration
BiodivERsA	European research network on biodiversity and ecosystem services
BONUS	Science for a Better Future of the Baltic Sea Region
CAP	Common Agricultural Policy
CIP	Competitiveness and Innovation Framework Programme
CIRCLE	Climate Impact Research and Response Coordination for a Larger Europe
CRUE	European flood research network
CIS-SPI	Common Implementation Strategy – Science–Policy Interface
COST	European Cooperation in Science and Technology
DBP	Disinfection by-product
DSS	Decision support system
EEA	European Environment Agency
EIFAAC-FAO	European Inland Fisheries and Aquaculture Advisory Commission
EIP	European Innovation Partnership
EIT	European Institute of Innovation and Technology
ERA	European Research Area
ERA-NET	Framework Programme instrument to step up the cooperation and coordination of research activities carried out at national or regional level in the Member States and associated states
ESPP	European Sustainable Phosphorus Platform
ETP	European Technology Platform
EU	European Union
EU-INBO	International Network of Basin Organisations
EWA	European Water Association
EWP	European Water Stewardship Standard
EWS	Early warning system
Eureka	Inter-governmental initiative supporting cooperative RDI to encourage the competitiveness of European companies
FACCE	Food Agriculture and Climate Change Joint Programming Initiative
FP	Framework Programme
GEOSS	Global Earth Observation System of Systems
GPC	High-level Group (Groupe de Programmation Conjointe)
Horizon 2020	The European Union Framework Programme for Research and Innovation (2014–2020)
ICT	Information and communications technology
IWRM-Net	European research network on water
JPI	Joint Programming Initiative
JPIAMR	Joint Programming Initiative on Antimicrobial Resistance
JTI	Joint Technology Initiative
KIC	Knowledge and Innovation Communities
LEIT	Leadership in Enabling and Industrial Technologies

MAR	Managed aquifer recharge
MDGs	Millennium Development Goals
NWRM	Natural water retention measure
PPP	Public–private partnership
PRIMA	Partnership for Research and Innovation in the Mediterranean Area
RDI	Research, development and innovation
SCs	several Societal Challenges
SMEs	Small and Medium-sized Enterprises
SPIRE	Sustainable Process Industry through Resource and Energy Efficiency
SRIA	Strategic Research and Innovation Agenda
SusChem	Platform for Sustainable Chemistry
TVET	Technical Vocational Education and Training
UN	United Nations
WatEUr	Tackling European Water Challenges, a 7th Framework Programme Coordination and Support Action energising the Water JPI
WFD	Water Framework Directive
WssTP	Water Supply and Sanitation Technology Platform

Foreword

Water is a precious natural resource. It is fundamental requirement for direct consumption, for sanitary purposes, for the maintenance of economic activities and for the protection of ecosystems. At the global level, according to the United Nations' (UN's) Millennium Development Goals Report 2015, 9% of the population still does not have access to an improved source of drinking water. The safeguarding of water is therefore a must for society, but there are a number of threats that are likely to compromise water being widely available for different uses in Europe. Despite measures put in place by local authorities, the continuing availability of water has become a real challenge in many regions of Europe. The effects of droughts and floods, the increasing levels of human pressure in cities due to urban sprawl, the emergence of new contaminants and the overexploitation of water for agricultural purposes will, among other factors, probably exacerbate the risk of water shortages in the years to come.

In this context, the Water Joint Programming Initiative (JPI) (www.waterjpi.eu) was approved by the European Council in December 2011. Currently, the Water JPI comprises 20 Member States and four observing countries. The Water JPI partners represent 88% of the European national public research, development and innovation (RDI) investment in water. JPIs were established in 2008 in order to address a number of key societal challenges in Europe (water was identified as one of them) that cannot be tackled by countries in isolation. JPIs propose new forms of cross-border cooperation that go beyond collaborative projects or mobility actions. Member States engaged in JPIs agree on common agendas – such as the one presented here – on the alignment of national research and innovation agendas around a number of common strategic goals, on activities to foster international cooperation and on the implementation of joint actions.

This document presents the Strategic Research and Innovation Agenda (SRIA), version 2.0, of the Water JPI. The publication of the SRIA 2.0 represents a milestone in the lifetime of the Water JPI, which was launched in 2010. The SRIA 2.0 was conceived to guide future water-related RDI measures in Europe, including, but not solely limited to, the Water JPI actions from the Implementation Plan. To this end, it sets out specific RDI priorities or areas where RDI measures are highly recommended.

Acknowledgements

Thanks to support from Member States, we are strongly convinced that the Water JPI has the capacity to act as a research and innovation platform offering new means of cross-border collaboration at both strategic and operational levels and paving the way towards identifying adequate solutions and improved sharing and pooling of expertise, skills and resources.

We also wish to acknowledge all the people who have contributed to the development of the SRIA 2.0: partners of the WatEUr project and other members of the Water JPI, members of the advisory boards of the Water JPI, delegates to the first and second consultative stakeholder workshops, and all the people who generously participated in the first and second public consultations. Thank you very much for all your efforts, your involvement and your strong belief in the capacity of the Water JPI to bring about change and to improve the quality of life of our society.

Signed by:

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Executive Summary

As set out in its "Vision Document", the grand challenge to be addressed by the Water Joint Programming Initiative (JPI) is to "achieve sustainable water systems for a sustainable economy in Europe and abroad". Addressing this challenge requires considerable communication and co-ordination among the competent decision-making authorities, end users and experts in the field. However, the European water sector is highly fragmented as a result of the considerable diversity of stakeholders (i.e. water resources are often locally managed and there are numerous research funding networks, businesses and organisations with a stake in water issues). This fragmentation is definitely an obstacle to developing a research and innovation strategy for a sustainable and competitive water sector.

Water JPI partners have worked on the development of its Strategic Research and Innovation Agenda (SRIA). The SRIA is the backbone of the Water JPI, being the reference document for the implementation of joint activities. It establishes research, development and innovation (RDI) priority actions in the water sector to address the challenges as far as freshwater, groundwater and transitional and coastal waters are concerned. The SRIA includes, but is not solely limited to, the Water JPI actions from the Implementation Plan.

The Water JPI's SRIA, presented herewith, is neither the intersection of national (and regional) SRIAs nor a brand new document resulting from a bottom-up approach. The SRIA has been conceived as a participatory, inclusive and forward-looking document that sets out the direction of RDI. As such, it builds upon the views and SRIAs of national (and regional) partner Member States, foresight studies, the strategic agendas of all the actors involved in water management, and feedback from internal and external consultations. In this sense, the methodological approach of the SRIA is inclusive and participatory, and it attempts to overcome the current fragmentation of the water sector.

The SRIA is followed by operational Implementation Plans. The Implementation Plan specifies which instruments are to be used for the implementation of joint RDI actions that have been suggested by the Water JPI's SRIA (e.g. calls, strategic and exploratory workshops, alignment of national programmes).

The present document is version 2.0 of the SRIA of the Water JPI.

The development of the SRIA 2.0 has been a long process, which started with the publication of the Water JPI Vision Document in 2011, following a number of consultations with the Water JPI advisory boards and with partner Member States at that time.

Adopting a branched structure, each of these themes was then broken down into subthemes, RDI needs and RDI objectives (i.e. specific RDI actions).

Version 0.5 of the SRIA was adopted in May 2013. This preliminary version teased out a number of relevant RDI requirements for water but did not prioritise them. The analysis of additional sources of information (including, among others, national RDI agendas, the strategic agenda of the European Innovation Partnership on Water (EIP Water), foresight studies, and the European Water Blueprint) allowed the identification of new Water RDI needs, as part of the Water JPI's SRIA 1.0, which was launched in 2014. Overall, more than 130 sources of information were consulted.

The Water JPI's advisory boards and the general public have been invited to provide input on the content of the agenda and to help prioritise the needs for water RDI. To this end, two public consultations (in 2014 and in 2015) and two stakeholder consultative workshops (held in April 2014 and in October 2015) were organised.

The Water JPI's SRIA 2.0 is structured as follows:

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

The SRIA 2.0 was adopted as a result of collaboration and consensus among Water JPI partners. This collaboration will be continued in future, as further updates of the SRIA will probably be required in order to align water RDI activities with emerging challenges.

The endorsement of this document proves that new forms of collaboration and cooperation have emerged in Europe, as Member States have shown their willingness to establish a common agenda, to coordinate their RDI activities and to increase the efficiency and impact of national public research and innovation funding in strategic areas. The Water JPI, for which the adoption of the SRIA 2.0 is a key milestone, is therefore expected to play an important role in the construction of the European Research Area in the field of water.

1. Introduction

1. Introduction

1.1 The Water Challenge

Water is a precious natural resource, essential for the survival of living organisms and the maintenance of ecosystems. At the global level, new sustainable development goals were adopted in late September 2015, with an individual sustainable development goal related to water challenges and specific targets on drinking water and basic sanitation, on water quality and wastewater management, on water scarcity and efficiency of use, on integrated water resources management, and on the protection and restoration of water-related ecosystems. The safeguarding of water resources is therefore a must for society.

In Europe, water has a wide range of applications in our daily lives and is a driver for economic prosperity, generating a turnover of some EUR 80 billion a year[1]. Water can be used for energy production and it supports a large number of industrial and agricultural activities. Aquatic ecosystems provide important ecosystem services such as the storage of freshwater, the housing and safeguarding of biodiversity and the buffering of micro-climatic changes. But there are a number of threats that are likely to compromise the wide availability of water for different uses in Europe. The protection of water resources has been a priority for Europe since the late 1970s. Concerted policy actions have been taken at the European level through the adoption of legislative instruments and policies, such as the Water Framework Directive (WFD, Directive 2000/60/EC), which established a legal Community framework to protect and restore clean water across Europe and to ensure its long-term and sustainable use. There are also other water-focused directives, such as the Floods Directive (Directive 2007/60/EC), the Drinking Water Directive (Directive 98/83/EC), the Bathing Water Directive (Directive 2006/7/EC), the Urban Waste Water Directive (Directive 91/271/EEC) and the Nitrates Directive (Directive 91/676/EEC), the last two being focused on water pollution issues. The 2012 Blueprint to Safeguard Europe's Water Resources (COM(2012) 0673 final) could currently be deemed the flagship water policy framework in Europe.

Several thousand research and innovation projects have also been carried out in order to identify sound and viable measures and solutions for the protection of water resources. Water was identified as one of the “focus areas” of the first Horizon 2020 Strategic Programme, which provides a number of priorities for research, development and innovation (RDI) in its 2014–2015 work programme.

Horizon 2020’s calls have aimed to seize new market opportunities, while safeguarding water resources, through a new approach based on the development of new tools, methodologies and technologies for water management.

Despite policy- and research-driven efforts at national and European levels, water resources are still under pressure in many regions and significant challenges remain. According to the European Environment Agency (EEA)[2], this pressure is likely to increase in the years to come. In this context, the main water challenge for Europe is to develop solutions that guarantee its water supply while ensuring the sustainable use of ecosystems and its economic prosperity.

[1] Horizon 2020 Strategic Programme.

[2] European Environment Agency (2012). Water Resources in Europe in the Context of Vulnerability: EEA 2012 State of Water Assessment. EEA Report 11/2012. Available at:
http://europedirect.pde.gov.gr/images/pubs/Water-resources-in-Europe-in-the-context-of-vulnerability.pdf

The following points outline some of the main pressures Europe has to face in order to achieve this aim:

- Competition between different uses of water (agriculture, public services, energy, industry and environmental protection) has made this resource a limiting factor. Thus, across the European Union (EU), agriculture alone accounts for approximately one-quarter of the water used. That figure is as high as 80% in southern European countries[3]. Agriculture plays a major role in the sustainable management of water. Water resources need to be carefully allocated and used across the different economic sectors.
- The 2007 Communication of the European Commission on Water Scarcity and Droughts[4] stated that water stress already affects 30% of Europe's population. Water scarcity impacts mainly southern European countries, but northern European countries are also affected. Climate change (through the uneven distribution of seasonal rainfall and the increased incidence of extreme events such as droughts and floods) and increasing urban sprawl will probably increase the gap between water supply and water demand, thereby exacerbating water scarcity in more areas of Europe (the number of river basins experiencing water scarcity is expected to increase by up to 50% by 2030).
- In addition, almost half of Europe's water bodies will not achieve the WFD 2015 targets[5], primarily due to diffuse pollution (mainly agriculture and forestry) and the inadequate treatment of wastewater. Fertilisers, micro-pollutants, emerging pollutants and pathogens all have a clear effect on water quality – putting both human health and ecosystem conservation in jeopardy – and water utilities. Furthermore, the presence of pollutants in water increases the costs of water treatment and reduces the region's economic potential. Natural events, such as floods, can reduce water quality, as soil particles are washed out in run-off and accumulate in water bodies, or as water treatment plants stop functioning as a result of the build-up of eroded soil particles.
- The availability of water resources in many areas is affected by the overabstraction of groundwater and the construction of infrastructure for the regulation and supply of water. The excessive use of groundwater for agricultural purposes does not only limit access to water for other uses but also may lead to societal conflicts and to the unfair distribution of natural resources across sectors. Overabstraction of groundwater is also a cause of salt intrusion in coastal areas.
- Infrastructure such as dams, reservoirs and dykes has often resulted in improved control and monitoring of water resources. Nevertheless, such structures are also responsible for a range of hydromorphological changes, with typically adverse ecological consequences.
- At the technology level, major scientific and technological breakthroughs are still needed to cope with emergent challenges such as the growing concern over multi-resistant microorganisms, the need to recover and reutilise phosphorous and nitrogenous fertilisers from wastewater, the deployment of capital-intensive water infrastructure, and the need to reduce energy inputs into all water processes.

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[3] European Environment Agency (2012). Towards Efficient Use of Water Resources in Europe. EEA Report 1/2012. Available at: http://www.eea.europa.eu/publications/towards-efficient-use-of-water

[4] European Commission (2012). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, "Report on the review of the European Water Scarcity and Droughts Policy". COM(2012) 0672 final. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0672&from=EN

[5] European Environment Agency (2012). European Waters – Assessment of Status and Pressures. EEA Report 8/2012. Available at: http://www.eea.europa.eu/publications/european-waters-assessment-2012

- Europe has one of the longest track records in water management in the world and is still a global industrial leader in terms of service provision and technology development[6]. When considering the performance of innovation systems in a global context, South Korea, the United States and Japan all have a lead over the EU[7]. South Korea outperforms the EU by 24%, the United States by 22% and Japan by 14%. While the gap between the EU and both the United States and Japan is decreasing, it is widening when compared with South Korea. The EU-28 does still have a lead in terms of performance over Australia, Brazil, Canada, China, India, Russia and South Africa. This lead is, however, declining. Policies and programmes need to favour appropriate conditions for relevant innovations in RDI. Such innovations within the water sector could lead to significant benefits to the EU.
- In conclusion, maintaining the availability of water for different uses has become an increasing challenge for European society in the near future owing to a number of factors (listed above). From a policy perspective, the importance of water needs to be permanently reflected in research and innovation policies, and Member States must commit to fully enforce Community legislation. In line with the objectives of the Water Blueprint, water issues need to be fully integrated into other policies.

Europe has a long record of RDI. However, all the expertise acquired so far needs to be further shared and exploited by the RDI community. New tools, methodologies and technologies may need to be developed in order to respond more effectively to current and emerging challenges and the demands of society. New approaches to RDI based on eco-innovation, the circular economy or nature-based solutions should be further explored, which will in turn open up new business opportunities.

1.2 Joint Programming Initiatives: A New Framework for Addressing Societal Challenges

Joint Programming Initiatives (JPIs) were launched by the Competitiveness Council of the European Union in 2008[8]. JPIs aim to tackle societal challenges in strategic areas by fostering cross-border collaboration and RDI policy coordination among Member States. This implies the pooling of national RDI efforts and funding in order to make better use of Europe's public RDI resources.

The new means of European cooperation favoured by JPIs include, inter alia:

- harmonisation of national RDI agendas through the development and implementation of a Strategic Research and Innovation Agenda (SRIA); the SRIA lays out a number of specific RDI actions to address major European challenges;
- the mobilisation of skills, knowledge and resources to develop common solutions to major challenges and to enable the cross-border dissemination of research findings;
- the alignment of national and regional RDI programmes;
- the definition of joint framework conditions regulating peer review procedures, foresight activities, evaluation, funding of cross-border research, dissemination and use of research findings, and protection, management and sharing of intellectual property rights issues.

[6] EU Water Alliance (2014). Main Priorities for Water under the Juncker Commission (2014–2019). Available at: http://eu-wateralliance.eu/wp-content/uploads/2014/09/Main-priorities-for-water-under-the-Juncker-Commission-2014-2019.pdf

[7] EU Water Alliance (2014). Main Priorities for Water under the Juncker Commission (2014–2019). Available at: http://eu-wateralliance.eu/wp-content/uploads/2014/09/Main-priorities-for-water-under-the-Juncker-Commission-2014-2019.pdf

[8] European Commission (2008). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, "Towards joint programming in research: working together to tackle common challenges more effectively". COM(2008) 468 final.

Based on a variable geometry approach, the participation of Member States is voluntary. Ten JPIs[9] have been launched so far in order to respond to a societal challenge that cannot be solved by any European country in isolation.

JPIs contribute to developing common solutions, to optimising the efficiency and impact of public research funding, to supporting the implementation of joint actions (such as cross-border collaborative projects or infrastructure sharing), and to improving coordination with other national and European RDI programmes. JPIs are therefore meant to play a key role in the construction of the European Research Area (ERA).

1.3 The Water Joint Programming Initiative: Its Mission

The Water JPI (entitled "Water Challenges for a Changing World") was launched in 2011.

The mission of the Water JPI is to strengthen collaboration and coordination on water RDI among Member States in order to enhance Europe's leadership and competitiveness in the water sector. To this end, the Water JPI will seek opportunities to pool and mobilise appropriate skills, knowledge and resources to offer solutions that address the challenge of "achieving sustainable water systems for a sustainable economy in Europe and abroad".

The physical domain of the Water JPI is coincident with that of the WFD: "inland surface waters, transitional waters, coastal waters and groundwater". This JPI was endorsed by the High Level Group (GPC) in May 2010, and as of June 2015 it can count on the participation of 20 partner countries (Austria, Cyprus, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Italy, Moldavia, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Turkey and the United Kingdom), in addition to the European Commission, and four observing countries (Belgium, Greece, Hungary and Latvia).

According to the first mapping exercise concluded in April 2011, the European Member States and associated countries run Water RDI programmes amounting to an annual investment of about EUR 370 million. Current Water JPI partners represent 88% of this funding (EUR 328 million).

In order to address the overall challenge indicated above, the Water JPI has set out specific objectives:

1- involving water end users in effective uptake of the results of RDI;

2- attaining a critical mass of research programmes – the goal is to involve at least two-thirds of the public investment in water RDI in Europe;

3- achieving effective and sustainable coordination of European water RDI;

4- harmonising national water RDI agendas and activities in partner countries; joint programming activities will amount to at least 20% of the total budget of partners' national water RDI programmes; and

5- supporting European leadership in water science and technology.

[9] On-going JPIs: Alzheimer and other Neurodegenerative Diseases (JPND); Agriculture, Food Security and Climate Change (FACCE); A Healthy Diet for a Healthy Life; Cultural Heritage and Global Change: A New Challenge for Europe; Urban Europe – Global Urban Challenges, Joint European Solutions; Connecting Climate Knowledge for Europe (Clik'EU); More Years, Better Lives – The Potential and Challenges of Demographic Change; Antimicrobial Resistance – The Microbial Challenge – An Emerging Threat to Human Health (AMR); Water Challenges for a Changing World; and Healthy and Productive Seas and Oceans.

1.4 The Water Joint Programming Initiative within the European Context

Water is at the core of the activities of a wide range of European initiatives. Many of these have already developed and implemented their own strategic research and innovation agenda.

The Water JPI does not aim to duplicate the strategic work carried out by all these neighbouring initiatives. On the contrary, it seeks to coordinate and find synergies with them, so that the Water JPI's SRIA will be a comprehensive and integrated document that (i) identifies the research gaps and RDI needs documented in the strategic documents of other European initiatives; (ii) identifies complementarities; and (iii) sheds some light on potential opportunities for collaboration (through, by way of example, project co-funding). To this end, and as detailed in Chapter 2, the strategic documents of selected RDI actors in Europe have been carefully analysed and their needs for and gaps in RDI have been included in the SRIA.

Figure 1 illustrates some of these neighbouring European initiatives. As shown, the initiatives are classified according to the following criteria:

- Are they or are they not RDI funding instruments?
- If they are RDI funding instruments:
    - o What is the main RDI focus (i.e. are they more oriented towards research or towards innovation)?
    - o What is the main source of funds (private, public or both)?

The Water JPI (like all the other JPIs) covers the full range of RDI, as the national programmes comprising it fund projects from blue-sky research to support for industrial innovation. A mapping analysis of these research programmes allowed the estimation of the centre of gravity of the Water JPI, which would have about 75% research and 25% innovation. Its full coverage of the research–innovation axis means that the Water JPI is able to adapt to changing societal needs and policy environments.

Horizon 2020 and the Structural Funds are similar to the Water JPI, as they also cover the full RDI chain. However, the current push towards innovation places both programmes closer to the innovation pole. The intergovernmental programme European Cooperation in Science and Technology (COST) is, on the other hand, located closer to the research pole. Its objective is to support activities at the outset of research projects. The centre of gravity of Article 185 is principally located at the research–development pole, whereas that of LIFE (the EU's finding instrument for projects on the environment and climate change) is located at the demonstration–piloting pole. The functioning of all these instruments depends on public funding.

Horizon 2020, which is the main European Commission RDI funding programme in Europe, over the period 2014–2020, aims to build a knowledge- and innovation-based economy while contributing to sustainable development. During the first 2 years of Horizon 2020, "boosting water innovation" was identified as one of the 12 focus areas. For the 2016–2017 work programmes, water issues are now addressed across the whole of Horizon 2020 and are integrated into the Leadership in Enabling and Industrial Technologies (LEIT) and several Societal Challenges (SCs) initiatives (in particular, SC2, SC3, SC5 and SC6). In 2015, in preparation for the work programme for 2016–2017, the European Commission published three experts' group reports of relevance to the Water JPI:

- **A European Research and Innovation Roadmap for Climate Services**[10]: The Water JPI was identified as a potential actor in the Climate Services Roadmap, which can support or facilitate the implementation of the specific activities identified in the roadmap:
    - o Main activity 1.2: Growing the climate services market – establishing the means of enhancing the awareness of, and promoting, climate services.
    - o Main activity 1.3: Demonstrating the added value – demonstrating the impacts and full value of climate services as standalone services and/or as services integrated into broader decision support systems.
    - o Main activity 2.1: Communities and infrastructures to support and grow the climate services market – developing a viable climate services community that engages users, providers, purveyors and researchers.

- **Nature-based Solutions and Re-naturing Cities**[11]: Four principal goals have been identified that can be addressed by nature-based solutions:
    - o enhancing sustainable urbanisation;
    - o restoring degraded ecosystems;
    - o developing adaptation to and mitigation of climate change;
    - o improving risk management and resilience.

- **From Niche to Norm**[12]: The experts group suggested a roadmap of actions to ensure that Horizon 2020 funding and broader EU policy can help foster a systemic approach to eco-innovation. The actions of particular relevance are under:
    - o Pillar 4: Fostering a single market for resources:
        - 4.3: Support consumers in the transition to a circular economy.
        - 4.4: Develop resource conservation and replacement plans.
    - o Pillar 5: Ensuring consistent, conducive and coordinated policy-making:
        - 5.1: Develop a comprehensive resource roadmap to 2050.
        - 5.2: Assess new targets for sustainable resource use.
        - 5.3: Create synergies between other EU funding mechanisms.

Public–private partnerships (PPPs) (SPIRE (Sustainable Process Industry through Resource and Energy Efficiency) for the water domain) mainly concern innovation and are based on public (European Commission) and private (industry) funds. Joint Technology Initiatives (JTIs) are similar to PPPs, covering the whole RDI chain. However, while the PPPs implement their strategic research agendas via Horizon 2020, the JTIs implement their strategic research agendas via joint undertakings that manage research projects and organise their own calls for proposals. Their functioning is not based on contracts between actors. There are currently no specific JTIs on water.

[10] Available at: http://bookshop.europa.eu/en/a-european-research-and-innovation-roadmap-for-climate-services-pbKI0614177/

[11] Available at: http://bookshop.europa.eu/en/towards-an-eu-research-and-innovation-policy-agenda-for-nature-based-solutions-re-naturing-cities-pbKI0215162/

[12] Available at: http://bookshop.europa.eu/en/from-niche-to-norm-pbKI0115206/

Moving towards innovation, several initiatives are worthy of mention, such as the European Innovation Partnership on Water (EIP Water), the Climate Knowledge and Innovation Community (KIC) and the Eureka Cluster for Water (ACQUEAU). The expected output of ACQUEAU and the Climate KIC is the setting up of innovation projects, whereas EIP Water also aims to "mainstream" (i.e. make it part of everyday practice) and speed up water innovation in Europe by removing existing barriers.

EIP Water and ACQUEAU are not funding initiatives. EIP Water will mobilise public European Commission, national and regional funds, along with private funds. ACQUEAU labels projects for subsequent national funding.

Three other EIPs are also relevant to the Water JPI. These include:

- EIP Agricultural Productivity and Sustainability[13];
- EIP Smart Cities and Communities[14];
- EIP Raw Materials.

The European RDI landscape is completed by a number of other initiatives that do not directly fund or streamline RDI activities. Examples of these initiatives include:

- European Technology Platforms (ETPs), whose primary objective is to ensure the growth and competitiveness of the European water sector by fostering collaboration between the industry and research and higher education centres and water users. Examples of relevant ETPs for the Water JPI include:
    - the Water Supply and Sanitation Technology Platform (WssTP), whose thematic interests coincide with those of the Water JPI;
    - the Platform for Sustainable Chemistry (SusChem);
    - the European Sustainable Phosphorus Platform (ESPP);
- networks of research organisations, contributing to the development of European science and technology (e.g. Euraqua);
- associations of water professionals (e.g. EurEau, the European Water Association);
- policy-driven initiatives (e.g. Common Implementation Strategy: Science–Policy Interface (CIS-SPI)), aiming to support the implementation of European policies;
- initiatives driven by information sharing, such as the European Water Stewardship Standard and River Commissions;
- lobbying-driven initiatives, such as the European Water Alliance.

A more thorough description of all these initiatives is provided in Tables 1 and 2. In addition, the Water JPI will seek to enhance synergies with other JPIs in order to establish common activities. In this sense, the Water JPI has at this point reviewed the strategic agendas of other JPIs and it has identified specific research areas of the Water JPI's SRIA that could contribute to tackling the societal challenges addressed by other JPIs. The results of this analysis are shown in Annex III.

[13] European Commission (2013). Communication from the Commission to the European Parliament and the Council on the European Innovation Partnership "Agricultural Productivity and Sustainability". COM(2012) 079 final. Available at: http://ec.europa.eu/eip/agriculture/sites/agri-eip/files/communication_on_eip_-_en.pdf

[14] EIP on Smart Cities and Communities (2013). Strategic implementation plan. Available at: http://ec.europa.eu/eip/smartcities/files/sip_final_en.pdf

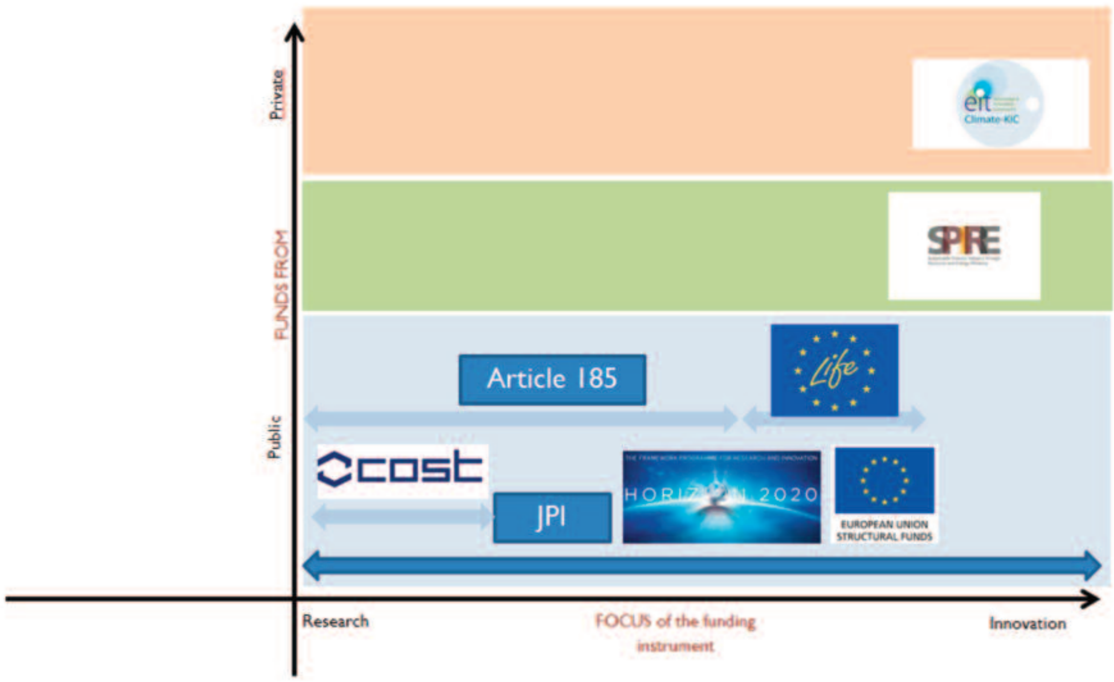


Figure 1 Neighbouring European initiatives.

Initiative	What is it? What are its aims?	Complementarity with the Water JPI
Horizon 2020	Main RDI funding programme in Europe, using a 7-year programming period (2014–2020). It aims to build a knowledge- and innovation-based economy while contributing to sustainable development. It combines previous efforts: the Framework Programme + CIP + EIT	The Water JPI fits Horizon 2020 priorities. Horizon 2020 instruments may support the activities of the Water JPI. This SRIA may be a programming tool to help in the preparation of Horizon 2020 work programmes
ERA-NET	Specific funding instrument of FP6, FP7 and Horizon 2020 aimed at fostering the cooperation and coordination of research activities within a specific research domain. ERA-NETs within Horizon 2020 are implemented through the ERA-NET Cofund instrument	Several ERA-NETs have been put in place within the water domain (e.g. IWRM-Net, CRUE or CIRCLE/CIRCLE-2). A number of other ERA-NETs, only partially related to water, have launched water projects (e.g. BiodivERsA). The experience and the output of these ERA-NETs are being used to produce the Water JPI's SRIA
Structural funds (ex. Interreg programme)	These funds aim to remove economic, social and territorial disparities across the EU while making the EU more competitive	Structural funds represent one of the funding instruments available for the partners of the Water JPI to support their activities
LIFE	This financial instrument aims to contribute to the implementation, updating and development of EU environmental and climate policy and legislation	It can be one of the funding instruments supporting Water JPI activities
Article 185	European funding scheme that allows the Commission to participate in research and development programmes undertaken jointly by several Member States. A formal funding commitment by partner countries is needed. Two Articles 185 are particularly relevant for the Water JPI: PRIMA (Mediterranean area; thematic fields: health, environment, food, water resources) and BONUS (Baltic area; thematic fields: marine research, water catchment)	This SRIA should be considered by Water JPI partners and the Commission in the preparation of future Article 185 initiatives (particularly PRIMA)
European Institute of Innovation and Technology (EIT)	Established by the European Commission in 2008 to boost innovation through the implementation of KICs, which bring together actors from higher education, research and business. There is no specific KIC on water, although the Climate KIC includes interests relevant to water, namely the land and water management and engineering for adaptation (LWEA) platform	KICs may involve the funding of RDI actions

Differences from the Water JPI	RDI focus	Origin of funds (publ)
Horizon 2020 is a European programme, while the Water JPI is an intergovernmental initiative. Horizon 2020 has a closed budget, while the Water JPI creates budget for its activities using variable geometry	All RDI chain, although slightly oriented towards innovation	Public
The European Commission partly funds ERA-NET activities (top-up funding); JPIs are intergovernmental initiatives and, as such, they fall under the full financial responsibility of partner countries	Mainly research activities	Public
In the same vein as Horizon 2020, structural funds have their own budget for the full programming period	All RDI chain (Interreg is more centred on demonstration activities)	Public
This programme is focused on policy development and implementation	Policy-oriented pilot/demonstration projects	Public
An Article 185 has its own funds to develop activities, obtained from partner countries and the European Commission	Research and development	Public
The Water JPI covers the whole RDI span, and devotes efforts to programme coordination. The EIT is partly funded by Horizon 2020	Innovation	Private

Initiative	What is it? What are its aims?	Complementarity with the Water JPI
COST	Intergovernmental organisation supporting cooperation in science and technology through the funding of networking, capacity-building and/or mobility actions	COST can support the kick-off of Water JPI research activities and the implementation of joint actions (in particular, mobility)
Public–private partnerships – SPIRE	Contractual arrangements (cPPPs) between the European Commission and representative industrial associations for key sectors of Europe's economy. In this way, the EU and industry provide vital funding for research and innovation activities in sectors that are essential to Europe's industrial leadership Launched in 2013, SPIRE aims to develop sustainable process industry through resource and energy efficiency. SPIRE takes into account eight industrial sectors, of which water is just one Both PPPs and the Water JPI address societal challenges. They are both implemented, among other instruments, through the launch of RDI calls	The participation of industrial actors is a key element in the development and implementation of the PPP. Industry proposes the strategy of the PPP and advises on work packages. The functioning of PPPs depends on both private and public funding All RDI chain Public (EU) + private (industry)

BiodivERsA, European research network on biodiversity and ecosystem services; BONUS, Science for a Better Future of the Baltic Sea Region; CIP, Competitiveness and Innovation Framework Programme; CIRCLE, Climate Impact Research and Response Coordination for a Larger Europe; CRUE, European flood research network; EIT, European Institute of Innovation and Technology; FP, Framework Programme; IWRM-Net, European research network on water; KIC, Knowledge and Innovation Community; PPP, public–private partnership; PRIMA, Partnership for Research and Innovation in the Mediterranean Area; SPIRE, Sustainable Process Industry through Resource and Energy Efficiency.

Differences from the Water JPI	RDI focus	Origin of funds (publ)
COST funds activities in the early stage of re-search projects, whereas the Water JPI funds activities in any of the stages of the RDI chain (although priority is given to research actions)	Early stages of research actions	Public

Table 2 Other selected European initiatives

Initiative	What is it? What are its aims?	Complementarity with the Water JPI
ACQUEAU	ACQUEAU is the Eureka Cluster for Water. It encourages cooperation between SMEs, research centres and universities on industrial innovation. It labels innovation projects as PPPs	The labelling of projects allows the provision of national funds for the implementation of innovation projects. ACQUEAU can act as a facilitator of innovation projects
Aqua Research Collaboration (ARC)	European collaboration involving leading research institutes working on the water use cycle	Member organisations can provide their views on relevant RDI needs in water
Common Implementation Strategy – Science Policy Interface (CIS-SPI)	Ad hoc activity established to support the implementation of the WFD	Both the CIS-SPI and the Water JPI focus on research gaps/needs
EIPs (European Innovation Partnerships): EIP Water; Agricultural Productivity and Sustainability: Smart Cities and Communities; Raw Materials	European initiative that intends to stimulate the creation of innovative solutions to tackle water challenges. It is based on bringing together, through a number of “action groups”, private and public actors from RDI, water users and water utilities. These actors are then invited to propose innovative projects, to coordinate existing funding instruments, and to facilitate the access of innovative products to the market	Some of the priorities of the EIP Water coincide with those of the Water JPI
EurEau	A European federation that brings together drinking water supply and wastewater operators	This group represents the voice of water operators in Europe, thereby it is able to provide relevant input to the Water JPI on drinking water supply and wastewater treatment
European Technology Platforms (ETPs)	Industry-led stakeholder forums recognised by the European Commission as key actors in driving innovation, knowledge transfer and European competitiveness	ETPs can act as one of the channels of external advice for the programming and implementation of the Water JPI

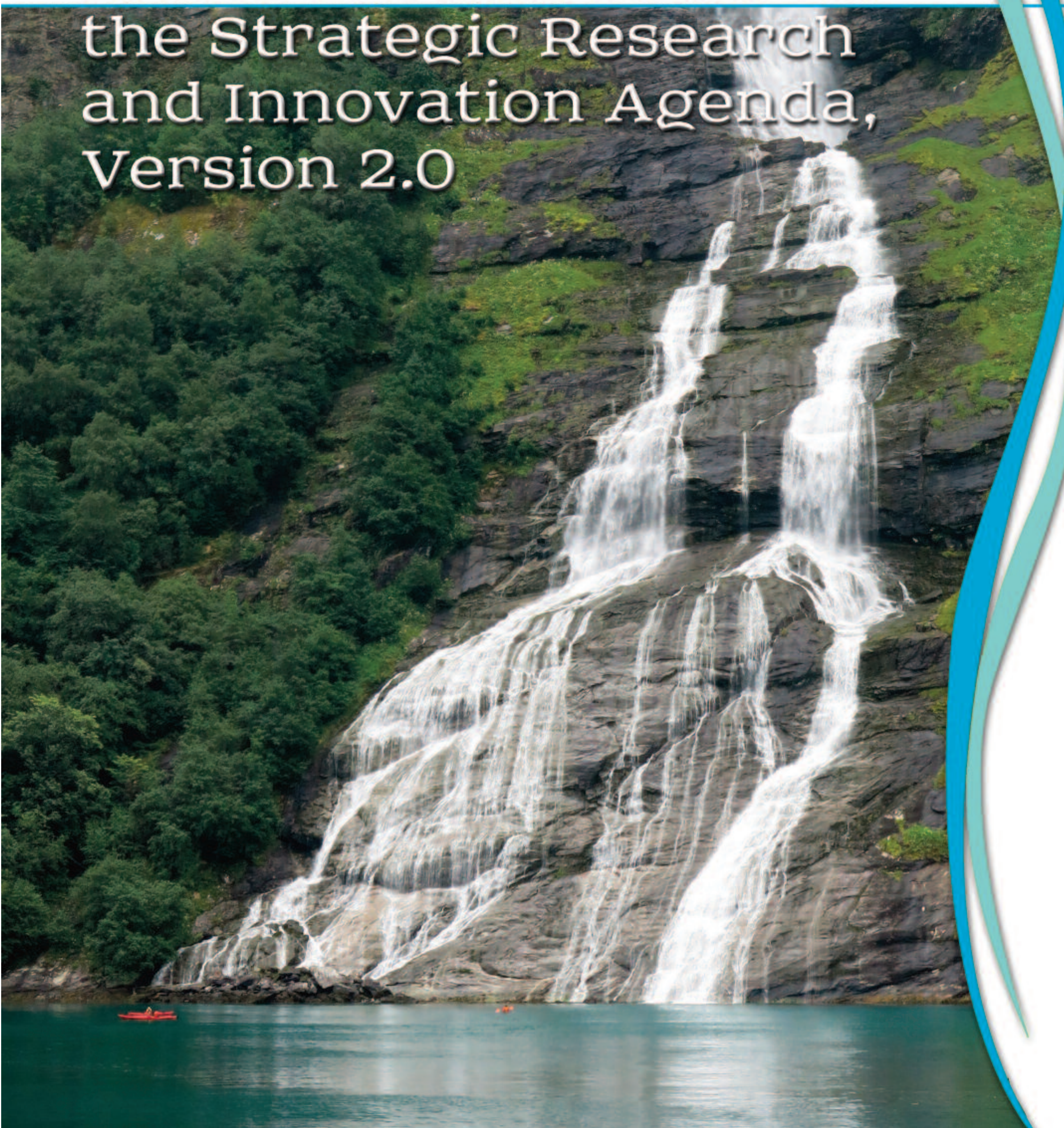
Differences from the Water JPI	RDI focus	Origin of funds (publ)
The Water JPI covers the whole RDI span, whereas ACQUEAU supports near-market water projects	Innovation	Private
ARC is a network of research organisations. No RDI activities are funded by ARC	Mainly applied research	Public
No RDI activities are funded/executed by this activity	No RDI	-
The Water JPI covers the whole RDI span and devotes efforts to programme coordination. The EIP is more centred on innovation aspects	Innovation	Mainly private (some Commission support is given to action groups)
Brings together both private and public water operators. No RDI activities are directly funded by EurEau	No RDI	–
ETPs cover only innovation projects. ETPs are self-financing activities, whereas Water JPI actions mainly depend on Member States' contributions	Innovation	Private

Initiative	What is it? What are its aims?	Complementarity with the Water JPI
European Water Association (EWA)	Informal coalition of more than 500 organisations across the entire value chain representing a wide range of water stakeholders (RDI actors, water utilities, European federations, national associations, water users)	As the EWA brings together a group of stakeholders, its vision is of great interest in the development of the Water JPI's SRIA
European Water Stewardship (EWP)	Not-for profit organisation that brings together people and stakeholders around a common water vision for Europe. It develops policies and standards, and fosters sharing of best practice	Both the EWP and the Water JPI promote coordination and the establishment of a common vision. The EWP can offer external advice to the Water JPI
Global Earth Observation System of Systems (GEOSS)	This will be a flexible global network of content providers that will allow decision-makers to access observation data and information	GEOSS may become an important provider of data and information
International Network of Basin Organisations (EU-INBO)	A group aiming to enrich the implementation of water policies in Europe through the organisation of meetings, the exchange of practical experiences and the dissemination of tools to EU Member States	Member countries can give their view on RDI needs for the implementation of water policies
River Commissions (Rhine, Danube)	River Commissions coordinate the interest of member basin states. They also discuss common basin problems, exchange experiences and seek joint actions	Both members of River Commissions and the Water JPI seek coordination in order to address a specific challenge. River Commissions can provide advice on Water JPI strategic activities

PPP, public–private partnership; SME, small and medium-sized enterprise.

Differences from the Water JPI	RDI focus	Origin of funds (publ)
No RDI activities are directly funded/executed by the EWA	No RDI	–
No RDI activities are funded/executed by EWP members	No RDI	–
No specific RDI actions are undertaken within GEOSS. It is conceived as an information dis-semination tool	No RDI	–
No RDI activities are funded/executed by this group	No RDI	–
No RDI activities are funded/executed by River Commission members	No RDI	–

2. The Process towards the Strategic Research and Innovation Agenda, Version 2.0



Tackling European Water Challenges

2. The Process towards the Strategic Research and Innovation Agenda, Version 2.0

The Water JPI's SRIA 2.0 results from a collective, forward-looking exercise that identifies and sets out an integrated vision of water RDI priorities at regional, EU and global level.

The Water JPI Implementation Plan establishes how some of those RDI directions and priorities will be implemented through the Water JPI's instruments, and it makes recommendations on how some of these needs could be addressed under other European and international initiatives (e.g. Horizon 2020).

The development of the SRIA 2.0 has been a long process that started with the preparation of a Vision Document[15] in 2011, and that was followed up with the development of two preliminary versions of the SRIA (versions 0.5 in 2013 and 1.0 in 2014). The Vision Document, which defines the main objectives and research questions and themes of the Water JPI, was endorsed by the governing board in 2011. Research questions were derived from contributions from partners and members of the advisory board appointed at that time, as well as from a preliminary analysis of national RDI agendas (first European RDI mapping).

Figure 2 summarises the process leading to the elaboration of SRIA 2.0 and the main documents published prior to its adoption. The figure also illustrates the main features of each document (the main outcome information) and the information sources taken into account in their preparation.

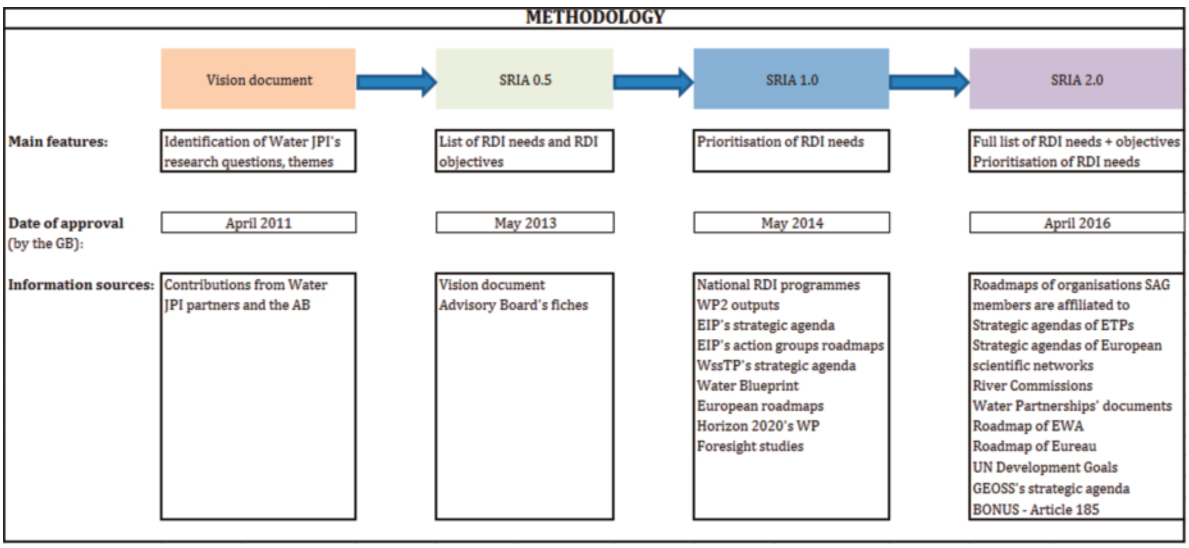


Figure 2 Methodological approach for the elaboration of the SRIA 2.0.

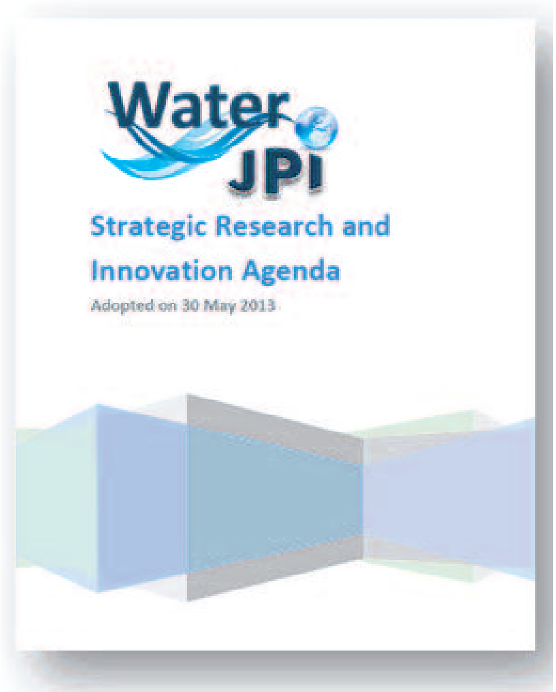
[15] Available at: http://www.waterjpi.eu/images/documents/Vision_Document.pdf

* For the sake of clarity, RDI needs refer to specific key questions that have not yet been answered through RDI programmes; RDI objectives refer to specific topics or action lines that could be put in place to respond to RDI needs.

Development of the SRIA 0.5

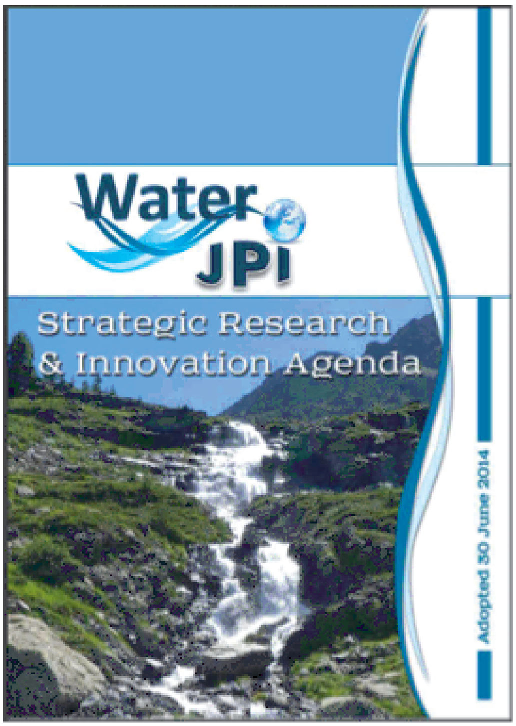
Following the first consultation with the members of the Water JPI's advisory board, a number of specific proposals on RDI topics and the most appropriate instruments for their implementation were outlined. Those contributions were collected in a number of "RDI fiches" (two- to three-page documents).

As shown in Figure 2, both the Vision Document and the advisory boards' "fiches" were taken into account in the preparation of the SRIA 0.5. The Water JPI's SRIA 0.5, adopted in May 2013, lists a number of RDI needs for each of the five RDI themes of the Water JPI, as well as specific RDI objectives linked to those needs and potential implementation instruments.



Development of the SRIA 1.0

The Water JPI's SRIA 1.0 was built on the SRIA 0.5, and followed the same structure. However, in version 1.0, specific implementation instruments were not proposed for the identified needs, as this information was included in the later Water JPI Implementation Plan, presented in October 2014. In comparison to the SRIA 0.5, the SRIA 1.0 included a longer list of RDI needs and objectives, which were identified through the review of numerous information sources (e.g. national agendas, strategic agendas of other European initiatives).



However, the main feature of the SRIA 1.0 relates to the fact that RDI needs were prioritised in time according to the feedback provided by the advisory boards of the Water JPI and national experts in an ad hoc consultative workshop (Lyon, 2014). Water RDI needs were categorised according to the timescale in which action should be taken (short, medium and long term). The allocation of a timescale to RDI needs allowed the alignment of the Water JPI's SRIA with the preparation of Horizon 2020's work programmes. Short-term priorities referred to RDI needs for which funding was recommended between 2014 and 2016 (the first Horizon 2020 work programme); medium-term priorities referred to RDI needs for which funding should be provided between 2016 and 2020 (coinciding with the implementation of the second and third work programmes of Horizon 2020); and long term priorities were those for which funding was recommended beyond 2020.

The SRIA 1.0 was adopted in June 2014 and officially presented to the European Commission and the general public on 21 October 2014 in Brussels.

This latest version of the SRIA (2.0) completes the list of RDI needs and objectives, following a review of additional information sources. Overall, more than a hundred information sources were reviewed between June 2013 and February 2015. RDI needs were prioritised according to a number of criteria (listed in section 2.2.2) and not according to the timescale in which action should be taken.

2.1. Review of Information Sources: Collecting and Processing of Information

The purpose of this activity was to improve understanding of the water landscape by looking at water policies, RDI programmes, and existing societal, scientific and technological challenges as a way of identifying: (i) potential new core themes and subthemes for the Water JPI; and (ii) current and emerging RDI needs and objectives. The following information sources have been reviewed (Annex V gives the full list of references):

- national RDI programmes[16];
- Deliverable 2.1 of the WatEUr project, aiming to map European water RDI (policies and strategies, funding schemes and performance);
- the strategic agenda of the EIP and related action groups;
- the strategic agenda of the WssTP;
- policy documents, including the Water Blueprint and European roadmaps;
- Horizon 2020's 2014–2015 work programme;
- foresight studies;
- strategic agendas of ETPs, in particular SusChem, Forestry, Sustainable Mineral Resources, The Future of the Steel Sector, Food for Life and Textiles for the Future;
- strategic agendas of European scientific networks – Euraqua, EuroGeoSurvey, Norman, European Water Alliance;
- River Commissions (Rhine, Danube);
- water partnerships – vision documents and the European Water Stewardship Standard;
- European associations: European Water Association, EurEau;
- the Post-2015 Development Agenda process towards the UN's Sustainable Development Goals;
- agendas of relevant ERA-NETs in the field of water;
- the strategic agenda of GEOSS.

[16] The countries that have had their national RDI programmes analysed are Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal and Spain.

2.2. Critical Review Activity: Selection and Prioritisation of Research, Development and Innovation Needs

Another key activity in the development of the SRIA 2.0 was a critical review, with the aim of prioritising all the water RDI needs identified. To achieve this, two public consultations were launched and two stakeholder consultative workshops organised.

2.2.1. Public consultations

Two public consultations were launched by the Water JPI. Both aimed to gather the opinions of society at large on the contents of the SRIA. In the first public consultation, opened in the first quarter of 2014, respondents were asked to give their opinion on the importance and urgency of each of the themes of the SRIA 1.0 (at that time under development). Importance referred to the extent to which RDI in a particular domain could contribute to responding to societal needs at the socio-economic/environmental or policy levels (social importance) and to answering scientifically relevant questions (scientific importance). Urgency referred to the timescale in which an action should be taken – short, medium or long term – according to its social and scientific importance. More than 600 responses were received.

The second public consultation was structured slightly differently from the first. It asked respondents to select the three most important subthemes listed in the SRIA. For each of those subthemes, respondents were then requested to indicate the most important RDI need (later categorised as “high” RDI priority). No information on medium and low RDI priorities was therefore obtained. Launched in the first quarter of 2015, more than 400 responses were collected.

2.2.2.Stakeholder consultative workshops

Members of the Water JPI’s advisory board, experts in water RDI and other stakeholders representing water utilities, scientific committees and water policy associations – to cite just a few examples – were invited to give their feedback on the contents of the SRIA and to prioritise RDI needs in two consultative workshops. The first one took place in Lyon (France) in April 2014. The second one was held in Orléans (France) in October 2015.

During the first consultative workshop, participants prioritised RDI needs on the basis of their importance and urgency – as was done in the first public consultation. As a result, RDI needs were categorised as short-, medium- and long-term priorities.

However, a different set of criteria was used for the second consultative workshop, namely (i) contribution to safeguarding water resources and aquatic ecosystems;

(ii) contribution to improving the well-being of our society (e.g. public health); and

(iii) contribution to generating growth and jobs (the main objective of the Innovation Union Strategy of the EU). The use of these criteria seemed to be more appropriate, as it allowed more specific information to be obtained on how RDI action on each need could help achieve specific objectives at the socio-economic, policy and environmental levels.

Results from the public and workshop consultations are given in Annex IV.

The SRIA 2.0 document, along with public consultations, workshops proceedings and advice from the advisory boards will help the Water JPI governing board to draw up a new Implementation Plan.

3. An Integrated Vision for Water Research, Development and Innovation Challenges

Theme 1	Improving Ecosystem Sustainability and Human Well-being
Theme 2	Developing Safe Water Systems for Citizens
Theme 3	Promoting Competitiveness in the Water Industry
Theme 4	Implementing a Water-wise Bio-based Economy
Theme 5	Closing the Water Cycle Gap Improving Sustainable Water Resources Management

3. An Integrated Vision for Water Research, Development and Innovation Challenges

The Water JPI's SRIA identifies and sets out integrated regional, European and global water RDI priorities, which could be implemented by the Water JPI (as detailed in its Implementation Plan) but also by other EU funding mechanisms, such as Horizon 2020, LIFE and Article 185.

Water issues addressed in the SRIA encompass water as defined in the WFD.

As indicated in the Water JPI's Vision Document (20 April 2011)[17] the Water JPI requires a multidisciplinary approach, as economic, ecological and societal challengess are to be addressed (Figure 3).

Figure 3 Drivers and multidisciplinary challenges to be addressed (from the Water JPI's Vision Document, 2011, page 4).

[17] Available at: http://www.waterjpi.eu/images/documents/Vision_Document.pdf

Based upon this view, the 2011 Vision Document identified five main themes, constituting the core of the SRIA:

1- Maintaining Ecosystem Sustainability;

2- Developing Safe Water Systems for Citizens;

3- Promoting Competitiveness in the Water Industry;

4- Implementing a Water-wise Bio-based Economy; and

5- Closing the Water Cycle Gap.

The five themes have been divided into 11 RDI subthemes, and this structure has been discussed and agreed by the Water JPI partners through the iterative process of the SRIA. In this latest version of the SRIA (version 2.0, 2016), the five themes have been further elaborated and are divided into 11 RDI subthemes:

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

Each theme represents a specific aspect of the Water JPI's grand challenges for which multi- and interdisciplinary research and innovation actions are required. Themes are therefore challenge driven. The expected social, economic, technological, environmental and policy impacts of recommended RDI actions are outlined.

Themes are divided into subthemes. For each of these, specific RDI needs and related objectives have been identified. Some of the RDI objectives proposed here are linked to other RDI needs and objectives, as RDI activities and outputs from the latter may be of interest to the former. Those linkages are indicated when relevant.

Although the branched structure gives an effective insight into the main RDI needs in each of the five themes, it is essential to maintain an integrated perspective (holistic view).

The global and European contexts are marked by greater changes over time and emerging needs in terms of energy, raw materials (including water), products and services, when the local, landscape scale is compared with that of the planet. Society needs a holistic vision and integrated management to adapt to those needs and new challenges. This integrated management requires an understanding of the processes and mechanisms inherent in these complex systems. Meeting this challenge requires developing an understanding both of the processes behind the changes and of their impact on local or regional resources, societies and human activities. It will also require social innovations, policies and technologies to avoid or reduce the impacts, compensate or rehabilitate environments and adapt to new constraints and opportunities.

Thus, the SRIA 2.0 has been simultaneously structured both by the five theme pillars and by cross-cutting issues. This "two-dimensional" structure helps the reader to follow the state of the art in each theme without ignoring the challenge of integrating the five themes that is, integrating the complex interactions between ecosystems and socio-economic systems and among environment, customs, practices and actors. RDI actions can then contribute to the adaptation and/or greater resilience of socio-ecosystems to changes.

Such an integrated vision is illustrated in Table 3, which shows to what extent a number of key water-related issues are addressed in each of the five themes of the SRIA. A number of these issues (e.g. energy, climate and global change) are distributed across all five themes.

Table 3 Horizontal RDI needs across the Water JPI's SRIA themes

	Theme 1 Improving Ecosystem Sustainability and Human Well-being	Theme 2 Developing Safe Water Systems for Citizens	Theme 3 Promoting Competitive-ness in the Water Indus-try	Theme 4 Implementing a Water-wise-Bio-based Economy	Theme 5 Closing the Water Cycle Gap
Ecosystems' ecological status, resilience, services and restoration	+++	+	+	+	++
Pollutants: risks and remediation	+	+++	++	++	+
Water and energy	+	+	+++	+	++
Water and agricul-ture	+	+	+	+++	++
Water and citizens	+	++	+	+	+++
Water and climate	++	++	+	+	++
Water data (monitoring, citizen participative sciences)	++	++	++	++	+++
Sensors, technologies and smart systems	++	++	+++	++	++
Governance and accept-ance Removing barriers (legislation, funding schemes, governance, acceptance)	+	+	+++	++	+++
Developing new tools combining in situ and re-mote sensing data: models	+	+	+	+++	+++
Integration of water policies in the EU	++	++	++	++	++

Notes:

- Data collected based on (i) developing new tools, combining in situ and remote sensing data, and (ii) citizen participative sciences for data collection concerning all five themes with two main objectives. These are (i) to feed simulation models and interpret model results, and (ii) to upskill citizens to improve the quality of data provided by lay persons. These needs have to be linked to education programmes and also to research on how to integrate various sources of data with different detection and sensitivity levels.

- Some RDI needs related to specific territories (Mediterranean, Baltic, Danube) are included in Theme 5 (Closing the Water Cycle Gap), but these needs are regional and not at the same level as other needs.

The five RDI themes are described below:

1- Improving Ecosystem Sustainability and Human Well-being;

2- Developing Safe Water Systems for Citizens;

3- Promoting Competitiveness in the Water Industry;

4- Implementing a Water-wise Bio-based Economy; and

5- Closing the Water Cycle Gap – Improving Sustainable Water Resources Management.

Theme 1

Improving Ecosystem Sustainability and Human Well-being

Tackling European Water Challenges

Theme 1. Improving Ecosystem Sustainability and Human Well-being

The overall goal is to maintain the essential functions, processes and services of water bodies and associated ecosystems over the long term through integrated and interdisciplinary RDI actions.

Rationale

Healthy water ecosystems have important environmental functions such as the purification of water, the provision of habitats for wildlife or the attenuation of floods. From a more social perspective, healthy water bodies and ecosystems provide a safe supply of water for human consumption and opportunities for recreational activities. However, increasing water demand in many regions, the overexploitation of water resources for various uses, pollution, sea-water intrusion, structural works and climate change inducing short- to long-term variations in water availability (including extreme events) have increased the stress on European water bodies and associated ecosystems.

Further efforts to manage water resources and RDI actions are currently needed to ensure the protection and/or restoration of water bodies and ecosystems while meeting the socio-economic, political and cultural needs of current and future generations.

The core purpose of the WFD is the long-term protection of the aquatic environment. Article 4.1 defines the general objective of the WFD of achieving good status of water bodies by 2015, and it introduces the principle of preventing any further deterioration in status. Research on ecosystem sustainability will also support a relatively wide range of national, European and international policy initiatives, including the EU Biodiversity Strategy and the Habitats Directive (Directive 92/43/EEC)and the Floods Directive.

Research will also provide a better understanding of the role of biodiversity in maintaining the strength and sustainability of aquatic ecosystems. From an operational point of view, functional indicators will be developed to better understand the condition and ecological dynamics of water bodies and to aid their conservation and rehabilitation. As such, innovative applications of ecological engineering can help to restore water resources, biodiversity and aquatic environments (e.g. wetland restoration or hydromorphological sediment management, restoration of ecological continuity, reintroducing emblematic species).

This theme is broken down into three subthemes:

- 1.1.- Developing approaches for assessing and optimising the value of ecosystem services;
- 1.2.- Integrated approaches: developing and applying ecological engineering and ecohydrology;
- 1.3.- Managing the effects of hydro-climatic extreme events.

The research needs and objectives for each subtheme of Theme 1 are detailed below. It is worth noting that the cross-cutting RDI needs identified in Table 3 are also integral and of relevance to this theme.

Expected theme impacts

Impact	Description
Social	Contribute to safeguarding natural resources for future generations. Research on aquatic and riparian ecosystem sustainability will contribute to identifying, proposing and prioritising measures to help societies adapt and react to current and future pressures. Better protection of public health and the environment from effects of extreme weather events
Economic	Address market failures (integration of externalities in policy-making), considering that preservation costs are lower than restoration costs Monetary and non-monetary methods of valuation will contribute to better decision- and policy-making processes as well as economic impacts
Technological	Increased availability and usefulness of data and decision-making products for extreme weather events Development of new tools in ecological engineering and early warning systems (EWSs), including sensors, web services, numerical codes and ecological restoration technology
Environmental	Better assessment and evaluation of ecosystem service approaches. Better understanding of hydromorphological processes. Achieving sustainable resource use. Improved water management and availability of good water quality in the case of extreme weather events
Policy	Research on ecosystem sustainability will support a relatively wide range of national, European and international policy initiatives including the WFD, the Floods Directive and the EU Biodiversity Strategy (COM(2011) 244 final), particularly Target 2: 'By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems.' By monitoring and predicting adverse effects, an EWS gives time to allow policy-makers to take appropriate measures

Subtheme 1.1. Developing approaches for assessing and optimising the value of ecosystem services

Rationale

The key to sustainable development is to achieve a balance between the exploitation of natural resources for socio-economic development and conserving ecosystem services that are critical to human well-being and livelihoods[18].

Ecosystem services are defined as the benefits people obtain from nature (Falkenmark et al., 2007[19]). Ecosystem services have been proposed as useful tools for decision-making, and monetary valuation methodologies have been developed to permit the monetary valuation of non-marketable issues in the decision-making process. Thus, ecosystem services are a promising concept to support the implementation of the WFD (regarding disproportionate costs, cost recovery and incentive pricing) and the Millennium Development Goals (MDGs).

However, the use of ecosystem services in water decision-making is still rather limited. This is largely because most ecosystem services are difficult to measure and assess, and therefore so is their contribution to socio-economic well-being.

[18] Falkenmark, M., Finlayson, M., Gordon, L.J., Bennett, E.M., Chiuta, T.M., Coates, D., Ghosh, N., Gopalakrishnan, M., de Groot, R.S., Jacks, G., Kendy, E., Oyebande, L., Moore, M., Peterson, G.D., Portuguez, J.M., Seesink, K., Tharme, R. and Wasson, R. (2007). Agriculture, water, and ecosystems: avoiding the costs of going too far. In: Molden, D. (ed.), Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture, Earthscan, London, UK, and International Water Management Institute, Colombo, Sri Lanka, pp. 233–277.

In this context, the development of approaches for assessing and optimising ecosystem services is here identified as a strategic orientation in water RDI. Overall, a better understanding of and approach to the assessment of ecosystem services relies on research on the ecological functioning of aquatic and riparian ecosystems.

Currently identified needs and related objectives

1.1.1. Developing approaches for assessing the ecological functioning of ecosystems

- o Understanding and quantifying the ecological functioning of ecosystems.
- o Developing an ecosystem services multi-scale approach based on this better understanding and quantification of the ecological functioning of ecosystems.
- o Developing indicators and other monitoring schemes regarding the good functioning of aquatic ecosystems in support of the WFD, the Floods Directive and international policies/strategies (e.g. MDGs). Developing the next generation of monitoring schemes and indicators of the good functioning of aquatic and riparian ecosystems. Developing new bio-assessment tools and validation methodologies.
- o Understanding the role of biodiversity as a driver of ecosystem resilience.
- o Assessing the role of aquatic ecosystems in the global biogeochemical cycle.
- o Developing mechanistic models for the forecasting and evaluation of changes in ecosystems in response to water management measures.

1.1.2. Developing and testing methodologies for the valuation of ecosystems services (link with 5.2.2)

- o Developing and applying harmonised databases and new methodologies for assessing and mapping the social, economic and environmental value of water ecosystem services.
- o Evaluating methodologies for the valuation and monitoring of ecosystem services and for predicting the impacts of water management measures on ecosystem functioning through full-scale test cases.

1.1.3. Establishing multiple pressure–impact–response relationships in aquatic, riparian and groundwater-dependent ecosystems

- o Developing a better understanding of the effects of hydromorphological pressures (damming, embankment, channelling, non-natural water-level fluctuations) on the structure and functioning of aquatic and riparian ecosystems (link with 1.2.1).
- o Quantifying the effects of pollution on biological communities. In this regard, it is necessary to further analyse the links between ecotoxicological tools and biological assessment tools based upon the structure of biological communities.
- o Assessing the vulnerability of ecosystems to pressure factors.
- o Supporting experimental research (e.g. microcosms) to quantify multiple impacts on ecosystems.
- o Understanding the resilience of ecosystems to multiple pressures.

[19] The Millennium Ecosystem Assessment Synthesis Report (2005). Available at: http://millenniumassessment.org/en/index.html

- o Assessing risks related to multiple pressures on ecosystems and developing innovative risk management approaches.
- o Improving knowledge of the direct and indirect effects of climate change and climate change adaptation strategies.

1.1.4. Integrating ecosystem services into management of water resources

- o Developing meta-ecosystem services by overcoming the existing fragmentation of responsibilities and the dispersion of knowledge between disciplines.
- o Developing innovative water management schemes.
- o Developing a better understanding of the barriers to policy application and implementation in terms of ecosystem services.
- o Adopting an ecosystem services approach to the roles of agriculture, forestry and aquaculture to allow for careful planning in the use of water resources while addressing the needs of local users. A comprehensive monetary and social evaluation of all secondary services provided by all agents is required.

1.1.5. Adapting and integrating our water/ecosystem management, planning and governance systems with better environmental data and information (link with 5.2.3)

- o Aligning the monitoring and reporting frameworks through ecosystem approaches.
- o Developing new integrated systems for in situ and remote sensing data collection seamlessly coupled with mechanistic modelling that is open to stakeholders' and citizens' involvement in data collection and water management processes.

Subtheme 1.2. Integrated approaches: developing and applying ecological engineering and ecohydrology

Rationale

Other than the ecosystem services approach, new approaches have emerged with the objective of safeguarding and restoring degraded water bodies and associated ecosystems. Among others, the following are particularly relevant for the Water JPI:

1. Ecological engineering. Ecological engineering has been defined as the application of the principles of engineering and the life sciences (i.e. reliance on the self-designing capacity of ecosystems, conservation of non-renewable energy sources and conservation of biological resources) to the design of sustainable ecosystems integrating human society with its natural environment for the benefit of both (Mitsch and Jørgensen, 2004[20]). The applications of ecological engineering range from the microscopic to river basins and beyond.

Potential applications of ecological engineering in rural landscapes may include wetland treatment, as well as hydromorphological restoration or sediment management. At the urban level, potential applications of ecological engineering can be found by combining the expertise of landscape architects, urban planners and specialists in urban storm water management.

[20]Mitsch, W.J. and Jørgensen, S.E. (2003). Ecological engineering: a field whose time has come. Ecological Engineering Journal 20, 363–77.

2. Ecohydrology. Ecohydrology is a discipline aimed at providing a better understanding of the effects of hydrological processes on biotic processes, and vice versa, in freshwater and coastal zone ecosystems from the molecular to the river basin scale (Zalewski, 2002[21]; Hannah et al., 2004[22]). The ultimate goal of ecohydrology research is to enhance the carrying capacity of ecosystems while ensuring water quality, biodiversity, ecosystem services and ecosystem resilience.

Potential applications of ecohydrology in rural areas include the construction of biogeochemically reactive barriers in land–water ecotones and in pollution hot-spots (Bednarek et al., 2010[23]; Izydorczyk et al., 2013[24]) in order to intensify the degradation of nutrients and, therefore, protect water ecosystems. In urban areas, blue–green networks of surface waters and ecosystems could be used to deliver clear benefits to society such as reducing pluvial flooding, reducing urban heat island effects and improving air quality (Zalewski, 2012).

3. Nature-based solutions. Within the framework of the European Framework Programme Horizon 2020, nature-based solutions have appeared as a promising approach to restoring ecosystems. Nature-based solutions are actions that use the features and complex system processes of nature in order to achieve desired outcomes[25]. They are therefore inspired by, supported by or copied from nature. Nature-based solutions are ideally energy and resource efficient and resilient to change. They must be adapted to local conditions.

Potential applications include the re-vegetation of riverbanks, the restoration of riparian vegetation to assist in the reconnection of rivers and the restoration of meanders in rivers.

4. Green infrastructure. This can be broadly defined as a strategically planned spatial structure providing benefits from nature to people[26]. Green infrastructure is meant to deliver valuable ecosystem goods and services. It allows, among other benefits, the provision of clean water, the removal of pollutants and the retention of flood waters.

Currently identified needs and related objectives

1.2.1. Restoring morphology continuity and hydraulic connectivity

- o Developing hydromorphology options to understand the processes and dynamics of sediment transport, hydraulic connectivity, flow regimes and fish migration within river systems (link with 1.1.3).
- o Overcoming difficulties (in particular resilience and stability) in assessing ecological status in temporary streams.
- o Understanding the processes and dynamics of sediment transport, hydraulic connectivity, flow regimes and fish migration within river systems (link with 1.1.3).

[21]Zalewski, M. (2002). Ecohydrology – the use of ecological and hydrological processes for sustainable management of water resources. Hydrological Sciences Journal 47, 823–832.

[22]Hannah, D.M., Wood, P.J. and Sadler, J.P. (2004). Ecohydrology and hydroecology: a new paradigm? Hydrological Processes 18, 3439–3445.

[23]Bednarek, A., Stolarska, M., Ubraniak, M. and Zalewski, M. (2010). Application of permeable reactive barriers for reduction of nitrogen load in the agricultural areas – preliminary results. Ecohydrology and Hydrobiology 10, 355–362.

[24]Izydorczyk, K., Frątczak, W., Drobniewska, A., Cichowicz, E., Michalak-Hejduk, D., Gross, R. and Zalewski, M. (2013). A biogeochemical barrier to enhance a buffer zone for reducing diffuse phosphorus pollution – preliminary results. Ecohydrology and Hydrobiology 13, 104–112.

[25]European Commission, Directorate General for Research and Innovation (2015). Towards an EU Research and Innovation Policy Agenda for Nature-based Solutions and Re-naturing Cities. Final report of the Horizon 2020 Expert Group on 'nature-based solutions and re-naturing cities'. Available at: https://ec.europa.eu/research/environment/pdf/renaturing/nbs.pdf

[26]European Commission (2013). Building a Green Infrastructure for Europe. Available at: http://ec.europa.eu/environment/nature/ecosystems/docs/green_infrastructure_broc.pdf

- o Developing methodologies to assess the impacts of restoring good hydromorphological status through, inter alia, reconnecting aquatic systems. Understanding the underlying remobilisation, phase transfer, availability and transport of contaminants in sediments, particularly under extreme conditions.
- o Studying the linkage between the terrestrial parts of a catchment and the aquatic ecosystem, including wetlands and peatlands.
- o Analysing the linkage between upstream and downstream areas, the role and functional importance of floodplain/lateral connectivity and channel dynamics, and the interaction between groundwater and the hyporheic zone (e.g. analysing hydrochemical and microbial dynamics along flow lines – surface water and groundwater).
- o Improving knowledge of the quantity and quality of matter flowing across the various reactive zones between soil–plant systems and the different water bodies (vadose zone, capillary fringe, hyporheic zone and coastal zone).

1.2.2. Managing the risks caused by invasive species and options for remediation

- o Understanding the impacts of alien species on river balance, notably on water quality (dilution capacity, nutrient cycles and chemistry of the biomass).
- o Developing techniques for the long-term removal of alien species and for the restoration of infested river bed material (gravel, pebbles) with minimum impact on river ecology.

1.2.3. Understanding and managing ecological flows

- o Quantifying ecological flows in order to enable the good functioning of ecosystems while ensuring the availability of water for different uses. Estimating ecological (or environmental) flows for different habitats for fauna and flora.
- o Improving the theoretical background to quantify the effects of different flow regimes on ecosystems using hydraulic, hydrological and ecological data and models.

1.2.4. Integrated eco-technological solutions for the remediation and mitigation of degraded water bodies and aquatic ecosystems

- o Developing systems-based approaches – including socio-economic aspects – for the identification of existing or innovative cost-effective measures to restore or design sustainable ecosystems.
- o New green infrastructure, nature-based solutions and ecological engineering methods for cleaning up lakes, streams, inner waters, etc.
- o Understanding the techniques and approaches, including modelling tools, that can be efficiently used to maintain and improve the ecological potential of heavily modified water bodies, that is, those defined as being subject to several concurrent pressure factors.

Subtheme 1.3. Managing the effects of hydro-climatic extreme events

Rationale

Water bodies and associated ecosystems are under threat from a variety of pressure factors including pollution, water abstraction and hydromorphological changes. Furthermore, global climate change is likely to increase the pressure on water bodies and associated ecosystems through the greater incidence of hydro-climatic extreme events (droughts and floods).

In order to improve the presentation to stakeholders and policy-makers of information on the interaction between hydro-climatic events and multiple pressures on ecosystems, the further development and use of integrated systems and forecasting tools must be encouraged. Integrated systems for collecting, analysing, interpreting and communicating data can be used to make decisions early enough to protect public health and the environment from the effects of extreme weather events and to avoid raising concern among and to minimise inconvenience to the population. The primary objectives of forecasting tools (including EWSs) are to improve anticipation of catastrophic events (floods, droughts) and to minimise the impacts on human lives, natural ecosystems, cultural heritage and food cycles.

Currently identified needs and related objectives

1.3.1. Understanding the causes of drought/scarcity, predicting drought events and water scarcity and developing adaptation measures

- o Diagnosing the causes of water scarcity in Europe, and forecasting the incidence of drought events under climate change scenarios. Studies at the regional scale will be favoured.
- o Developing management strategies focusing on cost–benefit analyses of agricultural evapotranspiration versus water conservation for alternative hydrological uses.

1.3.2. Developing innovative (or improved) tools for adaptation to hydro-climatic extreme events, especially floods (link with 2.2.1)

- o Developing innovative tools (such as EWSs) for adaptation to extreme events, including sensor technology and monitoring networks.
- o Improving EWSs for the forecasting of flooding and the assessment of associated risks.
- o Implementing trans-national strategies on flood event management and recovery (for trans-boundary catchments).

1.3.3. Improving water management to mitigate the harmful impacts of extreme events (extreme weather events, impaired water quality) (link with 2.2.1)

- o Diagnosing droughts, floods and impaired water quality as a result of climate change. Developing people-centred monitoring and EWSs, including both expert and local knowledge. Relevant questions include: Is local knowledge concerning hazards and impacts reliable enough? What are the main limitations of local knowledge regarding natural phenomena? How can we overcome these limitations? How can we improve the integration of local and scientific knowledge? How can we deal with the different time and spatial scales?
- o Setting up risk management strategies taking into account socio-economic needs, environmental dynamics/risks and land use in areas vulnerable to droughts and floods. Key stakeholders should be involved in setting up such strategies.
- o Maximising the reliability of projections of precipitation on various spatial scales and timescales.
- o Improving the historical database of past events to establish the risk of future events in response to the effects of climate change.
- o Improving the short- to medium-term forecasting of extreme events.

- o Preparing strategies for improving the handling of extreme weather events through the collection and analysis of post-disaster data (including practices/measures).
- o Developing integrated modelling across surface water and groundwater, coastal and fluvial systems, hydrological and meteorology, water and sediment transport.
- o Improving existing hydrodynamic models, coupled with the development of a monitoring scheme adapted for aquifers, in order to improve the quantitative management of the resource.
- o Assessing the role of aquatic systems in nutrient and carbon fluxes and other global bio-chemical cycles in response to climate change and extreme events.

Water JPI

Theme 2

Developing Safe Water Systems for the Citizens

Tackling European Water Challenges

Theme 2. Developing Safe Water Systems for Citizens

The main goal of RDI actions under this theme is to protect Europeans' health through the provision of safe water. Attention is paid in particular to (i) the impacts of emerging pollutants, and (ii) natural hazards and water infrastructures on water and human health.

Rationale

Millions of Europeans receive high-quality drinking water every day. However, the 2010 World Health Organization report Health and Environment in Europe: Progress Assessment concluded that "unsafe water remains a burden to public health throughout the European Region, in particular in many countries in the East". The provision of safe water for drinking purposes is threatened by, among other factors, the improper disposal of chemicals, animal and human wastes and pesticides, emerging pollutants and emerging risks from "established" pollutants, an ageing water supply infrastructure, sub-optimal water management and natural hazards.

Policy measures have been taken in Europe in order to address these and other threats (i.e. the Urban Waste Water Directive, the WFD, the Floods Directive, the EU Water Scarcity and Droughts Strategy (COM(2007) 0414 final), the Drinking Water Directive and the Bathing Water Directive). In order to achieve the appropriate implementation of all these policies and protect the health of Europeans, the Water JPI proposes that further RDI actions be undertaken in the areas of emerging pollutants, water infrastructure and natural hazards.

Key knowledge gaps remain around the environmental behaviour of emerging pollutants and their impacts on human health.

Water distribution and storage facilities may be old and their performance far from optimum. Scientific and technological attention needs to be paid to innovative practices for minimising the risks associated with water distribution and storage facilities.

Moreover, with more frequent, higher intensity storms and droughts projected as a result of global climate change, water utilities and local authorities face the need to update water supply and sanitation systems while making them more resilient to natural hazards.

This theme is then organised around two subthemes:

2.1. Emerging pollutants and emerging risks of established pollutants: assessing their effects on nature and humans and their behaviour and opportunities for their treatment;

2.2. Minimising risks associated with water infrastructures and natural hazards.

The research needs and objectives for each subtheme of Theme 2 are detailed below. It is worth noting that the cross-cutting RDI needs identified in Table 3 are also integral and of relevance to this theme.

Expected theme impacts

Impact	Description
Social	This theme faces the social water challenges directly, as it addresses the protection of human life, health and assets. The international profile of the topic contributes to alleviating water challenges inside and outside Europe, where most of the global population increasingly lives in urban areas
Economic	As an indicator of the relevance of managing urban water systems, the World Business Council for Sustainable Development estimated that nations in the Organisation for Economic Co-operation and Development need to invest at least USD 200 billion per year for water supply and sanitation, including the replacement of ageing water infrastructures to guarantee supply, reduce leakage rates and protect water quality
Technological	This theme needs technological innovation in terms of chemical/physical and biological tools and EWSs to detect and prevent natural, chemical and biological risks and to enhance the resilience of urban water systems
Environmental	Emerging pollutants and accidents related to water infrastructure status or management result in relevant environmental concerns. Floods have similar effects, as in storm water retention ponds or water treatment plants. Reducing the impact of emerging pollutants on water bodies
Policy	Understanding the fate and behaviour of emerging pollutants in water bodies and improving the performance and resilience to floods of the urban network will support the implementation and refinement of specific policies. While a number of European policies gravitate around this theme, it is important to recall the numerous national and local policies both in Europe and in other countries targeted for the deployment of these technologies (WFD, the Water Blueprint, the Floods Directive and national policies).

Subtheme 2.1. Emerging pollutants and emerging risks of established pollutants: assessing their effects on nature and humans and their behaviour and opportunities for their treatment

Rationale

Emerging pollutants, also known as pollutants of emerging concern, are defined as "chemicals that are not commonly monitored but have the potential to enter the environment and cause adverse ecological and human health effects"[28]. Emerging pollutants include polar compounds, pharmaceuticals, personal care products, perfluorinated and organosilicon compounds, endocrine disruptors, disinfection by-products (DBPs), antibiotic-resistant bacteria and viruses, cyanotoxins, microplastics and nanomaterials. These emerging pollutants are commonly derived from municipal, agricultural and industrial wastewater sources. In addition to these emerging pollutants, "established" pollutants may be considered as factors contributing to emerging risks (e.g. endocrine disruption). There are many gaps in our knowledge regarding their behaviour in the environment over the long term (in water, soil, air, living organisms) and their long-term impact on the health and lives of ecosystems and citizens, especially as the contaminants are present in mixtures, usually poorly understood and representing an unknown danger. It is imperative to develop tools for monitoring and risk prediction, but also innovative treatment of these contaminants in the water, as soon as possible.

[28] Geissen, V., Mol, H., Klumpp, E., Umlauf, G., Nadal, M., van der Ploeg, M., van de Zee, S. and Ritsema, C.J. (2015). Emerging pollutants in the environment: a challenge for water resource management. International Soil and Water Conservation Research 3, 57–65.

In some cases, an emerging pollutant may have been released into the environment for a long time but it has not been possible to detect it earlier with existing techniques. In other cases, emerging pollutants may have resulted from changes in the use and disposal of existing and readily detected chemicals.

Future RDI should contribute to filling current knowledge gaps regarding the environmental behaviour of pollutants and their effects on human health, the development of innovative rapid analysis and detection systems, opportunities for water treatment, impacts of wastewater reuse on human health, and social behaviour around emerging pollutants and new water management practices.

Currently identified needs and related objectives

2.1.1. Developing analytical techniques for groups of substances

- Improving techniques and methodologies for the sampling, detection, quantification and monitoring of emerging substances, pathogens, resistant microorganisms and DBPs, their metabolites and degradation products in different compartments of the environment. The development of real-time, warning systems and online technologies is of special interest.
- Developing new approaches to analyse the combined effects of chemicals (i.e. chemical mixtures), integrative bio-assessment tools and new biomarkers and bioassays.
- Setting up a long-term strategy aimed at developing analytical approaches that could be deployed in situ for challenging measurements.

2.1.2. Understanding and predicting the environmental behaviour and effects of by-products, pollutants and pathogens, including their environmental effects

- Assessing the different potential sources of pollutants with a view to emission control at local and regional levels.
- Understanding and predicting the environmental behaviour of pollutants in surface water, sediments, soil and groundwater. Modelling transport, growth and degradation of emerging pollutants and pathogens. Assessing the transfer time of different pollutants, as well as understanding the processes during transfer within the various compartments.
- Expanding our knowledge base on antibiotic resistance in aquatic environments: developing comparable and validated data sets on the prevalence and spread of major bacteria in the aquatic environment, with clinically and epidemiologically relevant antimicrobial resistance, and endocrine disruptive criteria in Europe.
- Developing integrated risk assessment procedures, including the effect of long-term exposure, for antibiotics and other emerging pollutants acting at sub-lethal levels.
- Understanding the factors that control the bioavailability and fate of emerging pollutants in organisms.
- Characterising the effects of emerging pollutants and their metabolites on human health and on ecosystems.
- Assessing both the occurrence and the toxicity of regulated and emerging DBPs.
- Understanding the processes involved in the degradation of emerging pollutants within the sub-surface – soil and unsaturated – zone and degradation/transformation products.

2.1.3. Remediation of pollutants: developing strategies to reduce pollutants (DBPs, emerging pollutants, pathogens, including their environmental effect)

- o Developing a better understanding of the extent to which emerging pollutants are removed or modified by water treatment plants/natural processes in soil and water.
- o Assessing and implementing management measures and technologies to reduce the impact of emerging pollutants and pathogens on water quality. Particular focus should be given to wastewater and sludge reuse.
- o Developing strategies to reduce emerging pollutants at source (e.g. airports, golf courses, rail tracks, highways, hotels, pharmaceutical sources, farms, non-point sources).
- o Improving technologies for the specific removal of natural organic matter from surface water so as to avoid the formation of DBPs during the chemical disinfection process (with chlorine, chloramine, and ozone) (link with 3.1.2).
- o Rehabilitation of degraded water zones (surface and groundwater).
- o Developing biotechnological tools for the detection, monitoring, prevention and removal of pollution from soil and water.
- o Developing suitable indicator sets of established parameters to be measured at plants to confirm the effectiveness of treatment under various weather conditions.
- o Improving environmental models to determine the patterns and extent of natural dispersion of sewage, agricultural effluents and industrial waste.
- o Establishing protocols to standardise tests and methods for assessing the removal of antibiotic resistance.
- o Evaluating and comparing the performance of technologies for the remediation of pollutants. For the sake of that evaluation and comparison, the same experimental conditions, in respect of their capacity to remove micropollutants, antibiotic resistance and toxicity should be used.

Subtheme 2.2. Minimising risks associated with water infrastructures and natural hazards

Rationale

Protecting the capacity of water networks to deliver water to citizens with target quality standards is a major goal for both European and non-European countries. The water infrastructure concentrates large public investments, guarantees the right to access to water and represents a very important niche for multinational European companies of all sizes. Research can protect citizens, investments and businesses by supporting innovative management and decision-making.

Global changes, most notably climate change, and natural hazards could challenge the ability of water infrastructures – drinking water, wastewater and storm-water utilities – to provide safe water. Flooding may cause the rupture of drinking water and sewage pipelines through the accumulation of excessive volumes of water. Furthermore, many flood defences are reaching their capacity due to increasing sea levels. On the contrary, prolonged drought periods can cause a decline in water quality and water supply. The water infrastructure is particularly vulnerable when subject to multiple stresses.

Needless to say, it is in this context that the water sector needs to respond to extreme weather events, sea level rise, temperature changes and changes in the patterns of precipitation through the development and implementation of innovative practices.

Currently identified needs and related objectives

2.2.1. Progressing towards flood-proof cities (from small settlements to large suburban areas) (link with 1.3.2, 1.3.3, 3.1.1, 5.2.1)

- o Developing and setting up technological (e.g. a smart city approach to integrating sensors and EWSs) and integrated systems for the prediction and risk management of urban floods (overflows in advanced wastewater treatment facilities, urban hydrology, surrounding river flow, hydrodynamics, internet of things, drainage design, social sciences and climate change analysis).
- o Design of new green infrastructure, nature-based solutions and ecological engineering methods to avoid or mitigate flood damage.

2.2.2. Improving the performance of water systems

- o Developing methodologies and technologies for the effective monitoring and control of urban water networks and storm water systems.
- o Enhancing the resilience of urban water systems (i.e. pipeline networks, drinking-water reservoirs, pumping stations and large water treatment plants).
- o Improving the efficient use of state-of-the-art monitoring and control systems.
- o Developing decision-support systems (DSSs) for long-term rehabilitation decisions based on the evolution over time of system conditions.
- o Improving data management routines (link with 3.1.1).
- o Sustainable water management in and around urban areas – enhancing water services through efficient water management.
- o Strengthening interaction between settlement development and water infrastructure planning (link with 3.1.3).
- o Developing technologies for the monitoring of water losses and water consumption, including the localisation and repair of leaks in live systems.
- o Developing solutions for decentralised treatment and water management (wastewater and storm water).
- o Promoting the sustainable use of storm waters and groundwater and drainage in cities. Promoting innovative separation and extraction technology pilot projects in industrial zones to harvest resources from wastewater and reused water. Projects must take into account current and emerging global changes and local infrastructure needs.

2.2.3. Assessing the impact of water scarcity on safe drinking water (link with 5.2.1)

- o Developing and setting up technological and managerial solutions to droughts.
- o Producing integrated systems for the prediction and risk management of water scarcity.
- o Developing smart innovations to tackle water scarcity in the city.

Water JPI

Theme 3

Promoting Competitiveness in the Water Industry

Tackling European Water Challenges

Theme 3. Promoting Competitiveness in the Water Industry

The Water JPI's joint actions under this theme will aim at developing products and services that promote the competitiveness of the European water industry, thereby contributing to fuelling the European economy.

Rationale

The world water market has an estimated size of EUR 234,000 million, and Europe is currently leading it with a combination of large multinational companies and technology-rich SMEs[29]. The European water sector is of prime economic importance as it offers jobs for hundreds of thousands of citizens. Thus, according to the Strategic Research Agenda of the WssTP[30] the European water sector has an annual turnover of EUR 72,000 million, sustains 600,000 jobs, manages a network of 5.7 million kilometres and operates 70,000 wastewater plants.

The Water JPI is committed to prioritising and funding problem-solving RDI leading to the development of market-oriented solutions in Europe and beyond. Investments in water technology around the world increase every year in a market that has become very competitive. The European water industry can benefit from this market by developing customised solutions for site-specific problems.

The Water JPI will seek cooperation with stakeholders at all levels to ensure that research results are swiftly transformed into business opportunities. Innovation will be particularly promoted in this theme, taking advantage of the capabilities and know-how of specialised innovation agencies that are partners in the Water JPI. Activities will focus on aspects such as new materials and processes, management tools, ICT (information and communications technology) and energy efficiency.

Technological innovations are crucial in enhancing the competitiveness of the water industry. Nonetheless, and because the implementation and validation of knowledge are often impaired by the existence of strict policy regulations and governance issues, the Water JPI is fully engaged in the identification and implementation of innovative governance solutions, as well as in removing existing barriers to the marketing of innovative products and services. RDI actions will also focus on social aspects, individual and collective perceptions, public acceptance and users' appropriation. The Water JPI will favour the transfer of solutions identified in case studies to other sectors and areas of Europe and the world.

This theme is broken down into two subthemes:

3.1. Developing market-oriented solutions for the water industry;

3.2. Enhancing the regulatory framework.

The research needs and objectives for each subtheme of Theme 3 are detailed below. It is worth noting that the cross-cutting RDI needs identified Table 3 are also integral and of relevance to this theme.

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[29]Small and medium-sized enterprises.

[30]Water Supply and Sanitation Technology Platform (2006). Strategic Research Agenda. Available at: ftp://ftp.cordis.europa.eu/pub/etp/docs/wsstp_en.pdf

Expected theme impacts

Impact	Description
Social	Smart water technologies will contribute to societal well-being through better human health as a result of better water quality. More water resources will be available for societal uses, particularly in areas of low-quality water, water scarcity and drought vulnerability. Society's acceptance of reused waste will improve significantly
Economic	Bring about major business opportunities inside and outside Europe, laying the foundations for sustained economic growth and industrial leadership. RDI activities will contribute to sustaining the competitive advantage of Europe, reducing innovation time to market. The water–energy nexus will be entirely understood and savings made in energy costs
Technological	More reused wastewater will be available for agricultural and industrial uses; groundwater storage will increase. The current European leadership in water treatment for urban and industrial purposes will be upheld
Environmental	Water technology will contribute to improving the status of water bodies in quantitative and qualitative terms. Natural resources will be used in a more efficient way
Policy	A number of European and national policies will be streamlined to support market uptake of water innovations. Water policies (e.g. WFD, Water Blueprint) will be indirectly supported by RDI activities on this theme

Subtheme 3.1. Developing market-oriented solutions for the water industry

Rationale

The Water JPI is committed to developing solutions aimed at ensuring water provision in situations of water stress and achieving sustainable use of water while contributing to enhancing the competitiveness of the European water sector. With this aim in mind, the Water JPI will support the development of innovative and cost-effective technologies, processes and services with potential application in Europe and beyond in the areas of:

1. **Water distribution and measurement**. There is room for improvement in the performance of water conveyance networks in Europe and worldwide, the monitoring of water losses and the development of flow meters adapted to different accuracy requirements and water quality standards. Telemetry and remote control are commonly used in these types of applications, but standardisation and interoperability remain an issue.

2. **Overall solutions for water treatment and reuse.** Potential applications of reclaimed water include agricultural and landscape irrigation, groundwater recharge, industry and, in specific areas, potable use. More efforts are needed in technology, but also in supporting measures, for example those leading to societal acceptance. Reclaimed water is an alternative source of water in areas affected by population growth, agricultural and forest production and climate change.

3. **Water desalination.** Desalination is currently challenged by the installation and energy costs and by environmental issues such as brine management. The Water JPI will address both issues in order to make desalination more environmentally viable and economically feasible.

4. **Validation of wastewater sewage/sludge and desalination brine** through the recovery of energy (converting organic matter into biogas using sludge digestion) and raw ma-

terials.

Public acceptance and perceptions of water quality and environmental safety standards and regulations will be taken into account in the development and deployment of solutions.

Currently identified needs and related objectives

3.1.1. Developing smart water technologies (sensor networks and real-time information systems in water distribution and wastewater networks) (link with 2.2.1, 2.2.2)

- o Developing innovative, easily maintained, affordable (micro- and nano-) sensors and detection systems, remote control systems, data networks, intelligent methods and DSSs to manage (monitor and control) water distribution and wastewater networks. Standardisation and interoperability will support competitiveness and defend consumers' interests.
- o Developing algorithms and software tools for modelling and simulating water acquisition and control systems.

3.1.2. Delivering technological solutions for water and wastewater treatment

- o Developing innovative membrane systems, including their support materials, for water and wastewater treatment.
- o Developing innovative, safe, efficient and low-cost advanced processes for water treatment and assessment. Research should respond to the demand for decentralised water and wastewater in European regions, especially in rural areas. Scaling up of sanitation technology solutions in local areas should be ensured. Advanced processes for water treatment and assessment should be able to treat micro-pollutants in wastewater.
- o Assessing the robustness of biological water treatment processes and boosting the shift from conventional water treatment plants to biological water treatment plants.
- o Understanding how natural organic matter behaves during advanced treatment processes (link with 2.1.3).
- o Performing life-cycle assessments of treatment technologies to identify strategies aimed at increasing the efficiency of the water treatment process (e.g. reduction in the amount of inputs, low energy consumption, smaller footprints).
- o Optimising water and wastewater treatment systems through holistic modelling and simulation approaches.
- o Developing opportunities for the analysis of hybrid systems (i.e. systems combining conventional treatment processes and membrane filtration) combining several degradation/removal mechanisms in different compartments.
- o Enhancing the efficiency of wastewater treatment plants (in terms of energy efficiency, zero emissions) through the conception and validation of new processes (link with 3.1.4).
- o Developing water treatment processes taking into account the principles of biomimetics (nature-based solutions) and ecosystem services.
- o Plant-wide modelling, optimisation and control of new water treatment systems.

3.1.3. Promoting innovative approaches to asset management

- o Managing water assets in a context of sustainability. Setting up objectives, criteria and metrics to analyse the current situation and need for development.

- o Developing methodologies for assessing current and expected impacts of climate and global changes on infrastructures and on customers' expectations. Technological and social science approaches will be considered (link with 2.2.2).
- o Developing innovative procedures and fair economic systems to analyse and disseminate costs and benefits related to the improvement of water efficiency.
- o Developing diagnostic tools to improve the assessment of the need for and/or potential to renovate an infrastructure. Diagnostic tools should be based on an iterative approach (e.g. serious games) to test possible alternatives.
- o Transferring and promoting concepts and methodologies into practice. Developing smarter and more efficient approaches.
- o Strengthening the interaction between settlement development and infrastructure planning.
- o Addressing pricing and the contradiction between fixed costs and declining water consumption.

3.1.4. Supporting the energy–water nexus (namely on efficiency and sustainability)

- o Improving the understanding of the water–energy nexus, in particular developing a better awareness of the role of water in energy production.
- o Assessing energy use in the whole water cycle in different environments.
- o Joint planning of water management and energy production.
- o Reducing energy consumption and recovering energy from water taking a watershed perspective.
- o Maximising renewable energy use and production from wastewater processes through innovative technologies, including the management of thermal energy and heat recovery from sewage.
- o Developing low-energy and high-efficiency technologies and processes. Focus should be put on the use of renewable energy, for example osmotic power generation.
- o Developing innovative, efficient and cost-effective technologies to recover energy from wastewater.
- o Developing wastewater anaerobic processes for temperate and cooler climates and/or low-chemical oxygen demand wastewater.
- o Implementing new applications such as solar thermal energy for disinfection, water treatment, water desalination, etc.
- o Reducing the energy footprint of water management.
- o Understanding the influence of climate change on the water–energy nexus.
- o Developing emerging technologies for water-based renewable energies.
- o Developing district heating and desalination from nuclear cogeneration as a way of solving freshwater shortages.

3.1.5. Mitigating the impact of obtaining energy from the ground and the sea

- o Predicting and preventing environmental impacts linked to the exploitation of fracking and shale gas, sand oil (and oil recovery). Developing treatment processes for the water used for shale gas extraction.

3.1.6. Mitigating the impact of obtaining water from the ground and the sea (link with 4.2.3)

- o Improving the allocation of groundwater for different uses according to its quality and quantity (e.g. drinking water, energy extraction, agriculture). Methodologies for the assessment of groundwater quality and quantity are needed.
- o Predicting and preventing environmental impacts linked to desalination.

3.1.7. Developing and demonstrating water reuse and recycling concepts; recovering products and energy from treatment plants (link with 4.2.3)

- o Improving technologies and setting up demonstrators for the reuse of wastewater for agricultural and aquaculture and for water management purposes (i.e. artificial aquifer recharge). Supporting innovative separation and extraction technology pilot projects in industrial zones to harvest resources from wastewater and reused water.
- o Reusing wastewater for different purposes according to its quality, based on risk, safety and health perspectives.
- o Developing and evaluating innovative and sustainable decentralised treatment systems allowing the reuse of storm water and grey water as well as energy recovery from black water.
- o Developing safe, affordable and sustainable processes for the production of drinking water from wastewater.
- o Developing mobile water-cleaning systems for the production of drinking water.
- o Developing harmonised and established standards for water reuse in irrigation throughout Europe and worldwide.
- o Developing biofuels from algae: technologies for water recycling, especially wastewater and eutrophic water bodies.
- o Developing the concept of treatment plants as producers of valuable resources (such as nutrients (phosphate), energy, sludge, bioplastics and heavy metals (from brines)) through sustainable processes.
- o Developing holistic approaches to control aimed at optimising water quality, energy and resource recovery (link with 3.1.2 and 1.1.4).
- o Generating technologies aimed at reducing gas emissions in treatment plants (and their associated odours and toxicity). Developing new, eco-friendly materials; supporting the sustainable management of urban waste and recycling of raw materials to produce energy and to recover nutrients from waste and biomass.
- o Removing barriers to the commercialisation of the products obtained.
- o Combining energy and nutrient recovery (such as combustion/gasification of sewage sludge in combination with phosphorus recycling).

Subtheme 3.2. Enhancing the regulatory framework

Rationale

The world water market is estimated to reach EUR 1 trillion by 2020[31]. The unlocking of innovations in the water sector could contribute to job creation and competitiveness. Nonetheless, innovative water solutions often fail to reach their full economic potential. Among other factors, limited access to appropriate forms of finance can be a constraint on water-related innovations. New frameworks aimed at protecting the economic value of European innovations, as well as improving the anticipation of the needs for regulation and adaptation are requested in order to minimise existing risks when developing or adapting new technologies in the water sector.

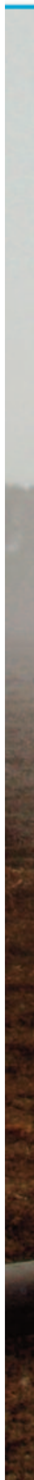
There is also a need to explore new frameworks in the fields of education and governance regarding innovations (risk vs reward) in order to remove existing bottlenecks.

Currently identified needs and related objectives

3.2.1. Removing barriers to innovation

- o Exploring regulatory, governance, education (i.e. technical vocational education and training or TVET) and management conditions that contribute to removing barriers to innovation and to strengthening the competitiveness of European industries.
- o Exploring approaches to closing the gap (reducing the time) between the initial demonstration of research-related innovations and their first appearance on the market.
- o Developing indicators measuring the social value of innovations in the water sector.
- o Developing management models for new technological solutions to support sustainable operations, maintenance and market uptake.
- o Favouring knowledge transfer from other scientific fields regarding key lessons in the marketing and commercialisation of products. Supporting the transfer of relevant results from other scientific fields for their application in the water RDI domain.
- o Understanding the requirements driving society's adoption and acceptance of innovations by integrating technical and social science and humanities research and innovation, by involving stakeholders at the appropriate levels and scales of participation and by enabling large-scale socio-technical experimentation.
- o Identifying opportunities for the creation of new financial mechanisms for an innovative water sector.

[31] Joint Research Centre (2014). Water Reuse in Europe – Relevant guidelines, Needs for and Barriers to Innovation. Available at: http://publications.jrc.ec.europa.eu/repository/handle/JRC92582



Water JPI

Theme 4

Implementing a Water-Wise Bio-Based Economy

Tackling European Water Challenges

Theme 4. Implementing a Water-wise Bio-based Economy

The emergence of the bio-economy in Europe is expected to increase pressure on natural resources. The overall goals of RDI actions are (i) to encourage the sustainable use of water resources, and (ii) to safeguard water resources by reducing and limiting pollution.

Rationale

The bio-economy refers to an economy based on the use of renewable resources from land and sea and the conversion of these resources and waste streams into value-added products such as food, feed, bio-based products and bioenergy[32]. The bio-economy has been proposed as a radically new economic approach in response to the need to cope with an increasing global population and the depletion of natural resources.

One of the most likely effects of the bio-economy is the intensification of agriculture, forestry and aquaculture. Pressure on natural and artificial resources (water, land and agrochemicals) is expected to increase, and more efficient agroforestry systems will be needed. The full deployment of the bio-economy will surely pose numerous RDI, environmental and socio-economic challenges, but it will also open up new market opportunities for European society. The bio-economy will also contribute to the creation of jobs in the fields of agriculture, forestry and aquaculture. The annual turnover of the bio-economy is around EUR 2 trillion and it employs around 22 million people. Last but not least, the further use of renewable natural resources is expected to reduce Europe's dependence on fossil fuels.

The implementation of the bio-economy constitutes one of the EU's top policy priorities. A strategy on the bio-economy was launched by the European Commission in 2012[33], and it is one of the RDI pillars of the Horizon 2020 Framework Programme. The budget for Horizon 2020's calls on the bio-economy will serve to increase the adoption of the bio-economy on the European scale and to drive forward economic growth. Thus, as stated by the European Commission, it is estimated that each euro invested in EU-funded bio-economy research and innovation will trigger EUR 10 of added value in bio-economy sectors by 2025[35].

In the Water JPI, agricultural water use is analysed from the point of view of natural resources and not as a production factor.

This theme is organised around two subthemes:

4.1. Improving the efficiency of water use for a sustainable bio-economy sector;

4.2. Reducing soil and water pollution.

The research needs and objectives for each subtheme of Theme 4 are detailed below. It is worth noting that the cross-cutting RDI needs identified in the Table 3 are also integral and of relevance to this theme.

[33]Available at: http://ec.europa.eu/research/bioeconomy/pdf/201202_1297_memo.pdf

[34]Available at: http://ec.europa.eu/research/bioeconomy/pdf/official-strategy_en.pdf

[35]Available at: http://ec.europa.eu/research/bioeconomy/index.cfm?pg=home

Expected theme impacts

Impact	Description
Social	Society will benefit from more environmentally friendly farming operations, which will ensure compatibility between current land use activities and the envisaged deployment of the bio-based economy. Water abstraction and consumption will not limit other societal uses of water
Economic	The productivity of agriculture, forestry and aquaculture will increase if appropriate measures (aimed at reducing soil and water pollution and at enhancing resource efficiency) are taken. In 2016, the European bio-economy (standard and innovative applications) is already worth more than EUR 2 trillion annually and employs over 22 million people. The implementation of a water-wise bio-based economy will create more employment opportunities and wealth
Technological	Development of new agricultural and forest practices – and blue biotechnology in aquaculture
Environmental	Better use and protection of European natural resources, substantiated in the protection of water levels in aquifers and lakes and discharge to streams. Additionally, environmental water quality will improve as a result of actions targeting farming and forest pollution
Policy	This theme supports: (i) the Bioeconomy Strategy (SWD(2012) 11 final), released by the European Commission in 2012; (ii) the Water Blueprint; (iii) the priority recommendations from the lead market initiative for bio-based products; (iv) the Common Agricultural Policy (CAP), including the Rural Development Programmes funded by the European Forum on Agricultural Research for Development; (v) the EIP Agriculture and the Rural Development Programmes stemming from the CAP; and (vi) a wide variety of national policies targeting water quality and the agriculture and forestry sectors

Subtheme 4.1. Improving the efficiency of water use for a sustainable bio-economy sectorF

Rationale

Resource efficiency represents one of the main challenges of our society. A resource-efficient economy aims to meet the needs of a growing population while minimising impacts on the environment. The purpose of resource efficiency is therefore to create more with less and to deliver greater value with less input.

Resource efficiency approaches applied to water are particularly needed within the European agricultural and forestry sectors, currently challenged by the development of the bio-based economy, food security and climate change. These sectors account for the majority of global freshwater withdrawals, and they are responsible for the vast majority of societal water consumption in Europe.

Resource efficiency is required in both rain-fed and irrigated systems. Even small improvements in water productivity can result in substantial water savings.

At the policy level, resource efficiency constitutes one of the flagship initiatives of the Europe 2020 Strategy, the EU's growth strategy for a 'smart, inclusive and sustainable economy'[35]. Research is needed in a variety of disciplines, including agronomy, forestry, plant breeding and irrigation science – to cite a few.

[35]European Commission (2014). Country-specific recommendations 2014. Available at: http://ec.europa.eu/europe2020/index_en.htm

Currently identified needs and related objectives

4.1.1. Implementing efficient water use systems and practices for the European and overseas markets

- o Developing, testing and evaluating innovative and efficient irrigation systems and practices combining crop water requirements, crop physiology, ground-based sensors, imagery satellite, ICT and expert systems. Resource efficiency will be extended to the use of energy and agrochemicals (i.e. fertigation). Systems will be developed for different development environments to ease access to a variety of markets.

4.1.2. Developing integrated water-conserving farming and forestry practices and varieties

- o Developing techniques to improve water management on farm and outside the farm gate.
- o Designing water-efficient, cost-effective farming/forestry techniques and technologies supporting water conservation and efficiency (link with 4.1.4).
- o Assessing more water-efficient and/or salt-tolerant crops and forestry species and varieties.
- o Evaluating the application of organic materials, the activity of bio-fertilisers such as bacteria and mycorrhizae and other amendments to improve soil properties related to water.
- o Developing technologies and management tools to achieve greater agricultural productivity while minimising the land surface and water used.

4.1.3. Setting up water valuation schemes for agriculture and forestry (link with 5.2.2 and 1.1.2)

- o Establishing new criteria for valuing water in agriculture and forestry.
- o Developing appropriate tools for assessing linked environmental resource costs (i.e. costs without externalities: the values of soils and surface- and groundwater bodies) used in agriculture, aquaculture and forestry.

4.1.4. Progressing towards future-proof agricultural water use

- o Analysing the effect of future climatic conditions and water availability on agriculture and forestry through the use of experimentation and integrated models.
- o Designing future agriculture and forestry systems, including land management, under different climate change conditions and availability of water resources (link with 4.1.2).

4.1.5. Ensuring the efficient use of water resources in the bio-economy sector

- o Developing solutions for a sustainable and competitive agro-food industry through the more efficient use of water resources.
- o Enhancing the efficiency of water use and sustainability in the production of biomass-based fuels. Research should focus on the development of science-based, rational and transparent criteria, indicators and methodologies.

Subtheme 4.2. Reducing soil and water pollution

Rationale

Efforts to reduce farming-induced soil and water pollution have not yet removed farming as the major cause of poor soil and water quality in certain parts of Europe. Along with sewage treatment plants and industrial discharges, farming activities represent the most important sources of pollution in Europe (EEA, 2008[36]).

With regard to agricultural, forestry and aquacultural water pollution, nutrients from fertilisers (mainly nitrogen and phosphorus), pesticides and their transformation products, pathogenic microorganisms excreted by livestock and organic pollution from manure are regularly detected in water bodies at levels sufficiently high to affect aquatic and riparian ecosystems.

This subtheme will feed crop technology and bio-economy policies with site-specific research oriented towards the sustainable intensification of farming and land use activities.

Currently identified needs and related objectives

4.2.1. Developing sustainable production systems

- o Developing monitoring schemes and indicators, assessment methods and management tools to identify, quantify and minimise sources for pollution from agriculture, aquaculture and forestry, as well as to assess impacts of pollution.
- o Reducing diffuse and point source pollution caused by agrochemicals, mineral fertilisers and manure. This will require the development of cost-effective, easily accessible and adaptive technologies, including (among others) manure separation and treatment and energy recovery technology, irrigation, precision farming, regulated drainage and an adapted management of buffer strips.
- o Preventing water-related soil degradation, including salinity, erosion, structural degradation, compaction and oxidation of organic soils, among others.
- o Developing production systems and practices for aquaculture to minimise water pollution and bio-hazards, thus maintaining economically viable production.
- o Developing new, integrative simulation models for soil, water and crop management providing agrochemical dynamics in soil and water to build effective tools for decision-making on natural resources and policy support (link with 4.1.2).

4.2.2. Designing measures underpinning water and land-use policies (link with 4.1.3 and 4.1.4)

- o Developing methodologies to define appropriate monitoring scales and locations for policy development/assessment.
- o Developing new tools combining in situ and remote sensing data collection and simulation models and allowing stakeholders and citizens to contribute to data collection and interpretation of model results (this needs to be linked to a programme of education and up-skilling of citizens in order to raise the quality of data provided by lay persons) – (link with 5.2.3).

[36]European Commission (2014). Country-specific recommendations 2014. Available at: http://ec.europa.eu/europe2020/index_en.htm

- o Comparing combinations of context-specific, cost-effective, acceptable measures to reduce water pollution from agriculture and forestry in various climatic and pedological conditions.
- o Delineating specific policy target areas and designing measures, as well as monitoring their effectiveness.

4.2.3. Promoting reuse of water in irrigated agriculture and forestry (link with subtheme 5.2)

- o Understanding, managing and communicating the potential reuse of water in agriculture and forestry.
- o Harmonising and establishing standards on water reuse in irrigated agriculture and forestry throughout Europe (link with 3.1.6).
- o Assessing social perceptions, costs, water quality and technical and safety bottlenecks.

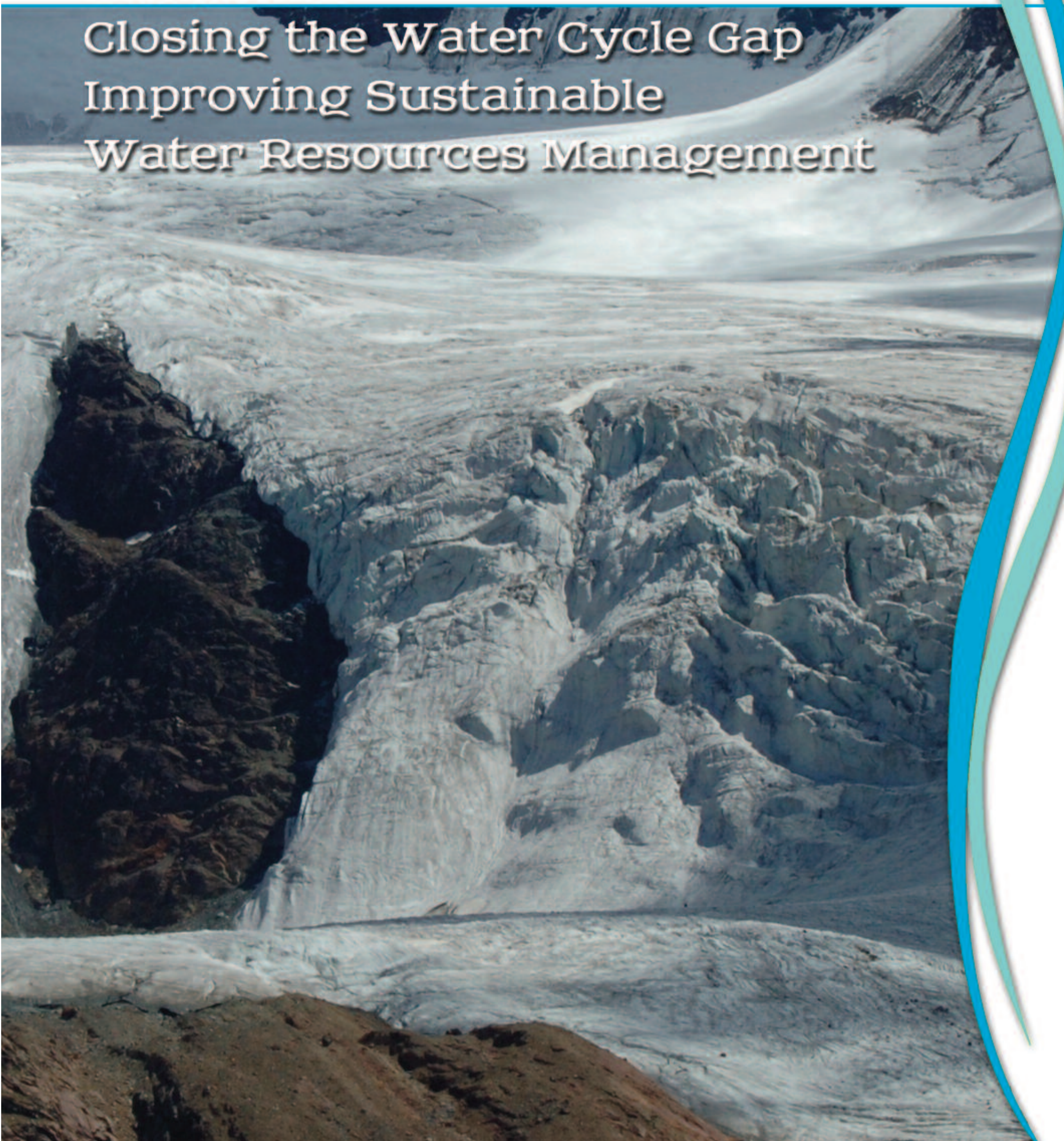
4.2.4. Providing good-quality water resources in support of the European bio-economy

- o Developing and implementing strategies to improve and maintain the good quality of water resources in order to ensure safe food production.

Water JPI

Theme 5

Closing the Water Cycle Gap
Improving Sustainable Water Resources Management



Tackling European Water Challenges

Theme 5. Closing the Water Cycle Gap – Improving Sustainable Water Resources Management

In many regions of Europe, it may be difficult to reconcile water supply and demand in both quantitative and qualitative terms. The aim of RDI actions under this theme is therefore to bridge the gap in “supply–demand” by enabling the sustainable management of water resources. Innovative strategies and approaches will be developed where appropriate.

Rationale

Europe is not an arid continent, but water scarcity has become a concern for millions of people. Water scarcity affects at least 11% of the European population and 17% of the territory[37].

In quantitative terms, the availability of water for different uses is threatened by increasing episodes of drought. According to data provided by the European Commission, droughts since 1980 have cost the European economy about EUR 100 billion. Leakages in the water supply infrastructure, the considerable exploitation of freshwater for agricultural purposes and the lack of appropriate water-saving technologies will increase pressure on limited water resources in many regions. To make matters worse, water consumption for public, industrial and agricultural use is expected to increase by 16% by 2030[38]. Although southern regions are more severely affected, central and northern regions are also affected by droughts.

In qualitative terms, water pollution from nutrients, organic matter, heavy metals and other chemical by-products poses a serious threat to water availability. Despite the efforts of local authorities to curb water pollution, the concentration of nutrients and heavy metals is high in many watersheds.

In response to this situation, legislative measures have been put in place by the European Commission (WFD, Water Blueprint, Water Scarcity and Droughts Strategy). Experience shows that the enforcement of some of the measures and recommendations put forward by these policies is not an easy task (i.e. the case of water pricing in products). Legislative measures need to be coupled with the implementation of measures for appropriate water management, and this is where RDI actions can play a crucial role. As detailed below, there is a need for new integrated concepts relating to water reuse, energy, recovery of valuable substances, etc. Observation and modelling of water resources will be required to improve understanding of hydrological processes and to analyse and forecast the effect of management measures. Socio-economic approaches are also necessary to investigate questions of participation, behaviour and the costs and benefits of proposed measures.

This research will need to articulate knowledge of ecology, social sciences, economics, geography, environmental sciences, geosciences and technology in various space–time dimensions and on different scales and by integrating water policy with other public policies (agricultural, industrial, domestic, urban, regional planning, transport, energy, biodiversity). In the context of increasing tensions around water, tools for monitoring, forecasting, providing information and decision-making are needed to anticipate and manage such tensions and avoid conflict.

[37,38] European Commission Directorate-General for the Environment (2010). Water Scarcity and Drought in the European Union. Available at: http://ec.europa.eu/environment/water/quantity/pdf/brochure.pdf

This theme is broken down into two subthemes:

5.1. Enabling sustainable management of water resources;

5.2. Strengthening socio-economic approaches to water management.

The research needs and objectives for each subtheme of Theme 5 are detailed below. It is worth noting that the cross-cutting RDI needs identified in Table 3 are also integral and of relevance to this theme.

Expected theme impacts

Impact	Description
Social	The diversity of pressures and impacts on water bodies suggests that water policy can be effective only if it is implemented in a close "horizontal" dialogue with stakeholders interested in clean water and healthy water ecosystems. The impacts of water crises are not equally distributed in society, and they can be a source of conflict between different water users. Improved water management will alleviate societal tensions
Economic	Economic instruments such as taxes and subsidies can act as incentives for prudent water management. They constitute a vital complement to water regulation, and they can assist in allocating water between competing user demands. Mitigation measures and short-term solutions to overcome water scarcity (e.g. water transfers) will be included in the assessment of costs related to scarcity or drought and the assessment of economic vulnerability of users and assets
Technological	Improvement of the techniques for managing of water resources (aquifer recharge, DSSs, inter alia) with interoperability of databases, sensors and combined socio-economic and physical water models
Environmental	Both water quantity and water quality are key factors in aquatic and riparian ecosystems. A decrease in available water resources jeopardises environmental flows as a minimum requirement for a healthy ecosystem. Other impacts include the loss of biodiversity and the degradation of landscape quality
Policy	Regulatory measures are essential tools to ensure compliance with environmental standards for water quality and quantity. Economic policy instruments contribute to supporting these regulations, as expressed in the 2012 EU Water Blueprint. Understanding the mechanisms leading to improved water management will lead to better policy design and adaptation

Subtheme 5.1. Enabling sustainable management of water resources

Rationale

Enabling sustainable water management is a prerequisite for achieving water systems fit for a sustainable economy in Europe and abroad. From an RDI perspective, this requires improving our understanding of integrated water management through further analysis involving surface water, groundwater and soil management, erosion and pollution control, flood management and wastewater.

The integrated models of the entire water cycle, including all compartments (surface soil, groundwater) and water use (vegetation, humans), have yet to take into account scenarios of water demand and predict the impact of global change (including climate). This work must be based on observation processes, experimentation and models, including the development of new measuring instruments (e.g. sensors, geo-information systems) that are reliable and cost-efficient. Information is needed to define regional scales, close to territories that must take management or adaptation decisions and evaluate the consequences of certain choices. Links between pressures and water resources need to be established to elucidate specific connections among water resources, pressures and uses, and to establish the most appropriate adaptation strategies. Finally, the application of innovative concepts – such as managed aquifer recharge (MAR), soil–aquifer treatment or natural water retention measures (NWRMs) – or solutions developed locally needs to be further explored. In particular, there is a need to improve the assessment and quantification of their effectiveness.

Currently identified needs and related objectives

5.1.1. Promoting water RDI infrastructures for a better understanding of hydrological processes on different scales

o Supporting the establishment of a European research infrastructure combining: (i) physical infrastructures (e.g. experimental catchments or field labs); and (ii) big data, databases, exchange platforms (with long-term records).

o Specific needs regarding physical infrastructures:

- Establishing a network of experimental catchments and field labs in order to allow, among other benefits, the benchmarking of emerging analytical/sensing technologies and the validation of performance against standardised methods/equipment.
- A suitable test basis for new integrated hydrological models that take into account mass and energy balances.
- A suitable test basis for new sensors for precipitation, surface and subsurface water stores.
- Improving remote observation systems for coastal ecosystems.

o Specific needs regarding data, big data, databases, platforms:

- Improving monitoring and data capture.
- Establishing comprehensive, easily accessible and interoperable databases.
- Improving access to data and the assessment of uncertainties related to climate change mitigation, climate adaptation strategies and the monitoring of the global water cycle.
- Gaining data for certain variables (e.g. extreme events, soil moisture, evaporation, surface wind speed, precipitable water over land, short-term heavy rainfall, amount/intensity and frequency of global precipitation, water quality).
- Improving the free and open distribution of hydrological data.

Article 185 of the Treaty on the Functioning of the European Union (TFEU) [ex Article 169 of the Treaty establishing the European Community (TEC)] enables the EU to participate in research programmes undertaken jointly by several member states, including participation in the structures created for the execution of national programmes.

- o Advancing the development of theories and tools for the upscaling of water flow (run-off and groundwater), reactive transport and ecosystems to the relevant scale in order to facilitate policy implementation and assist scientists worldwide.

5.1.2. Promoting adaptive water management for global change

- o Assessing the impacts and risks of extreme weather events and global change on the water cycle and uses.
- o Developing and testing improved plans and methodologies for adaptive water management in relation to global change.
- o Development of indicators of spatial vulnerability to global change.
- o Developing indicators to monitor adaptation strategies.
- o Developing, deepening and testing practical methods (e.g. water footprint) to assess the overall success of different water management schemes.

5.1.3. Implementing MAR and other NWRMs

- o Developing MAR projects for the joint management of surface water, groundwater and recycled water resources to stretch limited water supplies, in order to protect, prolong, sustain and augment groundwater supplies. These would be based on the international state of the art, and the aim would be to set up demonstrators in various hydrogeological settings, considering surface and reclaimed water (treated and/or not), and developing economic and ecotechnological operations and adequate monitoring of water transfer within the unsaturated zone to assess the efficiency of the operations and provide data for risk assessment.
- o Implementing NWRMs in a multidisciplinary way, including integrated analysis of environmental policies at the local scale and testing their efficiency in urban and rural areas, and providing quantified data, with robust and long-term monitoring. Systematic monitoring of NWRMs will bring additional knowledge on their effectiveness and on the multiple benefits they deliver. Performing more robust assessments of NWRMs that capture the various ecosystem services delivered, comparing, in particular, ecological engineering and grey engineering solutions or their best combinations.
- o multi-functional measures that aim to protect water resources and address water-

5.1.4. Innovating on practical, low-cost technologies treating wastewater to produce resources that are safe for reuse (link with 3.1.6, 3.1.7 and subtheme 5.2)

- o Removing emerging contaminants on a large scale during wastewater treatment.
- o Developing integrated approaches combining technological solutions with social acceptability.

5.1.5. Mitigating water stress in coastal zones

- o Developing a systemic approach to comprehensive coastal zone management based on monitoring and modelling. Integrating the different uses on coastal zones to prevent degradation of water quality and quantity. Demonstrating the feasibility of aquifer storage and recovery by using various sources of water. Evaluating inter-seasonal freshwater storage possibilities in existing aquifers.
- o Developing novel geophysical and hydrogeophysical models for the characterisation of

water bodies on a finer scale. Models will include water supply and demand scenario builders and DSSs.

- o Monitoring and dynamic modelling of artificial recharge and natural infiltration.
- o Establishing management plans for the prevention of pollution in coastal and inland waters.
- o Measuring coastal and inland water quality.
- o Evaluating the effect of measures to deal with salt intrusion, eutrophication and land use change.
- o Achieving better coordination between the WFD and the Marine Strategy Framework Directive. To this end, a better understanding of sources and impacts of nutrient emissions discharged from the land to the sea will be required.

5.1.6. Securing freshwater in the Mediterranean and Baltic basins (Article 185)

- o Developing a systemic approach to studying, managing and protecting Mediterranean and Baltic catchments. There is a need to improve current knowledge on hydrological, hydrogeological and biogeochemical processes (water and nutrient flows and transfer of contaminants) and socio-economical drivers and responses. The balance between fresh and brackish water in coastal areas will also be targeted.
- o Specific needs for the Mediterranean catchment: assessing available water resources, developing scenario analyses (50–100 years) regarding the availability of water, and developing sustainable integrated management approaches covering landscapes and natural resources.
- o Specific needs for the Baltic catchment: developing new concepts for zoning different land uses such as urban, agriculture, forest and wetlands based on integrated modelling and long-term projections of land cover change as a way of improving our understanding of the flow of nutrients in the catchment.

5.1.7. Securing freshwater in the Danube (Danube Knowledge Cluster, Article 185)

- o Developing a systemic approach to protect water resources through an integrated approach to the management of water resources.
- o Managing sediment balance in the Danube river basin.
- o Investigating the occurrence of invasive alien species and developing type-specific methods for the evaluation of WFD elements of biological quality.
- o Planning and designing measures on downstream fish migration.
- o Developing a better understanding of the sources and occurrence of mercury in fish.

Subtheme 5.2. Strengthening socio-economic approaches to water management

Rationale

In the context of tensions around water use, it is essential to develop and support interdisciplinary and integrated research into a global understanding of a system as complex as a socio-hydro-ecosystem. Social, economic and governance systems need to find innovative solutions to achieving sustainable management, improving the balance between water demand and availability. These approaches need to bring together different stakeholders – users and water authorities – on different scales – local, regional, national and international – to provide platforms for fruitful discussion. These platforms are conceived to identify problems, to facilitate dialogue and to identify alternatives that can be taken into account in decision-making. This process of horizontal and vertical integration of stakeholders will be effective only if stakeholders have access to high-quality scientific and technical information on which to base their discussions. Efforts should therefore be made to educate society at large about the latest scientific knowledge on water resources and about the social processes for disseminating information and decision-making. Research is needed to develop support systems that facilitate the exchange of information between scientists and different stakeholders, users and water authorities in order to foster the integration of scientific knowledge in decision-making. The knowledge base on water users' behaviour and water economics needs to be expanded. Practical applications include the willingness of consumers to use alternative water sources (such as recycled water for agricultural or forest purposes or for artificial recharge) and water governance – particularly regarding frameworks, instruments, pricing policies and integrated models.

Currently identified needs and related objectives

5.2.1. Integrating economic and social analyses into decision-making processes

- o Improving baseline economic information and communication tools and methodologies for local decision-makers.
- o Developing resilience and adapting to hydro-climatic extremes (droughts and floods); developing risk-based decision-making and planning tools including social sciences, economics, effective communication and conflict resolution (links with 2.2.1 and 2.2.3).
- o Understanding the effectiveness of current economic instruments, such as pricing policies and related policy instruments (e.g. subsidies), in order to promote sustainable water management and a circular and green economy.
- o Developing incentives for efficient water use.
- o Providing insight on the transaction costs resulting from the implementation of the WFD measures (cost-effective analysis of measures, assessing the disproportionality of costs to justify exemptions, water pricing and assessing the cost recovery level of water services, as well as the contradiction between fixed costs and declining water consumption).
- o Promoting integrated management of water resources and water rights in the development of sustainable water management plans.
- o Fostering trans-boundary cooperation on sound legal and institutional arrangements.

5.2.2. Connecting socio-economic and ecological issues

- o Developing methodologies for valuation of and payment for ecosystem services, including tangible and intangible services (link with 1.1.2).
- o Examining the impacts on water resources of the main types of consumption in Europe.

5.2.3. Promoting new governance and knowledge management approaches

- o Developing new approaches and tools for water management aimed at setting up innovative alternatives suitable for decision-making. These approaches should be ideally based on (i) the broad participation of stakeholders; (ii) multidisciplinary research; and (iii) the development of scenarios to support decision-making in the short and long term.
- o Developing new water management approaches enabling stakeholders and citizens to carry out their own supplementary monitoring of water resources. Such approaches should allow stakeholders to assess how the information they provide is integrated by local authorities (link with 4.2.2).
- o Envisaging education and communication initiatives, including e-learning, to raise social awareness of consumption habits and water scarcity (technical and behavioural approaches, including knowledge of the water cycle). Educational schemes should be expanded to include the use of water-monitoring techniques and the interpretation of environmental data.
- o Increasing the levels of social acceptance and use of recycled water.

Cross-cutting priorities

The following RDI needs and objectives relate to two or more themes (intra-theme links have not been listed in the table below):

Theme(s)	Priorities
1 and 5	Valuation of ecosystems services (1.1.2 and 5.2.2)
1 and 5	Adapting and integrating our water/ecosystem management, planning and governance systems with better environmental data and information (1.1.5 and 5.2.3)
1 and 2	Risks of extreme events: data, tools, information, management (1.3.2, 1.3.3, 2.2.1, 5.2.1)
2 and 3	Remediation of pollutants (2.1.3 and 3.1.2)
2 and 3	Smart water technologies (2.2.1, 2.2.2, 3.1.1, 3.1.3)
3, 4 and 5	Water reuse (3.1.6, 3.1.7, 4.2.3, 5.1.4, subtheme 5.2)
1, 4 and 5	Water and agriculture (1.1.2, 4.1.4, 4.1.3, 4.1.4, 5.2.2)
1, 2 and 5	Integrating economic and social analyses into decision-making processes (subthemes 1.1, 2.2, 5.2)
4 and 5	Enabling stakeholders and citizens to contribute to data collection and interpretation (4.2.2 and 5.2.3)

4. Next Steps

Future Joint Activities and the Way Forward for the Strategic Research and Innovation Agenda, Version 3.0

4. Next Steps: Future Joint Activities and the Way Forward for the Strategic Research and Innovation Agenda, Version 3.0

Joint actions, based on the Water JPI SRIA, are already ongoing or planned:

- Theme 1: No joint actions have been carried out on this theme. Future actions are yet to be confirmed.
- Theme 2: A pilot call on emerging pollutants was launched in November 2013 (total budget EUR 9 million; seven projects funded).
- Theme 3: A joint call (cofunded with the European Commission under the ERA-NET Cofund Water Works 2014 – budget EUR 15.2 million) was launched in 2015 (water treatment, reuse, recycling and desalination; water resources management; mitigation of the impacts of extreme events (floods and droughts) at the catchment scale).
- Theme 4: A joint call (cofunded with the EC under the ERA-NET Cofund Water Works 2015 and in collaboration with the FACCE JPI – expected budget EUR 26.1 million) is to be launched in early 2016 (research and innovation to support the implementation of water policies, in particular on sustainable water use in agriculture, in order to increase the efficiency of water use and to reduce soil and water pollution).
- Theme 5: A joint action is planned in the frame of an ERA-NET Cofund as part of the Horizon 2020 Societal Challenge 5 Work Programme for 2017.

The Water JPI's SRIA is a living document that will be periodically reviewed and updated in order to properly integrate emerging RDI needs. A new version, the SRIA 3.0, will be produced within the framework of the ERA-NET Cofund Water Works 2014 and published in 2019.

Future reviews and updates of the Water JPI SRIA will be carried out in a flexible manner, allowing for the updating of specific emerging needs, when and as relevant (see Annex IV). The full review of the SRIA carried out as part of developing version 3.0 will have the following objectives:

- To identify new water RDI needs. Additional strategic documents, coming from other European neighbouring initiatives (e.g. the strategic agenda of PRIMA – Article 185), as well as findings and recommendations for future research arising from EU-funded projects in the area of water, will be reviewed by project partners and the findings will be integrated into SRIA 3.0.

- To build upon the contributions (contents, format, updating procedure, etc.) of the recently re-appointed Water JPI's advisory board members, who will be invited to have input into the updating process and the contents of the SRIA. The template below (see Annex IV) will help to collate their recommendations regarding the inclusion of new water RDI needs. Needless to say, the organisation of stakeholder's consultative workshops, exploratory workshops on dedicated water-related issues and advisory board meetings will offer excellent opportunities to discuss the contents of the agenda.

- To review the current prioritisation of water RDI needs (high/medium/low). The same prioritisation methods could be used so that comparisons between the results obtained for the SRIA 2.0 and the SRIA 3.0 can be easily made.

- To further analyse possible opportunities for collaboration with other JPIs and other neighbouring initiatives, as well as networking with EU water-related projects. If possible, specific collaboration actions (e.g. joint calls or other collaborative activities) will be described.

- As shown in Chapter 3, the SRIA identifies specific water RDI needs, specific objectives (topics) and their priority levels. Following recent recommendations from the Water JPI's advisory boards, the SRIA 3.0 will put more emphasis on the targets to be achieved when carrying out RDI actions for each of the needs listed, so that readers can have a better understanding of the expected impacts, as well as quantifying the progress made towards reaching these targets.
- Finally, the SRIA 3.0 will provide a new view of specific activities and the initial results of the Water JPI in the fields of international cooperation and policy alignment.

Annex I: List of Water Joint Programming Initiative Partners and Observers

JPI Partners

Country	Leading representing institution(s)
AT, Austria	Environment Agency Austria
CY, Cyprus	Research Promotion Foundation (RPF)
DE, Germany	Federal Ministry of Education and Research (BMBF), Jülich Forschungszentrum (Jülich)
DK, Denmark	Innovation Fund Denmark (IFD), Danish Hydraulic Institute (DHI)
EE, Estonia	Ministry for Environment, Tallinn University – Institute of Ecology
ES, Spain, co-chair	Ministry of Economy and Competitiveness (MINECO)
FI, Finland	Academy of Finland (AKA)
FR, France, coordinating country	French National Research Agency (ANR), French Geological Survey (BRGM) and Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture (IRSTEA) members of AllEnvi
IE, Ireland, co-chair	Environmental Protection Agency (EPA)
IL, Israel	Ministry of Energy and Water
IT, Italy, co-chair	Ministry of the Environment, Ministry of Education, University and Research (MIUR), Institute for Environmental Protection and Research (ISPRA)
MD, Moldova	Academy of Sciences of Moldova
NL, the Netherlands	Ministry of Infrastructure and the Environment
NO, Norway	Research Council of Norway (RCN), Norwegian Environment Agency (DN)
PL, Poland	European Regional Centre for Ecohydrology (ERCE)

Country	Leading representing institution(s)
PT, Portugal	Science and Technology Foundation (FCT)
RO, Romania	National Authority for Scientific Research (ANCS)
SE, Sweden	The Swedish Research Council Formas (FORMAS), Swedish Agency for Marine and Water Management (SWAM)
TR, Turkey	The Scientific and Technological Research Council of Turkey (TUBITAK)
UK, United Kingdom	Natural Environment Research Council (NERC)
EC, European Commission	(Non-voting partner)

JPI Observers

Country	Leading Representing Institution(s)
BE, Belgium	Flemish Environment Agency
EL, Greece	National Technical University of Athens
HU, Hungary	National Research, Development and Innovation Office
LV, Latvia	University of Latvia

Annex II: Members of the Water Joint Programming Initiative Advisory Boards

Members of the Scientific and Technological Board

Member	Institution
Dermot DIAMOND	Dublin City Uni mversity, Ireland
Agathe EUZEN	Centre national de la recherche scientifique (CNRS) – Laboratoire Techniques Territoires et Sociétés (LATTS), France
Despo FATTA-KASSINOS, chair	Nireas – International Water Research Centre, Cyprus
Ing-Marie GREN	Swedish University of Agricultural Sciences, Sweden
Jaap KWADIJK	Deltares/University of Twente, the Netherlands
Inmaculada ORTIZ	University of Cantabria, Spain
Jens Christian REFSGAARD	Geological Survey of Denmark and Greenland, Denmark
Seppo REKOLAINEN, co-chair	Finnish Environmental Institute, Finland
Karl-Ulrich RUDOLPH	Institute of Environmental Engineering and Management, University of Witten, Germany
Adrian STANICA	National Institute of Marine Geology and Geoecology – GeoEcoMar, Romania

Members of the Stakeholders Advisory Group

Acronym	Institution
ACQUEAU	The EUREKA Cluster for Water
ARC	Aqua Research Collaboration
CIS	Common Implementation Strategy
EIFAAC-FAO	European Inland Fisheries and Aquaculture Advisory Commission
EIP Water	European Innovation Partnership on Water
EU-INBO	International Network of Basin Organisations
Euraqua, chair	European Network of Freshwater Research Organisations
EurEau	European Federation of National Associations of Water and Wastewater Services
EWA	European Water Association
WssTP, co-chair	Water Supply and Sanitation Technology Platform

Annex III: Synergies Between the Water Joint Programming Initiative and Other Joint Programming Initiatives

Name of the JPI	Relevant Water JPI's subtheme and research needs
JPIAMR	2.1. Emerging pollutants and emerging risks of established pollutants: assessing their effects on nature and humans and their behaviour and opportunities for their treatment RDI needs: *2.1.2. Understanding and predicting the environmental behaviour and effects of by-products, pollutants and pathogens, including their environmental effects*
Climate	1.3. Managing the effects of hydro-climatic extreme events RDI needs: *1.3.1. Understanding the causes of drought/scarcity; predicting drought events and water scarcity and developing adaptation measures* *1.3.2. Developing innovative (or improved) tools for the adaptation to hydro-climatic extreme events, especially floods* *1.3.3. Improving water management to mitigate the harmful impacts of extreme events (extreme weather events, impaired water quality)* 2.2. Minimising risks associated with water infrastructures and natural hazards RDI needs: *2.2.1. Progressing towards flood-proof cities (from small settlements to large suburban areas)* *2.2.3. Assessing the impact of water scarcity on safe drinking water* 3.1. Developing market-oriented solutions for the water industry RDI needs: *3.1.3. Promoting innovative approaches to asset management* 5.2. Strengthening socio-economic approaches to water management RDI needs: *5.2.1. Integrating economic and social analyses into decision-making processes* 4.1. Improving the efficiency of water use for a sustainable bio-economy sector RDI needs: 4.1.4. Progressing towards future-proof agricultural water use 5.1. Enabling sustainable management of water resources RDI needs: 5.1.2. Promoting adaptive water management for global change

Relevant Water JPI's subtheme and research needs	
FACCE	1.1. Developing approaches for assessing and optimising the value of ecosystem services RDI needs: *1.1.1. Developing approaches for assessing the ecological functioning of ecosystems* *1.1.2. Developing and testing methodologies for the valuation of ecosystem services* *1.1.3. Establishing multiple pressure–impact–response relationships in aquatic, riparian and groundwater-dependent ecosystems* *1.1.4. Integrating ecosystem services into water resource management* 3.1. Developing market-oriented solutions for the water industry RDI needs: *3.1.7. Developing and demonstrating water reuse and recycling concepts; recovering products and energy from treatments plants* 4.1. Improving the efficiency of water use for a sustainable bio-economy sector RDI needs: *4.1.1. Implementing efficient water use systems and practices for the European and overseas market* *4.1.2. Developing integrated water-conserving farming and forestry practices and varieties* *4.1.3. Setting up water valuation schemes for agriculture and forestry* *4.1.4. Progressing towards future-proof agricultural water use* 4.2. Reducing soil and water pollution RDI needs: *4.2.1. Developing sustainable production systems* 5.1. Enabling sustainable management of water resources RDI needs: *5.1.2. Promoting adaptive water management for global change*
Urban Europe	3.1. Developing market-oriented solutions for the water industry RDI needs: *3.1.1. Developing smart water technologies (sensor networks and real-time information systems in water distribution and wastewater networks)* *3.1.2. Delivering technological solutions for water and wastewater treatment* *3.1.3. Promoting innovative approaches to asset management* *3.1.4. Supporting the energy–water nexus (namely on efficiency and sustainability)* *3.1.7. Developing and demonstrating water reuse and recycling concepts; recovering products and energy from treatment plants* 3.2. Enhancing the regulatory framework RDI needs: *3.2.1. Removing barriers to innovation* 5.1. Enabling sustainable management of water resources RDI needs: *5.1.1. Promoting water RDI infrastructures for a better understanding of hydrological processes at different scales* *5.1.2. Promoting adaptive water management for global change* *5.1.4. Innovating on practical, low-cost technologies treating wastewater to produce resources that are safe for reuse* 5.2. Strengthening socio-economic approaches to water management RDI needs: *5.2.1. Integrating economic and social analyses into decision-making processes* *5.2.3. Promoting new governance and knowledge management approaches*
Oceans	1.3. Managing the effects of hydro-climatic extreme events RDI needs: *1.3.3. Improving water management to mitigate the harmful impacts of extreme events (extreme weather events, impaired water quality)*

Annex IV: Proposed Template

Question 1. Are there any water RDI needs missing from the document? If yes, which one?

Question 2. Themes and subthemes

Theme 1 Maintaining Ecosystem Sustainability

Subtheme 1.1 Developing approaches for assessing and optimising ecosystems services

Subtheme 1.2 Integrated approaches: developing and applying ecological engineering and eco-hydrology

Subtheme 1.3 Managing the effects of hydro-climatic extreme events and multiple pressures on ecosystems

Theme 2 Developing Safe Water Systems for Citizens

Subtheme 2.1 Emerging Pollutants and emerging risks of established pollutants: assessing their effects on nature and humans and their behaviour and opportunities for their treatment

Subtheme 2.2 Minimising risks associated with water infrastructures and natural hazards

Theme 3 Promoting Competitiveness in the Water Industry

Subtheme 3.1 Developing market-oriented solutions for the water industry

Subtheme 3.2 Enhancing the regulatory framework

Theme 4 Implementing a Water-wise Bio-based Economy

Subtheme 4.1 Improving the efficiency of water use for a sustainable bio-economy sector

Subtheme 4.2 Reducing soil and water pollution

Theme 5 Closing the Water Cycle Gap – Improving Sustainable Water Resources Management

Subtheme 5.1 Enabling sustainable management of water resources

Subtheme 5.2 Strengthening socio-economic approaches to water management

Other themes?

Other subthemes?

Question 3. How could RDI actions on that/those new need(s) contribute to:

a) Safeguarding water resources and aquatic ecosystems?

b) Improving the well-being of our society (e.g. public health)?

c) Generating growth and jobs (objective of the Innovation Union Strategy of the European Union)?

Question 4. Are there any horizontal topics you would like to add to the document? If yes, which one?

RDI objective: Related RDI need:

Question 5. Are there any water RDI objectives you would like to add to the document? If yes, which one? Which RDI need does it refer to?

RDI objective: Related RDI need:

Annex V: Results from the Mapping Activity and Participatory Activities (public consultations, workshops)

Core themes and RDI needs	Results from the mapping survey	Results from the first public consultation Importance (% respondents)		Results from the second public consultation Importance (% respondents)	Results from the first stakeholder workshop (short-, medium-, long-term priorities)	Results from the second stakeholder workshop
Theme 1: Maintaining Ecosystem Sustainability	**High (58%), medium (19%), low (4%)**	**High (47%), medium (37%), low (8%), N/A (8%)**	**High (35%), medium (43%), low (13%), N/A (9%)**			
Subtheme 1.1: Developing approaches for assessing and optimising ecosystem services				**Medium (22%)**		
1.1.1. Developing approaches for assessing and optimising ecosystem services and the ecological functioning of ecosystems				High (53%)	Short	–
1.1.2. Testing methodologies for the valuation of ecosystem services				Low (13%)	Short	–
1.1.3. Integrating ecosystem services into water resources management				Medium (34%)	Short	xx
Subtheme 1.2: Integrated approaches: developing and applying ecological engineering and ecohydrology				**Medium (22%)**		
1.2.1. Establishing pressure–impact–response relationships in aquatic and riparian ecosystems				Medium (33%)	Medium	–
1.2.2. Understanding the impacts of pressures on the terrestrial and aquatic interface				Low (20%)	Medium	–
1.2.3. Restoring continuity and hydraulic connectivity				Low (10%)	Short	xx
1.2.4. Managing the risks caused by alien species				Low (2%7)	Short	–
1.2.5. Understanding the implications of ecological flows				Low (4%)	Short	xx

1.2.6. Integrated eco-technological solutions for the remediation and mitigation of degraded water zones				Medium (30%)	Did not exist at the time	–
Subtheme 1.3: Managing the effects of hydro-climatic extreme events and multiple pressures on ecosystems				**Medium (28%)**		
1.3.1. Setting the causes of drought/ scarcity; predicting drought events and water scarcity				Low (14%)	Short	xx
1.3.2. Developing innovative (or improved) tools for the protection and prevention of hydro-climatic extreme events				Medium (30%)	Short	xxx in first place for Theme 1
1.3.3. Improving water management to mitigate the harmful impacts of extreme events (extreme weather events, impaired water quality)				Medium to high (41%)	Short	–
1.3.4. Managing multiple pressure–impact liaisons on ecosystems				Low (16%)	Medium to long	–

Theme 2: Developing Safe Water Systems for Citizens	**High (38%), medium (22%), low (6%)**	**High (49%), medium (34%), low (7%), N/A (10%)**	**High (38%), medium (40%), low (12%), N/A (10%)**			
Subtheme 2.1: Emerging pollutants: assessing their effects on nature and humans and their behaviour and opportunities for their treatment				**High (41%)**		
2.1.1. Developing analytical techniques for groups of substances				Low (11%)	Short	xx
2.1.2. Understanding and predicting the environmental behaviour and effects of by-products, emerging pollutants and pathogens, including their environmental effects				High (40%)	Short	x
2.1.3. Remediation of pollutants: developing strategies to reduce pollutants (disinfection by-products, emerging				High (49%)	Did not exist at the time	xxx

pollutants, pathogens, including their environmental effect)						
Subtheme 2.2: Minimising risks associated with water infrastructures and natural hazards				**Medium (23%)**		
2.2.1. Exploiting ageing urban water systems for dependable and cost-effective service				Low (19%)	Long	–
2.2.2. Progressing towards flood-proof cities				Medium (25%)	Short	xx
2.2.3. Improving the performance of urban water systems*				Medium (36%)	Medium	xx
2.2.4. Assessing the impact of water scarcity on safe drinking water				Low (20%)	Medium	–

Theme 3: Promoting Competitiveness in the Water Industry	High (17%), medium (17%), low (17%)	High (40%), medium (35%), low (10%), N/A (15%)	High (30%), medium (39%), low (16%), N/A (15%)			
Subtheme 3.1: Developing market-oriented solutions for the water industry				**Medium (24%)**		
3.1.1. Developing smart water technologies (sensor networks and real-time information systems in water distribution and wastewater networks)				Low (17%)	Short	xx
3.1.2. Delivering technological solutions for water and wastewater treatment				Medium (27%)	Medium	xx
3.1.3. Promoting innovative approaches to asset management				Low (4%)	Medium	xxx
3.1.4. Supporting the energy–water nexus (namely on efficiency and sustainability)				Low (4%)	Short	xx
3.1.5. Obtaining water and energy from the ground and the sea				Low (5%)	Short	xx
3.1.6. Developing water reuse and recycling technologies and concepts				Medium (36%)	Short	xxx
3.1.7. Recovering products and energy from treatment plants				Low (6%)	Medium	xxx
Subtheme 3.2: Enhancing the regulatory framework				**Low (55/390)**		
3.2.1. Removing barriers to innovation				High (100%)	Short	xxx

Theme 5: Closing the Water Cycle Gap	High (22%), medium (22%), low (13%)	High (35%), medium (35%), low (12%), N/A (18%)	High (28%), medium (38%), low (16%), N/A (18%)			
Subtheme 5.1: Enabling sustainable management of water resources				**High (38%)**		
5.1.1: Promoting water RDI infrastructures				Low (10%)	Short	xxx
5.1.2: Promoting adaptive water management for global change				High (33%)	Short	xxx
5.1.3: Implementing MAR and other NWRMs				Low (6%)	Short (regional)/ medium (global)	xx
5.1.4: Securing freshwater in the Mediterranean and Baltic basins				Low (4%)	Short (regional)	x
5.1.5: Securing freshwater in the Danube (Danube Knowledge Cluster, Article 185)				Low (1%)	Short (regional)	x
5.1.6: Mitigating water stress in coastal zones				Low (7%)	Short	xx
5.1.7: Innovating on practical, low-cost technologies treating wastewater to produce resources that are safe for reuse				High (38%)	Short	xxx
Subtheme 5.2: Strengthening socio-economic approaches to water management				**Medium (21%)**		
5.2.1. Integrating economic and social analyses into decision-making processes				Medium (34%)	Medium	xxx
5.2.2: Reconnecting socio-economic and ecological issues				Medium (25%)	Long	x
5.2.3: Promoting new governance and knowledge management approaches for water management				Medium (41%)	Short	x

Theme 4: Implementing a Water-wise Bio-based Economy	**High (15%), medium (17%), low (13%)**	**High (38%), medium (36%), low (10%),** N/A (16%)	**High (29%), medium (39%), low (15%),** N/A (17%)			
Subtheme 4.1: Improving the efficiency of water use for a sustainable bio-economy sector				**Medium (100/390)**		
4.1.1. Implementing efficient water-use systems and practices for the European and overseas markets				Low (23%)	Short	xxx
4.1.2. Developing integrated water-conserving farming and forestry practices and varieties				Low (15%)	Medium	xx
4.1.3. Setting up water valuation schemes for agriculture and forestry				Low (7%)	Long	xx
4.1.4. Progressing towards future-proof agricultural water use				Low (15%)	Medium	xx
4.1.5. Ensuring the efficient use of water resources in the bio-economy sector				High (40%)	Did not exist at the time	x
Subtheme 4.2: Reducing soil and water pollution				**High (41%)**		
4.2.1. Developing sustainable production systems				High (40%)	Short	xxx
4.2.2. Designing measures underpinning water and land use policies				Medium (25%)	Medium	xx
4.2.3. Overcoming barriers preventing water reuse in irrigated agriculture and forestry				Low (18%)	Medium	x
4.2.4. Providing good quality water resources in support of the European bio-economy				Low (17%)	Did not exist at the time	x

Annex VI: List of References Reviewed to set up Strategic Research and Innovation Agenda, Version 2.0

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