

Digital Water Innovation Ecosystems Mapping

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Deliverable Leader

Sustainable Innovation Technologies Ltd (SITES)

Lead Author

Maria Lima-Toivanen (SITES)

Other Authors

Leonardo Piccinetti, with collaboration from Aneesa Reeve, Elisabeth Nikolaishvili, Alessandro Tiraborelli and Matteo Sternini with inputs from DEU-DESU, MCAST, MENDELU, NMBU, UNEXTER, UNI, UNIRC, TUAS

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EXECUTIVE SUMMARY

This report presents the results of the study, performed in the context of the project “Transforming Advanced Water Skilling through the Creation of a Network of Extended-Reality Water Emulative Centres” (WATERLINE), about local innovation ecosystems in the field of digital water in the 8 countries covered by WATERLINE Higher Education Institutions’ (HEI) partnership. These countries are: Czech Republic, Finland, Italy, Malta, Norway, Serbia, the UK, and Türkiye.

WATERLINE's main goal is to build a network of universities in Europe, focusing on digital water education. This will be based on a unique innovation model involving the university, industry, government, and society. We aim to do this at chosen universities across Europe with the long-term goal of growing WATERLINE's research, education, and business opportunities. This is to take advantage of the resources we have at individual, institutional, and regional levels. The project ultimate aim is to bring about significant and lasting changes to how we learn and innovate in this area.

Investigating the local innovation ecosystems in digital water allows for understanding of the state of the art in the field, as well as for defining means of strengthening the participant HEIs role in their local innovation ecosystems. The study adopted the quadruple helix model of innovation and smart specialisation strategies (S3) as the theoretical framework to encompass the digital water ecosystems and their stakeholders’ roles. Examples revealed how digitalisation of the water sectors has been framed in policy documents and how the sector has progressed in the different countries by means of digital water ecosystem arrangements, e.g., digital water clusters and living labs, and mostly how S3 has been instrumental in the definition of priorities related to smart water and local ecosystems development.

Considering the capacity building approach of WATERLINE, with its inclusion of widening countries, it was possible to identify the gaps and potentials in terms of the knowledge of and adoption of digital water ecosystems across the different countries. A SWOT analysis reveals the overall findings of the study while the recommendations are based on WATERLINE’s project plan.

SWOT: WATERLINE Partnership Digital Water Innovation Ecosystems

Strengths	Weaknesses
<ul style="list-style-type: none"> • There are pioneering countries in the adoption of innovation ecosystem approaches in digital water. • There are pioneering HEIs teaching, research and innovation in digital water. • Formation of practical evidence on digital water workforce skilling profiles. • Universities with mandate to participate in regional development policies and innovation ecosystems. 	<ul style="list-style-type: none"> • Digital water innovation ecosystems are not a common feature across all countries. • Different levels of implementation of digital water education across HEIs. • Insufficient adoption of education frameworks in digital water. • Low level in the engagement of civil society in promotion of digital water ecosystems. • Digital water strategies are not uniformly adopted. • Mismatches between the skills needed by the industry and the knowledge of what skills HEIs are developing.

<ul style="list-style-type: none"> • Highly recognized S3, clusters and LL experiences functioning as international benchmarks. • Strong technological expertise and research capabilities. • Government support in policy and funding in some of the countries. 	<ul style="list-style-type: none"> • Lack of awareness and support to digital water.
Opportunities	Threats
<ul style="list-style-type: none"> • High potential for knowledge exchange among the Digital Water HEI Alliance partners, local development authorities and local governments. • Practical knowledge available through platforms for the dissemination of digital water innovation ecosystems. • S3 evolution in the inclusion of SDGs and societal challenges. • Digital water is consolidated as policy area in the EU. • Water-Smart Society framework as a comprehensive approach to the digitalisation of the sector. 	<ul style="list-style-type: none"> • Local legislations and policy guidelines still insufficient to promote digital water ecosystems although international guidelines are available for customization. • Risk of worsening the gap between leading and lagging regions in the implementation of digital water ecosystems as funding are increasingly more competitive. • Risk of failures in the implementation of the distributed campus and the HEI Alliance due to unbalanced status of HEIs activities in RDI in digital water. • Small market considering the size of some of the countries analysed hinder investment and the scalability of solutions. • Competition from foreign big corporations deter investments from local companies.

With the mapping, it is possible to draw some recommendations for the next steps in the execution of Waterline and for the development of digital water ecosystems in the partnership countries.

Recommendations

Capacity building and skills development
Investing in capacity building projects for digital education and the development of skills specific for water innovation. The last one is a task to be implemented together with the industry to close the gap in the mismatching of skills.
Collaboration and knowledge sharing
All countries can benefit from enhanced collaboration and knowledge sharing among academia, industry (including public utilities and startups), civil society and government agencies. Creating platforms and networks for information exchange, best practices, and lessons learned can accelerate digital water innovation. This is particularly valid for work package 2.
Awareness and outreach
Increasing awareness among stakeholders, including policymakers, industry leaders, and the society, about the benefits and potential of digital water innovation is essential. Communication campaigns and outreach activities should highlight success stories and showcase the impact of digital solutions in water management.
Funding and Investment

Access to funding and investment is crucial for the development and scaling up of digital water innovations. Governments and relevant stakeholders should explore mechanisms to increase funding opportunities and incentivize private investments in the water sector. Government authorities, including from the EU, must be engaged in knowledge sharing on successful practices for funding within the scope of regional development plans. Work Packages 3 and 5 are the adequate phases of WATERLINE to implement this exploration exercise.

Policy and Regulatory Frameworks

Governments should review and update policy and regulatory frameworks to ensure they support and facilitate digital water innovation. This includes addressing any barriers or gaps that hinder the adoption and scaling up of digital solutions in the water sector. Again, specific knowledge exchange mechanism should be established to show off strategic changes adopted at country level by governments to support the advancement of digital water implementation in a systemic approach, including education, awareness raising, local development and business development.

Overall, WATERLINE should co-create a roadmap for capacity building taking into consideration the above recommendations and the transferability of the responsibility for its implementation to local stakeholders after the end of the project. The project sustainability planning must build local engagement for its success.

List of abbreviations

Acronym	Meaning
4S	Smart Specialisation Strategy Serbia
AFD	French Development Agency
AI	Artificial Intelligence
ARERA	Autorità di Regolazione per Energia Reti e Ambiente
BEM	The Blue Economy Mikkeli
BI4E	Boosting INGENIUM for Excellence
BLUES	Blue and Eco industries cluster exchange for industrial modernisation
CEB	Council of Europe Development Bank
CEW	Center of Expertise Water Technology
CLEVER Cluster	Piedmont Cleantech and Energy Innovation Cluster
Cluster GREENTECH	Energy and Sustainable Development Cluster
Cluster SCC	Foundation Technology Cluster Smart Cities and Communities Lombardia
DEU-DESUM	Dokuz Eylül University
Digiwater	Digitalization of Water industry by Innovative Graduate Water Education
DIHs	Digital Innovation Hubs
DOSCON	Innovation for Water and Wastewater Treatment
DW	Digital Water
E ³ UDRES ²	Excellence and Impact in Research and Innovation
EAUC	The Environmental Association for Universities and Colleges
EDP	Entrepreneurial Discovery Process
ELY-Keskus centres	Centres for Economic Development, Transport and the Environment
ENOLL	European Network of Living Labs
ERDF	European Regional Development Fund
ESCP – 4x	European Strategic Cluster Partnerships for Excellence
ESCP- 4i	European Strategic Cluster Partnerships – Going International
ESF	European Structural Fund
EU	European Union
euWater4i-SD	European Water Initiative for Fostering International Sustainable Development
FIWA	Finnish Water Utilities Association

GIS	Geographic Information Systems
HAMK	Häme University of Applied Sciences
HC	Head count
HEI	Higher Education Institution
IAHS	International Union of Hydrological Sciences
ICT	Information and Communication Technologies
InCITIES	Trailblazing Inclusive, Sustainable and Resilient Cities
IoT	Internet of Things
IWT	Institute of Water Technology
JRC	Joint Research Center
KIC	Knowledge and Innovation Community
LE2C	Lombardy Energy Cleantech Cluster
LLs	Living Labs
LTER	Long-Term Ecosystem Research
LUT	Lappeenranta University of Technology
MCAST	The Malta College of Arts, Science & Technology
MENDELU	Mendelova Univerzita V Brne
NGOs	Non-Governmental Organizations
NIVA	Norwegian Institute for Water Research
NMBU	Norges miljø-og biovitenskapelige universitet
NTNU	Norges teknisk-naturvitenskapelige universitet
NVE	The Norwegian Water Resources and Energy Directorate
OAMK	Oulu University of Applied Sciences
OsloMet	Oslo Metropolitan University
PoVE Water	Platform for Vocational Excellence Water
R&D	Research and development
RDAs	Regional Development Agencies
RDI	Research, development and innovation
RIS3	Research and Innovation Strategies for Smart Specialisation
S3	Smart Specialisation Strategy
SAKKY	Savo Vocational College
SDGs	Sustainable Development Goals
SINTEF	Foundation for Industrial and Technical Research
SITES	Sustainable Innovation Technology Services Ltd.
SMART4ENV	Enhancing the Scientific Capacity of TUBITAK MRC in the Field of Smart Environmental Technologies for Climate Change Challenges

SMEs	Small and medium-sized enterprises
SOVAK ČR	The Water Supply and Sewerage Association of the Czech Republic
SWAN	Smart Water Network
SWOT	Strenghts, Weaknesses, Opportunities and Threats
SYKLI	Sykli Environmental College
TUAS	Turku University of Applied Sciences
TUNI	Tampere University
UH	University of Helsinki
UKRI	UK Research and Innovation
UKRI EPSRC	UK Engineering and Physical Sciences Research Council
UKWIR	UK Water Industry Research
UM	University of Malta
UNEXE	University of Exeter
UNI	Univerzitet U Nisu
UNIRC	Università Mediterranea di Reggio Calabria
VET	Vocational education and training
Water JPI	Water Joint Programming Initiative
Water4All	European Partnership on Water Security for the Planet
WE	Water Europe
WE-SIRA	Water Europe's Strategic Innovation and Research Agenda
WISE	Water Informatics: Science and Engineering
WoLLs	Water-oriented Living Labs
WRM	Water resources management
WSC	Water Services Corporation
WSTs	Water Smart Territories
XAMK	South-Eastern Finland University of Applied Sciences

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1. Introduction

The project WATERLINE (Transforming Advanced Water Skilling through the Creation of a Network of Extended-Reality Water Emulative Centres) has as main objective to create a European Digital Water HEI Alliance, based on the quadruple helix model of innovation, in selected HEIs across Europe with the long-term aim of developing WATERLINE's HEI research, educational, and entrepreneurship capacities to leverage individual, institutional and regional resources required for a transformative structural and sustainable learning and innovation environment.

This report presents the results of the study about local innovation ecosystems in the field of digital water in the 8 countries covered by WATERLINE HEI partners. Investigating the local innovation ecosystems in digital water allows for understanding of the state of the art in the field, as well as for defining means of strengthening the participant HEIs role in their local innovation ecosystems.

The study utilised interviews and desk research for data gathering. Interviews were made with representatives of water cluster organisations belonging to the Smart Water Territories (WSTs) of the European Joint Research Center (JRC) and a representative of a center of expertise in water. The desk research survey was carried between February and March 2023, to characterize local digital water innovation ecosystems by identifying the ecosystems' performers, their needs and challenges, and supporting instruments in WATERLINE partner HEIs locations. The interviews were performed between November 2022 and April 2023.

For the identification of the innovation ecosystems two approaches were utilised. The first one is the quadruple helix approach, which in the context of WATERLINE considers governments and public sector organisations; the higher education, research, and vocational training sector; industry, business and services sector; and the civil society by means of non-government organizations (NGOs) and other types of associations. The second approach is related to the smart specialisation strategy (S3), which addresses sustainability challenges alongside regional development strategies within the quadruple helix innovation model to implement developments in the regions.

The quadruple helix approach is explained in D2.1 (WATERLINE, 2023a), a study that mapped stakeholders and skills for digital water in the WATERLINE HEI partnership countries. In this report, the focus is on the identification of digital water innovation ecosystems, therefore the most relevant information on S3s and ecosystems arrangements have been identified for the topic, as well as the role played by HEIs in digital water ecosystems.

The desk research survey conducted during the project has provided insights into the local digital water innovation ecosystems in the eight countries covered by the WATERLINE HEI partnership. The concept of digital water and policies supporting its innovation have been identified, as well as the role of WSTs in promoting sustainable water management solutions. Considering the focus of WATERLINE collaboration with universities of the widening countries, the project foresees capacity building activities, to which this report contributes by collecting HEIs activities in teaching and research in digital water, as well as the local digital water innovation ecosystems and the potential best practices that will be utilized for training and knowledge sharing among the HEIs involved in the project.

2. Literature review

The aim of this chapter is to offer the theoretical underpinnings of innovation ecosystems emphasizing their specialisations in the field of digital water and the role that universities can play in the local digital water ecosystems they belong to. This is done by elucidating what are water innovation ecosystems in the context of WATERLINE project and refer to the impact of digitalization in the transition to the achievement of local and EU policies in the water sector. We start by emphasizing the importance of remote learning, which has proved its significance in face of the COVID-19 pandemic and other big disruptions such as the war in Ukraine.

The impact of the COVID 19 pandemic led to a radical transformation in all societal systems, especially to education and training. According to García-Morales et al (2021) higher education institutions (HEIs) had to adopt online teaching in record time, implementing and adapting the technological resources available as capacity building to deal with those resources were acquired on-the-job, considering the unpreparedness of teaching and research staff.

In connection with these changes, García-Morales et al (2021) emphasis the provision of quality education in a scenario of digital transformation, disruptive technological innovation, and accelerated change in the educational framework as a duty of the HEI system. The proposed WATERLINE HEIs digital water campus to be implemented by the Digital Water HEIs alliance is in a means of addressing both the challenges to deliver remote education in more hands-on fields, such as water engineering for example, and the opportunities brought about by digital transformation, the European Universities Initiative of the European Commission (EC, 2021) and the guidelines on distance education and digital skills (EC, 2023a).

2.1 Digital Water

According to Bluefield Research (n.d.), the water sector is being transformed by a wave of new technologies for connectivity, mobility, automation, and data analytics. Proactive utilities and industrial firms are now incorporating more digital water solutions into everyday operations from customer and asset management to maximizing operational efficiency. The global growth of expenditures by water and wastewater utility sector in digital solutions will grow 8.8% annually, from US\$25.9 billion in 2021 to US\$55.2 billion in 2030 (Bluefield Research, n.d.).

In terms of strategic planning for implementation of water security and collaboration to address the global water challenges, the Water Europe (WE, 2023), the European Partnership on Water Security for the Planet (Water4All, 2022), and the Water Joint Programming Initiative (Water JPI, 2020) see the digitalisation as enablers for the achievement of sustainability of water systems in the pursue of a sustainable and Water-Smart Society. According to the Water4All (2022, p.14), the digital revolution (big data, AI, IoT, remote Earth observation, water sensors real-time monitoring, data assimilation) offer an untapped potential for the monitoring of water resources and ecosystems, the visualization and evaluation of management/ policy options, increased connectivity of water users, the real time access to water information, and the communication of decisions.

Genné & Campling (2019, p.13) explain that digital water ranges from data management to water system innovation, in which rapidly developing approaches for handling “Big Data” is creating an increased ability to share and exchange data at various scales: local / urban, regional and river basin, but also to engage with and inform stakeholders. This rapidly evolving digital environment provides a huge potential to manage water resources and services more intelligently and efficiently. Data-driven and process-based models as well as advances in artificial intelligence are offering more precise water monitoring, forecasting and visualization capabilities for water managers and policy makers. At the urban level, water service providers now use a wide range of IT tools for monitoring, surveillance and analysis. The monitoring and management of large water resources systems is equally being transformed. There are new remote sensing techniques for tracking water levels and flows from surface and groundwater bodies. High precision flood modelling and forecasting is being used to introduce timely measures to mitigate the impact of flooding events and reduce losses and costs. More strictly, this view can be seen in the concept:

The digital water exploits the benefits of the extreme interconnectivity of people, devices and processes, and create capillary networks capable of monitoring the water system, starting at its multiple sources through to the individual end-user, thus generating continuous flows of valuable data for innovative decision-support systems at different governance levels (WE, 2023, p. 17).

Vairavamoorthy (2019) emphasises the proposal of a smarter approach to water management, which consists of:

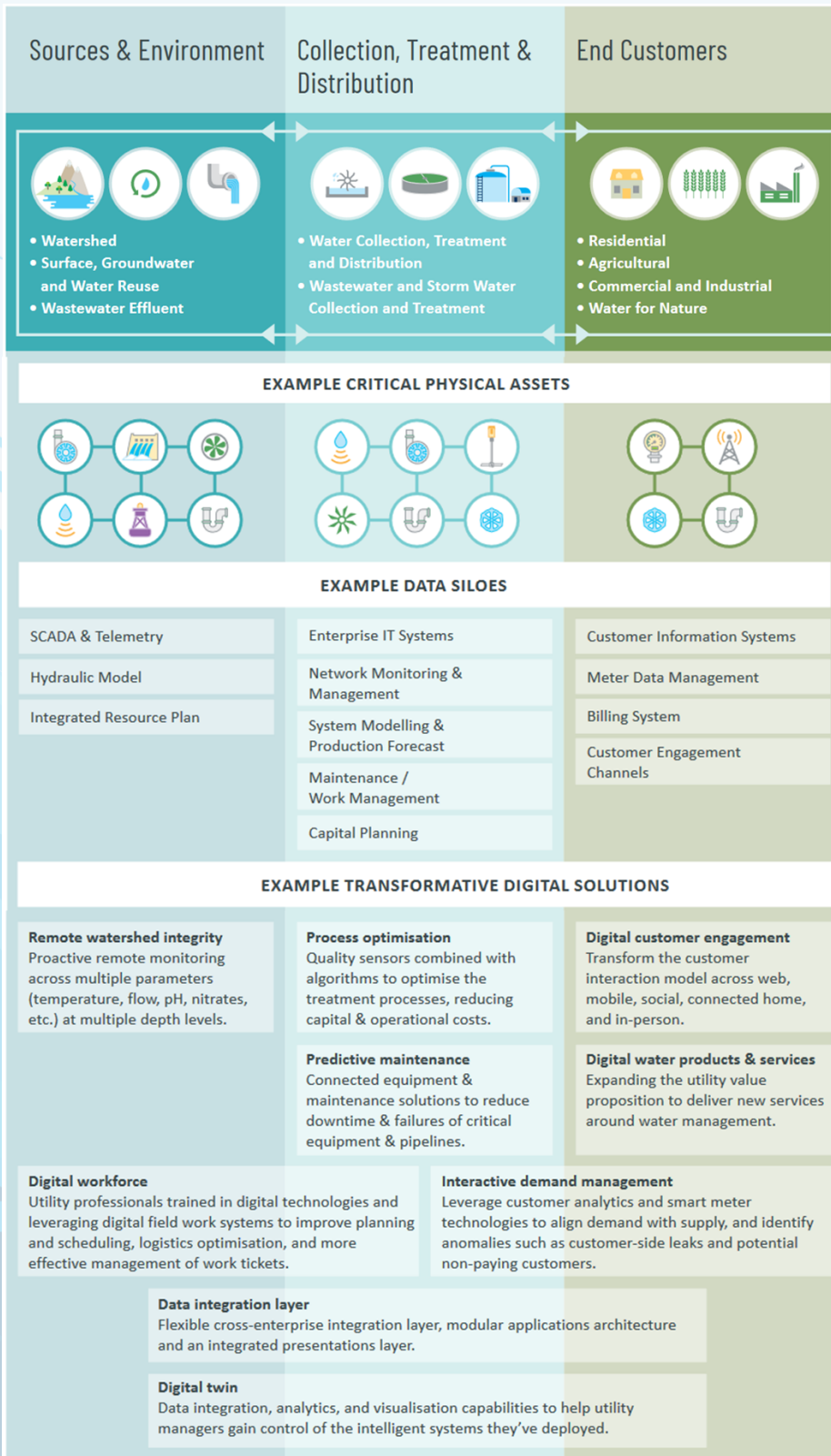
Smart by design: adaptive off-grid, distributed systems that provide diversity and modularity, characteristics critical for resiliency;

Smart Use: combining concepts of water fit for purpose (different grades for different uses), and resource recovery and reuse (of water, energy, and nutrients from wastewater); and

Smart Control: IoT supporting data-driven models that can help integrate and optimise smart pumps, valves, sensors and actuators, and enabling each device to ‘talk’ to each other, or for that matter to a customer’s smartphone, and send real-time information to be accessed and shared via the cloud.

Figure 1 illustrates the representation of how digitalization can be deployed across the water systems.

Figure 1. Technology inputs and solutions of a Digital Water and Wastewater Utility



- pumps
- dams
- turbines
- sensors
- buoys
- pipes
- mixers
- aeration
- valves
- communication
- meters

Source: Sarni et al (2022, p.4)

Expanding the systemic approach of society in which digital water plays a role WE (2023) has disseminated a vision of a Water-Smart Society, which integrates the value of water and the means to secure its access to all. According to that vision:

Water-Smart Society is one in which the value of water is recognised and realised to ensure water security, sustainability, and resilience; all available water sources are managed so that water scarcity and pollution are avoided; water and resource loops are largely closed to foster a circular economy and optimal resource efficiency; the water system is resilient against the impact of climate and demographic change; and all relevant stakeholders are engaged in guaranteeing sustainable water governance (WE, 2023, p.4).

The realization of the vision of a Water-Smart Society seems more plausible taking into consideration the current European Union policies that rely also on digitalisation to implement investments in cross-cutting themes approached by various policies. According to Ulf Stein et al (2022), in the case of water, these investments aim to make the EU a green, sustainable, and climate-proof industry leader in the sector. Policy makers at the EU and local levels are setting the framework and guidelines for future investments, relying heavily on policy decisions that guide the digital transition process in the EU water sector. The COVID-19 recovery programmes (e.g., through funds earmarked for boosting digitalisation) and the wave of ecosystem restoration that the Biodiversity Strategy will drive (e.g. through the need to monitor restored river stretches and wetlands) create further momentum to accelerate the spread of digital water solutions.

Policy guidelines for water management digitalisation in Europe is compiled in the Rolling Plan for ICT Standardisation (EC, 2023b). The plan states the policy landscape, knowledge sources, projects and activities that have been implemented with the aim to define long-term regulatory strategy concerning the adoption of smart water technologies in coordination with relevant stakeholders and standards organisations, to ensure smooth digitalisation of water services over the next decade.

In terms of the policy landscape, the European Green Deal¹, the INSPIRE Directive², the Zero Pollution Initiative and Zero Pollution Action Plan³, the EU Data Strategy⁴ and the Artificial Intelligence Act⁵ are the main policies ruling on the topic. For knowledge resources, the ICT4Water⁶ cluster is a hub for EU-funded research and innovation projects developing digital solutions for the water sector. ICT4Water supports its members in exchanging information and best practices, disseminating and exploiting project outputs, contributing to define digital water strategies and to policy development in digital and water domains (EC, 2023b).

2.2 Smart specialisation strategies focusing on digital water

¹ https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

² <http://inspire.ec.europa.eu/>

³ <https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-zero-pollution-action-plan>

⁴ https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en

⁵ <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021PC0206&from=EN>

⁶ <http://www.ict4water.eu/>

Smart specialisation strategies (S3) consist of a strategic approach to regional development aiming at enhancing its competitiveness internationally in specific areas in which industry, government, HEIs and civil society collaborate to promote innovation. Innovation ecosystems are strategically organized in and around S3 to reach the objectives of the S3s.

According to Mora et al (2022), S3s were conceived in the context of the transformation of Europe into a knowledge-based economy (European Council, 2000). For that end, key policy changes needed to be overcome. These were: to reduce the deficit in R&D activities and innovation capacity, to establish a stronger governance framework for sustaining science and technology systems in a globalised world, to strengthen the interrelation between technology production and diffusion, and reinforce the HEIs relationship with industry.

S3 has been one of the main instruments of implementation of the Cohesion policy of the European Commission and is defined as:

S3 is a place-based approach characterised by the identification of strategic areas for intervention based both on the analysis of the strengths and potential of the economy and on an Entrepreneurial Discovery Process (EDP) with wide stakeholder involvement. It is outward-looking and embraces a broad view of innovation including but certainly not limited to technology-driven approaches, supported by effective monitoring mechanisms (Smart Specialisation Platform, n.d.a)

As the focus of this study is only on general aspects of S3, it is advisable to consult the European Commission Smart Specialisation Platform (<https://s3platform.jrc.ec.europa.eu>) for a full account of the concept, its evolution and its applications in different countries and local level contexts. For a compact version, Miedzinski et al (2022) may be a good resource.

The four principles guiding the design and process of S3, originally proposed by Foray et al (2012) are:

Choices and critical mass: Focus on a limited number of priorities selected based on the local strengths and international specialisation, to avoid duplication and fragmentation in the European Research Area and help concentrate funding sources and ensure more effective budgetary management.

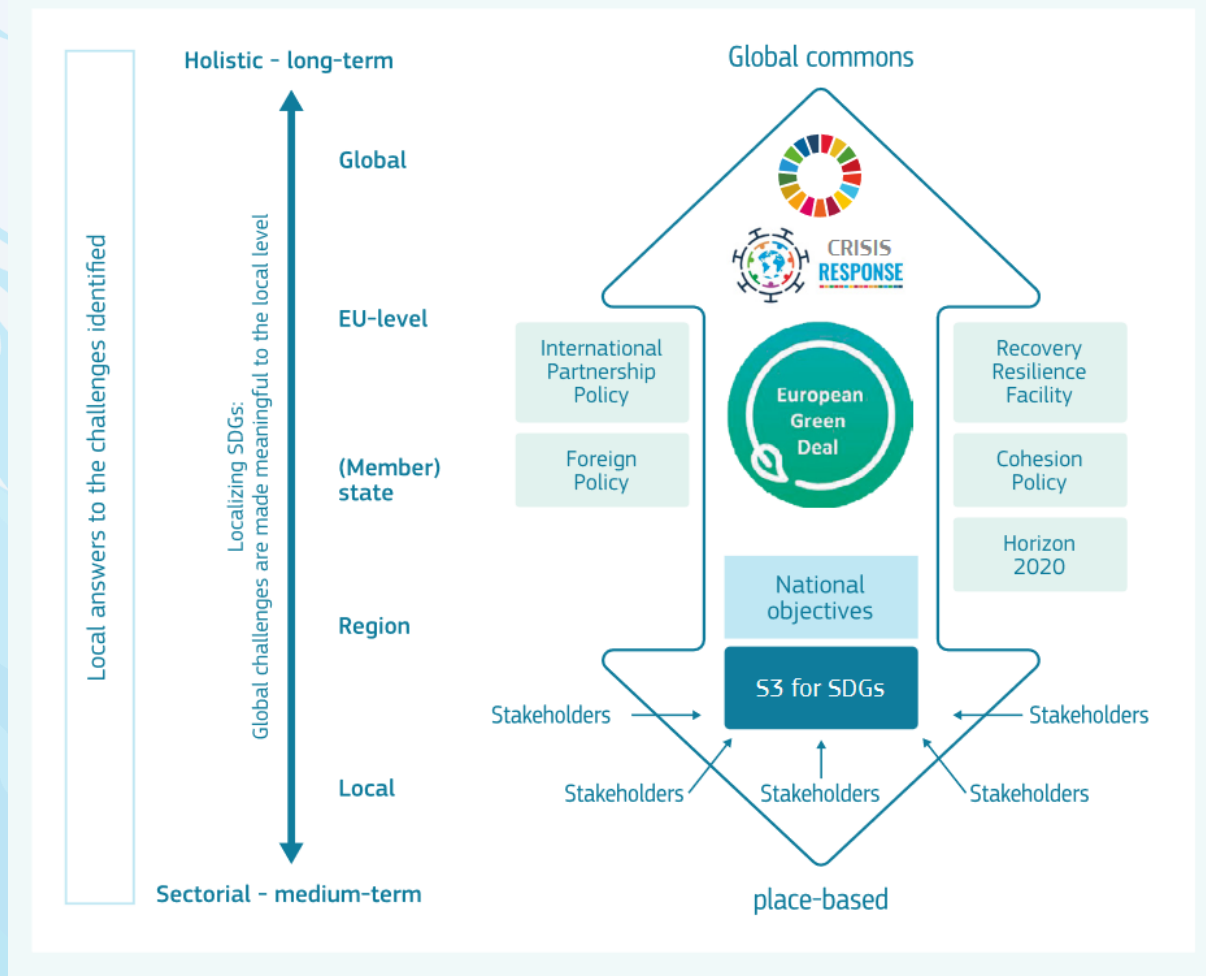
Competitive advantage: Mobilise talent by matching research and innovation capacities and business needs through an EDP.

Connectivity and clusters: Develop world-class clusters and provide arenas for related variety and cross-sector links internally in the region and externally to drive specialised technological diversification.

Collaborative leadership: Support efficient innovation systems as a collective endeavor based on public-private partnerships (quadruple helix) and provide an experimental platform to give voice to all parts that have a stake in the topic.

Recently, the S3 concept has been reframed to encompass the Sustainable Development Goals (SDGs) as means to mobilise research and innovation to respond to local sustainability challenges, raising the ambition to foster innovation to respond to societal challenges and systemic changes in key societal systems, such as energy, food, mobility or housing (Miedzinski et al, 2022). This approach conforms quite well the focus of WATERLINE project. Figure 2 illustrates how this approach incorporates the different elements of S3 and its actuation from local to global levels.

Figure 2. Localising S3: a directional approach combining top-down directionality with bottom-up development



Source: Nakicenovic et al (2021 as cited in Miedzinski et al, 2022)

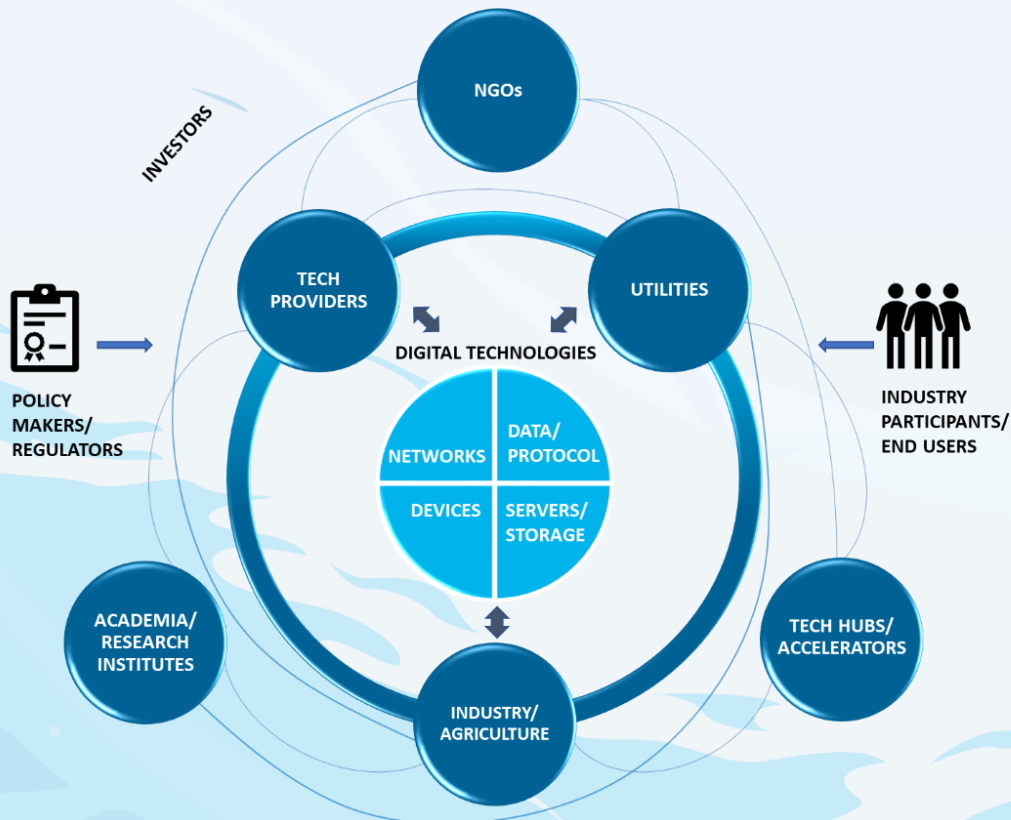
2.3 Digital Water Innovation Ecosystems

According to WE (2021), a Water-Smart Society goes beyond the digitalisation of the water sector to be linked to the ecosystem it belongs to. Water and wastewater utilities are at the center of a greater ecosystem of digital water, which includes their value chains and associated stakeholders. Generally, according to the International Water Association (IWA, 2022), digital water ecosystem incorporates stakeholders from across the water and wastewater spectrum, such as private and public utility peers, governmental bodies, technology solution providers, academic institutions, consultancies, industry associations and technology accelerators, which are engaged in developing solutions and digital

approaches to address water scarcity, quality, and resiliency concerns, among others (Sarni, 2022). The way that a utility interacts with its ecosystem varies depending on its digital adoption phase. It is evident that as utilities adopt digital solutions, they are evolving from having a limited, linear ecosystem to one that is more complex and interconnected.

The stakeholders of the digital water innovation ecosystem are represented in the Figure 3 and are listed according to their roles:

Figure 3. The Digital Water Innovation Ecosystem



Source: Sarni et al (2019, as cited in Sarni, 2022, p.46)

Utilities: They play a crucial role in the digital water ecosystem by providing the necessary infrastructure, resources, and services to ensure the safe and sustainable management of water resources. Digital water solutions rely on the data and information provided by utilities to enable real-time monitoring, analysis, and management of water systems. Many utilities are critical infrastructures; therefore, cybersecurity solutions are a main concern for their operations.

Agriculture: The agricultural sector is considered part of the digital water ecosystem for the high level (up to 70 percent) of annual freshwater usage for food production alone. The adoption of digital water solutions by companies with large agricultural components of their supply chains may create large-scale impacts across food supply chains, as well as adopt the solutions to increase their sustainability, decrease business risk and address climate impacts.

Industry: The industrial users share many of the same challenges as large agricultural users for having broad supply chains that negatively impact the local water sources. For this reason, pressure has been

applied for private entities to step up and take responsibility for water management along their entire global supply chains and digital solutions have a role in that.

Technology hubs and accelerators: They support entrepreneurs to develop digital water solutions and startup businesses and are critical for breeding and nurturing talent and ensuring the competitiveness of the start-ups when they go to market. They also can connect technologies with clients more quickly than through normal market entry routes.

Investors and digital water technology acquisitions: They are active in funding solutions that drive the water sector forward and are important especially for the water sector, considering the high costs to proceed with the digital transformation.

Academia: Universities and research institutes play a key role in the exploration and development of digital technologies and other innovations for the water sector. They have access to unique funding sources, talents, and industry connections and are distinctly placed to accelerate the adoption and development of digital water technology.

Non-governmental Organizations (NGOs): These actors deal with water-related issues of many different natures, including some that deal with advancement of technologies for the digital water sector.

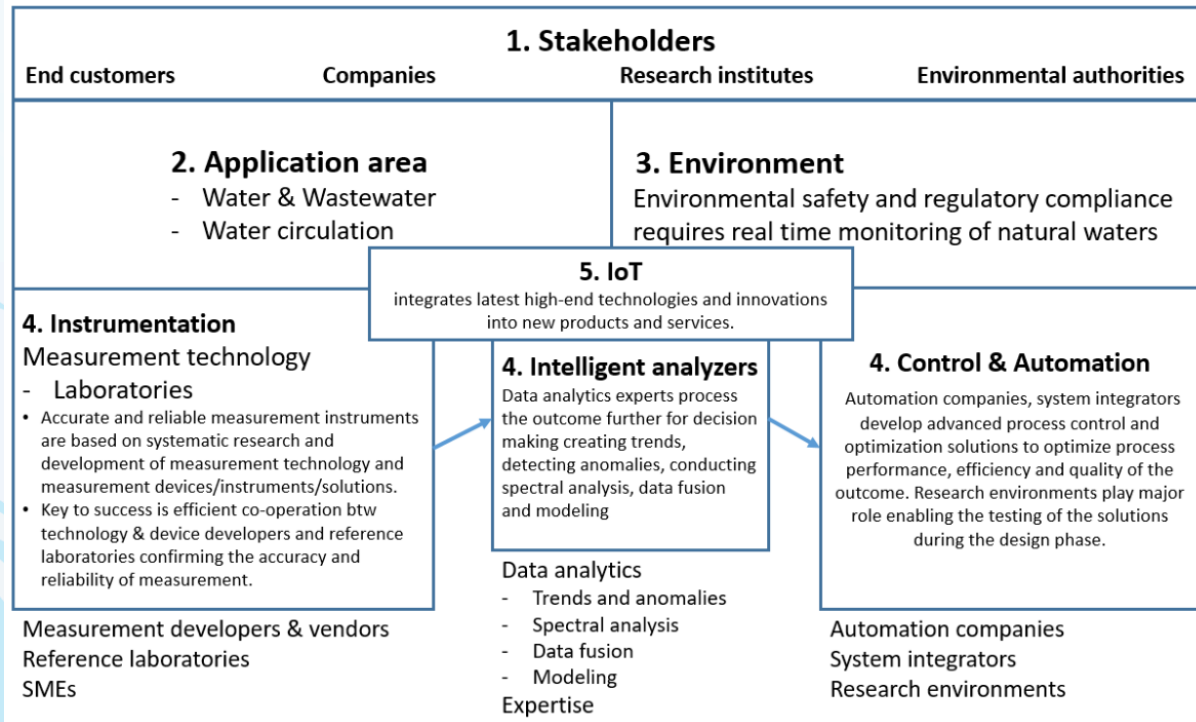
Public sector: These organizations are active in advancing new water technologies and research alongside the private sector, and oftentimes, they work in tandem. There are public sector initiatives that assist in advancing water science and the development of digital water applications.

Civil society is added to Sarni's (2022) description of digital water ecosystem stakeholders. Civil society can be represented by individuals as solutions or interventions end-users but is commonly represented by associations of end-users or categories representing their interest. NGOs or other collective organizations may represent civil society or industrial organizations interests.

An illustration (Figure 4) of the Allied ICT Finland Water Ecosystem established in Finland (Taskinen, n.d.) shows the different roles the stakeholders play in that Ecosystem, which focus on water and wastewater and water circulation, and considering different digital solutions in support of the sector. Another characteristic of the Allied ICT Finland Water Ecosystem worth noting is the role it plays to facilitate innovation in digital water (Taskinen, n.d., p.3):

- Act as neutral layer between end customers, measurement developers and vendors, automation companies, system integrators and environmental authorities
- Increase the co-operation of the participating companies, building consortiums and acting as a business quarterback; and
- Perform talent scouting and actively promoting research to business co-operation and communication.

Figure 4. Stakeholders, application areas and digital solutions - Allied ICT Water Ecosystem Finland



Source: Taskinen (n.d., p.4)

2.3.1 Ecosystem arrangements

For digital water innovation ecosystems arrangements, it is considered the clusters and living lab organisations, which bring together stakeholders to support the development of innovations and promote the sectors competitiveness.

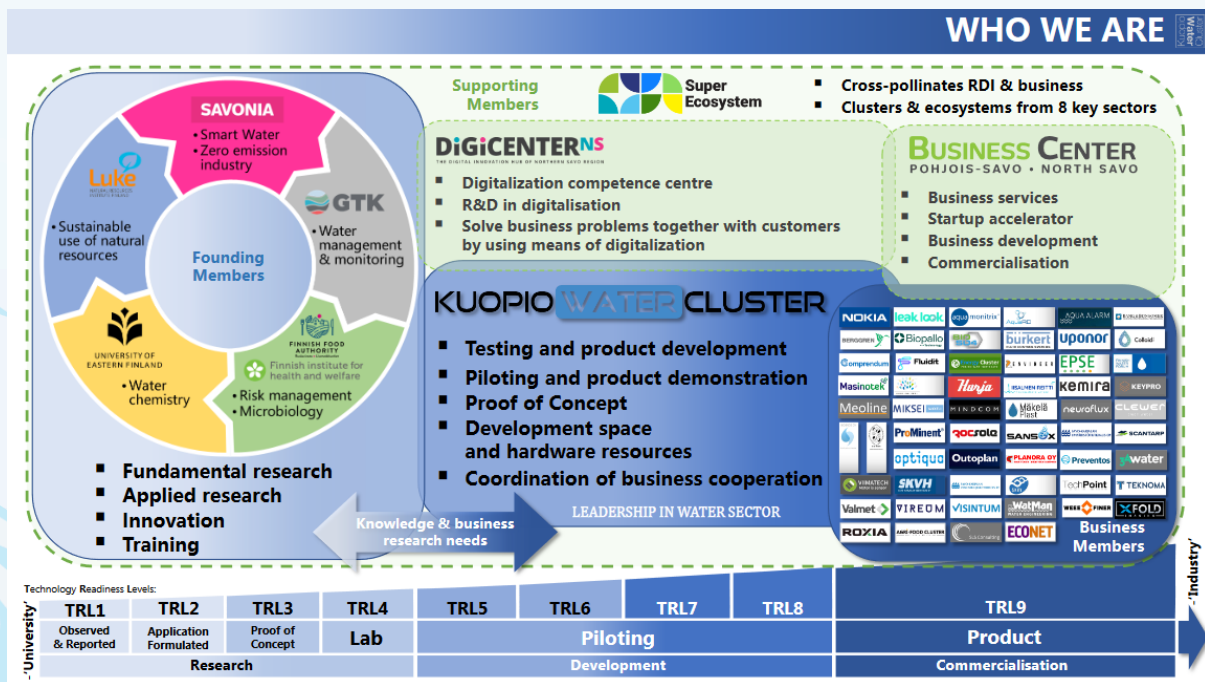
Digital water innovation clusters

Digital water innovation clusters are collaborative ecosystems that bring together technology companies, water utilities, universities, research institutions, and other stakeholders to develop and implement digital solutions for water management. They focus on creating a supportive environment for innovation, collaboration, and knowledge sharing.

Figure 5 shows the example of Kuopio’s Smart Water Cluster⁷, which is in the North-Savo region of Finland, to illustrate the structure of a smart water cluster and how the stakeholders collaborate to develop innovation within that structure.

⁷ <https://kuopiowatercluster.com/>

Figure 5. Structure of the Smart Water Cluster in Finland



Source: Antikainen (2022)

In terms of their focus on smart water, the Kuopio Water Cluster is one of the examples of clusters belonging to a country which is a partner in WATERLINE consortium. The other ones are in Kainuu, Northern Ostrobothnia and South Savo (Finland), Liberec region, South Moravia and Olomouc (Czech Republic), Lombardy (Italy) and Scotland (United Kingdom). These clusters are members of the Water Smart Territories.

The Smart Water Territories

An example of a public initiative that has brought about the focus on digital water across water clusters in Europe is the Water Smart Territories (WST) Partnership, which was founded by the European Union in 2019. WST’s main goal is to strengthen the innovation capacity of European regions beyond resource efficiency, to facilitate new investments based on open innovation infrastructure and new technologies for sustainable water management by clusters in regional ecosystems. By fostering closer and interdisciplinary collaboration by partner regions and regional cluster organizations, the water industry challenges will be addressed through advanced technological solutions to tackle European water territories and society needs (WST, 2021)

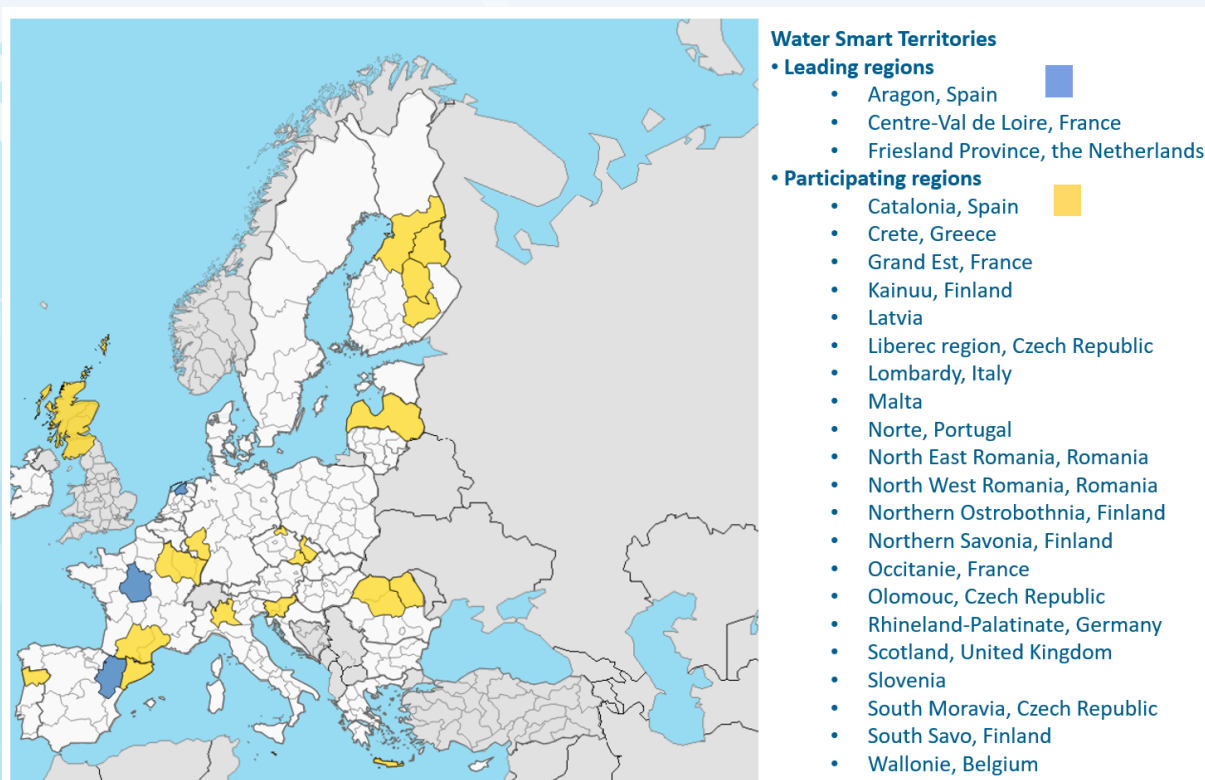
Cross sectoral collaboration in water and ICT sectors are sought to facilitate innovations, as well as exchange of experiences in interregional value chains, investment pipelines and investment platforms will enhance industrial dialogue and will allow the development of innovative technologies and services. Based on a report on specific collaborations (WST, 2021) it was seen some instances of collaborations implemented by WST:

- 1) The Digitalisation working group has worked in collaboration with the Digital Innovation Hubs (DIHs) to provide technologies for pilot studies.

- 2) Through Water Cluster Finland, WST collaborates with SuperIoT AI DIH, which has 300 ICT member companies and close operations with other DIHs around Europe as a member of DIHNET.EU. SuperIoT AI DIH can serve both SMEs and large global companies in developing digital products and services, digital transformation and scaling up the business. It is specialised in IoT and AI, including cloud-based services, Edge computing and wireless connectivity (5G/6G).
- 3) Through Water Alliance and ZINNAE, WST collaborates with an ESCP4i partnership (Techbridge) and an ESCP4x partnership (BLUES), as well as the European Enterprise Network. Aragon region collaborates with the European Business and Innovation Centre Network with more than 150 European business Incubators.

Currently, the WST is composed by clusters from the regions represented in Figure 6.

Figure 6. Water Smart Territories - Leading and participant regions



Source: WST (2021). Note: The Wallonie Region (Belgium) was not listed in the original website of the WST. It has been updated with personal communication (with Zinnea cluster manager).

Living Labs

According to the European Network of Living Labs (ENOLL, n.d.), living labs (LLs) are open innovation ecosystems, functioning in real-life environments and using iterative feedback processes throughout a lifecycle approach of an innovation to create sustainable impact. LLs focus on co-creation, rapid prototyping and testing and scaling-up innovations & businesses, providing (different types of) joint-value to the involved stakeholders. LLs foster co-creation and open innovation engaging the stakeholders of the quadruple helix model of innovation: companies/industry, users/citizens, public organisations/government and researchers/academia (ENOLL, n.d.; Ståhlbröst & Holst, 2012).

Specifically in the field of water research, development and innovation, there are the water-oriented Living Labs (WoLLs), which have two coexisting complementary definitions:

WoLL is a real-life demonstration and implementation instrument that brings together public and private institutions, government, civil society, and academia to jointly build structured grounds to develop, validate, and scale-up innovations that embrace new technologies, governance, business models, and advancing innovative policies to achieve a Water-Smart Society (WE, 2019a, p.12).

and

WOLLs are real-life, water oriented and demo-type and platform-type environments with a cross-sector nexus approach, which have the involvement and commitment of multi-stakeholders (including water authorities) and provide a “field lab” to co-create, develop, test, and validate a combination of innovative solutions, which include technologies, their integration as well as combination with new business models and innovative policies based on the Value of Water (WE, 2019b, p.8; project Water Smart Industrial Symbiosis (ULTIMATE) (n.d.)

The foundational elements of LLs, applied to the characterization of the WoLLs are the shown in Table 1.

Table 1. The foundational elements of WoLLs

Living Lab Elements	Objective in the context of Water-oriented Living Labs
User’s involvement	To involve users of water (e.g., urban/citizens, industry and/or agriculture) and users of innovations that enable a Water-Smart Society (e.g. the users of water + utilities, and service providers such as waste water management companies etc.), allowing them to influence the solution that will affect their life later on.
Service creation	To facilitate and support the development of new ideas, services and solutions that contribute to a sustainable and Water-Smart Society and offering representative (semi) real-life environments of water production, distribution and (re) use, for co-design and validation.
Infrastructure	To provide the physical or virtual environment, to integrate, try-out, validate and measure the performance of water innovations. This may include an experimental set-up (e.g., in labs or demo-sites) or real-life test environments including infrastructures for water production, distribution and (re)use (e.g. at utilities, urban areas, (agro) industrial sites).
Governance	To engage the quadruple helix from the water sector in a (inter) regional context and jointly agree on managing and maintaining the WoLL.
Innovation outcomes	To facilitate innovations that contribute to a sustainable and Water-Smart Society (‘mission focus’). These outcomes can be knowledge, new products and services and/or IPR, and in the form of finished end-user applications, prototypes or mere knowledge about usage patterns.

Living Lab Elements	Objective in the context of Water-oriented Living Labs
Methods and tools	To provide and continuously update specific (interoperable) methods and tools to acquire relevant large scale user data related to the targeted innovation outcomes within the water sector.

Source: WE (2019a)

About the spread of WoLLs across Europe, WE (2019b) mapped 105 LLs operating in the field. An attempt to update the number was made through consultation to the ENOLL website on 09.05.2023, but the search term “water” was not available in the menu options of the website and a mechanical search LL by LL did not prove feasible to try to get the information. The EU-funded project Industry Water-Utility Symbiosis for a Smarter Water Society (ULTIMATE, 2020-2024), is establishing 9 case studies of WoLLs but none of them in the geographical scope of WATERLINE, which would have given more material to understand the dynamics of the LL in the context of the innovation ecosystem.

With a strategic approach, WoLLs pilots are one of the key components of WE’s Strategic Innovation and Research and Agenda (WE-SIRA, 2019c). It aims at the development of innovations through visionary, large scale experimentations in real-life environments to foster the development of migration paths and strategies by means of integrating multiple, real-life living labs in forerunning water-systems in Europe and abroad (leveraging International Cooperation) to set-up realistic and full-scale users’ environments in which complex new combinations of technology innovations, new socio-economic models and practices as well as new governance set-ups can be experimented. The WE-SIRA foresee LL pilots in three areas: Rural, Future Industries and Smart (Peri-)Urban. Some LLs will combine these three area types at regional or international river basin scales targeting across border sustainable, robust, resilient and dynamic water-smart systems strengthening Europe’s contribution to overcome global societal challenges and strengthening the water market in Europe and beyond (WE, 2019c).

2.4 Universities and provision of skills in digital water innovation ecosystems

The role of Universities in S3, according to Markkula and Hune (2015), can be broken down into four areas:

Business innovation: Closely linked, although not exclusively, to the research function of the university

Human capital development: Linked to the teaching function.

Community development: Linked to the public service role of universities.

Institutional capacity of the region: The university contributes through engagement of its management and members in local civil society.

According to Woolford and Boden (2021), due to their multidisciplinary nature, HEIs can contribute to S3 across its different priority areas and functions, ranging from scientists in S3 priority areas, experts

in monitoring and evaluation to HEI managers acting as stakeholders, and potential beneficiaries of S3-related funding.

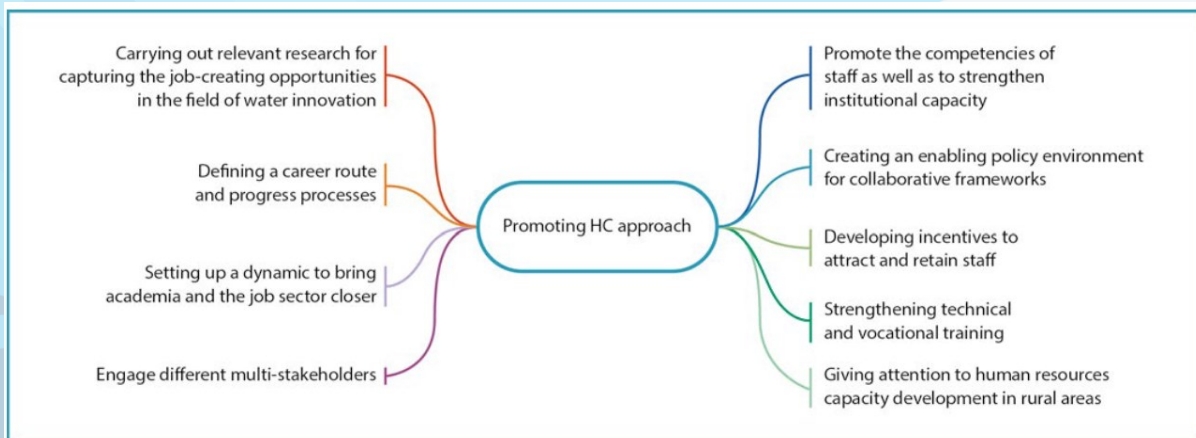
Basically, this role is independent of the focus area of the S3. Woolford and Boden (2021), emphasise the greatest contribution of HEIs lying in the provision of human capital and the capacities and skills of HEI students to implement regional development and growth. Being specific to digital water ecosystems, universities can play a crucial role in the development and implementation of digital water skills and support to the development of solutions to address the complex challenges of water management.

2.4.1 Provision of skills for the digital water ecosystems

Due to WATERLINE’s focus, the highlight is given to the provision of skills and research, development and innovation (RDI) for the sector. The digital water ecosystem requires a range of skills and expertise from professionals across different disciplines, especially trained to face the rapid changes faced by water utilities, which must cope with the rapid changes in the sector, the accelerated development of technologies, the release of new regulations, and the changing environment regarding the quality of wastewater to be treated. The professionals need, besides a sound vocational qualification, access to opportunities to update and renew their knowledge and skills in a process of lifelong learning (German Water Partnership, 2018). WE (2021) suggests from educators the updating of study programmes to include emerging water specialisations that connect learning, research and practice in the fields of digital water and cybersecurity, circular economy, nature-based solutions, and cities and basins of the future.

In transitioning toward a Water-Smart Society, there is a need to supports the upskilling of the workforce to diffuse digital culture in the water sector, which calls for a human capital approach (WE, 2021). The WE’s human capital approach is shown in Figure 7.

Figure 7. Promoting the human capital approach in the water sector



Source: WE (2021, p.15)

There are some examples of projects addressing digital water in education, such as Digitalization of Water industry by Innovative Graduate Water Education (Digiwater⁸) and the Platform of Vocational

⁸ <https://waterharmony.net/projects/digiwater-2/>

Excellence Water (PoVE Water⁹). Other examples of projects that focus on capacity building, education and skilling, institutional transformations and smart specialisations are: Cooperating for Excellence and Impact in Research and Innovation¹⁰ (E³UDRES² Ent-r-e-novators), Boosting INGENIUM for Excellence¹¹ (BI4E), Trailblazing Inclusive, Sustainable and Resilient Cities¹² (InCITIES), and Enhancing the Scientific Capacity of TUBITAK MRC in the Field of Smart Environmental Technologies for Climate Change Challenges¹³ (SMART4ENV), as shown in the clustering report (WATERLINE, 2023b).

Section 4.1 Benchmark: Innovation ecosystem focusing on digital water – WaterCampus Leewarden shows an example of an integrated digital water innovation ecosystem, as well as its connection with the local S3.

⁹ <https://www.povewater.eu/>

¹⁰ <https://www.entrenovators.eu/>

¹¹ <https://boosting-ingenium.com/>

¹² <https://incities.eu/>

¹³ <https://www.smart4env.com/SMART4ENVCOM/>

3. Material and methods

This study utilised a desk research survey as the main method for data gathering. This was combined with interviews to gather understanding of digital water ecosystems and identify benchmarks, which were done with three managers of clusters associated to the WSTs and a researcher associated to a research organization which serves to a digital water cluster and S3. The interviewees were selected based on indication from partners.

The purpose of the desk research survey was to map the innovation ecosystems arrangements, as well as the policy and legal support to local innovation in digital water. It was carried out by the HEI partners that compose the planned Digital Water HEI Alliance in the 8 countries where they are established. For the UK, UNEXE participated as an Associated Partner. The Table 2 lists the partners and countries they surveyed.

Table 2. Countries surveyed and partners

Country	Leading partner
Czech Republic	MENDELU
Finland	TUAS
Italy	UNIRC
Malta	MCAST
Norway	NMBU
Serbia	UNI
Türkiye	DEU-DESU
United Kingdom	UNEXE

The form for the for the collection of information, which is available in Annex 1. Waterline Survey – Guide, was designed by SITES and TUAS. SITES coordinated the task (Task 2.2) and the subsequent reporting.

The approach for the identification of stakeholders and their activities in the digital water innovation ecosystems considered the quadruple helix model of innovation and the S3 for regional development and sustainability.

The interviews were performed with the managers of the Zinnea Cluster for Efficient Use of Water (Aragón region in Spain), Kuopio Intelligent Water Cluster (North Savo region in Finland) and CREA Hydro&Energy (South Moravia region in the Czech Republic), all members of the WSTs. Additionally, an interview was held with a researcher of the Center of Expertise Water Technology (CEW) in the Netherlands.

To illustrate HEIs role in the provision of skills and R&D for digital water ecosystem, results of the survey on needs and availability of skills from industry stakeholders’ perspectives were used (WATERLINE, 2023a).

4. Results

This Session reports on a benchmark case showing a regional development approach to digital water. It is useful as a demonstration of the roles that the quadruple helix stakeholders play in the local digital water innovation system.

4.1 Benchmark: Innovation ecosystem focusing on digital water – WaterCampus Leewarden

This section reports on a benchmark case of digital water innovation ecosystem, which involves a cluster (WaterCampus Leewarden) which functions in the context of the S3 of the Friesland Province in the Netherlands. The main source of information for this case is Water Campus (2020), which was extended with information from interview and the cluster's website.

WaterCampus Leeuwarden¹⁴ is an open innovation ecosystem and business innovation hub in the field of water technology, based in Friesland, Northern Netherlands. It was founded in 2003 and has played a crucial role in tackling water challenges, such as clean water sourcing, natural water production, renewable energy, pollution reduction, and sustainable water use in industries and the circular economy and driving the green transition on both European and global level.

With a focus on research-education partnerships and collaboration with SMEs, WaterCampus brings together education, research, businesses, and public authorities in the water technology sector. It has increased its visibility by being involved on the draft of the S3 and Northern-Netherlands' European Structural and Investment Funds Operational Programme (2021-2027). Finally, it contributes to the European Green Deal and facilitates business investments for a green and resilient economy.

The territorial context and challenge faced: The Netherlands, as a densely populated country and as a host of several chemical companies, faces consistent pollution challenges due to its position in the Rhine River delta area. The Dutch have prioritized water purification for various purposes, including the treatment of urban and industrial wastewater. Thanks to its history regarding the building of dykes and water defences, the Netherlands, in the last decades, has stood out, on a global scale, in terms of developing a solid expertise in water technology. The country is well-equipped to address different flooding and water scarcity issues. COVID-19 has stressed the importance of clean water supplies. Thus, water technology appears fundamental for addressing various environmental challenges.

Content and implementation of the initiative: WaterCampus is supported by the city and by European Regional Development Funds from successive Northern-Netherlands' Operational Programs. Its infrastructure includes research facilities, an incubator for water technology-based companies, and conference spaces. Around 200 people are employed there, and it offers demo-sites for practical demonstrations of water technologies.

The main managing partners of WaterCampus, which form the Governing Board, are: Wetsus - European Centre of Excellence for Sustainable Water Technology; Water Alliance – the Netherlands national cluster organisation for innovative water technology SMEs; and the Centre of Expertise Water

¹⁴ <https://www.watercampus.nl/>

Technology (CEW) - linked to universities of applied sciences and supporting demonstration and upscaling innovation activities.

Other main partners are:

- City of Leeuwarden and Province of Friesland;
- Centre for Innovative Craftsmanship - Water – liaison organisation for water technology in Vocational Education and Training (VET) Schools;
- BioBizz hub - centre for scale-ups/ small business to test and validate their innovations to bring new technology to the market;
- Water Application Center – a research centre providing state-of-the art facilities for experimentation in the field of water technology.

WaterCampus is actively involved in education at various levels, from primary to university, as well as vocational training and adult learning. It holds strong partnerships with schools, vocational institutions, and nearby universities. For example, CEW, is the leading knowledge and innovation centre for applied research and product development in the field of water technology, which brings together expertise from education, research, government and industry. Although, not a training institute, CEW teaches through practice to students affiliated to universities, universities of applied sciences, including international students, by means of placements and apprenticeships.

Over 220 companies and 25 research centers have established solid links with WaterCampus. In 2019, its annual budget was around €20.3m, with a consistent funding from public, EU grants, and private sources.

Strong linkage with Smart Specialisation processes in the Northern Netherlands and beyond

Clean and safe water is a top priority in the Northern Netherlands S3, which has already adopted the sustainable development and societal challenges approach in its approach. In its current S3 it focuses on 4 (European) challenges for which the region has the capabilities to contribute to the solutions: Healthy and secure supply of food; sustainable use of energy; clean water and good health (Smart Specialisation Platform, n.d.b).

In addition, WaterCampus continues to contribute to S3 stakeholder discussions, including the newly formed Northern Innovation Partnership. It also participates in the interregional S3 Thematic Platform 'Water Smart Territories', promoting collaboration and attracting talent from across Europe and from other continents. This engagement has enhanced WaterCampus' visibility and facilitated potential investments through EU-level networking. Besides the WSTs, it collaborates with EU cross-border partnerships, including EIT RawMaterials and iWATERMAP. Furthermore, the managing partner Wetsus, facilitates interdisciplinary research involving 50 professors and 106 companies to develop the conditions for water technology solutions with a commercial relevance.

An example of WaterCampus project: European Platform for Vocational Excellence (PoVE)

WaterCampus management partner CIV-Water secured a €1m EU grant from ERASMUS in 2019 to establish a European Platform for Vocational Excellence (PoVE) in the water sector. The project involves VET institutions from the Netherlands, the UK, Latvia, Malta, and Czech Republic, aiming to promote VET's potential in sustainable growth and innovation. The implementation of the PoVE project at WaterCampus involves active contributions from various actors, enabling VET and university students to cooperate in SMEs during the testing phases.

Achievements

Since its establishment, WaterCampus has collaborated for:

- The generation of over 50 water technology start-ups.
- The development of over 80 high value water technology patents.
- International awards one by several companies supported by the WaterCampus.
- Over 100 PhD graduations.
- Publication of over 700 highly cited scientific articles.
- A numerous involvement of MSc thesis students in plenty of remarkable international cooperation projects lead by WaterCampus and partners.

4.2 WATERLINE HEIs partnership countries innovations ecosystem mapping

This section presents the results of the desk research survey implemented by WATERLINE partners in their respective local regions. The results are shown by countries listed in alphabetical order. The structure observed is the following:

Institutional environment showing the legislation and strategic guidance of the water sector, and if available, specifically for digital water.

Innovation Ecosystems showing the different arrangements present dedicated to the development of digital water innovations, following the quadruple helix approach.

Funding and business support showing the programmes and other opportunities to support RDI in digital water.

HEIs showing the activities performed by the local HEIs in the field of digital water, concerning education and R&D, and collaboration between industry and academia.

Civil society showing the civil society and other type of associations, non-governmental in their nature, engaged with promotion of RDI in digital water.

Finally, bearing on results from Task 2.1, it is shown how the needs of the industry and what skills are perceived as available for all the types of skills surveyed. This is done because of the assumption that the industry is the main locus for the development and deployment of innovations. Mismatches between needs and availability may jeopardize up taking of the innovations by the workforce or lead to unnecessary search efforts when same skills appear in both columns. The skills survey methodology is explained in detail in D2.1 (WATERLINE, 2023a).

4.2.1 Czech Republic

The challenges facing the development of the digital water sector in the Czech Republic are related to the awareness of the practical use of digital water. Czech companies are progressive and unfavorable cost-benefit relationship. Industry is able to fastly adopt new technologies, the general public and policy makers though, need longer time to adapt to changes. The most important and most

challenging obstacle for the coming years will be the proper marketing of the digital water to the civil society and policy makers. Nonetheless, it is noteworthy to inform that the Water Supply and Sewerage Association of the Czech Republic (SOVAK CR) has, already in 2021, organised the first “Digital Water Conference” in the Czech Republic, when it had very positive response from the cluster members and other stakeholders.

Institutional environment

The main legislation regarding water in the Czech Republic is Zákon č. 254/2001 Sb., zákon o vodách (“vodní zákon”) Water Act - The 2001 Water Act¹⁵ is the overarching law for the protection and management of water resources. It includes provisions for water conservation, flood prevention, economic instruments for water management, water planning and international co-operation. It also regulates water discharge permits. Table 3 shows the strategies and policies supporting the water sector in the country.

Table 3. Strategies and policies in the water sector - Czech Republic

Strategies and Policies	
Strategy/Policy	Short Description
2000/60/ES Water Framework Directive (WFD) ¹⁶	Good qualitative and quantitative status of all water bodies.
Nitrates Directive (91/676/EEC) ¹⁷	Reducing water pollution caused or induced by nitrate leaching from agricultural sources.
State Environmental Policy of the Czech Republic 2030 with outlook to 2050 ¹⁸	Defines priority problematic areas in relation to the environment in the Czech Republic, formulates strategic and specific objectives based on these areas, and outlines their possible solutions.
Koncepce environmentální bezpečnosti 2021-2030 s výhledem do roku 2050 ¹⁹	State concept of environmental security
Generel území chráněných pro akumulaci povrchových vod ²⁰	Areas designated for surface water accumulation
Koncepce na ochranu před následky suchapro území České republiky ²¹	Drought protection strategy
Strategie ochrany před povodněmi pro území České republiky ²²	Flood protection strategy
Mezinárodní komise pro ochranu Odry ²³	International Commission to protect the Odra from pollution
Mezinárodní komise pro ochranu Labe ²⁴	International Commission for the Protection of the Elbe River

¹⁵ <https://www.zakonyprolidi.cz/cs/2001-254>

¹⁶ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32000L0060>

¹⁷ <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A31991L0676>

¹⁸ [https://www.mzp.cz/C1257458002F0DC7/cz/statni_politika_zivotniho_prostredi/\\$FILE/SPZP-2030_4AK_EN-20220525.pdf](https://www.mzp.cz/C1257458002F0DC7/cz/statni_politika_zivotniho_prostredi/$FILE/SPZP-2030_4AK_EN-20220525.pdf)

¹⁹ [https://www.mzp.cz/C1257458002F0DC7/cz/environmentalni_bezpecnost/\\$FILE/OBKR-koncepce_environmentalni_bezpecnosti_2021_2030_2050_cz-20210916.pdf](https://www.mzp.cz/C1257458002F0DC7/cz/environmentalni_bezpecnost/$FILE/OBKR-koncepce_environmentalni_bezpecnosti_2021_2030_2050_cz-20210916.pdf)

²⁰ <https://eagri.cz/public/web/mze/voda/osveta-a-publikace/publikace-a-dokumenty/publikace/generel-uzemi-chranenych-pro-akumulaci-2.html>

²¹ <https://eagri.cz/public/web/mze/ministerstvo-zemedelstvi/koncepce-a-strategie/koncepce-na-ochranu-pred-nasledky-sucha.html>

²² https://eagri.cz/public/web/file/365715/Strategie_ochrany_pred_povodnemi.pdf

²³ <http://www.mkoo.pl/index.php?lang=CZ>

²⁴ <https://www.ikse-mkol.org/en>

Strategies and Policies	
Strategy/Policy	Short Description
Mezinárodní komise pro ochranu Dunaje ²⁵	International Commission for the Protection of the Danube River
Národní plán Dunaje ²⁶	Summary and management of Danube River basin
Národní plán Labe ²⁷	Summary and management of Elbe River basin
Národní plán Odry ²⁸	Summary and management of Odra River basin
Strategie přizpůsobení se změně klimatu v podmínkách ČR ²⁹	Adaptation measures against climate change
Plány pro zvládnání povodňových rizik ČR	Flood protection

Concerning strategic policy documents dedicated to smart water technology, the Czech Republic, based on Directive (EU) 2018/2002 of the European Parliament and of the Council amending Directive 2012/27/EU on energy efficiency³⁰, implemented remote metering for heating, cooling and domestic hot water. In the Czech Republic, implementation of smart water technologies is in the hands of individual companies and municipalities. It is in their interest to use the best available technology to save expenses and improve the quality of the work. This is supported by broad offers from various smart water technology brokers.

Smart Specialisation Strategies

The National Research and Innovation Strategy for Smart Specialisation of the Czech Republic is a strategic document ensuring that resources from European, national, and local budgets and related private resources are effectively targeted at supporting oriented and applied research and innovation within prioritised promising areas. The identification and development of these promising areas, i.e., the smart specialisation builds on the strengths of the Czech Republic and individual regions. It strives for targeted “smart” use of the opportunities offered by our economic background and research and innovation capacities. At the same time, the weaknesses of the innovation system, which represent barriers to the development of the innovation environment as a whole, are being addressed.

Water and wastewater and wastewater resources management is part of the national, as well as regional S3, nonetheless digital water is not explicitly mentioned in the strategical plans.

Digital water innovation ecosystems

Clusters

²⁵ <http://www.icpdr.org/main/>

²⁶ <https://eagri.cz/public/web/mze/voda/planovani-v-oblasti-vod/priprava-planu-povodi-pro-2-obdobi/zverejnene-informace/narodni-plany-povodi-1/narodni-plany-povodi-dunaje.html>

²⁷ <https://eagri.cz/public/web/mze/voda/planovani-v-oblasti-vod/priprava-planu-povodi-pro-2-obdobi/zverejnene-informace/narodni-plany-povodi-1/narodni-plany-povodi-labe.html>

²⁸ <https://www.poh.cz/narodni-plan-povodi-labe-odry/ds-1083>

²⁹ https://www.mzp.cz/cz/zmena_klimatu_adaptacni_strategie

³⁰ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L20021>

The clusters related to digital water in the country are the CREA- Hydro&Energy Cluster in the South Moravia region, the Nanoprogress Cluster in the Olomuc region, and the cluster represented by the Institute for Nanomaterials, Advanced Technologies and Innovation, in the Liberec region (CXI). All of them are members of the participant regions of the WSTs.

Nanoprogress Cluster³¹ has 57 member companies from different fields gathered for common interest in nanotechnologies development. Nanoprogress participates in several international projects, such as Blue and Eco industries cluster exchange for industrial modernisation (BLUES). BLUES supports collectively the competitiveness of the cluster community (especially SMEs) and use water sustainability and the green economy as a common thread. The partnership is based on interregional and intersectoral cooperation between water resources and technologies for all types of water users - industrial, urban, agricultural (Aqua Valley - France; ZINNAE - Spain) and key enabling technologies, such as plasma technology (BNPT - Germany), nanotechnology (Nanoprogress - Czech Republic) and ICT (MCICT - Poland).

CXI - The Institute for Nanomaterials, Advanced Technologies and Innovation is a research centre, one of the parts of the Technical University of Liberec. Applied research in collaboration with industry partners is one of its priorities. CXI offers cooperation in the form of expert consultation, measurement and analysis, contract research or joint research projects. CXI have access to the latest scientific knowledge and efficiently developing new or innovating your existing technologies and products.

CREA Hydro&Energy, z.s.³² is a cluster of companies, research institutions and universities operating in the field of technologies for water works, water and waste management and renewable energy sources. Members of the cluster jointly participate in research, development and innovative products, promotion of the field, presentations and implementation of projects in the Czech Republic and in the world. It participates in the project connected to smart water - European Water initiative for fostering International Sustainable Development³³ (euWater4i-SD) is as a member of the WSTs.

SOVAK. The Water Supply and Sewerage Association of the Czech Republic (SOVAK ČR) is a voluntary, non-profit organization in the field of water management and sewerage for the public sector.

Missions:

- To represent its members in negotiations with state bodies in matters which are in the common interest of its members (primarily related to the field of legislation, the technical normalization and to the creation of economic regulations),
- To secure activity and services according to the requirements and interests of its members, particularly those of an informative, methodical, consultancy and educational character,
- To co-operate with similar organizations at home and abroad,
- To issue the professional magazine Sovak for the use of its members,
- To hold an industry exhibition,
- To hold professional training sessions, courses and other educational events.

³¹ <https://www.nanoprogress.eu/en>

³² <http://www.creacz.com/index.php/en/homepage-in-english/>

³³ <https://profile.clustercollaboration.eu/profile/cluster-partnership-initiative/71ced087-0b2d-4c97-ab80-0dcc67bdf2ff>

Living Labs

The WoLLs operating in the Czech Republic are the Římov Reservoir and the Experimental basins Červík and Malá Ráztoka.

Římov Reservoir, hosted by the Biology Centre ASCR, Institute of Hydrobiology Biology Centre³⁴. Since 1996, the Římov reservoir has been a part of the Czech Long-Term Ecosystem Research (LTER) network. The parameters studied include physical, chemical and biological data on pelagic organisms like bacteria, protists, phytoplankton and zooplankton. Once per year, the abundance and species composition of fish is investigated. Besides regular monitoring, a lot of extensive studies were done of pelagic organisms, their diversity, interactions and functions as well as chemical processes in water and sediment, both in the lacustrine part and in the canyon-shaped riverine part near the inflow. Such intense studies were possible due to the vicinity of well-equipped labs in České Budějovice and the construction of a field station at the dam (in 1994).

The Experimental basins Červík and Malá Ráztoka³⁵ are hosted by the Forestry and Game Management Research Institute and consist of two small experimental basins Červík and Malá Ráztoka in the Moravian-Silesian Beskids started on the 1st of November 1953. The research has been focused on the evaluation of the forest's impact on the hydrological regime of the basins.

Funding

Information not supplied.

Business and development support

There are some examples of installations of companies developing measuring devices in the country. They are installed as part of smart city strategies, and basin enterprises install monitoring systems for data gathering. Brokers, like Ekotechnika s.r.o. and Santy, are suppliers and developers of corresponding digital water technology. SMEs are acting as suppliers of technology, but they can also ensure the maintenance and installation of the digital water systems.

There is no knowledge on start up support or other business accelerator programs supporting digital water sector in the country.

Higher Education Institutions

The Czech Republic does not have specific digital water education framework or guidelines. The trend of digitalisation is though covered by the Strategy for Education Policy of the Czech Republic up to 2030+³⁶. The need to create an education framework will appear with coming widening of the digital water use. Firstly, it is necessary to work on awareness campaign connected to water and wastewater use and the potential of digital technologies for smart management. Consequently, the educational system will be pushed to implement framework for the given topic. Digital water has been subject of teaching and research in the following HEIs shown in Table 4.

³⁴ <http://www.hbu.cas.cz/>

³⁵ <https://www.vulhm.cz/en/>

³⁶ https://www.msmt.cz/uploads/brozura_S2030_en_fin_online.pdf

Table 4. HEIs activities in digital water in the Czech Republic

Higher Education Institutions and activities in digital water						
Mendel University in Brno ³⁷	Czech Technical University in Prague ³⁸	Brno University of Technology ³⁹	Czech University of Life Sciences Prague ⁴⁰	University of Chemistry and Technology Prague ⁴¹	Jan Evangelista Purkyně University in Ústí nad Labem ⁴²	University of South Bohemia in České Budějovice ⁴³
Teaching and research focus on water resources management at all faculties (Agrisciences, Forestry and Wood Technology, Horticulture, Regional Development and International Studies, and Business and Economics.	Technical university with civil engineering study programmes, which among others focuses on water constructions.	Technical university with civil engineering study programmes which among others focuses on water constructions.	Life science university with teaching courses and research focused on water resources management at the Faculty of Environmental Sciences.	Activities at the Faculty of Environmental Technology focus on chemistry covering on water analysis and water/wastewater quality.	University with teaching and research in fields of geoinformatics and landscape reclamation at the Faculty of Environment.	Two faculties cover water management teaching and research: Fisheries and Water Protection and Agrisciences and Technology.

³⁷ <https://ldf.mendelu.cz/en/>, <https://af.mendelu.cz/en/>

³⁸ <https://www.fsv.cvut.cz/?lang=en>

³⁹ <https://www.fce.vutbr.cz/en>

⁴⁰ <https://www.czu.cz/en>

⁴¹ <https://ftop.vscht.cz/home?jazyk=en>

⁴² <https://www.fzp.ujep.cz/en/>

⁴³ <https://www.frov.jcu.cz/cz/>

The matching of skills on demand by the industry and skills available, either they believe their employees have or are trained to perform, in the Czech Republic is shown in Table 5. This is the result of the survey done in T2.1.

Table 5. Skills needed and present in digital water according to industry stakeholders – Czech Republic

Type of Skills	Needed	Present
Water resources management	Applying ICT in WRM	Applying ICT in WRM
Academic	Learning from experience Computer skills	Computer skills
Interdisciplinary teaching and learning	Problem solving	Collaboration
Soft	Accountability	Accountability
Technical	Data acquisition and processing	Data acquisition and processing Measurement and instrumentation
Transversal	Learning to learn Prioritising and organising Delivering quality and results	Learning to learn

Table 5 shows that most of the needs of the industry have a corresponding offer by the local HEIs. Only a few needs are not contemplated. Besides, in the case of incorporating these demanded skills into their curricula and capacity building activities, local HEIs should be aware that their skills supply is barely below the industry current needs. To face future demands pressed by the changes in the sectors, they should advance in their preparation to correspond to that scenario.

Industry-academia collaboration

Academia is cooperating with clusters and individual companies. As an example, it is the close cooperation of the Mendel University in Brno and Technical University Brno with the cluster CREA in the context of the project Mapping of the Innovation Ecosystem of Water Management⁴⁴ (iWATERMAP).

Civil society

There was no available information regarding the engagement of NGOs or other type of civil society organisations with the digital water sector.

4.2.3 Finland

Digital water solutions are widely adopted in Finland without major challenges, although cybersecurity remains a notable concern raised by expert groups. The main challenge points to the lack of studies focusing on digital water education in the country.

⁴⁴ <http://www.creacz.com/index.php/en/mapping-the-innovation-ecosystem-of-water-management/>

Institutional Environment

The main legislative documents and strategies and policies guidelines in Finland are listed in Table 6.

Table 6. Legislation, policies and strategies in the digital water sector

Legislation	Strategies and Policies	
	Strategy/Policy	Short Description
Vesilaki (587/2011) (Water law)	International Water Strategy 2019	Strategy focuses on Finland's international objectives and activities related to water.
Laki tulvariskien hallinnasta (620/2010) (Law on flood protection)	Strategy of the Finnish Water Utilities Association	The general development of water management and the operations of the utilities, including drinking water supply, wastewater and distribution.
Laki vesienhoidon ja merenhoidon järjestämisestä (1299/2004) (Law on water protection)	Water Resources Management Strategy of Finland 2030	Lays the foundation for the operations, finances and performance guidance of water resources management tasks by the Ministry of Agriculture and Forestry. Digitalisation is expressed in the context, no further operationalisation. Digitalisation and new technologies enable improved efficiency and effectiveness in water resources management tasks. Innovations also create new business.
Vesihuoltolaki (119/2001) (Law on water services)		

Smart Specialisation Strategies

South Savo and North Savo regions are the only ones which have specifically named water business development or smart water as one of their main spearheads in their S3.

South Savo's S3⁴⁵ strategic priorities are forest, food, and water. The water system spearhead has the following key objectives: comprehensive management and optimisation of water systems with the aid of digital methods and ensuring that companies in water-intensive industries can continue operating successfully through development of wastewater technologies. Additional objectives are ensuring enough competent people in water resources management and accelerating the implementation and market entry of water technology innovations with the aid of innovation ecosystems.

The North Savo⁴⁶ regional priority and S3 has among its focus areas "Smart water system", with a goal to achieve smart and comprehensive management of water and wastewater systems and growth in

⁴⁵ https://www.esavo.fi/resources/public/Kehittaminen/Maakuntastrategia/ES_maakuntastrategia_2030_25112020.pdf, <https://rakennerahastot.fi/en/south-savo>

⁴⁶ https://www.esavo.fi/resources/public/Kehittaminen/Maakuntastrategia/ES_maakuntastrategia_2030_25112020.pdf

business activities. The implementation of the S3 in the region follows the approach presented earlier in the case of the Kuopio Water Cluster in Sub-session 2.3.1 Ecosystem arrangements.

In Finland, the S3 and regional strategies in general are conducted by the regional council, which organises the involvement of a wide range of stakeholders, including businesses, the education sector, NGOs and citizens. The S3's formulation and implementation involve all stakeholders in the regions.

Innovation Ecosystems

Clusters

Finnish digital water clusters include the Kuopio Water Cluster, already presented in Sub-section 2.3.1 Ecosystem arrangements and the following:

Turku Water Ecosystem, which focus on enhancing collaboration between academia, authorities, and water utilities. It is located in Turku region and its stakeholders are the Turku University of Applied Sciences and the Turku University (academia, water services companies operating in Turku, the Union of the Baltic Cities (NGO) and the Turku city (public sector).

Allied ICT Finland (AIF), which is a collaboration network of 11 research institutes, 5 cities, 10 business ecosystems, thousands of researchers and more than 1200 companies. AIF ecosystems form a concentrated pool of smart specialisation, high technology assets and the latest knowledge for companies to co-operate and develop with each other and the other key players of the industry. The main goal of AIF ecosystems is to enable business growth and internationalization for Nordic companies. The Water Ecosystem is one of the AIF ecosystems and it focuses on developing more efficient, environmentally friendly, and high-quality methods for the operation and maintenance of industrial and municipal water processes. This is achieved by combining leading edge expertise and innovations from research fields, technologies, product development and commercialization.

The Blue Economy Mikkeli (BEM) cluster brings together companies, research institutes, and financiers to expand businesses in the water sector. The BEM cluster is concentrated around the EcoSairila MBR water treatment plant and the biogas plant connected to it. The cluster is a collaboration network intended to strengthen collaboration between its members and offer a range of services for testing and piloting in a genuine water plant environment.

Living Labs

Finland has a few WoLLs, but none of them are specifically focused on smart/digital/intelligent water. These labs focus often on single projects rather than a broader framework. The concept of a LL is not well-known in Finland, which could represent the reason behind the low number of WoLLs. However, there are several research facilities in the country that could potentially meet the criteria for a LL, such as the BEM cluster and Turku Water Ecosystem described above. In Finland the laboratories of universities are often open to external stakeholders like companies and collaboration projects.

Business Development support

There are numerous companies in the water sector that utilise digital tools in their products and services. Most of these companies are members of the Finnish Water Forum⁴⁷ (a platform for

⁴⁷ <https://www.finnishwaterforum.fi>

collaboration and information exchange within the industry). Full list of members is available on the website.

Funding

Nauwelaers et al (2022) give an overview of the role of government and public sector agencies regarding funding and policy making for regional development in Finland. For specific RDI projects, the main public funding sources are Business Finland, Academy of Finland, Tekes and Sitra (to these should be added the Ministry of Agriculture and Forestry), but they do not consider regional S3s in their funding procedures. These is only done by regionally distributed Centres for Economic Development, Transport and the Environmen (ELY-Keskus centres), under the Ministry of Employment and Economy. The ELY-Keskus centres manage Cohesion Policy Funds and have received a new obligation to check projects for alignment with regional S3s. European funding comes from the European Regional Development Fund (ERDF), European Structural Fund (ESF) and INTERREG. are the main sources of national funding. Horizon Europe as well as Interreg and regional EU fundings are commonly used for funding water-related research and innovation.

Higher Education Institutions

There is a lack a national education framework or policy specifically targeting digital water sector in Finland. However, recent studies have highlighted the importance of incorporating digital competences into the education of future water experts, emphasizing the need for increased emphasis on this aspect (Salminen et al, 2015).

A working group was set up by the Finnish National Agency for Education to define the future competence needs in the fields of water supply and water protection and emissions management⁴⁸. The anticipation group examined each industry in the light of cooperation with other industries and stakeholders that will be needed in the water sector and identified the following trends and needs:

- Cooperation with various parties is expected to increase. There will be a growing demand for interdisciplinary competence and exploitation of digitalisation and new technologies in the water sector. The water sector will need experts with a broad understanding of how to utilize their competence in a rapidly changing and increasingly international environment.
- There is a need for versatile water sector expertise, a need to master the operating environment, and communication skills. ICT and the exploitation of digitalisation and artificial intelligence, including data analytics, improved efficiency of processes and knowledge management, risk management, skills in product development and commercialisation of technologies, and the development of networking and cooperation models, as well as communication were seen as important future competences.

Error! Reference source not found. shows the HEIs active in Finland in the field of digital water.

⁴⁸ https://www.oph.fi/sites/default/files/documents/vesi_vanhin_voitehista.pdf (abstract in English)

Table 7. HEIs activities in digital water - Finland

Higher Education Institutions and activities in digital water						
Savo Vocational College ⁴⁹ (SAKKY)	South-Eastern Finland UAS ⁵⁰ (XAMK)	Aalto University ⁵¹	University of Oulu ⁵²	University of Jyväskylä ⁵³	Sykli Environmental College ⁵⁴ (SYKLI)	Lappeenranta UT ⁵⁵ (LUT)
SAKKY offers vocational qualification in the field of environment, expertise in water management.	XAMK offers a Bachelor of Engineering, Environmental Engineering.	Aalto offers a degree in Water and Environmental Engineering, Master of Science. Courses Hydrological Modelling, Modelling and Control of Water and Wastewater Treatment Processes Research calculation and modelling research	Courses environmental measurements and monitoring. Research modelling research	Courses Geoinformatics, data management, modelling Research biodiversity and genomics data	SYKLI offers vocational qualification in the field of water management. Courses education in automation and measurement	Courses Education in measurement and automation technology LUT is doing research to create a new wastewater treatment plant that will meet the challenges of the future.

Note: UAS= University of Applied Sciences

⁴⁹ <https://sakky.fi/fi/koulutukset/ymparistoalan-ammattitutkinto-vesihuollon-osaamisala-toivala> (Only in Finnish)

⁵⁰ <https://www.xamk.fi/en/degrees/bachelor-of-engineering-environmental-engineering-b-eng/>

⁵¹ <https://www.aalto.fi/en/programmes/masters-programme-in-water-and-environmental-engineering>

⁵² <https://www oulu.fi/en/university/faculties-and-units/faculty-technology/water-energy-and-environmental-engineering>

⁵³ <https://www.jyu.fi/science/en/bioenv/research/natural-resources-and-environment>

⁵⁴ <https://sykli.fi/koulutusalat/vesihuolto/> (only in Finnish)

⁵⁵ <https://www.lut.fi/en/studies/technology/bachelors-programme-technology-and-engineering-science>

Table 7: Continuation

Higher Education Institutions and activities in digital water							
	Hyria	Turku UAS (TUAS)	University of Helsinki (UH)	Häme UAS (HAMK)	Oulu UAS (OAMK)	Tampere University (TUNI)	Tampere UAS
	Hyria offers a vocational education in environmental management	<p>Courses Smart water topics included in several water courses</p> <p>Research: Research in many topics</p>		<p>Bachelor of Natural Resources</p> <p>Courses: basics about monitoring</p>	Energy and environmental engineering	<p>Water Engineering</p> <p>Research: online measuring and monitoring</p>	Environmental engineering

Note: UAS= University of Applied Sciences

Table 8 shows the skills required and the skills assumed as available for the industry. In this specific case, Finnish business stakeholders did not answer the survey, but it was verified that cluster managers answered as HEIs and research centres, as in Finland the clusters are often managed by local universities, and utilities answered as public sector. So, answers from these groups of stakeholders are utilized as proxy for industry.

Table 8. Skills needed and present - Higher education and research institutions and public sector - Finland

Type of Skills	Needed	Present
Water resources management	Using of mathematical models for the simulation of water related processes Understanding of climate changes, hydrological hazards and their effects on WRM	Understanding of climate changes, hydrological hazards and their effects on WRM Understanding of the Water Framework Directive and its implementation processes Understanding the hydrologic cycle, the various natural processes, and the simulation methods
Academic	Research skills Computer skills Goal planning Communication and networking skills	Communication and networking skills Content creation Computer skills Presentation and public speaking skills
Interdisciplinary teaching and learning	Critical thinking Creativity Open-mindedness Problem solving	Critical thinking Problem solving Collaboration Open-mindedness
Soft	Conflict management Analytical	Self-management Teamwork Decision-making Analytical Self-motivation
Technical	Project management	Measurement and instrumentation Social media Project management
Transversal	Sense of initiative and entrepreneurship Leadership Self-profiling Prioritising and organising Delivering quality and results	Prioritising and organising

For most skills needed they are also assumed as available, which seems the stakeholders are not fully aware of what it is available on the market.

Academia industry-collaboration

Active academia-industry collaboration involves various practices like visiting lecturers, part-time academic staff in industry, RDI project collaborations, accessible research facilities, and student projects for companies. Water clusters play a vital role in fostering partnerships and innovation. There is currently no available evaluation of the performance of this collaboration.

Civil society

Finnish Water Utilities Association (FIWA) and Finnish Water Forum are the two water-related organisations which play a crucial role in fostering innovation, by bringing together different actors and organizing experts into different working groups.

4.2.4 Italy

In Italy, the attention paid to the digitalisation of water management is growing only recently, and there are many challenges to face at local, regional, and national levels, to implement innovation. It is due to the lack of related policies, of proper financial tools and of industrial skills. One relevant document is the National Strategy for Circular Economy⁵⁶, derived from the National Recovery and Resilience Plan. It is a strategic document providing actions, objectives and measures that are intended to be pursued as institutional policies with the purpose to ensure an effective transition towards a circular economy. It highlights the strategic role to be entrusted to digitalization and to the related technologies, which can be developed and integrated for the efficient use of resources, including water, water services management, wastewater valorization, and the contribution of the water supply chain to the country's circular transition.

Institutional Environment

The main legislative documents and strategies in the field of water management and, particularly in digital water are listed in Table 9.

Table 9. Legislation, strategies and policies in the water sector - Italy

Legislation	Strategies and Policies	
	Strategy/Policy	Short Description
Legislative Act 2006/152 "Environmental Standards"	EC Directive on Water Framework (Directive 2000/60/EC).	Water management, water resources, inland waterway, groundwater, surface water, territorial waters, water protection.
Legislative Act 2023/18 on the Adoption of EU Directive 2020/2184 on quality of water intended for human consumption	EU Directive on quality of water intended for human consumption (Directive 2020/2184 - recast), adopted in Italy with Legislative Decree 2023/18	Water for human consumption, human health, water safety, management of water supply systems.

⁵⁶ https://www.mase.gov.it/sites/default/files/archivio/allegati/PNRR/SEC_21.06.22.pdf

Law Decree 121/2021 Urgent measures on investment and infrastructure security	Regulation on minimum requirements for water reuse (EU Regulation 2020/741)	Water quality, risk management, use of reclaimed water in the context of integrated water management.
	National Plan of Infrastructural Interventions and Safety in the Water Sector	Mitigation of drought-related damage, water infrastructure innovation, resilience of water systems to climate change, water resource saving.
	National Recovery and Resilience Plan	Water-related topics: digitalization and innovation in ensuring security of supply and sustainable management of water resources integrated monitoring and analysis of climate change effects through advanced and systems education and training.
	White Paper 2021 "Water Value for Italy"	Smart water meters.

In terms of strategic documents, it is worth mentioning the White Paper 2021 "Water Value for Italy", which deals with the issue of water resource management as a driver of competitiveness and sustainable industrial development, with the aim of making proposals to the country system. Starting from current situation, it provides a set of priorities of action to orient the water supply chain in the country towards an efficient and sustainable resource use, in sight of the country's circular transition.

Smart Specialisation Strategies

Italian regions' S3 have approached digital water as shown in the examples below:

The Piedmont's Intelligent Specialisation Strategy⁵⁷ approaches the topic in the field of activity "Technologies and services for sustainability and the circular economy" and trajectory "Urban services and utilities", as:

- Digital solutions for monitoring, analysis, management and protection, networks of distribution networks for water, energy, gas and services.
- Digital solutions for resource demand optimisation (water, energy, gas and services that reduce waste) through profiling and engagement of citizens and large consumers.
- Systems for measuring consumption and monitoring the quality of water resources water, control of water networks.

In the **Smart Specialisation Strategy of the Autonomous Region Valle D'aosta/Vallée D'aoste 2021-2027**⁵⁸ digital water is approached within the "Energy Infrastructures, Interconnections and Smart

⁵⁷ <https://www.agenziacoazione.gov.it/s3-smart-specialisation-strategy/s3-nella-programmazione-2021-2027/>
https://www.agenziacoazione.gov.it/wp-content/uploads/2022/08/S3_2021_2027_Piemonte_completa-1.pdf

⁵⁸ <https://www.agenziacoazione.gov.it/s3-smart-specialisation-strategy/s3-nella-programmazione-2021-2027/>
https://www.regione.vda.it/Portale_impreses/Strumenti_di_programmazione/Smart_Specialisation_Strategy/s3vda_i.aspx

Energy Systems” trajectory, with a focus on Infrastructure for the collection, adduction and distribution of water for the different uses, including pumping.

The Smart Specialisation Strategy for Research and Innovation of the Lombardy Region⁵⁹ approaches digital water within the green industry focus area, which includes water management and purification and prioritizes the reduction of water consumption and recovery, and water quality amongst other key priority themes in energy and cleantech.

In the **Smart Specialisation Strategy for Liguria**⁶⁰, one of the axes of the S3 is connected to the “Centre of Competence Security and Optimisation of Strategic Infrastructure 4.0 - Start 4.0”, for the security and safety of data and infrastructures linked to energy, water and other strategic resources.

The **Smart Specialisation Strategy for Emilia-Romagna**⁶¹ focuses on the water nexus to address water challenges in a cross-sectoral manner, integrating water, energy, food, and ecosystems into a single circularity challenge, with measurable environmental, economic, technological and social impacts.

The **Smart Specialisation Strategy for Campania**⁶² (**RIS3 Campania 2021-2027**) has focused on investments in the adaptation of water and wastewater infrastructure to climate change also through the reduction of network losses with innovative technological systems.

The **Smart Specialisation Strategy - Apulia Region**⁶³ has as one of its main objectives to promote the efficient use of water resources, through key enabling technologies related to life sciences, advanced materials and nanotechnology.

In the **Smart Specialisation Strategy for Innovation and Research of Calabria Region 2021-2027**⁶⁴, the region has invested in the experimentation and implementation of new technologies for systems for water service management, through smart monitoring networks and chemical-biological and physical control systems using sensors and IoT.

The **Smart Specialisation Strategy - S3 Sicily, 2021-2027**⁶⁵, focuses on technologies for the circular economy and water management, using emerging enabling technologies as biobased/biotechnology.

S3s in Italy follows the same methodology as in other regions of Europe, that is the main reason just to mention how the strategies focus on digital water and not on the arrangements through which they are implemented. As a methodological requirement they promote the engagement with the quadruple helix stakeholder groups and are funded through the Regional Councils.

⁵⁹https://www.s3.regione.lombardia.it/wps/wcm/connect/46779282-7753-4802-be85-837f90ace3ed/RIS3_Lombardy_Executive+Summary_20160411.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-46779282-7753-4802-be85-837f90ace3ed-nv01KGv

⁶⁰ https://www.agenziacoesione.gov.it/wp-content/uploads/2019/06/S3_Liguria.pdf

⁶¹https://www.agenziacoesione.gov.it/wp-content/uploads/2022/08/S3-2021-2027_Regione-Emilia-Romagna.pdf

⁶² <http://ris3.regione.campania.it/>

⁶³https://www.agenziacoesione.gov.it/wp-content/uploads/2022/08/RII_DEL_2022_00009_AllegatoProposta_Puglia.pdf
<https://www.regione.puglia.it/web/competitivita-e-innovazione/strategia-regionale-di-specializzazione-intelligente-s3>

⁶⁴ <https://calabriaeuropa.regione.calabria.it/s3/>

⁶⁵<https://www.regione.sicilia.it/istituzioni/regione/strutture-regionali/assessorato-attivita-produttive/dipartimento-attivita-produttive/strategia-s3-sicilia>

Clusters

Lombardy has two clusters in which digital water plays a crucial role, the Foundation Technology Cluster Smart Cities & Communities Lombardia⁶⁶ (Cluster SCC), the Lombardy Energy Cleantech Cluster⁶⁷ (LE2C), the Piedmont Cleantech & Energy Innovation Cluster (CLEVER Cluster), and the Energy and Sustainable Development Cluster (Cluster GREENTECH) in Emilia Romagna.

The **SCC cluster** is an alliance of companies and institutions working for the development of smart efficient and sustainable cities, and for the design and the implementation of advanced technological solutions for the integrated management of urban and metropolitan systems (with particular reference to: renewable energy and energy efficiency, water, security and monitoring of the territory, mobility, health, well-being, e-government and justice, education and training, cultural heritage and tourism). It is characterized by several members, among which 9 big enterprises, 54 small and medium enterprises, 5 agencies and services, 6 universities, and 8 Research centres.

Regarding water, the cluster focuses on the water monitoring and management systems by means of IoT solutions, to provide operators, farmers, and businesses with the ability to measure, monitor and control their water distribution networks and distributed water quality.

LE2C cluster is the industrial and research network for energy and the environment officially recognised by the Region of Lombardy, based on the multiple helix model where it is possible to develop projects across research, innovation, and training. It was founded in 2009 and has among its members 103 enterprises, 12 universities and research centres, 14 industrial associations and non-profit organisations, 8 public bodies and institutions, 2 financial institutions and 4 media companies. Funding for its operations has been provided from the ERDF and the Lombardy region.

LE2C focus areas and the knowledge and R&D stakeholders associated to it are illustrated in Figure 8. Closer to the focus of WATERLINE is the Water Energy Nexus area. This area is primarily concerned with the supply chain related to Integrated Water Service, which includes the energy produced using water, the energy consumed to extract, purify, deliver, treat and dispose of water, and the management of residuals and impacts on the environment. LE2C addresses two challenges in this area, both utilizing digital water to be addressed: technologies and tools for wastewater and drinking water treatment and integrated technologies to support water planning, management, and monitoring.

In Piedmont, the **CLEVER** Cluster operates in the Energy and Clean Technologies field. CLEVER boasts the participation of more than 250 businesses, among which are companies, mainly of small and medium size, and research centers, both public and private, active in all the technological fields of the Cluster. The Cluster Managing authorities, which are the interface between the Piedmont Region and the Clusters members are Environment Park, and Consortium UNIVER.

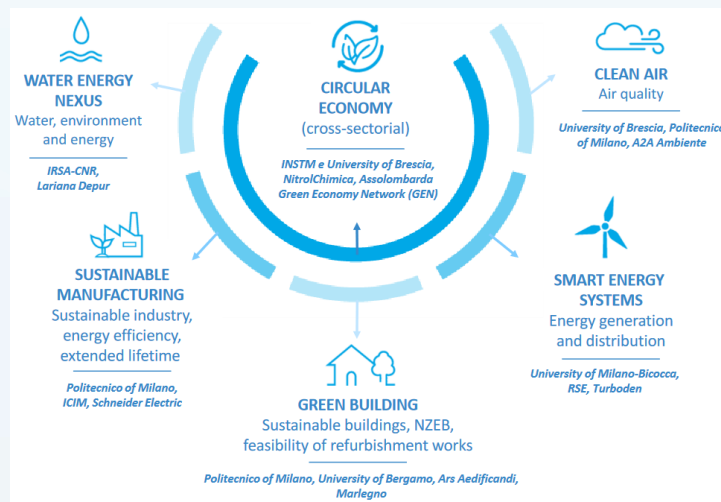
The Cluster's technological and operative areas are energy and energy efficiency, water resources, the circular economy, climate change for infrastructures and distribution networks, sustainable mobility and clean solutions. Regarding water, CLEVER Cluster deals with the efficiency and the rational use of water resources, with specific reference to core technologies for the reduction of water demand in

⁶⁶ <https://clusterscclombardia.it/ilcluster/>

⁶⁷ <http://www.energycluster.it/en/about-us>

the civil, industrial and service sectors, wastewater treatment and the recovery of materials and energy from water management processes.

Figure 8. Lombardy Energy Cleantech Cluster - Italy



Source: LE2C (2022)

In Emilia Romagna, the Energy and Sustainable development **Clust-ER GREENTECH** is an association of public and private bodies: companies, research centres and training institutions that share skills, ideas and resources to support the competitiveness of the sector. In 2020, GREENTECH has been awarded with the “Cluster Management Excellence Label BRONZE - Striving for Cluster Excellence”. It deals with energy and sustainable development sectors, which are strategic in supporting the regional economy transition to a low environmental impact system. It promotes the digital transformation of the production system, by means of eco-design, eco-innovation, green chemistry, industrial symbiosis, and integrated water and waste management.

Living Labs

There are four LLs focused on water management, two of them listed among the WoLL mapped by WE (2019b, p.32).

The **Lago di Tovel LTER**⁶⁸ Site. This living lab, hosted by the Edmund Mach Foundation, specifically deals with smart water technologies and assesses the role and response of lakes in a changing environment.

The **Open-Air Living Lab Apulia**⁶⁹ in the Apulia Region is hosted by IRSA-CNR (Research Institute on Water Resources- National Research Council). Among its goals are the increase of water availability, the adoption of alternative resources (e.g., treated wastewater reuse), the adoption of sustainable solutions for water management for agriculture.

The **Lagoon of Venice LTER** Site is coordinated by the Institute of Marine Sciences (ISMAR), and National Research Council (NRC), and promote applied research in the field of effects on terrestrial, freshwater, and marine ecosystem by the most relevant pressures (agriculture, urban sources, industrial activities and ports).

⁶⁸ <https://www.irsa.cnr.it/wp/>

⁶⁹ <https://b-watersmart.eu/living-lab/venice-italy/>.

The **B-Water Smart** is located in Venice and was funded by the European research project “Building a water-smart society and economy”. It aims at developing and demonstrating smart technologies and circular economy approaches, to accelerate the transformation to water-smart economies and societies in coastal Europe, by reducing the use of freshwater resources, improving the recovery and reuse of resources, and increase water use efficiency.

The **Open-Air Living Lab - Po Valley** is hosted by Alma Mater Studiorum – University of Bologna and focuses on the definition, co-design, deployment, monitoring/modeling, KPI, market development, and co-benefits.

Business Development support

There are companies in the water sector which employ digital tools, and ARERA⁷⁰ regulates the water services sector. Regional funding programs, such as Water Jade⁷¹ and PipeCare Italia⁷², support start-ups and innovative companies integrating digital tools for water technology management and risk mitigation.

Funding

The National Recovery and Resilience Plan in Italy, under the Next Generation EU program, revolves around the protection of water resources and the sustainable management of water services. The objective is to support the country's green revolution and ecological transition.

Higher Education Institutions

There is no specific educational framework or guidelines focusing on digital water in Italy. The HEIs active in supplying education in the field of digital water are listed in Table 10.

Table 10. HEIs activities in digital water - Italy

Higher Education Institution					
Politecnico di Milano⁷³	University of Naples Federico II⁷⁴	Sapienza University of Rome⁷⁵	University of Parma⁷⁶	University of Bologna⁷⁷	University of Pisa⁷⁸
Degree Programme in Civil Engineering - Water Engineering,	Master’s degree in Hydraulic and Transport Systems,	Civil Engineering degree and PhD on Environmental and Hydraulic	The master’s degree in civil engineering enables the acquisition of professional	Degree Programme in Civil Engineering - Hydraulic and Land	The master’s degree in civil and environmental Infrastructure Engineering offers advanced

⁷⁰ https://www.arera.it/it/operatori/operatori_idr.htm

⁷¹ <https://www.waterjade.com/it/>

⁷² <https://www.pipecareitalia.com/>

⁷³ <http://www.ingciv.polimi.it/en/percorsi/idraulica/>

⁷⁴ https://www.unina.it/en_GB/-/1484133-ingegneria-dei-sistemi-idraulici-e-di-trasporto-isit

⁷⁵ <https://www.uniroma1.it/en/pagina-strutturale/home>

⁷⁶ <https://ilmondochetiaspetta.unipr.it/Im-ingegneria-civile/#toggle-id-2> (in Italian)

⁷⁷ <https://corsi.unibo.it/2cycle/civileLMEN/course-structure-diagram/piano/2022/0930/958/000/2022>

⁷⁸ https://esami.unipi.it/esami2/ects_cds.php?cgs=ICE-L&aa=2022

deals with the study of water behaviour and the design of works related to its exploitation and management ⁷⁹	teaches design, construction and management of works and systems of interest to civil engineering and the design of hydraulic infrastructures, interventions and works for the hydraulic protection of the territory ⁸⁰	Engineering offers training and research in fluid mechanics, hydraulics and environmental engineering and models for the assessment of impacts in the natural environment ⁸¹	knowledge and skills relating to the design, construction, management and control of civil works with specialisation in the fields of construction, hydraulics, transport infrastructure and structures ⁸²	Management Engineer teachings in the field of structural engineering, geotechnics and hydraulic construction ⁸³	level teaching and practical activities with an experimental character in laboratory exercises and the development of project activities ⁸⁴
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Table 11 shows the skills needed and perceived as available by the industrial stakeholders who answered the survey in T2.1.

Table 11. Skills needed and present in digital water according to industry stakeholders – Italy

Type of Skills	Needed	Present
Water resources management	Understanding of climate changes, hydrological hazards and their effects on WRM	Optimizing and managing available resources in WRM systems Applying modern tools that facilitate the spatiotemporal management of the water resources, Geographic Information Systems (GIS) and WRM
Academic	Computer skills Presentation and public speaking skills Working in an international context	Research skills Working in an international context

⁷⁹ <http://www.ingciv.polimi.it/percorsi/idraulica/>

⁸⁰ <https://www.unina.it/-/1484133-ingegneria-dei-sistemi-idraulici-e-di-trasporto-isit>

⁸¹ <https://www.uniroma1.it/it/offerta-formativa/dottorato/2021/ingegneria-ambientale-e-idraulica>

⁸² <https://corsi.unipr.it/cdlm-ic>

⁸³ <https://corsi.unibo.it/magistrale/civile/esplora-il-corso>

⁸⁴ <https://www.unipi.it/index.php/lauree/corso/11139>

Type of Skills	Needed	Present
Interdisciplinary teaching and learning	Collaboration Team building	Problem solving Team building Innovation
Soft	Self-management Adaptability Accountability Ability to work under pressure	Time management Adaptability Accountability
Technical	Data acquisition and processing Forecasting Industry-related knowledge Technical writing	Data acquisition and processing Data analysis Industry-related knowledge Technical writing Project management Analytical skills (Scientific)
Transversal	Sense of initiative and entrepreneurship	Delivering quality and results

The data shows that there seems to be more skills on offer than the industry is capable to perceive. Communication channels with industry should be established to close the gap.

Civil society

Most of the NGOs work in the field of water sustainability, eg. ASVIS⁸⁵, for the implementation of the Sustainable Development Agenda 2030 in Italy.

4.2.5 Malta

A brief overview of the challenges for the development of the digital sector in Malta revolve mainly around the points identified below:

Education: identification of an education-industry collaboration and financial support for the research within DW.

Industrial: the capacity for research and the availability of the skilled human resources;

Innovation management: management of innovation funding mechanisms and programmes, such as Climate KIC - financial assistance and assigning human resourcing.

Institutional Environment: Legislation, Strategies and Policies

The main legislative apparatus and strategic supporting documents are listed in *Table 12*.

Table 12. Legislations, strategies and policies in the water sector - Malta

⁸⁵ www.asvis.it

Legislation	Strategies and Policies	
	Strategy/Policy	Short Description
Water Services corporation Act (Chpt 355) ⁸⁶	Water Framework Directive (Directive 2000/60/EC) ⁸⁷	Water management, water resources, inland waterway groundwater, surface water, territorial waters, water protection
Quality required of surface water intended for the abstraction of drinking water regulations (S.L. 549.21) ⁸⁸	Water Services Corporation Customer Charter	Water and sewerage services
Management of bathing water quality regulations (S.L. 465.9) ⁸⁹	Distribution and collection networks WSC operating manual ⁹⁰	Water distribution in Malta
Protection of groundwater against pollution and deterioration regulations (S.L.549.53) ⁹¹	Significant Water Management: Issues in the Malta River Basin District ⁹²	Water Management and River Basin Management Plan
Pollution caused by certain dangerous substances discharged into the aquatic environment regulations (S.L. 549.10) ⁹³	National Strategy for Research and Innovation in Energy and Water 2021-2023 ⁹⁴	Water policy, Water management Research & Innovation

Smart Specialisation Strategies

Malta's S3⁹⁵ is within the Water policy framework regulations (S.L. 549.10). The current program (2021–2027) focuses on six smart specialisation areas, although none of them directly address the theme of smart water. This may be indirectly contemplated in these two areas:

⁸⁶ <https://legislation.mt/eli/cap/355/eng/pdf>

⁸⁷ <https://www.eea.europa.eu/policy-documents/directive-2000-60-ec-of>

⁸⁸ <https://legislation.mt/eli/sl/549.21/eng/pdf>

⁸⁹ <https://legislation.mt/eli/sl/465.9/eng/pdf>

⁹⁰ <https://www.wsc.com.mt/wp-content/uploads/2021/03/handbook.pdf>

⁹¹ <https://legislation.mt/eli/sl/549.53/eng/pdf>

⁹² https://energywateragency.gov.mt/wp-content/uploads/2022/04/Significant-Water-Management-Issues-Documents_final-1.pdf. https://energywateragency.gov.mt/wp-content/uploads/2022/04/Significant-Water-Management-Issues-Documents_final-1.pdf

⁹³ <https://legislation.mt/eli/sl/549.10/20101220/eng>

⁹⁴ <https://energywateragency.gov.mt/wp-content/uploads/2022/04/National-Strategy-for-Research-and-Innovation-in-Energy-and-Water-2021-2030-EWA-web.pdf>

⁹⁵ <https://mcst.gov.mt/wp-content/uploads/2021/12/RIS3-2021-2027.pdf>

Sustainable Use of Resources for Climate Change Mitigation and Adaptation, with a focus on net-zero carbon buildings, renewable energy generation and energy storage solutions, resource efficiency in industry and turning waste into a resource.

Future Digital Technologies (this is both a vertical priority and a horizontal enabler for the former five areas), with a focus on big data and data analytics, open data, smart space applications, human-centric applications, digitizing industries and sustainable use of resources or climate change mitigation and adaptation.

The main stakeholders in the implementation of the Malta S3 are the Water Services Corporation (WSC) (industry), MCAST and University of Malta (academia), Malta Water Interest Group and NatureTrust (NGOs and associations) and the Energy and Water Agency and the Regulator for Energy & Water Services (government authorities).

The main RDI supporting instruments utilised to implement the Malta's S3 are acquired from European funding programs (INTERREG, Prima, Horizon Europe) and local funding (Energy and Water Agency Research and Innovation Grant Scheme, Fusion).

Innovation Ecosystems

Clusters

Although there is knowledge about Malta being active in the WSTs, and the regions are represented by clusters, no further information was possible to identify with the Malta Intelligent Energy Management Office (MIEMA), which participates in the WSTs Initiative as the country's representative, about its functioning.

Living Labs

In Malta LLs in digital water are limited and not prominent. Nevertheless, the Institute of Applied Sciences can be considered active in this field such as the MCAST Water Research and Training Centre: focused on efficient and effective water systems and networks. It sees the involvement of MCAST and WSC working in a field lab to develop and test solutions related to water metering, water losses and water distribution.

Business development support

Services and products are provided by SMEs at different tier levels in digital water, without the operativity of startups and accelerator programmes.

Funding

The funding for digital water is derived mainly from European funds: Horizon Europe and Prima schemes.

Higher Education Institutions

Due to the size of the country, there are only 3 HEIs engaged with activities in the digital water domain. They are listed in Table 13, as well as the activities they carry out in the field.

Table 13. HEIs activities in digital water - Malta

Higher Education Institution		
MCAST ⁹⁶	University of Malta ⁹⁷ (UM)	Institute of Water Technology ⁹⁸ (IWT)
<p>MCAST is a vocational education and training institution dedicated to teaching, R&D.</p> <p>MCAST offers a MSc in Integrated Water and Resource Management</p> <p>Its key external projects include: Fowarim, MICROWATTS, Green Roof & Greywater, PoVE-Water and WATERLINE.</p> <p>These are further supported through a series of undergraduate and post graduate research studies.</p>	<p>UM is dedicated to teaching, R&D. Its main activities in digital water are located at the Faculty of the Built Environment</p> <p>UM offers two: Bachelor of Science (Honours) degrees: BSc in Built and Environment Studies and BSc in Spatial Planning.</p> <p>Both degree programmes include courses on: 1) Hydrology and Water Resources, 2) Civil Engineering Hydraulics, 3) Water Resources, and 4) Waste Management.</p> <p>Water is indicated as one of the research areas of the Department of Spatial Planning and Infrastructure. UM is dedicated to several water-related externally funded projects⁹⁹.</p>	<p>IWT is a unity of the Water Services Corporation (WSC) that provides classroom, on-site and on-line training for employees within the WSC and stakeholders.</p> <p>The training courses for the WSC are organized either: a) as part of a training programme originating from the Training Needs Analysis or b) as part of a training programme originating from the Training and Development Section.</p>

Regarding the skills match between the needs and the skills existing or perceived as available and by the industry, Table 14 shows how this situation is seen by the industrial stakeholders.

Table 14. Skills needed and present in digital water according to industry stakeholders – Malta

Type of Skills	Needed	Present
Water resources management	Implementing water supply and water efficiency plans and programs	Implementing water supply and water efficiency plans and programs
Academic	Learning from experience	Goal planning

⁹⁶ <https://moodle.mcast.edu.mt/course/view.php?id=3596>

⁹⁷ <https://www.um.edu.mt/ben/spatialplan/ourresearch>, <https://www.um.edu.mt/courses/studyunit/SPI3734>, <https://www.um.edu.mt/courses/studyunit/SPI2731>, <https://www.um.edu.mt/courses/studyunit/SPI3731>

⁹⁸ <https://www.wsc.com.mt/facilities/iwt/>

⁹⁹ https://www.um.edu.mt/finance/projectsupport/projectssearch/nameacademic?queries_name_query=water&search_page_447784_submit_button=Submit

Type of Skills	Needed	Present
Interdisciplinary teaching and learning	Problem solving Innovation	Problem solving
Soft	Ability to work under pressure	Teamwork Ability to work under pressure
Technical	Industry-related knowledge	Forecasting Industry-related knowledge
Transversal	Learning to learn Reflection on strengths and shortcomings Prioritising and organising Delivering quality and results	Prioritising and organising Delivering quality and results

There is an evident mismatch in terms of the number of skills demanded and what is offered by the HEIs. A dialogue could be implemented by the HEIs with the industry to qualify these demands and organizing of means to respond to them. The experience of MCAST in working together with the industry (WSC) is a facilitator both, for the engagement and for the testing of how to deliver the skills needed.

Academia industry-collaboration

This information is for the MCAST only. The involvement of industry in academia at MCAST is a long-standing practice. Alongside the internal consultation process with staff, students and alumni, the MCAST curricula development and review necessitates a dialogue with industry to ensure continued relevance of the content delivered within the MCAST study programmes. This practice has been enshrined in the MCAST policies and promulgated through the MCAST Strategic Plan 2022-2027 (Support, structure, and encourage the involvement of stakeholders to actively contribute towards the development and review of curricula).

MCAST engages with industry in different for a and through different structures. One relevant example is the signing of a Memorandum of Understanding between MCAST and the WSC to collaborate also on the MSC in Integrated Water Resources Management.

Civil society

Few NGOs are present, but most of them are active in the water sector, with a focus on sustainability. For example, Malta Water Association¹⁰⁰, a pressure group, and Nature¹⁰¹.

¹⁰⁰ <https://www.facebook.com/groups/MaltaWaterAssociation/>

¹⁰¹ <https://naturetrustmalta.org>

4.2.6 Norway

There is a limited availability of industrial expertise in the digital water solutions field, hindering the design, implementation, and maintenance of such systems. Small municipalities face challenges in staying updated with new technology and carrying out major upgrades due to staffing limitations and a conservative industry culture. There is an evident lack of political facilitation and investment in innovation, as highlighted in the reports from the Norwegian Water Resources and Energy Directorate¹⁰².

Institutional Environment: Legislation, Strategies and Policies

The main legislation for the field of water in Norway is the Norwegian Drinking Water Regulation (drikkevannsforskriften) and regulations relating to pollution control (forurensningsforskriften).

Table 15 shows the strategies and policies guiding operations in the field of water in Norway.

Table 15. Strategies and policies in the water sector - Norway

Strategy/Policy	Short Description
Guidance from the Norwegian Environment Agency on topics within water management	Management sewage
Adjusted framework plan for updating the water management plans and process until final approval of the regional water management plans (2022 - 2027)	Water management
National guidelines for regulated waterways (2014)	Waterways with power generation
National guidelines for work on updating the regional water management plans (2019)	Municipal spatial planning, sewage, impact from salmon lice and escaped farmed fish, agriculture, foreign species (including king crab), drinking water and bathing water, and transport
The Energy Act	Act on production, transformation, transfer, turnover, distribution, and use
The Administrative Act	Act on the method of processing in administrative matters
The Pollution Act (Forurensningsloven)	Act on protection against pollution and on waste
The Food Act (Matloven)	Act on food production and food safety, etc.
The Industrial Licensing Act (Industrikonsesjonsloven)	Act on the acquisition of waterfalls, quarries, etc.

¹⁰² <https://nmbu.brage.unit.no/nmbu-xmlui/handle/11250/3016012,>
<https://norskvann.no/wp-content/uploads/sluttrapportArbeidsgruppeForEffektivOrganisering.pdf>

The Environmental Information Act (Miljøinformasjonsloven)	Act on the right to environmental information and participation in public. decision-making processes of importance for the environment
The Planning and Building Act (Plan- og bygningsloven)	Act on planning and construction proceedings
The Water Resources Act (Vannressursloven)	Watercourses and Groundwater Act
Watercourse Regulation Act (Vassdragsreguleringsloven)	Watercourse Regulations Act
Water in state planning guidelines for climate and energy planning and climate adaptation (2018)	Climate adaptation, distribution, supply
Water in national expectations for planning (2019)	Water management
The water regulations (Vannforskriften)	Surface water and some groundwater
The Water Directive - EU framework directive for water (Vandirektivet)	Drinking water, nitrates, sewage, pollution control, bathing water and nature conservation, etc

Norway has several strategic activities related to smart water, aimed at improving water management and promoting sustainability. Some of these initiatives include:

The Digitalisation Circular¹⁰³ of 21.12.2022 addressing digitalisation in the public sector in general.

The Norwegian Water Resources and Energy Directorate¹⁰⁴ (NVE) is responsible for managing Norway's water resources and energy sectors, including monitoring water levels, quality, and flow, and ensuring their sustainable use. As part of this mandate, NVE may be involved in exploring and implementing smart water technologies to improve water management and conservation in Norway.

Digitalisation and Innovation working groups - groups within Norsk Vann that work on promoting digitalization and innovation in the Norwegian water sector. The committee focuses on identifying emerging trends, challenges, and opportunities related to smart water solutions and advising the water utilities and stakeholders, e.g., Working group for optimal data flow from construction to operation of VA facilities¹⁰⁵.

Smart Specialisation Strategies

Since Norway is not member state of the EU, they are not required to adopt S3, however, they have adopted a methodology of the S3. The name of the strategy is "Smart City Halden¹⁰⁶" located in Halden. The aim of this project is to carry out comprehensive control, management, monitoring, and measurement of the water grid together with Hafslund/AMS Halden's infrastructure, plan to develop

¹⁰³ <https://www.regjeringen.no/no/dokumenter/digitaliseringsrundskrivet2/id2952701/>

¹⁰⁴ NVE <https://www.nve.no/en/>

¹⁰⁵ <https://norsk vann.no/arbeidsgruppe-for-optimal-dataflyt-fra-bygging-til-drift-av-va-anlegg/>

¹⁰⁶ <https://smartinnovationnorway.com/en/prosjekt/smart-vann-digitalisering-vanninfrastruktur-3/>

automatic metering and settlement (Meter to Cash) as well as remove unregulated deviations in the water network.

The project is based on utilizing existing infrastructure for communication with all electricity meters in Halden, which will be installed in the near future.

The main stakeholders of the project are eSmart, Cowi and Hafslund. However, they do not have any educational organizations involved. Further on, they associate with the NGO Smart Innovation Norway.

Innovation ecosystems

Clusters

Norwegian Water Cluster¹⁰⁷ (Vannklyngen) objectives are to increase exports of Norwegian technology to international markets, create co-deliveries across members and promote business-oriented innovation. Vannklyngen has altogether 51 stakeholder company members, and the educational organizations affiliated to it are Norges miljø-og biovitenskapelige universitet (NMBU) and University of South-Eastern Norway. The members NGOs are the Foundation for Industrial and Technical Research (SINTEF) and the Norsk Institutt for Vannforskning (NIVA).

Living labs

There are three living labs dealing with digital water in Norway.

Wireless Trondheim Living Lab¹⁰⁸ focuses on wireless networking and research. It is hosted by Wireless Trondheim and Norwegian University of Science and Technology (NTNU). The NGOs associated to the LL are SpareBank 1 Midt-Norge, Adresseavisen. The city of Trondheim, the Sør-Trøndelag County Council and Trondheim Energiverk are the representatives of the public sector.

The Norwegian National Centre for Climate Adaptation¹⁰⁹ is hosted by SINTEF and NTNU and operates in agri ecosystems. These are the companies involved: Skanska Norway, Multiconsult AS, Mestergruppen Bolig, Norgeshus AS, Saint-Gobain Byggevarer AS, Isola AS, and Spenncon AS. The Norwegian Business School also has a stake in the LL. The NGO affiliated is Jernbaneverket of Avinor AS. The public sector members are the Norwegian Meteorological Institute (MET Norway), the Norwegian Geotechnical Institute, Statsbygg, Statens vegvesen, the Norwegian Water Resources and Energy Directorate and Finance Norway.

Intelligent Nanofiltration Membrane Systems for Natural Organic Matter Removal in Water Treatment focuses on applied R&D of intelligent membrane systems for natural organic matter removal in drinking water treatment. It is hosted by NMBU, having member companies Scan Water and DosCon, participating government organizations are the municipalities Sunnfjord kommune, Sogndal kommune and Vestvågøy kommune. For funding of the LL, the municipalities and the Institute of Public Health have provided lump sums, in addition to hours and direct expenses from all parties.

¹⁰⁷ <https://vannklyngen.no/>

¹⁰⁸ https://enoll.org/network/living-labs/?livinglab=wireless-trondheim-living-lab%22%20\|%20%22description,https://no.linkedin.com/company/wireless-trondheim?original_referer=https%3A%2F%2Fwww.bing.com%2F

¹⁰⁹ <https://watereurope.eu/wp-content/uploads/2019/07/Atlas-of-the-EU-Water-Oriented-Living-Labs.pdf> (p.38)

Business development support

There are some examples of existing or developing businesses from industry and services perspectives in the field of digital water. They include universities and research centres, big corporations, local utilities.

Funding

The main of funding for RDI in digital water can be acquired from the Research Council of Norway¹¹⁰, Innovation Norway¹¹¹, Miljødirektoratet¹¹², Norwegian Institute of Public Health¹¹³, Norwegian Water¹¹⁴.

Higher Education Institutions

Digital tools and concepts have been incorporated into study programs at NMBU and NTNU in water related courses. NMBU is starting a new 2- year MSc on digital tools in water treatment, and Oslo Metropolitan University is starting a program on Smart Water. At present they are implemented as dedicated lectures in the existing curricula. In the future there will be dedicated study programs. Table 16 shows the specific activities these HEIs are developing in digital water.

¹¹⁰ <https://www.forskningsradet.no/en/>

¹¹¹ <https://www.innovasjon norge.no/en/start-page/>

¹¹² <https://www.miljodirektoratet.no/>

¹¹³ <https://www.fhi.no/en/>

¹¹⁴ <https://norsk vann.no/information-in-english/>

Table 16. HEIs activities in digital water - Norway

Higher Education Institutions and activities in digital water		
Norwegian University of Science and Technology ¹¹⁵ (NMBU)	Norwegian University of Science and Technology ¹¹⁶ (NTNU)	Oslo Metropolitan University (OsloMet)
<p>NMBU specialises in environmental and natural sciences.</p> <p>Courses¹¹⁷</p> <p>Civil Engineering, Water Engineering for Landscape Planners, Water Supply, Sewerage and Drainage, Basics of water and wastewater treatment technology, On-Site Wastewater Systems, Resource recovery from waste and circular economy, Planning and design of urban water systems, Advanced water and wastewater treatment engineering, Water & Wastewater, Water Management in Cold Climate, Environmental Analysis, and Environmental Microbiology. Research groups deal with data sciences and digitalization of the water sector. Projects on Water and Health¹¹⁸, Water Harmony¹¹⁹.</p>	<p>Courses</p> <p>Water resources and sanitation, Water and Wastewater Treatment, Water and drainage technology, Water Supply and Wastewater Engineering Basic Course, Model-based water engineering, Water and Wastewater Systems</p> <p>Research</p> <p>https://www.ntnu.edu/ibm</p>	<p>Courses</p> <p>Storm water, Water planning and treatment, Infrastructure</p>

Besides the above-mentioned HEIs, Høyskolen Kristiania also offers degree programs and courses in smart water technology, collaborating with industry partners for internships, training, and joint research projects. This fosters skills development for future water professionals in areas like water resources engineering, environmental science and hydro informatics. Høyskolen Kristiania offers studies focusing on innovation and sustainability, and students have opportunities to do joint research projects with NGOs.

The skills needs and skills perceived as available for the digital water sector by the Norwegian industry stakeholders are shown in

¹¹⁵ <https://www.nmbu.no>

¹¹⁶ <https://www.ntnu.edu>

¹¹⁷ <https://www.nmbu.no/course/THT100?studieaar=2022>

¹¹⁸ <https://www.nmbu.no/en/faculty/realtek/research/groups/water/waterandhealth/projects>

¹¹⁹ <https://waterharmony.net/>

Table 17.

Table 17. Skills needed and present in digital water according to industry stakeholders – Norway

Type of Skills	Needed	Present
Water resources management	Understanding of climate changes, hydrological hazards and their effects on WRM	Understanding of climate changes, hydrological hazards and their effects on WRM Devising strategies and developing methodology and methods of emergency as part of WRM
Academic	Computer skills Presentation and public speaking skills	Computer skills
Interdisciplinary teaching and learning	Team building	Problem solving Collaboration Team building Innovation
Soft	Self-management Teamwork Time management Self-motivation Adaptability Accountability	Teamwork Self-motivation Accountability
Technical	Data acquisition and processing Industry-related knowledge	Process engineering Measurement and instrumentation
Transversal	Reflection on strengths and shortcomings Prioritising and organising Delivering quality and results Leadership	Delivering quality and results

Academic, soft and transversal skills are more needed by the industry than what is perceived as available. WRM and interdisciplinary teaching and learning skills are more abundant than what is needed, although not always the skills available match with the skills needed.

Academia industry-collaboration

Universities like NTNU and NMBU collaborate with industry partners for smart water solutions. For instance, NTNU partnered with Trøndelag Vann to develop an efficient smart water system. DOSCON, a spin-off from NMBU, focuses on real-time control and optimal chemical dosing, contributing to projects like Digiwater¹²⁰.

¹²⁰ <http://waterharmony.net/projects/digiwater/>

Civil Society

Innovation Norway and various projects initiated by municipalities facilitating innovations in the water sector.

4.2.7 Serbia

Overall, in Serbia there is insufficient investment in the water sector and a limited availability of industrial expertise in the digital water solutions field. The water industry sector is limited in applying innovative technologies due to financial constraints and staffing limitations.

Institutional environment

The Water Law is the main legislation for regulation in the water sector in Serbia. It legislates on the legal status of water, integral water management, management of water facilities and water land, sources and method of financing water activities, supervision over the implementation of this law, as well as other issues important for water management. Strategies and policies for the sector are shown in Table 18.

Table 18. Strategies and policies in the field of water - Serbia

Strategy/Policy	Short Description
Water Management Strategy in the Territory of the Republic of Serbia Until 2034	Long-term planning of the functioning of the water sector, based on the principle of sustainable development, that is, the performance of water activities in its basic areas (regulation and use of water, protection of water from pollution and regulation of watercourses and protection from the harmful effects of water), as well as other necessary jobs and activities for functioning and development (financing, monitoring, etc.).
Action Plan for the Implementation of the Water Management Strategy in the Territory of the Republic of Serbia for the Period from 2021 to 2023	Definition of appropriate indicators, which, in addition to monitoring the implementation of the Strategy, also ensure harmonization with activities that are relevant in the European Union for the areas of environment and water, specific indicators that need to be monitored at the national level and parameters that improve statistics in the area of water, as and defining activities with deadlines and authorities, organizations and public enterprises responsible for the implementation of those activities, for the period of validity of the Action Plan.

Smart Specialisation Strategies

Serbia started planning its smart specialisation process in 2017¹²¹. The Smart Specialisation Strategy Serbia (4S) for the period 2020-2027¹²² is one of the key documents adopted by the Government to develop a knowledge-based society. The Strategy is an important instrument for improving the innovation and research ecosystem and directing future investment in industrial areas to raise the competitiveness of the Serbian economy. It represents a part of a new paradigm of innovation policy which gathers decision-makers, academic and business communities and civil society. Four regions were identified for implementation of S3 and the domains, although having potential for applications of digital water solutions, e.g., agriculture and other industries, there is no specific focus on water or digitalization in the sector.

Innovation Ecosystem

Clusters

According to the Industrial Policy Strategy of the Republic of Serbia from 2021 to 2030¹²³, there is an unused potential for increasing competitiveness that can be provided by clusters in the Republic of Serbia. This potential has not been used due to the existence of mistrust of companies towards clusters, as well as fierce competition that overrides the desire for associations. The promotion of the digital transformation of the industry in Serbia is carried out by organizing events, using the services of the Center for Digital Transformation¹²⁴, as well as organizing the exchange of information between industrial companies, IT clusters and the start-up community.

There is no cluster operating in the field of digital water in Serbia.

Living Labs

There is no LL connected directly with the digital water in Serbia. However, there are two LLs that can be indirectly connected with water in the agricultural sector. The **Precision Agriculture Living Lab**¹²⁵ based on the responsible research and innovation approach offers possibilities to test ideas and prototypes in the real-world setting. **The Sustainable Agriculture and Preservation of Natural Environment Living Lab** developed under project COMMECT¹²⁶ focuses on digital farming and environment protection in Žabalj municipality, providing services for digital farming, continuous monitoring of environmental parameters and autonomous and remote control of the energy, connectivity and edge processing infrastructure on the community level.

Business Development support

SME sector is crucial for growth and development of the Serbian economy. The Serbian startup scene is rapidly developing and provides a good business opportunity for new and ambitious teams and companies.

Under the StartTech Innovation Support Program, start-up teams, entrepreneurs, micro, small and medium enterprises can apply for grants and invest funds in the development of innovative products

¹²¹ <https://s3platform.jrc.ec.europa.eu/serbia>

¹²² https://pametnaspecijalizacija.mpn.gov.rs/wp-content/uploads/2021/06/Strategija-pametne-specijalizacije_EN_WEB.pdf

¹²³ <https://ras.gov.rs/uploads/2023/04/strategija-industrijske-politike-republike-srbije-od-2021-do-2030-godine.pdf>

¹²⁴ <https://www.cdt.org.rs/>

¹²⁵ <https://biosens.rs/en/themes/living-lab>

¹²⁶ <https://www.horizoneurope-commect.eu/living-labs/5-serbia-sustainable-agriculture-and-preservation-of-natural-environment>

and services, conquering new markets, and creating new jobs. The enhanced Entrepreneurship Portal¹²⁷ presenting all available support programmes, important news and networking opportunities, is available to Serbian entrepreneurs. The Startup Portal¹²⁸ is the place to go in case they wish to use all opportunities offered in the changing and dynamic startup ecosystem.

There are four Science and Technology Parks in Serbia (Belgrade, Čačak, Niš and Novi Sad) established by the Government as organizations for providing infrastructural support to innovation activity, which within the area entrusted to its management provides infrastructural and professional services to business companies, scientific research and innovation organizations in order to connect them and as quickly as possible apply new technologies, create and placement of new products and services on the market.

Funding

The main funding derives from the Innovation Fund¹²⁹ and Science Fund¹³⁰ of the Republic of Serbia as well as the Ministry of Agriculture, Forestry and Water Management¹³¹. Digitalisation of the water sector is planned to be done through funding under the project “Strengthening Serbia’s water supply network”¹³² financed by the French Development Agency (AFD). It is planned to modernize the Serbian hydraulic network and extend its existing infrastructure. To meet the required standards for energy efficiency, pumping stations used for flood and irrigation management in central Serbia will be updated. Reducing greenhouse gas emissions will be achieved through the reconstruction and modernization of the drainage and hydraulic system and its digitalization.

The Government of the Republic of Serbia financed development, modernization and operating a state-of-the-art water treatment plant in the City of Zrenjanin based on application of innovative technologies¹³³. This is a strategic project and the first public-private partnership project for the realization of a water treatment plant facility in Serbia, which will help the country to achieve its Water Management Strategy in support of the country’s 2020-2025 Vision and sustainable development goals.

As a part of the Serbian investment plan 2025, the project for constructing the Belgrade’s central sewerage system which will serve 1.5 million inhabitants started in 2020¹³⁴.

The Council of Europe Development Bank (CEB) approved a project to the Serbian government to support investments in water supply and wastewater management in 60 municipalities to reduce of water loss, enhance water supply coverage and improve quality of water¹³⁵.

¹²⁷ <https://preduzetnistvo.gov.rs/>

¹²⁸ <https://startup.gov.rs/en/>

¹²⁹ <http://www.inovacionifond.rs/en/>

¹³⁰ <http://fondzanauku.gov.rs/?lang=en>

¹³¹ <http://www.minpolj.gov.rs/>

¹³² <https://www.afd.fr/en/actualites/strengthening-serbias-water-supply-network>

¹³³ <https://smartwatermagazine.com/news/metito/serbias-first-public-private-partnership-water-treatment-project-awarded-metito>

¹³⁴ <https://smartwatermagazine.com/news/smart-water-magazine/chinas-cmec-build-eu771-million-wastewater-treatment-unit-serbia>

¹³⁵ <https://smartwatermagazine.com/news/coucil-europe-development-bank-ceb/ceb-approves-eu200-million-support-water-supply-and>

Higher Education Institutions

The Serbian HEIs started preparing themselves in collaboration with the labour market for the Industry 4.0. Currently, the modernization of study programmes oriented to the water sector and their digital transformation can be seen. Three HEIs in Serbia (University of Nis, University of Belgrade, University of Novi Sad) offer facilities for the water education and digital transformation including changes in laboratory exercises and teaching materials.

Table 19 shows the activities performed by Serbian HEIs in digital water.

Table 19. HEIs activities in digital water - Serbia

Higher Education Institutions and activities in digital water		
University of Niš ¹³⁶	University of Belgrade ¹³⁷	University of Novi Sad ¹³⁸
<p>Activities of teaching, research and R&D in water are concentrated at two faculties. At the Faculty of Civil Engineering and Architecture the courses taught are: Hydrotechnics, Hydroinformatics, Engineering risk management of natural disasters. The Faculty of Occupational Safety teaches Environmental protection.</p>	<p>Activities of teaching, research and R&D in water are concentrated at two faculties. The Faculty of Civil Engineering teaches Environmental Protection and Hydro construction. The Faculty of Forestry Ecological engineering in the protection of land and water resources.</p>	<p>The Faculty of Technical Sciences is activity in teaching, research and R&D. It teaches Water treatment and protection engineering.</p>

The skills needs and skills perceived as available for the digital water sector, according to answers by the industry stakeholders in Serbia are shown in Table 20.

Table 20. Skills needed and present in digital water according to industry stakeholders – Serbia

Type of Skills	Needed	Present
Water resources management	Applying ICT in WRM	Understanding of climate changes, hydrological hazards and their effects on WRM Implementing water supply and water efficiency plans and programs
Academic	Communication and networking skills	Goal planning

¹³⁶ <https://gaf.ni.ac.rs/index1.php>; <https://gaf.ni.ac.rs/akreditacija2014/2014/index.php?dir=dos-h-en/>

¹³⁷ <https://gaf.ni.ac.rs/index1.php>; <https://gaf.ni.ac.rs/akreditacija2014/2014/index.php?dir=dos-h-en/>, <http://www.sfb.bg.ac.rs/studijski-programi/osnovne-akademske-studije/studijski-programi/ekoloski-inzenjering-u-zastiti-zemljisnih-i-vodnih-resursa/>

¹³⁸ <http://www.ftn.uns.ac.rs/n1499046765/inzenjerstvo-tretmana-i-zastite-voda---tempus>

Type of Skills	Needed	Present
	Goal planning	
Interdisciplinary teaching and learning	Creativity Innovation	Problem solving
Soft	Self-motivation Analytical	Teamwork
Technical	Data analysis	Data acquisition and processing
Transversal	Reflection on strengths and shortcomings	Reflection on strengths and shortcomings Prioritising and organising

Academia industry-collaboration

During the implementation of two Erasmus+ projects “Strengthening of Master Curricula in Water Resources Management for the Western Balkans HEIs and Stakeholders”¹³⁹ and “Serious Games for Digital Readiness of Water Education”¹⁴⁰, the University of Nis initiated collaboration with the industrial water sector through roundtable meetings and preparation of course materials. The representatives of the water sector participated into the modernisation of the curricula studied at the University of Nis, Faculty of Civil Engineering and Architecture. Also, professionals from the water sector were selected to participate in the training in water resources management focusing on the following topics: water management and climate change adaptation, flood, and drought risk management, managing the quality of stormwater, wastewater treatment and reuse of treated wastewater, IT tools in the water resources management.

Civil society

There is no knowledge available about any roles that NGOs and other types of civil society associations have in fostering innovation in the domain of digital water Serbia.

4.2.8 Türkiye

According to Yıldız & Özgüler (2020), in Türkiye, the digital water concept is more realized through the Water 4.0 applications of the water and sewerage departments of local municipalities. Here, the following benefits are highlighted:

- With the central software, remote index reading, accrual and billing and meter performances can be monitored. Thus, in addition to increasing accruals, service quality and customer satisfaction can be increased.

¹³⁹ www.swarm.ni.ac.rs

¹⁴⁰ smartenproject.eu

- The delivery of the fault notifications from the subscribers to the teams working in the field via computers by the call centre and the processing of the information that the fault repair has been completed in the system will not only increase the customer satisfaction by getting back to the applicants but will also increase the efficiency in the work of the field teams by keeping records.
- Drinking water and sewerage infrastructure can be brought to a manageable level by transferring them to the digital environment. This system can work on mobile devices (phone, tablet, etc.) at any point where internet access is available. This situation provides very positive contributions to the efficiency of the network operation.
- After the Drinking Water and Wastewater SCADA system, it can be passed to the Network SCADA System and the Asset Management System can be established and the service quality provided by the administration, the value of the citizens and the sector can be increased.

Institutional Environment

Table 21 shows the main institutional apparatus regarding legislation, strategies and policies for the water sector in Türkiye.

Table 21. Legislation, policies and strategies in the water sector – Türkiye

Legislation	Strategies and Policies
	Strategy/Policy
Regulation on Protection and Management of Water Basins on the Preparation of Plans (17 October 2012 dated Official Newspaper and No. 28444)	Strategy for the preparation of watershed management plans within the scope of harmonization with the EU water framework directive.
Surface Water Quality Regulation	National Water Plan (2019-2023) published by the Ministry of Agriculture and Forestry National Water Plan aims to determine and improve Türkiye's Turkey's current and future water policies, involving public, private and non-governmental organisations in a participatory process.
Monitoring of Surface Waters and Groundwaters Regulation	Türkiye's Policy on Water Issues -governed by the Ministry of Foreign Affairs
Vulnerable Water Bodies and those Affecting these Bodies	Water Law and Policy - governed by the Ministry of Agriculture and Forestry
Determination of Areas and Water Quality	
Regulation on Improvement	
Urban Wastewater Treatment Regulation	Report of Water Resources and Water Security (2019-2023) published by the Ministry of Development
Regulation on the Protection of Waters against Agricultural Nitrate Pollution	Report on Water Efficiency Action Plan (2023-2033) published by the Ministry of Agriculture and Forestry
Regulation on the Protection of Groundwater Against Pollution and Deterioration	National reports on Basin Management, Drought Management, and Action Plans published by the Ministry of Agriculture and Forestry
Regulation on Preparation, Monitoring and Implementation of Flood Management Plans	

In Türkiye, RIS3s are not defined at the national level, however, there are 6 regions piloted in the smart specialisation platform¹⁴¹. Western Black Sea and East Marmara regions have been initiated by the Regional Development Agencies (RDAs). The Eastern Marmara Development Agency's RIS is the most noteworthy because it is a good example of a S3 focusing on promotion of innovation. The other S3s, on the other hand, mostly focus on traditional regional innovation strategies, which typically focus on attracting investment and promoting R&D (Erdil & Çetin, 2018). None of the regions directly concentrates on digital water issues as of the initial designations.

Innovation ecosystems

Clusters

There are no clusters in Finland operating in the fashion of the digital water innovation clusters approached in this document. There are some organisations that bring together experts from public and private sectors operating in fields related. They participate in policy formulation and R&D activities.

The Turkish National Hydrology Commission (TUHK) is an organisation consisting of academic members engaged in education and research activities in the field of hydrology and experts working in this field in the public and private sectors. TUHK is the national branch of the International Union of Hydrological Sciences. It is also one of the 7 commissions affiliated to the Turkish National Geodesy and Geophysics Union run by the General Directorate of State Hydraulic Works, as part of International Union of Geodesy and Geophysics.

Hydraulics and Hydraulic Structures Specialisation Board, Coast and Sea Specialisation Board are the commissions consisting of both academic members and experts working in these fields, enrolled as a commission performing under the Chamber of Civil Engineers.

Living Labs

An example of a LL in the digital water sector in Türkiye is the Başakşehir Living Lab¹⁴², which is hosted by Başakşehir Municipality and focuses on Information Technologies and Design. Başakşehir LL's "Strategic Interest Water Europe Clusters" include the themes value in water, value of water, digital water and hybrid grey-green infrastructure (WE, 2019b). The ecosystem of Başakşehir LL involves:

Universities: Bahçeşehir University, Bilgi University, Kültür University, İstanbul Sabahattin Zaim University; (Other research Institutions) Bahçeşehir Science and Technology High School, Wissen Akademi, Oracle.

Industry: KOSGEB, İkitelli Organized Industrial Zone, Turkish Exporters' Assembly, Denizbank, Turkcell, Superonline, TNet, Tikle, BE Sistem, MERU Networks, Wallrite, Hayal Gücü, Prokare, Avea, Pentagon Design.

Government: Başakşehir Municipality.

¹⁴¹ <https://s3platform.jrc.ec.europa.eu/where-we-are>

¹⁴² <https://basaksehir-livinglab.com/BLL/home/>

Business support organisations: European Network of Living Labs, Startupbootcamp Türkiye, Turkish Fit Startup Factory, Boğaziçi University Entrepreneurship Association, Istanbul Startup Angels, Keiretsu Forum, Genç Başarı, DEİK, Mobilsad, Istanbul Design Factory, Aalto Design Factory.

The living lab is funded by its supporting associations¹⁴³.

Funding

There are some sources of R&D funding in Türkiye, which are managed by different national organisations and also in international collaboration.

TUBITAK (The Scientific and Technological Research Council of Türkiye) is the main funding hub for research on the water topic in Türkiye. This is mainly achieved through program calls including in international partnerships, such as the Water4All transnational call of the WaterJPI, water management related support through bilateral agreements, those provided through the COST network support, as well as the mechanism to support water related projects managed through industry-university collaboration.

Regional development agencies as research bodies of the Ministry of Development are another active means of funding that provide RDI support for several topics of sectorial development processes where water management is key.

The World Bank¹⁴⁴ also provides some local support for local authorities and municipalities through projects that cover effective water management, e.g., transition into efficient irrigation systems, or treated wastewater reuse for green areas irrigation, etc. The Government of Türkiye (GoT) and the World Bank have a long history of collaboration through project financing in the water supply and sanitation sector. As part of this collaboration, and to inform a broader sector dialogue, the World Bank secured a grant from the Water Partnership Program (WPP) to conduct an analytical work entitled “Sustainable Urban Water and Wastewater Services in Türkiye,” which is the basis for this report.

The Small and Medium Enterprises Development Organization of Türkiye (KOSGEB) is also an important source of funding for R&D, as it aims to increase the shares of SMEs and entrepreneurs in economic and social development to reach an innovative, technological and competitive structure through effective supports and services.

Higher Education Institutions

As for HEIs activities in the field of digital water, some examples are shown for the universities that are active in the field.

Istanbul Technical University is a partner in the project Digiwater¹⁴⁵, which is a Erasmus+ project co-funded by the European Union, aiming a) enhancing digital innovations in curricula during education as a basic method for later implementation and application in business like industry, administration, consultancy; b) establishing smart specialisation for digital water through the upgrade of curricula in partner universities with participation from industry; and c) improving the

¹⁴³ <https://basaksehir-livinglab.com/BLL/ngos-associations-and-foundations/>

¹⁴⁴ <https://www.worldbank.org/en/country/turkey/publication/turkey-sustainable-urban-water-supply-and-sanitation-report>

¹⁴⁵ <https://waterharmony.net/projects/digiwater-2/>

orientation of academia towards societal and market needs through internationalisation of universities, Digital Water LL and Innovation Camps.

Mugla Sıtkı Kocman University¹⁴⁶ provides a graduate course, which targets identifying the factors that can affect the innovative water management approach in smart cities and the main characteristics of drought-resistant cities, determining the indicators for defining the water safety of the cities and the water safety of the cities and revealing the method that can evaluate the set of indicators, working on digital water, and conducting research in AI uses for water-related SDGs.

A Turkish initiative has also developed a device that produces water from moisture and heat changes in the air¹⁴⁷. The device, in its beta phase, is developed by the Istanbul Technical University, and can convert the relative humidity of air into water and produce electricity with an innovative method.

Table 22 shows the skills needed and the skills perceived as available according to the industry stakeholders.

Table 22. Skills needed and present in digital water according to industry stakeholders – Türkiye

Type of Skills	Needed	Present
Water resources management	Applying ICT in WRM Optimizing and managing available resources in WRM systems Applying specialised civil engineering fields in WRM Understanding of the Water Framework Directive and its implementation processes Using of mathematical models for the simulation of water related processes Applying modern tools that facilitate the spatiotemporal management of the water resources, GIS and WRM Identifying problems, needs and priorities, including facilitation of group efforts to define and prioritize broad water resource program needs	Optimizing and managing available resources in WRM systems
Academic	Research skills	Learning from experience Computer skills
Interdisciplinary teaching and learning	Problem solving Collaboration	Problem solving Collaboration

¹⁴⁶

https://adds.mu.edu.tr/Rapor.aspx?ders_kodu=1314502&dil_kodu=Tr&tur=normal&AspxAutoDetectCookieSupport=1 (In Turkish)

¹⁴⁷ <https://www.repg.com.tr/2021/01/19/producing-water-electricity-from-air-easier-than-thought/?lang=en>

Type of Skills	Needed	Present
Soft	Self-management Teamwork Time management Analytical	Self-motivation Accountability
Technical	Technical writing	Project management
Transversal	Sense of initiative and entrepreneurship Prioritising and organising Delivering quality and results	Sense of initiative and entrepreneurship Self-profiling Delivering quality and results

It is observed a mismatch in terms of what the industry stakeholders need and what they perceive as having access to. This is further elaborated below in the example of the SCADA systems education.

Academia industry-collaboration

There are apparent focuses on digital water technologies on both university and industry sides, but they do not really converge into a joint effort. For example, SCADA systems education is given in some university programs while it is intentionally implemented in several municipality water authority departments. Still there are no venue to expand the apply this knowledge on the ways of adapting the water technology components onto regional dynamics and on the ways to generate added-value experiences from the application of digital water technologies at these scales are not realized.

The following items are few examples to the industry-university research collaborations mostly supported under the Technology and Innovation Support Programme TEYDEB of The Scientific and Technological Research Council of Türkiye (TUBITAK):

- Smart Water Treatment Telemetry and Teleoperation System, which includes measurement, monitoring, remote control and guidance, optimization, decision support systems, cloud server systems and the development of user interfaces to obtain flexible technological infrastructures.
- Creation of an Embedded Automation System to provide Control of Water Quality in Drinking-Process-Wastewater Facilities, this is a commercial product under producing a solution to be applied at drinking-process-wastewater facilities of public and private institutions.

A range of projects funded in the 2010's has focused on sensing technologies, water treatment devices, water metering devices, remote water management technologies. These examples speak about the advance of RDI in digital water in the country as well.

Civil society

NGOs promoting strategy development on digital water:

- Water Foundation (Su Vakfi)¹³⁰: Water Foundation may be indirectly contemplated in water and water related publications.
- The Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats¹³¹ (TEMA). TEMA Foundation's reason for existence is to protect and preserve

the soil. So far, they have carried trainings and become partnered in the projects. The project "Civil Society Network for Expanding Climate in Agricultural Policies"¹⁴⁸ is one of the EU projects in which smart water applications are recommended.

- Water Policies Association (Su Politikaları Derneği)¹³²: The Water Policies Association published the report "Digital Water World", which examined how digitalisation has transformed the water sector through developments in water and wastewater infrastructures¹⁴⁹. The report provides an overview of the current state of digital applications in the water sector, the benefits of digital solutions and the lessons learned from the digital journey.

4.2.9 The United Kingdom

For the UK it is verified the observation of Savić (2022), according to whom the digitalisation progress in the water sector is lagging behind other areas due to several challenges, including legacy data collection and management systems, difficulties in establishing a clear business case for digital applications, cybersecurity issues, and the lack in human capital prepared to work in the sector.

Institutional environment

The legislation and strategies and policies composing the institutional environment of the water sector operations in the UK is presented in Table 23.

¹⁴⁸ https://cdn-tema.mncdn.com/Uploads/Cms/web_03_politika_onerileri_tarim_a4_tema_ab_rapor.pdf

¹⁴⁹ <https://www.hidropolitikakademi.org/uploads/editor/images/DIJITAL%20SU%20DÜNYASI%20RAPORU.pdf>

Table 23. Legislation, strategies and policies in the water sector - the UK

Legislation	Strategies and Policies	
	Strategy/Policy	Short Description
Water Act 2014	2010 to 2015 government policy: water quality	How the government is improving the quality of our rivers and inland waterbodies.
Water Industry (Financial Assistance) Act 2012	25 Year Environment Plan	The plan sets out what we will do to improve the environment, within a generation.
Flood and Water Management Act 2010	Drainage Strategy Framework - For water and sewerage companies to prepare Drainage Strategies	For water and sewerage companies to prepare drainage Strategies
Water Consolidation (Consequential Provisions) Act 1991	Drought: managing water supply	How water companies plan for dry weather and drought to make sure they can supply water and protect the environment.
Water Resources Act 1991	Environment Bill 2020	Documents related to the 2020 Environment Bill. The Bill will bring into UK law environmental protections and recovery.
Water Industry Act 1991	Future water: The government's water strategy for England	The strategy sets out a framework for water management in England.
Public Utility Transfers and Water Charges Act 1988	Managing water abstraction	How government, water companies and the Environment Agency make sure there is enough water for future needs of both people and the environment.
Water (Fluoridation) Act 1985	Meeting our future water needs: a national framework for water resources	Explores England's long term water needs, setting out the scale of action needed to ensure resilient supplies and an improved water environment.
Water (Scotland) Act 1980	National Flood and Coastal Erosion Risk Management Strategy for England	The strategy sets out a vision of a nation ready for, and resilient to, flooding and coastal change – today, tomorrow and to the year 2100.
Water Charges Equalisation Act 1977	National policy statement for wastewater	A framework document for planning decisions on nationally significant wastewater infrastructure.
Water Act 1973	River basin management plans	River basin management plans describe the challenges that threaten the water environment and how these challenges can be managed and funded.

Legislation	Strategies and Policies	
	Strategy/Policy	Short Description
Oil in Navigable Waters Act 1971	Storm overflows discharge reduction plan	The storm overflows discharge reduction plan sets stringent new targets to protect people and the environment. This will require water companies to deliver the largest infrastructure programme in water company history.
	Strategic policy statement for Ofwat	Strategic policy statement setting out the government's priorities for Ofwat's regulation of the water sector in England.
	Wastewater treatment in the UK (2012)	What the UK has done to improve wastewater treatment and meet its commitments under the Urban Wastewater Treatment Directive.
	Water 2020	This decision document sets out the future regulatory framework for the water and wastewater industry in England and Wales to enable the water sector to address the challenges it faces and to help build trust and confidence among customers and wider society.
	Water abstraction plan	Setting out how the government will reform the way we manage water abstraction, to protect the environment and improve access to water
	Water industry strategic environmental requirements	A strategic steer to water companies on the environment, resilience, and flood risk for business planning purposes.
	Water research and innovation framework	A framework for water research and innovation in the UK.
	UK's Digital Strategy	The government's vision for harnessing digital transformation and building a more inclusive, competitive and innovative digital economy.

Guiding the digital water sector, the UK has two strategies. Time to act, together: Ofwat's strategy¹⁵⁰ sets out the ambition for the water sector and the UK 2050 Water Innovation Strategy¹⁵¹ seeks to guide innovation investment across the sector and will provide insight for us in rolling out the £200m innovation fund. It also signals new opportunities for partners and suppliers of all sizes to innovate and collaborate more easily and efficiently across the whole sector.

¹⁵⁰ <https://www.ofwat.gov.uk/publication/time-to-act-together-ofwats-strategy/>

¹⁵¹ <https://waterinnovation2050.org.uk/>

Smart Specialisation Strategies

No information about the state of the art of S3 in the UK was available. Only government documents available referred to the first period of implementation of S3 (2014). Therefore, they were disconsidered.

Innovation Ecosystems

Clusters

The UK Smart Water Network¹⁵² (SWAN) is the UK Water Partnership¹⁵³ bringing together water utilities, solution providers, and industry experts to promote the applications of smart water solutions in drinking water, wastewater, and stormwater areas to improve the use of a utility's physical assets by better measuring and acting upon network events. The UK Water Partnership was established in 2015 to connect institutions in the water sector for collaborations in creating a strategic vision for the development and growth of the UK water industry.

Living Labs

No LLs operating in digital water were identified in the UK.

Business Development Support

There are several initiatives to support businesses, as well as established business, in the UK working in smart water related fields. What they are and what they do is illustrated:

- Spring¹⁵⁴, formed in 2021 based on the UK Water Innovation 2050 strategy, to work closely with UKWIR in supporting UK water sector in accelerating transformation via innovation and collaboration.
- Waterscan¹⁵⁵ is providing tailored knowledge to guide organisations to improve water sustainability performance and reducing their environmental impact.
- Icosawater¹⁵⁶ is advising households, businesses, developers and retailers, as well as providing water and wastewater services in multiple regions in England.
- Detectronic¹⁵⁷ is developing equipment and offering services for monitoring water and wastewater systems.
- AVK UK¹⁵⁸ is developing solutions for monitoring conditions in water networks for smart water management.
- Develop Training¹⁵⁹ is providing compliance, technical, and safety training to engineers in sectors in utilities, constructors, facility management, etc.
- WRC Group¹⁶⁰ is offering knowledge base and training courses to help the clients building sustainable and efficient solutions in water management.

¹⁵² <https://swan-forum.com/ecosystem/>

¹⁵³ <https://www.theukwaterpartnership.org/>

¹⁵⁴ <https://spring-innovation.co.uk/>

¹⁵⁵ <https://waterscan.com/>

¹⁵⁶ <https://www.icosawater.co.uk/>

¹⁵⁷ <https://detectronic.org/>

¹⁵⁸ <https://www.avkuk.co.uk/>

¹⁵⁹ <https://www.developtraining.co.uk/>

¹⁶⁰ <https://www.wrcgroup.com/>

Funding

The main funding bodies in the UK supporting water engineering research include:

- The UK Research and Innovation’s (UKRI) Innovate UK programme¹⁶¹
- UKRI’s EPSRC (Engineering and Physical Sciences Research Council)¹⁶² (EPSRC)
- UK Water Industry Research¹⁶³ (UKWIR)

Higher Education Institutions

The water-focused initiatives in UK HEIs include:

- GW4 Water Security Alliance¹⁶⁴, which brings together a community of interdisciplinary researchers, spanning disciplines from Natural, Earth, Biological and Social Sciences to Economics and Engineering.¹⁶⁵
- The Environmental Association for Universities and Colleges¹⁶⁶ (EAUC), environmental and sustainability champion within Further and Higher Education in the UK and Ireland.¹⁶⁷

The EPSRC has funded a several number of Centre for Doctor Training (CDT)), that are targeting on digital water research: These centres are:

- Water Informatics: Science and Engineering (WISE) CDT ¹⁶⁸
- Stream The Industrial Doctorate Centre for the Water Sector¹⁶⁹Stream the Industrial Doctorate Centre for the Water Sector ¹⁷⁰
- Water and Waste Infrastructure Systems Engineered for Resilience (Water-WISER) CDT¹⁷¹ and Water and Waste Infrastructure Systems Engineered for Resilience (Water-WISER) CDT¹⁷²Water and Waste Infrastructure Systems Engineered for Resilience (Water-WISER) CDT ¹⁷³
- Water Infrastructure and Resilience CDT¹⁷⁴Water Infrastructure and Resilience CDT¹⁷⁵
- Water Infrastructure and Resilience CDT ¹⁷⁶

The European Research Council Synergy Grant the Water-Futures ¹⁷⁷ project that is aiming at training next generation of water professionals to design future smart water systems.

The individual HEIs teaching and d digital doing research on digital water-related subjects are listed in Table 24.

Table 24. HEIs activities in digital water - The UK

Higher Education Institutions and Activities in Digital Water		
University of Bath ¹⁷⁸	University of Exeter ¹⁷⁹	University College London ¹⁸⁰
<p>Courses Water Informatics: Science and Engineering¹⁸¹</p> <p>Research Active control for multi-degree-of-freedom wave energy converters¹⁸²</p>	<p>Courses Water Informatics: Science and Engineering¹⁸³ Stream The Industrial Doctorate Centre for the Water Sector¹⁸⁴ Water-Futures¹⁸⁵</p> <p>Research Hydroinformatics and Artificial Intelligence¹⁸⁶</p>	<p>Courses Spatio-Temporal Analytics and Big Data Mining MSc¹⁸⁹</p> <p>Research Protecting our lighthouses for the safety of mariners¹⁹⁰</p> <p>Outreach SpaceTimeLab research on water mapping¹⁹¹</p>

	Innovation and Technology ¹⁸⁷ Outreach CWS seminars ¹⁸⁸	
University of Leeds ¹⁹²	University of Bristol ¹⁹³	Cardiff University ¹⁹⁴
Courses Water and Waste Infrastructure Systems Engineered for Resilience ¹⁹⁵ Research	Courses FRESH Centre for Doctoral Training ¹⁹⁹ Water Informatics: Science and Engineering ²⁰⁰ Research	Courses FRESH Centre for Doctoral Training ²⁰⁵ Water Informatics: Science and Engineering ²⁰⁶ Research

¹⁶¹ <https://www.ukri.org/councils/innovate-uk/>

¹⁶² <https://www.ukri.org/councils/epsrc/>

¹⁶³ <https://ukwir.org/>

¹⁶⁴ <https://gw4water.com/>

¹⁶⁵ <https://gw4water.com/>

¹⁶⁶ <https://www.eauc.org.uk/>

¹⁶⁷ <https://www.eauc.org.uk/>

¹⁶⁸ <http://wisecdt.org.uk/>

¹⁶⁹ <http://www.stream-idc.net/>

¹⁷⁰ <http://www.stream-idc.net/>

¹⁷¹ <https://www.waterwisercdt.ac.uk/>

¹⁷² <https://www.waterwisercdt.ac.uk/>

¹⁷³ <https://www.waterwisercdt.ac.uk/>

¹⁷⁴ <https://www.ncl.ac.uk/engineering/research/civil-engineering/environmental-engineering/wire/>

¹⁷⁵ <https://www.ncl.ac.uk/engineering/research/civil-engineering/environmental-engineering/wire/>

¹⁷⁶ <https://www.ncl.ac.uk/engineering/research/civil-engineering/environmental-engineering/wire/>

¹⁷⁷ <https://waterfutures.eu/>

¹⁷⁸ <https://www.bath.ac.uk/research-centres/water-innovation-and-research-centre-wirc-bath>

¹⁷⁹ <https://engineering.exeter.ac.uk/research/cws>

¹⁸⁰ <https://www.ucl.ac.uk/civil-environmental-geomatic-engineering>

¹⁸¹ <http://wisecdt.org.uk/>

¹⁸² <https://www.bath.ac.uk/projects/active-control-for-multi-degree-of-freedom-wave-energy-converters/>

¹⁸³ <http://wisecdt.org.uk/>

¹⁸⁴ <http://www.stream-idc.net/>

¹⁸⁵ <https://waterfutures.eu/>

¹⁸⁶ <https://engineering.exeter.ac.uk/research/cws/research/hydroinformatics-ai>

¹⁸⁹ <https://www.ucl.ac.uk/prospective-students/graduate/taught-degrees/spatio-temporal-analytics-and-big-data-mining-msc>

¹⁹⁰ <https://www.ucl.ac.uk/civil-environmental-geomatic-engineering/research-projects/2021/feb/stormlamp>

¹⁹¹ <https://www.ucl.ac.uk/civil-environmental-geomatic-engineering/news/2021/aug/spacetime-lab-research-water-mapping-featured-sentinel-success-stories>

¹⁸⁷ <https://engineering.exeter.ac.uk/research/cws/research/innovation-technology>

¹⁸⁸ <https://engineering.exeter.ac.uk/research/cws/newsandevents/events/>

¹⁹² <https://water.leeds.ac.uk/>

¹⁹³ <https://www.bristol.ac.uk/engineering/research/water/>

¹⁹⁴ <https://www.cardiff.ac.uk/water-research-institute>

¹⁹⁵ <https://waterwisercdt.ac.uk/>

¹⁹⁹ <https://www.gw4fresh.co.uk/>

²⁰⁰ <http://wisecdt.org.uk/>

²⁰⁵ <https://www.gw4fresh.co.uk/>

²⁰⁶ <http://wisecdt.org.uk/>

<p>A European training and research network for environmental flow management in river basins¹⁹⁶</p> <p>The Yorkshire Integrated Catchment Solutions Programme¹⁹⁷</p> <p>Outreach</p> <p>Water Security and Sustainable Development Hub¹⁹⁸</p>	<p>SWITCH-ON²⁰¹</p> <p>Beyond the networked city²⁰²</p> <p>Outreach</p> <p>The Land of the Summer People²⁰³</p> <p>Women in Engineering Workshop for primary and secondary schools²⁰⁴</p>	<p>Digital Solutions for Water Risk Management²⁰⁷</p> <p>Outreach²⁰⁸</p>
Cranfield University ²⁰⁹	Newcastle University ²¹⁰	University of Sheffield ²¹¹
<p>Courses</p> <p>Stream The Industrial Doctorate Centre for the Water Sector²¹²</p> <p>Water Infrastructure and Resilience²¹³</p> <p>Research</p> <p>WASHTech²¹⁴</p> <p>SMART-Plant²¹⁵</p> <p>Outreach</p>	<p>Courses</p> <p>Hydroinformatics and Water Management²¹⁷</p> <p>Water Infrastructure and Resilience²¹⁸</p> <p>Research</p> <p>High-Definition Modelling²¹⁹</p> <p>Newcastle Urban Observatory²²⁰</p> <p>Outreach</p>	<p>Courses</p> <p>Stream The Industrial Doctorate Centre for the Water Sector²²²</p> <p>Water Infrastructure and Resilience</p> <p>Research</p> <p>Sensors²²³</p> <p>Urban Drainage Systems²²⁴</p> <p>Co-UDlabs²²⁵</p> <p>Outreach</p> <p>Engagement and governance</p>

¹⁹⁶ <https://environment.leeds.ac.uk/faculty/dir-record/research-projects/996/euroflow>

¹⁹⁷ <https://environment.leeds.ac.uk/faculty/dir-record/research-projects/1072/icasp-the-yorkshire-integrated-catchment-solutions-programme>

¹⁹⁸ <https://gtr.ukri.org/projects?ref=ES%2FS008179%2F1>

²⁰¹ <http://www.water-switch-on.eu/>

²⁰² <http://www.bristol.ac.uk/engineering/research/water-and-sanitation/beyond-the-networked-city/>

²⁰³ <https://thelandofthesummerpeople.org/>

²⁰⁴ <https://www.bristol.ac.uk/engineering/research/water/projects/wie.html>

²⁰⁷ <https://www.cardiff.ac.uk/water-research-institute/research/research-themes/digital-solutions-for-water-risk-management>

²⁰⁸ <https://www.cardiff.ac.uk/water-research-institute/partnerships>

²⁰⁹ <https://www.cranfield.ac.uk/centres/water-sciences-institute>

²¹⁰ <https://www.ncl.ac.uk/engineering/research/civil-engineering/water/>

²¹¹ <https://www.sheffield.ac.uk/penninewatergroup>

²¹² <http://www.stream-idc.net/>

²¹³ <https://cdtwire.com/>

²¹⁴ <https://www.cranfield.ac.uk/case-studies/research-case-studies/water-sanitation-and-hygiene-technologies>

²¹⁵ <https://www.cranfield.ac.uk/case-studies/smart-plant>

²¹⁷ <https://www.ncl.ac.uk/postgraduate/courses/degrees/hydroinformatics-water-management-euro-aquae-msc/>

²¹⁸ <https://cdtwire.com/>

²¹⁹ <https://www.ncl.ac.uk/engineering/research/civil-engineering/water/flood>

²²⁰ <http://www.urbanobservatory.ac.uk/>

²²² <http://www.stream-idc.net/>

²²³ <https://www.sheffield.ac.uk/penninewatergroup/research/sensors>

²²⁴ <https://www.sheffield.ac.uk/penninewatergroup/research/urban-drainage-systems>

²²⁵ <https://co-udlabs.eu/>

Innovation partnership to tackle environmental challenges of the water sector ²¹⁶	EPSRC Infrastructure Transitions Research Consortium ²²¹	
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Regarding the survey on skills needs and skills perceived as available by the industry stakeholders in the UK, the results are shown in Table 25.

Table 25. Skills needed and present in digital water according to industry stakeholders – The UK

Type of Skills	United Kingdom	
	Needed	Present
Water resources management	Applying ICT in WRM Devising strategies and developing methodology and methods of emergency as part of WRM Implementing water supply and water efficiency plans and programs	Understanding of the Water Framework Directive and its implementation processes Implementing water supply and water efficiency plans and programs
Academic	Computer skills Presentation and public speaking skills	Computer skills
Interdisciplinary teaching and learning	Critical thinking Problem solving Innovation	Problem solving
Soft Skills	Teamwork Time management	Time management Self-motivation
Technical	Data analysis Technical writing	Industry-related knowledge
Transversal	Prioritising and organising Delivering quality and results	Learning to learn Exploring work-related and career-related opportunities Delivering quality and results

²¹⁶ <https://www.cranfield.ac.uk/press/news-2022/innovation-partnership-to-tackle-environmental-challenges-of-the-water-sector>

²²¹ <https://www.itrc.org.uk/>

Industry-academia collaboration

Our Rainwater Ltd²²⁶, which originated at the University of Exeter, is an example of a current company that is helping homeowners' adaptation of smart rainwater management systems to reduce the surface runoff entering sewer networks.

Civil society

No organisations belonging to civil society or associations were identified as being involved in the planning, decision-making or implementation of activities related to digital water in the UK.

²²⁶ <https://ourrainwater.com/>

5. Analysis

This report has led to a stocktaking of digital water activities within the context of regional development strategies and innovation ecosystems, as well as the identification of activities HEIs have performed to foster the skilling of workforce, knowledge development and engagement with digital water innovation ecosystems. Specific results considering each of the categories of innovation ecosystems elements: policies, arrangements, education, stakeholders' roles and how they collaborate for the promotion of solutions and innovation in the digital water sector, are discussed.

Starting with the challenges highlighted by the partners as the most affecting to the advancement of the digital water sector in the 8 countries, they can be summarized as:

- Lack of industrial expertise in the field;
- Conservative industry culture;
- Lack of political facilitation and investment in innovation in digital water;
- Lack of stakeholders' awareness for the development of expertise, cooperation, and support to research in the field.

The European Union has progressed significantly in the promotion of activities leading to a framework for the adoption of digital water, whose importance has been recognized in the context of sustainability transitions, digital transformation and the Water-Smart Society. Finland, Norway, the UK are the leading countries in terms of the framework they have implemented to support digital water. They are concerned with their local capabilities, or the lack thereof, to promote the digital and sustainability transition of the water sector, skilling of the workforce, local innovation ecosystems and support to R&D in the field.

S3 and the cluster activities associated to them has significant examples coming from Finland, Czech Republic, Italy and Malta and the other regions associated to the WSTs, as seen in the benchmark case of the WaterCampus Leewarden and the Frysland region in the Netherlands. Through the cases presented and the vast sources of reference, for example, the Smart Specialisation Platform and the Cluster Collaboration Platform from the EC, as well as many initiatives connected with them and the European Joint Research Institute and among the clusters in the context of projects (EU framework programs, INTERREG, etc.). These are opportunities to advance in the generation of knowledge and sharing of practices and to allow for the lagging regions to learn from them.

The LLs has been the arrangement most countries have experience in utilizing. All countries, but Serbia, have cases, including registered in the WE's WoLLs mapping (WEWE, 2019c). For example, the HEI countries of Waterline alone have 20 LLs listed by WEWE: Czech Republic (1), Finland (3), Italy (4), Norway (1), Türkiye (1), the UK (10), out of 105 mapped throughout Europe. The importance of LLs lies especially in the fact that the experimentation spaces are one of the basic structures for the development of innovations in collaboration with industry and society.

Finally, HEIs have showed evidence of how they are preparing the workforce by means of teaching at various levels from vocational to doctoral programmes, and of their engagement in research in the field. Again, some leading expertise can be brought to the group by the UK, Finland, Italy, Malta and Norway, and the other countries HEIs in a continuum from medium to low engagement ending with Serbia with less activities demonstrated.

Still, the mismatches observed between the skills needed by the industry and what they perceive as available, including offered by local HEIs, is an important indicator that more dialogue is needed

between HEIs and industry to disseminate what HEIs do and how industries could benefit from those activities and develop the skills and expertise they need, as well as to allow for the industry to have a say on the planning of teaching and training by the HEIs. This could bring more opportunities also for the students to acquire practical knowledge in internships in companies and for the companies to participate in class activities, by means of talks for example, with the students.

The analysis of these different elements of the digital water innovation ecosystems has allowed for the elaboration of a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, shown in Table 26 to illustrate the potential the countries have to close the gap in relation to the lagging countries, or more specifically how HEIs can get inspirations to define more strategic roles to play in the digital water innovation ecosystems. Although it applies mostly for those lagging in engagement, but it also holds potentials for the leading ones, in terms of what they can do to facilitate the process by sharing knowledge and expertise.

Table 26. SWOT analysis: Digital water innovation ecosystems in the context of WATERLINE

Strengths	Weaknesses
<ul style="list-style-type: none"> • There are pioneering countries in the adoption of innovation ecosystem approaches in digital water. • There are pioneering HEIs teaching, research and innovation in digital water. • Formation of practical evidence on digital water workforce skilling profiles. • Universities with mandate to participate in regional development policies and innovation ecosystems. • Highly recognized S3, clusters and LL experiences functioning as international benchmarks. • Strong technological expertise and research capabilities. • Government support in policy and funding in some of the countries. 	<ul style="list-style-type: none"> • Digital water innovation ecosystems are not a common feature across all countries. • Different levels of implementation of digital water education across HEIs. • Insufficient adoption of education frameworks in digital water. • Low level in the engagement of civil society in promotion of digital water ecosystems. • Digital water strategies are not uniformly adopted. • Mismatches between the skills needed by the industry and the knowledge of what skills HEIs are developing. • Lack of awareness and support to digital water.
Opportunities	Threats
<ul style="list-style-type: none"> • High potential for knowledge exchange among the Digital Water HEI Alliance partners, local development authorities and local governments. • Practical knowledge available through platforms for the dissemination of digital water innovation ecosystems. • S3 evolution in the inclusion of SDGs and societal challenges. 	<ul style="list-style-type: none"> • Local legislations and policy guidelines still insufficient to promote digital water ecosystems although international guidelines are available for customization. • Risk of worsening the gap between leading and lagging regions in the implementation of digital water ecosystems as funding are increasingly more competitive. • Risk of failures in the implementation of the distributed campus and the HEI Alliance due

- Digital water is consolidated as policy area in the EU.
- Water-Smart Society framework as a comprehensive approach to the digitalisation of the sector.

to unbalanced status of HEIs activities in RDI in digital water.

- Small market considering the size of some of the countries analysed hinder investment and the scalability of solutions.
- Competition from foreign big corporations deter investments from local companies.

6. Conclusions

The mapping of digital water innovation ecosystems in the countries participating in the Digital Water HEIs Alliance proposal showed evidence of ecosystems and supporting strategies and HEIs activities. Therefore, demonstrating a potential for engagement in knowledge sharing from HEIs who are placed in leading ecosystems and have themselves developed activities to provide skilling and innovation support to the ecosystem. There is, though the risk of the Digital Water Alliance is not consolidated in the absence of strong sustainability case for the Alliance.

Having concluded the mapping of the digital water innovation ecosystems and HEIs activities in them, it is possible to draw some recommendations for the next steps in the execution of Waterline and for the development of digital water ecosystems in the Widening countries.

6.1 Recommendations

Based on the work carried out in this report, the following recommendations are presented to support an verify that the activities of the consortium.

1. *Foster industrial expertise*

Covering the gaps in industry's capabilities within the digital water innovation ecosystems can be achieved by implementing activities with a view to:

- Encourage collaboration between HEIs and industry to bridge the gap in industrial expertise.
- Establish partnerships that include synergistic activities and initiatives with leading countries (Finland, Norway, the UK) for knowledge exchange and joint projects.
- Develop targeted programs to attract professionals from the industry into academia for knowledge transfer.

WATERLINE's T2.1 and T2.2 have identified, respectively, skills gaps and different innovation ecosystem arrangements, and the gaps among the countries in this regard as well. We recognize fostering engagement with the industry as an important means to address the lack of industrial expertise in the Widening countries. The industry can benefit from the development of capabilities by the local HEIs and provoke spillover effects by adopting measures that bring digital innovation to society's fruition. Activities in WP2, WP4, WP5, and WP6 must be implemented with all regard for the engagement of the industry.

T2.2 has produced knowledge from interviews with stakeholders from the Smart Water Territories Platform, Smart Water Cluster, as well as the project partners have good knowledge of policy support and funding mechanisms related to ICT4Water, S3 platform, cluster collaboration platform. The knowledge gathered through the interviews and innovation ecosystem mapping allowed for the identification of best practices, for example, how the Smart Water Cluster of Kuopio, in Finland, works with the ecosystem stakeholders, especially local authorities, and how a concerted search for funding has yield positive returns.

2. *Political facilitation and investment*

Policymakers have the power to drive changes by means of policies and targeted investments. HEIs, besides the involvement with teaching, education and research can raise awareness of society,

implement partnerships with the industry and support governments with facts that facilitate the decision-making. So, activities to facilitate political engagement and funding shall be driven to:

- Advocate for increased political support and investment in digital water innovation by showcasing its importance for sustainability and societal development.
- Collaborate with policymakers to develop policies that promote digital water ecosystems.
- Establish partnerships with international organizations to leverage funding opportunities.

Besides the knowledge acquired in T2.2, WP3, WP5 and WP6 will be spaces to promote the engagement of stakeholders with the project's activities. These will be established through communication and dissemination activities (WP6), training activities (WP3), and identification of funding opportunities and the development of a policy exploitation guideline for future implementations of similar programs and for shaping the policy recommendations for the water professional training curriculum (WP5).

3. Stakeholders' awareness and engagement

Stakeholders' awareness and engagement is at the core of the implementation of WATERLINE projects. So, the project activities shall focus on:

- Developing awareness campaigns to educate stakeholders about the benefits of digital water and the importance of collaboration.
- Organizing workshops, seminars, and networking events to facilitate interactions between academia, industry, and civil society.
- Encouraging participation in digital water innovation ecosystems through showcasing incentives and illustrative arrangements identified in this research.

The mapping of ecosystem stakeholders realized in T2.2 has identified the main stakeholders the project has to talk to, and related engagement and awareness activities are dealt with in WP2, WP4, WP5 and WP6. The project is committed to building and fostering a European network of academics/researchers, who will act as linchpins with actors from the surrounding quadruple helix ecosystem, including community, to allow partners to share and benefit from their different expertise in water domains and respective extended reality technologies to contribute better to education related to the water sphere.

As important plan towards meeting that goal, WATERLINE will create a platform for knowledge sharing, promote awareness-raising seminars and information sessions and stakeholder engagement processes, knowledge dissemination, and effective communication. It is also creating a technology transfer framework to enhance innovation and support the exchange of knowledge and technologies between Waterline partners and other stakeholders (WP4). Still, in WP2, there establishment of the management committee, with representatives of the quadruple helix, to support the consolidation of the Digital Water HEI Alliance will be a means of keeping the interests of the different stakeholder groups into consideration in the definition of training, education and research and innovation activities.

4. Strengthen local capabilities

WATERLINE is strongly geared towards creating impact at local level by collaborating in network of HEIs dedicated education, research and innovations to promote digital water and creating local capabilities. Specifically, this can be achieved through:

- Collaboration with leading countries and regions to strengthen local capabilities for digital water adoption.
- Implementation of S3 and cluster activities to create localized innovation ecosystems.
- Leveraging existing platforms such as the S3 Platform and the Cluster Collaboration Platform for knowledge sharing.

The two most important activities related to the strengthening of local capabilities will run in WP3 and WP4. The transformation of the already existent emulation laboratories (first LE) in the HEIs from Widening participating countries to extend to two extended-reality LEs (assisted reality and virtual reality), with the expert support of partner UNEXE, who already have a virtual reality LE for their emulation laboratory, will be dealt with in WP4. The WP3 will work to enhance innovation ecosystems capacity by reinforcing cooperation between R&I and business sectors, by the creation of the Smart Water curricula, implementing the scientific strategy of the project focusing on human capital development, and incentivizing an entrepreneurial mindset amongst researchers. In WP2/T2.3, it is recommended to include awareness-raising activity about digital water innovation ecosystem, including with the presentation of cases such as the ones identified in T2.2.

Effective participation in new projects is important for the continuation of the collaboration of the partners in WATERLINE, especially keeping the involvement of the Widening countries. Partners have identified the following calls for submission of proposals:

- HORIZON-WIDERA-2023-ACCESS-03: MCAST, UNI, SITES.
- Erasmus+: ACCEU, UNI, H2O
- HORIZON-WIDERA-2023-ACCESS-07: UNI, SITES, NMBU, Tubitak (from Turkey, a partner from SMART4Env project, with which WATERLINE has been collaborating).
- HORIZON-WIDERA-2023-ACCESS: SITE, NMBU, UNI.

5. Enhance education frameworks

This recommendation addresses one of the most important topics baseline for WATERLINE. It can be implemented by measures to:

- Standardize and enhance digital water education frameworks across HEIs.
- Facilitate collaboration between HEIs and industry to align educational programs with industry needs.
- Establish joint programs and initiatives with leading countries to share best practices in digital water education.

WP2, besides the identification of the industry educational needs, is designing a HEI knowledge governance framework and a R&I capacity building plan to facilitate of cross-institute joint research and collaboration with ecosystem stakeholders and reap the benefits of knowledge exchange. WP3 and WP4 will deal with the co-creation of the components for a Master program curriculum, which will cover distinct water themes and transforming emulated laboratories in participating Widening country HEIs into assisted reality and virtual reality LEs, with the support of non-Widening HEI, and the realization of summer schools and trainings.

7. Address mismatches in skills

- Facilitate dialogue between HEIs and industry to understand and address mismatches in skills.
- Establish internship programs, joint projects, and industry advisory boards to close the gap.

- Encourage industry involvement in curriculum planning and development.

Results of T2.1 are an important input for the definition of WATERLINE’s training and education program and curricula and engagement with industry. The project will seek a multi-stakeholder perspective about education, R&I, and current skills gap and skills mismatch on “Digital Water” from all relevant sectors and will investigate the legal, economic and curriculum regulations governing the participating HEIs. This topic is addressed by all WPs, mostly WP2, WP4, WP6. The Digital Water HEIs Alliance has the integration with the European HEI Initiative as a target. At the local level, bringing awareness about and strengthening the role of universities in the innovation ecosystems will benefit from both, the technical and the entrepreneurial, streams of education.

8. Supportive government policies

- Advocate for the development and adoption of supportive government policies for digital water.
- Work with policymakers to align national strategies with EU-level initiatives.
- Provide evidence-based recommendations to policymakers for informed decision-making.

WATERLINE’s mainly WP5 and WP6 are planned to support the implementation of this recommendation. WP6 will sustain the alliance of extended-reality water emulative centers through the establishment of structured ambassador networks and the identification of future R&I funding landscape and by creating synergies with EU initiatives, Institutions, other EU-funded projects, and the National Contact Points of Higher Education (NCP HE) networks through a network of networks approach. WP5 will compile a policy guideline for future implementations of similar programs and for shaping the policy recommendations for water professional training curriculum. Examples of government support policies identified in T2.2 can be used to instruct local stakeholders in Widening countries and foster their engagement with the topic and the establishment of supporting mechanisms.

9. Knowledge exchange and collaboration

- Promote knowledge exchange among Digital Water HEI Alliance partners, local development authorities, and governments.
- Facilitate the dissemination of practical knowledge through platforms dedicated to digital water innovation ecosystems.
- Encourage collaboration on research and innovation projects across borders.

The new digital water alliance governed by a WATERLINE governance framework (WP2), R&I capacity building plan (WP2) and technology transfer framework (WP4) will contribute to strengthening cooperation to raise non-Widening excellence, global competitiveness, and general attractiveness for international talents and investments and lead the path for the alliance to embark onto the potential future European Universities initiative.

6.2 Risks and mitigation measures

The recommendations originated from the research done in T2.2 have correspondence in the project plan. The main risk the project runs can be due to a weak implementation of the activities that aim to address them. Emphasis shall be put in the engagement of quadruple helix stakeholders beyond the HEI partner setting. It is an advantage for the Widening countries, and for the countries with less advanced digital water innovation ecosystems, to learn from the business, education, research and

innovation practices shown in this document to provide education, research, innovation, funding, and policy support for digital water and the positive impact on sustainability it holds as a promise.

WATERLINE has a great potential do demonstrate to all stakeholders, especially to universities, local governments and industry in the Widening countries, the opportunities brought by the digitalization of the water sector and how much can be achieved with the multi-location remote infrastructure established by the project. The project works to demonstrate the feasibility and benefits of digital water technologies in real-world settings. It is expected that WATERLINE can serve as well to showcase successful implementation of technologies, attract investment, and build confidence among stakeholders.

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Annex 1. Waterline Survey – Guide

WATERLINE



Waterline Survey Digital Water Innovation Ecosystems

Introduction

This survey aims at characterizing local digital water innovation ecosystems by identifying the ecosystems' performers, their needs and challenges, and supporting instruments in Waterline partner HEIs locations. For the identification of the ecosystem actors, we utilize two approaches: The first one is the quadruple helix approach, which in the context of Waterline considers governments, the higher education and vocational training sector, industry, business and services sector, and the civil society by means of non-government organizations and other types of associations. The second approach is related to the smart specialisation strategy for sustainability (S4), which addresses environmental sustainability challenges alongside regional development.

For illustration of the conceptual underpinning of S4, the [Smart Specialisation Platform](#) shows how European regions are designing specialisation strategies and how they enforce the mutual benefits of collaboration among organizations of the innovation ecosystem, from local and regional to national and international levels. For a reference list of smart specialisation strategies or clusters in the digital water domain, please see the map in JRC's [Smart Water Territories](#) and check whether your country has such type of organization as listed there.

The survey is directed to the HEIs participating countries in Waterline: Czech Republic, Serbia, Malta, Türkiye, Finland, UK, Norway, Italy.

Whenever available, please share with your response to this questionnaire, any documents you may find important to understand the actors and the roles they play for the actual and future implementation of digital water ecosystems locally in the context of your country or specific regions within.

For further information you may contact Maria Lima Toivanen (maria.limatoivanen@sinnovations.org).

Organization in charge:
Filled in by:

Country:
e-mail:

Questions

Which are the main policies and other strategic documents covering water-related topics in your country (please cite all that are concerned with collection, distribution, supply, education, etc)?

Policy/Strategy	Topics covered	Link

1. What are the main water-related legislation and supporting documents in your country?
2. Are there strategic policy documents or activities dedicated to smart water in your country? If yes, could you please cite them and the links to the documents?
3. Are there regions with a digital/smart/intelligent water smart specialisation strategy in your country (regional)? If so, please inform in a table for each region in case they are more than one:

Region	
Name of the strategy	
Focus of the strategy	
Stakeholder members (specify the names of organizations belonging in each category)	
Companies	
Education organizations	
NGOs and other associations	
Government authorities	
Supporting R&I instruments	
Relevant links	
Contact	

4. Are there clusters dedicated to smart/digital/intelligent water in your country? If so, please inform in a table for each cluster in case they are more than one.

Cluster name	
Cluster Focus	
Stakeholder members (specify all the names of organizations belonging in each category)	
Companies	
Education organizations	
NGOs and other associations	
Government authorities	
Supporting R&I instruments	

Relevant links	
Contact	

5. Are there living labs dedicated to smart/digital/intelligent water in your country? If so, please inform in the table. If there are more than one living lab, please fill in a table for each.

Living Lab name	
Hosting organization	
Focus area/s	
In case there is participation of other actors in the running of the living lab	
Companies	
Education organizations	
NGOs and other associations	
Government authorities	
How has the living lab activities been funded?	
Relevant links	
Contact	

6. Is there an education framework/policy focusing on digital water? Cite relevant documents. How has it been implemented? Have evaluations been done on its performance? If so, what are the main results of the evaluation? Which organizations (universities, universities of applied sciences, vocational education training) perform teaching, research and training in water-related topics in your country?

Organization name	
Type	University () UAC () VET ()
Activities	Teaching () Research () () Research and development
References in smart water (a brief description for each)	Courses
	Research
	Outreach activities
Relevant links	
Contact	

8. Are there any examples of existing or developing businesses (both from industry and services perspectives) in the field of digital water in your country?
- a. If so, which roles have the SMEs, e.g. startups profiles, acceleration programs, SMEs in the service, measurement and production sector?
9. How is academia-industry collaboration in the development of smart water in your country, including collaboration in skills development? Please cite relevant documents on evaluations of the performance of academia-industry collaboration in the field.
10. Which role have NGOs and other types of civil society associations had in fostering innovation in the domain of digital water in your country?
11. What are the challenges for the implementation of digital water solutions (education, industrial expertise, innovation ecosystems) in your country? Please cite relevant documents and evaluations.
12. What are the main sources of funding available for the implementation of digital water-related research and innovation activities in your country? Please consider also those related to regulations for funding green procurement and certification.

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