European Commission

# Digitalisation in the Water Sector

Recommendations for Policy Developments at EU Level

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# Executive Summary

This policy brief provides an overview of current gaps in the EU legislative framework that hinder the realization of the benefits of digitalisation in the water sector and offers concrete recommendations on how to overcome them. It builds on the findings of five Horizon 2020 projects that address different aspects of digitalisation in the water sector and jointly form the DigitalWater2020 (DW2020) synergy group: digital-water.city, ScoreWater, Fiware4Water, NAIADES and aqua3s. All five projects are the active members of the ICT4Water cluster.

This policy brief highlights that digital solutions and innovations are needed to ensure sustainable and cost-efficient water management that can tackle challenges such as climate change, pollution and depletion of water resources and cyber threats. Currently, digital solutions are not sufficiently integrated into EU water policies. **EU policies are missing a coherent terminology and clear definitions of digitalisation in the water sector.** At the same time, they have different targets and different target audiences. As a result, users of water services and even providers of digital services in the water sector often either do not know or do not understand the relevant water policies. Another hindering factor for the full use of the potential of digitalisation in the water sector is the lack of technology guidance and standards for monitoring.

Currently, EU and municipal policy makers must make fundamental decisions on future investments in the water sector. These decisions should be guided by EU policies that enable the Twin Transition (digital and green transition) in the EU water sector, making the EU a sustainable and climate-proof industry leader. As Next Generation Internet Technology (NGI) becomes more affordable (e.g. IoT, Blockchain, augmented reality, etc), different use cases in the water sector need to be better understood and adopted. **EU policies should better harness the potential of digital solutions.** Common shortcomings are **related to digital infrastructure and security, integration, standardisation, data sharing, and public involvement.**

Policy makers must recognise the importance of digitalising the water sector to dramatically advance the management of water. New digital solutions may improve the transparency and efficiency of decision-making within Integrated Water Resources Management. Digital data can make policies more tangible, understandable, and widely accepted.

**Key recommendations**

- Technological aspects
  - EU policies should facilitate the digital transition for water operators. This includes linking physical infrastructures more closely to digital infrastructures through standardisation, taking into account the nexus issue, i.e. interlinkages between water, energy, food and materials/chemicals sectors.
  - The creation of a volume market for sensing technologies should be stimulated.
  - Information exchange on cybersecurity threats and best practice sharing procedures between operators, not only in the water sector but also between critical facilities, should be encouraged.
  - Concrete measures to harmonise online monitoring standards at the Member State or river basin level should be promoted.
  - Water security regulation should be integrated and harmonised in water-relevant EU policy.

- Social aspects
  - Competence development programmes on advanced data management to increase the capacities of technical staff and management of utilities and municipal administration as well as data experts to apply digital solutions in the water sector need to be prioritised.
  - Cybersecurity training for water operators at different decision-making levels should be promoted to enable an effective and appropriate response.
  - The development and use of digital solutions for citizen involvement and environmental education at all levels to increase knowledge and awareness on water issues should be fostered.
- Environmental aspects
  - Reducing environmental impacts in the water sector through digital solutions should be promoted.
  - Digital solutions to realise the potential of concepts such as Zero energy and the Water-Energy-Food Nexus need to be promoted.
  - Research on the social, economic and environmental aspects of the digital transition needs to be intensified.

# 1. Introduction

Water is vital for the adequate functioning of ecological, social and economic systems. It saturates policy areas and economic sectors in the same way that digital technologies permeate our everyday lives. Europe's waters already face multifarious challenges simultaneously and addressing them will require the policy coordination and coherence that has often been recommended but remains elusive. In this context, the digitalisation of the water sector could become a relevant enabling factor to mainstream water policy and unlock more effective action. At the same time, citizens want governmental services to be delivered as effectively and efficiently as possible, with only the necessary costs incurred and allocated. Therefore, in a water-smart society, digital transformation and digital services contribute to immersing the water sector inside the data economy paradigm.

Currently, policy makers at European Union (EU) and local level set the framework and guidelines for future investments in the water sector, on the basis of which national and sub-national authorities and operators make decisions and implement them. This new investment cycle relies heavily on policy decisions that guide the digital transition process in the EU water sector. Ultimately, these investments aim to make the EU a green, sustainable and climate-proof industry leader in the water sector. As Next Generation Internet Technology (NGI) technologies become more affordable (e.g. Internet of Things - IoT, Blockchain, augmented reality, etc), we need to understand the different use cases and roll them out across the 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.

In the water sector the main challenges remain, amongst others: **standardisation, interoperability, but also the fragmentation of the key actors and regulatory policies**. There is a general aversion in the water sector to roll out digital technologies at scale, partly due to the gaps that emerge when digital solutions are installed and operated alongside outdated equipment in waterworks (DWC, 2019; Markropulou & Papakonstantinou, 2021). Water service providers are still lagging behind in adopting digital services, automation, and technological innovations that enable them to improve their operational and management obligations.

This policy document addresses the following issues to derive policy recommendations for the implementation and revision of key water policies in place:

- What are the gaps and opportunities for digitalisation in the water sector and in support of the EU Green Deal?
- What are the current gaps of the Water Framework Directive (WFD) and daughter directives regarding digitalisation?
- What changes in governance and policies are required to support the digital transition in the water sector for smarter and more sustainable cities?

# 2. Current gaps of the WFD and daughter directives regarding digitalisation

It is widely accepted that the WFD, daughter directives and even related European policies, such as the Climate Adaptation Strategy, are largely fit for purpose. The governance system of digitalisation in the water sector, however, is still characterised by incoherence. On the one hand horizontally (e.g. drinking water vs. wastewater), and, to a lesser extent, vertically (i.e. between EU, national and municipal levels). EU legislation should help overcome inter- and intra-sectoral rivalry and fragmentation to achieve a comprehensive and coherent integration of digitalisation aspects. This also applies to directives that have recently been revised or are currently being revised, such as the Bathing Water Directive (BWD), the Urban Wastewater Treatment Directive (UWWTD), or Industrial Emissions Directive (IED).

At the local, national, and European levels, there is a **time lag** between advances in technological development and the update of regulatory frameworks in this realm (DWC, 2019; European Commission, 2021).

All EU water policies have in common that they **lack a coherent terminology and clear definitions of digitalisation in the water sector**. At the same time, they have different targets and different target audiences. As a result, users of water services and even digital service providers in the water sector are often either unaware or do not understand the relevant water policies.

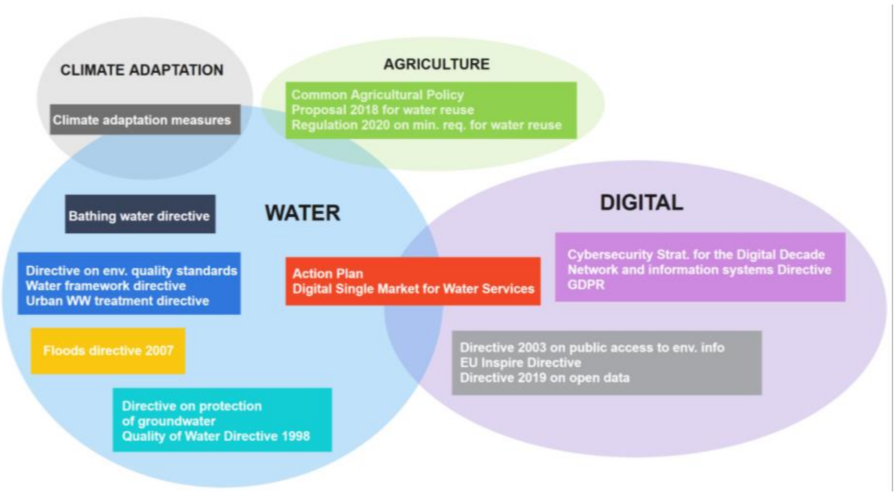


*Figure 1: Water and digital policy areas and related policy domains covered by DW2020 projects (Caradot, 2021)*

An analysis of current water policies shows (table 1) that **current policies should better harness the potential of digital solutions**. Common shortcomings are related **to the lack of technology guidance, monitoring standards, policy integration, standardisation and public involvement**. For example, there is a lack of regulations or at least (as a minimum) EU-wide **guidelines for online pollution monitoring** to enable the adoption of proven innovations for water quality monitoring. There is therefore little motivation for utilities and other actors to invest in sensing technologies and undertake large-scale surveillance campaigns. Similar conclusions could be drawn for urgent issues related to stormwater monitoring, combined sewer overflows, bathing water quality or predictive infrastructure maintenance.

**Table 1. Key water policies and gaps regarding digital transformation**

| | |
|---|---|
| **Water Framework Directive (WFD)** | • The WFD does not provide technical and organizational measures to manage security incidents and risks. Similarly, no list of threats or other incidents can be found in the text of the WFD, nor are there any notification policy requirements for competent authorities or supplies with regards to incidents.<br>• There is a lack of integration of relevant standards, ontologies and vocabularies from the digital domain. Even where they do exist, they are often not sufficiently integrated into administrative processes and are not mandatorily required by the competent authorities when awarding public contracts. The role of citizen science data collection is not addressed.<br>• A relevant topic addressed by the WFD is the synergy and coordination of other measures taken at Union level to tackle particular pollution problems. However, this synergy, in terms of coordination of measure and standards with other directives, is not explicitly extended to the Drinking Water Directive (DWD), even though the two directives have many points of contact under the umbrella of water security (aqua3S - D9.1 (2021)).<br>• River basin management plans according to WFD do not explicitly include concrete measures to digitise the water sector and harmonise standards for online monitoring. Guidance should be provided to ensure the comparability of measures taken by the competent authorities of transboundary or international river basins.<br>• In light of the increasingly frequent and prolonged water stress conditions, the potential of digital solutions to advance the EU Water Scarcity and Drought policy remains largely untapped. |
| **Bathing Water Framework Directive (BWD)** | • Online rapid bacterial measurement methods are not explicitly considered in the directive and do not have the same status as traditional measurement methods. Nevertheless, they can provide highly accurate and actionable risk assessment information, enabling timely preventive measures not included in the current BWD framework<br>• Modelling approaches and early warning systems are not currently considered to assess the compliance of bathing sites. In particular, it is not allowed to remove short-term pollution events from the evaluation period, even if it is possible to predict or confirm them through rapid online measurements.<br>• Citizen engagement is not yet sufficiently addressed (e.g. collecting sample data across the cities). |
| **Urban Wastewater Treatment Directive (UWWTD)** | • Legal requirements on online monitoring of pollutants from stormwater and combined sewage and stormwater systems are missing (SCOREwater, 2022).<br>• Guidelines on the use of sensor systems for predictive maintenance and flood control of wastewater systems (sewage, storm water and combined sewage and storm water) are missing (SCOREwater, 2022).<br>• Targets for energy savings by means of ICT solutions are missing. |
| **Drinking Water Directive (DWD)** | • The DWD lacks guidance on specific technologies, standards or monitoring techniques to ensure the quality standards defined there. According to a survey conducted amongst water sector stakeholders, this includes guidance on the use of sensor technologies to detect anomalies and triangulate information with citizen-generated information, as well as on technologies and procedures for more efficient risk communication across institutions within the member states (aqua3S, 2021). Furthermore, there is a lack of guidance on technologies to reduce water consumption and on technologies and procedures to reduce leaks (aqua3S, 2021). |

| | |
|---|---|
| | • Even though the latest DWD amendment considers synergies with other directives such as the WFD, the provision of drinking water of good quality and sufficient quantity is still considered a matter separate from the maintenance of the ecological status of water bodies (aqua3S, 2021). This dichotomy is particularly evident in situations of water scarcity, when the requirements of the two directives may be seen as somewhat conflicting. From the digitalisation perspective, the regulation at European level lacks a focus on integrated systems and technologies that can help resolve these conflicts and provide decision support, e.g. by prioritising targets of the two directives during crisis situations. |
| **Floods Directive (FD)** | • The FD deals with flood risk management at river basin scale and is closely linked to the WFD. Nevertheless, there are other water security directives assessing the protection of (water) infrastructure against natural hazards, including floods, such as the Directive of European Critical Infrastructures (ECID), the proposal for a Directive on the Resilience of Critical Entities (CER Directive), the Directive on security of network and information systems (NIS) and its proposal of revision (NIS2). These directives lack an explicit coordination with the FD on this topic, including practical guidance about how to achieve this.<br>• There is no reference in the WFD and the FD to integrated technologies and approaches for assessing critical water infrastructure (aqua3S, 2021).<br>• The FD is the first water security regulation to explicitly introduce the need to assess climate change impacts and define specific adaptation measure as part of flood risk management plans. However, guidance on how to practically assess their impacts in the case of water security is missing (aqua3S, 2021). |

# 3. Current state and gaps within the water sector with regards to digital transformation

The digitalisation of the water sector is characterised by technological, economic, social, regulatory and environmental aspects. The digital transformation is likely to include a wide range of actors and will take place over a longer period of time. During this fundamental change, new goods, services, business models and organisations will emerge, partially complementing and partly replacing the current ones. As a result, user behaviour and perception will shift.

## 3.1. Technological dimension

- **The water market is fragmented and lacks standardisation.** It is made up of numerous utilities of varying sizes, each with unique problems in need of tailor-made solutions. The digital solutions market is itself fragmented. A multitude of companies specialises in niche applications. Industry-wide standardisation is therefore difficult to achieve. This also has to do with the fact that digitalisation is not a vital element of water policies yet.
- **The sector is characterised by data exchange and interoperability issues**. In the water sector, there are different ways of exchanging data and different national and local semantic definitions of data that need to be improved. Thus, issues with data exchange and interoperability remain a key challenge to the uptake of digital solutions. In addition, data-sharing trustworthiness remains a challenge. The ability to share data has relatively little support from stakeholders due to the lack of trustworthiness of the information.
- **Vendor lock-in and legacy systems prevent the uptake of open-source solutions**. Many utilities are often bound by contracts that oblige them to the continued use of

current legacy[1] software systems. Another fear among water managers is that with a change to open-source software, 24/7 support will no longer be available. Current legacy systems can still be used for various purposes which further complicates a swift transition to open-source software. Furthermore, it is technically impossible to fully integrate new (IoT-oriented) technical solutions and services into the current (old) already functioning systems due to legacy systems lacking internet connection or not providing an API (Application Programming Interface) or similar mechanisms to obtain the information without scraping it. Coupled with the often large capital expenditures required to replace such legacy systems and equipment, these factors create difficulties in modernising these systems and affect their structure and behaviour.

- **The water sector lacks collective situational awareness of cyber threats.** Systematically sharing information on experienced cyber-attack events between water utilities and associated IT service providers could help to better assess the state of cybersecurity in the water sector, increase preparedness and the ability to protect the service. Including guidelines on information sharing in the EU Civil Protection Mechanism and embedding this requirement into UWWTD, DWD and other directives can help establish such coordinated exchanges.
- **There is a lack of measures and approaches that consider a global integrated security context, physical and cyber.** The process of digital transformation increases the interaction and connection between the two layers, the cyber and the physical. Therefore, water systems are evolving into cyber-physical systems in which physical processes and assets are integrated with computational engineered systems. Although safety has been a high priority in the water sector for years and cybersecurity is becoming increasingly important, measures and approaches that consider a global integrated security context – physical and cyber – are still missing. This leads to the inability to cope with combined cyber-physical attacks which are of major concern. This issue has been previously flagged as one of the main barriers to the digitalisation of the water sector.
- **Digitalisation is hampered by the market size of the water sector**. To make relevant digital solutions such as sensing technologies cost-effective, sensors need to be produced on a large scale. However, the water sector is relatively small economically. It is therefore difficult to create a market of sufficient size exclusively in the water sector (SCOREwater, 2022).
- **Wastewater systems are harsh environments**. Therefore, it is a challenge to make the use of sensors time-efficient in this infrastructure. Even if a cost-efficient sensor could be produced, it would have to be robust enough to require little maintenance. Otherwise, a system with many sensors in wastewater infrastructure, which often covers large geographical areas and requires intensive use of human resources, quickly becomes costly to maintain (SCOREwater, 2022). Compared to sensors at a wastewater treatment plant, where sensors are limited to a small area, this would require many man-hours.
- **The water security concept is not adequately integrated into the EU policy framework**. Most of the European Directives related to water security set (minimum) qualitative or quantitative standards to be reached and prescribe a minimum frequency for monitoring operations. However, they do not provide a common indication of terms of techniques, standards or technologies that can be used to achieve these goals. Thus, the potential of digital solutions for water security remains largely untapped. There is no single, comprehensive set of rules at EU level for water security. This results from the vastness of the topic and thus, most of the related directives focus on one of the specific topics recognised in the definition of water security (UN WATER, 2013). Consequently,

[1] A legacy system is outdated computing software and/or hardware that is still in use.

the different actors in charge of the implementation of a certain topic are usually unaware of the other lines of the water security regulation and of the interconnections between these different aspects (aqua3S, 2021).

- **The relation between standard and regulation is still not clear - even to many experts of the water sector** (aqua3S, 2021). There is a lack of references in EU legislation to EU standards that are to be explicitly used – or whose use is explicitly recommended – in key directives such as the INSPIRE Directive.

## 3.2. Social dimension

- **A broader social awareness on digitalisation in the water sector is needed.** As the topic of digital water management and governance is only emerging, most stakeholders are not aware of the importance and implications of introducing digital solutions in the water sector. Current approaches to raise social awareness focus more on targeted stakeholders and less on citizen engagement. Digital solutions to raise public awareness on sustainability issues in the water sector face challenges related to uptake and dissemination. Additionally, the potential of digital solutions to go beyond awareness raising and education, i.e., to foster public involvement in water governance, remains largely untapped (DWC 2022, SCOREwater, 2022).
- **Digital literacy within water utilities and administration is oftentimes insufficient**. In many instances, technical and management staff in utilities, but also in public administration, lack the digital literacy to assess the benefits and shortcomings of introducing new digital solutions. Related to this, capacities to use digital solutions in water management are often lacking which hampers the introduction and uptake of new digital solutions (DWC 2022, SCOREwater, 2022). Furthermore, a generational gap has become visible between younger, more digitally skilled employees and older, less skilled employees: Generational diversity and new technological change are leading to a shift in the way employers need to manage their human resources.

## 3.3. Environmental dimension

- **Energy use in urban water management is enormous and unsustainable**. Currently, inadequate control and lack of optimisation measures relying on traditional (non-smart) approaches result in unsustainable energy use. The relevant regulations, e.g. the UWWTD, lack targets for energy savings through ICT solutions.
- **The disconnection between SDGs and EU water policy masks potential losses in long-term sustainability.** The WFD and daughter directives make no (or only limited) reference to SDGs 1, 4, 5, 7, 10, 17. This may delay the implementation of said goals and targets and hinder the timely achievement of Agenda 2030. Furthermore, the non-inclusion of the education sector in the EU water directives may prevent the change in consumer behaviour and awareness of water-related challenges and affect the achievement of the directives and of SDG 6. Furthermore, the focus of the framework directive is limited on aspects of SDG 14 'Life below water', which may contribute to the loss of aquatic biodiversity. In addition, the limited references to energy and hydropower and resource efficiency may affect the successful achievement of SDG 7, 11 and 12 (NAIADES, 2021).
- **The improved data capacity on environmental parameters is not being used comprehensively.** Although improvements in data capacity are slowly being driven by

advances in digital technologies and their rollout into river basin management, industrial processes, and domestic water use, their potential is far from being fully realised. Sensor and modelling technologies have the potential to improve our understanding of water systems and dramatically improve water management. However, the prerequisites or instructions for their use are mostly lacking.

# 4. Recommendations

Policy makers must recognise the importance of digitalisation in the water sector to dramatically advance the management of water. Designed and implemented at scale, digital solutions in the water sector may have the potential to enable **a shift to integrated water assessments** that better reflect the interconnected array of relationships and feedback loops that make up the water cycle. New digital solutions can generate data and insights to **inform the design of more effective interventions** in the form of policies and measures and may improve the transparency and efficiency of the decision-making within integrated water resources management. More accurate, affordable and frequent on-the-ground monitoring of water quality and quantity can help improve and raise the ambition of regulations, while more effective communication can strengthen the link with society (e.g. consumers) while having a positive impact on the environment. Data can make policies more tangible, better understood and more widely accepted. Digitalisation in the water sector represents the very essence of the Twin Transition that is needed to contribute to the implementation of the EU's Green Deal.

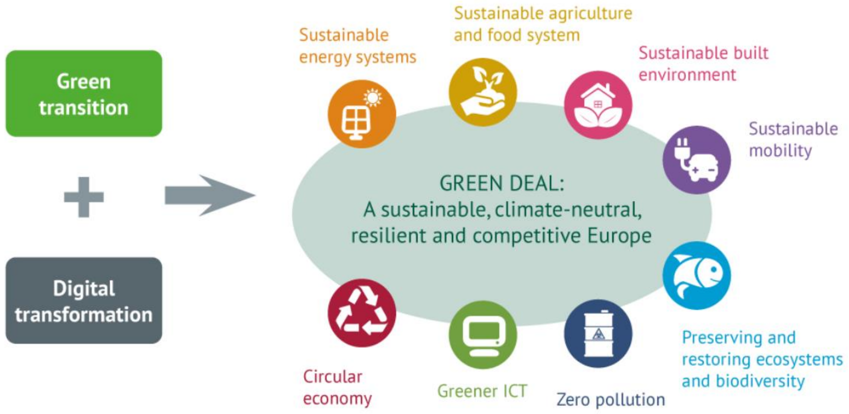


*Figure 2: Green transition, digital transformation and the European Green Deal (Hedberg and Šipka, 2020)*

## 4.1. Technological dimension

- **Stimulate the creation of a volume market for sensing and modelling technologies.** Upscaling a fragmented market is a major barrier for many of the digital technologies in the water market. Initially, the focus should be placed on areas of the water sector where the greatest demand could be expected and where the motivation is strongest. This includes, for example, optimising capital expenditures (CAPEX) and operating expenses (OPEX)[2]. Predictive maintenance and rehabilitation planning of water and wastewater networks is one such area. An example of a policy instrument that has successfully addressed upscaling in fragmented markets in other sectors is Pre-Commercial Procurement (PCP) (SCOREwater, 2022). To further support a volume market, requirements and guidance should be integrated into relevant policies to promote the use of sensors and modelling systems, e.g. for predictive maintenance in the UWWTD or water quality monitoring in the BWD. Policy makers should leverage digitalisation developments in the water sector by closely linking them to those in the digitalisation of other sectors.
- **Actively engage with relevant organisations to develop relevant standards and ensure semantic interoperability.** Standardisation is an important instrument to facilitate the deployment of solutions for smart water management. The prevailing traditional approach to standardisation hardly matches the speed of the market. A complementary approach with agile standardisation methods (with open licensed results) is needed to avoid market fragmentation. There is an urgent need to collaborate with standardisation entities such as ETSI at EU level and beyond to define and improve a common water ontology (e.g. SAREF4WATR). This ontology should then be linked to EU water legislation requirements or as a minimum to developing new guidance on the EU water sector digital transition. Relevant organisations include the Telecommunication Standardization Sector (ITU-T) of the United Nations, as well as ISO and CEN. Complementary efforts need to be made to ensure a comprehensive set of standards and these standards shall be explicitly mentioned to be used in the EU water legislation (e.g. WFD, UUWWTD, DWD, BWD, etc).
- **Foster a proper representation of semantic information by defining common data models (e.g. Smart Data Model programme).** These models should be close to real-world scenarios to facilitate a faster adoption of these data representations. Institutional and agile (user case-based) standardisation approaches need to work hand in hand. Therefore, guidance on the inclusion of digitalisation activities in relevant EU water directives should be a part of the actions required by EU legislation. A definition of open data exchange APIs as well as the data model support is needed to ensure that the meaning of the data model in the context of a subject area is understood by the systems involved.
- **Support water operators in the transitional shift to the IoT era, including the application of various, multiple data sources and smart data fusion.** Physical infrastructures should be better linked to digital infrastructure through standardisation. This can be promoted by the EU Data Spaces that encourage the wider use of free open data exchange and standardisation platforms (e.g. FIWARE). By combining different data sources and artificial intelligence, smart optimisation of ongoing water utility operations and predictive maintenance can be achieved. Technical staff dealing with water security issues (i.e., water utility operators) should be provided with guidance about international standards, new technologies, procedures and platforms such as

[2] See for example the growing use of modelling approaches for asset management.

FIWARE and their relationship with regulation. In this context, it is important to promote the adoption of standards that eliminate sectoral thinking in silos and facilitate data sharing across organisations, supporting the materialisation of the European Data Spaces and ensuring water safety and security. In addition, it is important to actively showcase working examples of interoperable data platforms to demonstrate the added value of data sharing in practice.

- **Promote information sharing about threats to cybersecurity and procedures to exchange best practices among operators, not only in the water sector but also across critical entities.** This is important to increase the ability to react swiftly and efficiently in case of cybersecurity incidents. One idea would therefore be to engage actors of different sectors at an EU-wide information-sharing platform including all types of water sector-related entities (being private, public, semi-private or semi-public).[3]
- **Enhance data sharing trustworthiness.** Data sharing must be based on non-repudiable and unambiguous agreements embedded in the relevant EU directives as a legal requirement. It should also integrate privacy and security concerns in the development of the corresponding data platforms and data-sharing applications. One way forward is the creation of a dedicated data space under the European Data Spaces framework.
- **Establish a cybersecurity culture through technical security measures, as well as through competence building, awareness creation and communication.** There is currently a gap in digital knowledge in general and specifically in cybersecurity in the water sector operation and EU-water legislation. The knowledge gaps are both potential sources of risks and barriers for the process of digitalisation. For the development of proper prevention and response strategies it is essential to increase cybersecurity awareness, education, training and best practices within the water industry in combination with technical security measures and embed these requirements into the EU water legislation (e.g. UWWTD).
- **Promote the use of digital solutions to enable more efficient allocation of water resources under the EU Water Scarcity and Drought Policy.** Digital solutions could be used for economic integration and coordinated economic planning, circular economy models, public participation and mutual learning when systematically integrated in the EU Water Scarcity and Drought Policy as well as into WFD.
- **Highlight the close relationship between technical standards and regulation and explicitly include the reference of the relevant EU-wide standards to the EU relevant (water) legislation.** As many regulatory reforms have been introduced in recent years, there is some uncertainty about the applicability and legally binding nature of certain standards, mainly due to the revision of outdated standards and the publication of new sector regulations. Against this background, it is important to highlight the close relationship between technical standards and legislation and clarify what results from this in practice.
- **Harmonise online monitoring standards under the WFD at the Member State or river basin level.** As a minimum requirement, guidance on how to ensure the comparability of measures to be taken by the Member States or river basin authorities (as a large number of river basins in Europe are international/transboundary) need to be provided.

**Commented [KV(1]:** You can propose as a measure to include in the permits systems for water utilities to have the obligatory measures and procedures and tools to ensure cybersecurity of operation of water utilities and networks (eg drinking water supply network). This should be included as a explicit requirements a the EU level legal instruments.

**Commented [KV(2]:** May be it is also worth to propose to include somespecific requirements on the compliance reporting in WISE for EU water directives?

[3] Shared definitions and data models of cyber risks are available here: https://github.com/smart-data-models/dataModel.RiskManagement (open licensed)

- **Foster the use of sensors and early warning systems within the BWD.** The combination of sensor technologies and modelling approaches can significantly improve microbial safety and optimise bathing site management. In particular, it should be possible to evaluate the compliance of bathing sites after discarding short-term pollution events from the evaluation period, if we are able to predict them. Fostering sensor technologies implies establishing a framework for EU-wide approval of scientifically validated sensors for rapid bacterial measurements. Currently, each country has individual policies and approval paths, hampering the dissemination of new validated technologies.
- **Establish guidelines for the deployment of forecasting systems based on sensors to further support a volume market and foster the uptake of the technology.** Initially, the focus should be placed on areas where the greatest demand could be expected and where the motivation is strongest, for example predictive maintenance of wastewater systems. Standardization is needed but should come later when the market has become more mature. If standardization comes too early, there may be lock in effects with technologies that are not optimal (SCOREwater, 2022).

## 4.2. Social dimension

- **Further explore specific situations in which digital solutions can foster public involvement and support policy goals (short and long term).** Where feasible, stakeholders should be involved in a transparent process of co-creation, implementation, and post-implementation analysis of a wide range of policies. These processes will serve to build cohesive, inclusive and, most importantly, sustainable policies using bottom-up approaches to support the adoption of policies that are society-driven. These include the potential to include guidelines on using digital solutions to foster public involvement in the River Basin Management Plan (RBMP) processes. The use of community-based Digital Social Platforms (DSPs) of Local Enabling Spaces (LES) established at regional level can be a part of the river basin management plan actions and would help build consensus and enable citizen involvement by making use of digital tools to foster their social capital and boost their societal impact in terms of innovation, knowledge transfer and business success. With regards to standardisation, agile methods based on user experience could foster direct user involvement.
- **Increase knowledge and awareness on water issues through digital solutions for citizen involvement and environmental education at all levels.** Digital transformation proceeds at the speed of trust. To achieve sufficient acceptance and promote the benefits of digital solutions, they must be presented in complete clarity and detail to the user. Complex scientific data must be translated into a language that captures the public's attention and inspires laypeople, policy makers, and other social actors to engage in discourse with scientists and water managers. User-friendly digital tools that break down complex water data need to be promoted. A traffic light indicator for bathing water quality for citizens could be provided publicly online or through a digital app as a public service.[4] Innovative digital involvement techniques (e.g. serious gaming, augmented reality, virtual reality, etc.) can foster stakeholder engagement, education, and policy communication in the water sector. The education sector also plays an important role in raising awareness around water-related challenges, stimulate behavioural change as well as research and knowledge-sharing. This could start at a young age, e.g. by integrating water issues more into curricula or training teachers on

[4] Such an app has been developed as part of the digital-water.city project in Paris.

digital tools for environmental education. In addition, research projects should continue to foster the cooperation between administrations, technology developers, utilities, researchers and citizens to pilot innovative formats.

- **Create competence development programmes on advanced data management for the water sector at regional and/or local scale and coordinate them at the EU and river basin levels.** Utilities have to develop strategies that attract talent and upskill existing employees in order to support and sustain the digital transformation. Managers should leverage the strengths of each generation and take full advantage of the multi-generational workforce. Additionally, utility companies should be able to offer personalised, dynamic learning and development strategies that give employees tools to take control of their professional development. Competence development programmes should be set up and actively promoted to improve the data management and digital capacities of technical staff and management at the utilities and urban administration levels. (SCOREwater, 2022). Clearly communicating and demonstrating the efficiencies that result from digitisation can increase the willingness of utilities to establish capacity building programmes, as these gains outweigh the costs of training.
- **Promote training activities on cyber security for water operators at different decision levels for an effective and adequate response.** The training should be based on core courses, augmented by a training programme involving discussion and operational exercises based on realistic and plausible scenarios (and even using AR applications or serious games tools).
- **Highlight social, environmental and ethical aspects in the development of digital solutions in the water sector**. Water is still mostly treated as a 'technical matter' by most actors. The focus should be on issues such as the inclusion of marginalised groups using new tools and a transparent communication of societal and environmental opportunities and challenges associated with the uptake of a respective digital solution. Water supply operators should be able to reflect on the legal and ethical implications of introducing digital solutions to the service they provide (aqua3S, 2021).
- **Mainstream water security in legislation, as well as in the water-related initiatives, research projects, educational and professional formative activities, dissemination events, etc., as a universally known and applied term, in all its implication, without ambiguities in its definition**. It should be ensured at a normative and legislative level that all actors are aware of the different complications of water security, the presence and roles of the other actors involved in this topic as well as the main goals of other water security regulations. This is crucial to ensure that the different aspects of water security are not treated as separate parallel matters or, even worse, as contradicting each other (aqua3S, 2021).
- **Increase the amount of open data generated in and for public data services**. Monitoring of water quality and quantity data is essential for taking and explaining water management decisions of general interest. In cases where the data cannot be made publicly available, e.g. due to concerns related to critical water infrastructure, public water authorities must be put into the position to analyse open data from third parties themselves, e.g. through capacity building.

## 4.3. Environmental dimension

- **Further Introduce EU regulations for online monitoring of pollutants from stormwater and combined sewage and stormwater systems.** At EU level, legal requirements on online monitoring of pollutants from storm water and combined sewage and storm water systems should be set (SCOREwater, 2022). It is recommended to start with some key parameters such as turbidity, pH and conductivity (technically viable and on the market today) that are not too costly to monitor. This would improve urban wastewater network management and the overall water quality of receiving water bodies, in particular, those located in urbanized areas (SCOREwater, 2022). This could also help advance the monitoring and enforcement capacity of the relevant authorities to support compliance with the Zero Pollution Action Plan and provisions such as the full cost recovery and polluter pays principles of the WFD and the implementation of the UWWTD.
- **Strengthen the alignment between the SDGs and the WFD and daughter directives.** Technological solutions and digital innovations provide enormous potential to support the achievement of the SDGs and their targets. To address the disconnect between the SDGs and the EU water directives, further SDGs should be considered in the EU water directives. This includes SDG 14 to support biodiversity and SDGs 7, 11 and 12 to stimulate resource efficiency, responsible consumption, and production, as well as renewable energy production (NAIADES, 2021).
- **Promote digital solutions to unleash the potential of concepts such as Zero Energy and the Water-Energy-Food and Materials-Chemicals Nexus.** Smart digital approaches can support to fully leverage the potential of the important but complex nexus approach. For example, digital solutions have shown to be a powerful tool to reduce energy consumption and thus greenhouse gas emissions during water and wastewater treatment by optimizing treatment processes. Furthermore, digital solutions are promising to assure a safe reuse of water for food production (i.e., agricultural irrigation). At EU level, the nexus approach and digital solutions for its implementation should be further promoted and embeded through setting some eg energy targets in the EU legislation. However, the new challenges associated with the shift to computationally expensive – and energy-intensive – digital solutions must be considered carefully. The cost-benefit analysis must be carefully applied to ensure an energy-positive or energy neutral EU water sector. Furthermore, alternative energy produced by the water sector (e.g., through wastewater treatment plants) shall be promoted through EU water as well as energy legislation, such as the Energy Performance of Buildings Directive. This directive shall be explicitly linked to the EU water legislation e.g., UWWTD, DWD and even WFD. The water sector can thus contribute to implementing each country´s national energy and climate plan.
- **Include nexus aspects into standardisations for digitalisation in the water sector.** Newer digital and physical standards should cover the link between water and interrelated infrastructures (NAIADES, 2021b). In agriculture, the Common Agricultural Policy (CAP) which links agriculture requirements with water quality and pollution, should be more closely aligned with the WFD, e.g. by including clear requirements to contribute to the WFD river basin management plans. Standards for data exchange and digitalisation should be adhered to in the development of both the River Basin Management Plans and the Rural Development Plans (CAP) as well as integrated nutrient management plans. In terms of digitalisation, concrete actions should be to (i) promote the creation of common data models including agile standardisation approaches; and (ii) work on common data vocabularies to interlink information and systems.

- **Promote research and development to reduce adverse environmental impacts in the water sector through digital solutions.** Digital solutions have a huge potential to mitigate negative effects in the environment by improving water treatment processes and reducing energy consumption. At EU, national and local levels, research, development, and adoption of Artificial Intelligence (AI) should be further stimulated in order to use the resulting innovations to reduce the carbon footprint of the water sector. However, the new challenges associated with switching to computationally expensive and energy-intensive digital solutions must be considered carefully.
- **Promote research on the social, economic, environmental effects of the digital transition.** Research has taken a big step forward - but much remains to be done capturing the technical, social, economic and environmental aspects of the digital transition through Horizon Europe and other R&D funding instruments. The digital technologies developed are often at an early stage and show future possibilities, but are not yet mature enough and need to be further developed and evaluated over longer time spans. Co-creational research activities and citizen science can assure long-term policy continuity and more societal relevance. With the development of portable online analysers, citizen science can provide risk assessment data in locations or regions that do not benefit from other monitoring activities (e.g. due to remoteness or lack of logistic resources). The same applies to research on consumer behaviour and awareness about water-related challenges. Environmental impacts must also be carefully considered, especially in attempts to reach net-zero water management. In this regard, more attention needs to be paid to the nexus approach, which integrates cross-sectoral water management and governance at all levels. In fact, continuous water quality monitoring through digital solutions can enable safe and proper reuse of treated water to be used for various purposes and minimise its discharge as waste. Many questions also remain unanswered in the area of economic sustainability and business case development, especially regarding the maturity costs and benefits of deploying digital solutions in the water sector, including performance benchmarking.

## List of acronyms

| | |
|---|---|
| AI | Artificial Intelligence |
| API | Application Programming Interface |
| BWD | Bathing Water Directive |
| CAP | Common Agricultural Policy |
| CAPEX | Capital expenditures |
| CER | Directive on the Resilience of Critical Entities |
| CEN | European Committee for Standardization |
| DW2020 | Digital Water 2020 |
| ECID | European Critical Infrastructure Directive |
| EU | European Union |
| DSP | Digital Social Platform |
| DWD | Drinking Water Directive |
| FD | Floods Directive |
| IoT | Internet of Things |
| ISO | International Organization for Standardization |
| ICT | Information and Communication Technology |
| IT | Information Technology |
| ITU-T | International Telecommunication Union - Telecommunication |
| LES | Local Enabling Spaces |
| NGI | Next Generation of Internet Technology |
| NIS | Directive on security of network and information systems |
| NIS2 | Proposal of the revision of the Directive on security of network and information systems |
| OPEX | Operating expenses |
| PCP | Pre-Commercial Procurement |
| RBMP | River Basin Management Plan |
| SDG | Sustainable Development Goal |
| UWWTD | Urban Wastewater Treatment Directive |
| WFD | Water Framework Directive |

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## H2020 projects involved in drafting this document

Programme: H2020-EU.3.5. - SOCIETAL CHALLENGES - Climate action, Environment, Resource Efficiency and Raw Materials; Topic SC5-11-2018 - Digital solutions for water: linking the physical and digital world for water solutions

and

Programme: H2020-EU.3.7. - Secure societies - Protecting freedom and security of Europe and its citizens ; Topic SU-DRS03-2018-2019-2020 - Pre-normative research and demonstration for disaster-resilient societies

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**DWC - DIGITAL-WATER.city - Leading urban water management to its digital future**

Coordinated by KWB KOMPENTENTZZENTRUM WASSER BERLIN gGMBH (DE)

EU contribution: € 4 997 161,66 (ID: 820954)

Website: https://www.digital-water.city/

**ScoreWater – SCOREwater - Smart City Observatories implement Resilient Water Management**

Coordinated by IVL SVENSKA MILJOEINSTITUTET AB (SE)
EU contribution: € 4 998 727,50 (ID: 820751)
Website: https://www.scorewater.eu/

**Fiware4Water - Fiware4Water FIWARE for the Next Generation Internet Services for the WATER sector**

Coordinated by OFFICE INTERNATIONAL DE L'EAU (FR)
EU contribution: € 4 997 945 (ID: 821036)
Website: https://www.fiware4water.eu

**NAIADES - NAIADES A holistic water ecosystem for digitisation of urban water sector**

Coordinated by ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS (EL)
EU contribution: € 4 999 980,13 (ID: 820985)
Website: https://www.naiades-project.eu

**aqua3S - aqua3S Enhancing Standardisation strategies to integrate innovative technologies for Safety and Security in existing water networks**
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