European Commission

Digital Single Market for Water Services Action Plan

FINAL REPORT

A study prepared for the European Commission
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Digital Single Market

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Abstract:

To face water challenges in line with the Sustainable Development Goals, Paris Agreement and United nation climate conference, ICT technology is a key enabler to improve water resources management in man-made or natural environment, especially regarding monitoring and reporting quality, quantity, reuse of water, extreme events (floods and water scarcity), smart Decision Support System (DSS), leakages and awareness of the true value of water by all stakeholders.

The water industry of the future will be smart and resource-efficient. Networked, intelligent systems will help make better use of energy, avoid unnecessary water losses and minimize the consumption of resources. Despite a promising technological scenario, currently, **the water domain is characterized by a low level of maturity concerning the standardization of ICT solutions, their business processes and the related implementation in the legislative framework.** This is due to the fragmentation of the sector, no holistic vision being set out and a lack of integration and standardization of the technology. The development of system standards is essential for smart water solutions that should ensure interoperability of solutions, i.e. adaptability of solutions to new user requirements and technological change as well as avoidance of entry barriers or vendor lock-in through promoting common meta-data structures and interoperable (open) interfaces instead of proprietary ones.

Two roadmaps based on the contribution of the ICT4Water cluster[1] that record gaps, social, organizational and technological challenges have been published (roadmaps published in 2015[2] and 2016[3)]. **A subsequent milestone is the publication of this report suggesting an Action Plan 2018-2030 that focuses on implementation of actions related to interoperability and standardization, data sharing, smart water, cyber-security, actors' awareness, policy and business models**.

This initiative contributes to the Connected Digital Single Market and the Resilient Energy Union objectives by promoting energy efficient smart ICT technologies in the water sector. **The innovation potential includes the shift from pilot scale initiatives to a vision beyond uncoordinated and isolated initiatives, wide market uptake, aiming to end up with the creation of a Digital Single Market for efficient and sustainable water services.**

[1] ICT4Water cluster counts currently 30 FP7/H2020 research projects in the field of ICT and water management - http://www.ict4water.eu/

[2] https://ec.europa.eu/digital-single-market/en/news/ict-water-management-roadmap-2015

[3] https://ec.europa.eu/digital-single-market/en/news/emerging-topics-and-technology-roadmap-ict-water-management-august-2016

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1. Call for digital water actions

The future-proof European model for a **water-smart society** entails a paradigm shift in the way our future society will be organised and managed with regard to water. It requires bold and courageous decisions, investments, changes and new types of collaboration for stakeholders at all levels of society, involving citizens, public authorities at all levels, industries and farmers, as well as representatives of our natural environment.

Its advantage comes from dramatically higher levels of manageability enabled by the emerging cyber-physical society, “digital water” technologies and increased availability of “multiple waters” to complement freshwater sources, as well as much deeper levels of awareness, integration and collaboration between organisations and citizens.

These important changes will offer a boost for European industry, which requires significant investment in redesigned and adapted infrastructure as well as innovative digital technologies.

The future European society based on the **circular economy** concept will manage the precious multiple water sources from clean rivers, surface and ground water, but also alternative sources such as rainwater, brackish and saline water, brines and used water, as a holistically integrated system. In the future we will optimise water management and allocation by storing, treating and distributing the right water for the right purpose to the right users in a synergetic combination of centralised and decentralised water treatment. Water use will be optimised based on the circularity principle for water such as cascading, reuse, recycling, while enacting new economic mechanisms and models based on the true value of water.

New digital technologies can introduce detailed measurement and near real-time monitoring and reporting of water extraction, treatment, distribution, use and reuse, with the potential to distinguish between different water qualities, sources, quantities and users. New governance and decision support systems, backed by powerful digital solutions, will support the rational use of multiple waters, based on the true value of water and new economic models, with minimised impact to natural water bodies.

As a matter of urgent priority, it is highly needed to define and **deploy a group of actions for the development of Digital Water Services in the single market**. These actions will provide clear signals to water stakeholders, operators and society on the way forward with long-term targets as well as a concrete, broad and ambitious set of activities. Such acts at EU level will drive investments and create a level playing field, removing obstacles stemming from European legislation or inadequate enforcement, deepening the single market, and ensuring favourable conditions for innovation and the involvement of all the stakeholders.

The action plan for digital water services is based on gaps identified by the ICT4Water cluster (ANNEX-II) and is in line with The Digital Single Market Strategy main pillars[4]:

- Better access for consumers and businesses to online goods and services across Europe
- Creating the right conditions for digital networks and services to flourish
- Maximizing the growth potential of our European Digital Economy

The Action Plan proposes actions relating to technology, market, business, awareness and possible regulation in the area of ICT supporting the water domain and its interactions. It will enhance emerging **Digital Water issues (current and future trends) in terms of services, data management, interoperability, intelligence, cybersecurity and standardisation, including synergies between the proposed solutions and with other related sectors (e.g. circular economy, water reuse, transport, energy, agriculture and smart cities)**, also considering social aspects (operators, consumers, legal issues, water value awareness).

New digital and water technologies offer advanced digital solutions for water in a capillary network of sensors in water distribution systems, capturing and using this new information to manage them in real time. Developing advanced digital water treatment solutions will contribute dramatically to achieve good status of European water bodies, by enabling synergies between centralised and decentralised treatments, as well as economically viable extraction and valorisation of valuable substances and energy in water. **Digital emerging and enabling technologies will empower Europe to reach previously unimaginable levels of control, manageability, and valorisation of water in our society**.

The present Action Plan consists in a list of actions relevant for boosting the uptake of ICT in the water sector across different domains within a 2030 timeframe. For each action the Action Plan details the main objectives, the activities challenges and a feasible timetable and proposes implementation tools.

The Action Plan provides for a dynamic and flexible approach, to keep track of the fast changing environment. It will serve as a catalyst to coordinate public sector modernisation efforts and resources in the field of digital water services. Beyond the actions identified in this Action Plan, further actions may be introduced, either by the ICT4Water cluster members or by the water community at large.

2. Action Plan development Methodology

The Action Plan for a Digital Single Market for Water Services focuses on actions at EU level with high benefit. Making digital water services a reality will require long-term involvement at all levels, from Member States, regions, rural areas and cities, to businesses and citizens.

4 COM/2015/0192 final, A Digital Single Market Strategy for Europe

The Action Plan for a Digital Single Market for Water Services is a step forward from roadmaps leaded by the European Commission focused in Emerging Topics and Technologies for Water Management, presented in 2015[5] and 2016[6]:

Roadmap 2015 **Focused on Water Management**	**Roadmap 2016** **Focused in Water Management**
Technological, social and organisational challenges:	Main Gaps and technological challenges to be addressed:
• Cost/Benefit analysis of ICT • Synergies across sectors • Data sharing • Interoperability • Standardisation • Indicators	• Big Data • Data infrastructures • Link with Smart Cities • Nexus, Water–Food-Energy • Standardisation • Lack of reliable field trials

In 2017, open workshops were held as core sessions of big water sector events, such as **WaterWise Conference, Water Innovation Europe, EIP Water conference 2017** and several bilateral events, with ICT4Water cluster members (ANNEX-II) discussing and proposing how to afford digital water challenges, so as to collect and define the views presented in this strategic documents. Additionally, collaborative contributions provided by co-members of several associations and working groups such as *the* **BDVA[7], AIOTI[8], WssTP[9], EIP Water[10]** complemented these activities**.**

As a follow up to the prior ICT4Water Cluster roadmaps, **The Action Plan for a Digital Single Market for Water Services** is focusing on a wider approach including **Water Management, Treatment, Reuse, Circular Economy and every water-related area, where ICT can contribute**. It proposes the creation of a borderless Digital single market for water services, emerging from the input/discussion gathered from FP7/H2020 research projects - grouped in the ICT4Water cluster and taking into account other relevant reports from water related initiatives[11].

This initiative **contributes to the Connected Digital Single Market and the Resilient Energy Union objectives by promoting energy efficient smart ICT technologies in the water sector**. The

5 https://ec.europa.eu/digital-single-market/en/news/ict-water-management-roadmap-2015

6 https://ec.europa.eu/digital-single-market/en/news/emerging-topics-and-technology-roadmap-ict-water-management-august-2016

7 http://www.bdva.eu/

8 https://aioti.eu/

9 http://wsstp.eu/

10 https://www.eip-water.eu/

11 http://wsstp.eu/wp-content/uploads/sites/102/2017/01/WssTP-SIRA_online.pdf

innovation potential includes the shift from pilot scale initiatives to wide market uptake, aiming to end up with the creation of a European Digital Market for energy efficient water services.

The Action Plan is an initiative of the European Commission through the request of an expert to design a strategy based on the contributions and documentation of the ongoing and finished EU funded project (grouped in ICT4Water). Additional relevant inputs to the Action Plan were made from the water community, WssTP[12], DG CONNECT, DG ENV, DG RTD and EASME.

The methodology applied was in response to growing Digital Single Market and Water sector demands. In a holistic and consistent approach, the action plan addresses digital water issues, from resources to societal changes, using a wide range of ICT solutions for data acquisition, data management, real-time monitoring, field operation management and sector awareness.

The general methodology used for developing the Action Plan is based on sequential steps, which can be summarised as follow:

Step 1 - Overview of the water value chains and their segments and systems at different scales starting from macro-level and focusing down to the different segments/components.

Step 2 – Analysis of Water business processes and ICT solutions related actions involved in the water value chains /Step 1) : definition of business processes, identification of needs, challenges and expectations on ICT solutions (products / services / technologies / business models / best practices…). These diagnostics characterise benefit from technological, economical, sociological and ecological aspects;

Step 3 – Prioritise the findings from the prior step and perform a Gap Analysis exercise into a series of gap closure strategies (Actions, quick wins and innovative solutions to be supported)

Step 4 – Develop the “level of sharing” of each ICT solution in order to address interoperability, standards, architecture and smartness for implementation issues;

Step 5 - Validation of innovative digital water technologies by the water stakeholders (ICT4Water cluster network of experts) with the objective to bridge the identified gaps during Step 3;

Step 6 – Defining the optimum sequence of actions;

Step 7 – Develop and Publish the Action Plan.

Initially the effort was focused on the analysis of the business processes, both for the artificial cycle and the natural cycle of water, for design and for operations. The business processes were described at a macro scale, where tiny differences between entities are not perceived and where just the common "backbone" is visible. These business models were used as "base maps" in order to show the

[12] WssTP : Water Technology Platform : http://wsstp.eu/

unequipped - or poorly equipped - steps in terms of ICT. Special attention was paid to the analysis of added value contained within these unequipped steps, using diagnostics that characterise the added value not only from the techno-economic points of view, but also from the sociological and ecological ones. The result is the list of the steps / processes that "deserve" to be equipped with new ICT tools, in addition to the common map for the water business processes.

Following this, a technology analysis of the needs and requests of water actors was carried out, including not only the assessment of the feasibility, the potential availability and the cost of the requests, but also proposing other paths/trajectories, unimagined or not foreseen during the previous steps. Alternating the leadership of the steps between the "water experts" - water companies and other stakeholders - and the "ICT experts" brings an efficient synergy, which is reflected in the details of this Action plan.

In conclusion, it is proposed a set of actions and activities, taking into consideration thematic areas and periods; these actions go gradually from immediate to long term ones. It is important to mention that these actions establish a path to follow, to be specified and developed in detail, as part of the development of the action itself.

3. Digital Single Market for Water Services

As part of an overall plan for the water sector in the EU, **the Digital Single Market for Water services** will provide the water business community (particularly SMEs) with new opportunities to scale up across the water sector. Immediate action is therefore required to break down digital barriers to cross-water cycle operational improvement; for information exchange and digital water educational outreach; for promoting the adoption of digital water solutions and direct financial incentives and investments; for promoting open water sector standards adoption and development, as well as digital billing and digital financial transactions.

An important component, i.e., **building water actors trust, requires affordable and high quality cross-domain delivery services,** which do not exist today. Digital water services must be safe, based on reliable, trustworthy, efficient data infrastructures and analytical services that safeguard data integrity, privacy and protection while also encouraging innovation. This requires a strong, competitive and dynamic ICT for water sector to carry out the necessary research and innovations, exploiting new technologies such as Semantics, Cloud computing, Big Data, Artificial Intelligence and the Internet of Things (IoT).These technologies are central to the EU’s competitiveness.

In the digital economy, **interoperability** means ensuring effective and meaningful data exchange between digital components like devices, tools, networks or data repositories. For the water sector, it represents connecting better along the whole water value chain or between industry and services sectors. It results in more efficient connections across systems, between domains/sectors and between

services and stakeholders. **Standardisation** has an essential role to play in increasing interoperability of new technologies within the Digital Single Market[13]. It can help steer the development of new technologies such as 5G wireless communications, digitisation of manufacturing (Industry 4.0), data driven services, cloud services, cybersecurity, e-health, e-transport and digital water, which must be an important component too. **The EU Rolling Plan for ICT Standardisation**[14] is an essential instrument in this regard. However, an increased effort is needed to ensure that standardisation outputs keep pace with changes in technologies. Currently, industry stakeholders decide 'bottom-up' in which areas to develop standards and this is increasingly taking place outside of Europe, undermining our long-term competitiveness. We need to define missing technological standards that are essential for supporting the digitisation of our industrial and services sectors (e.g. IoT, cybersecurity, Big data and Cloud computing) and mandating standardisation bodies for fast delivery.

Availability of standards is often not sufficient to ensure interoperability, if existing standards are not integrated by suppliers in their solutions. Public procurement plays an important role in promoting standards and the water sector needs to create **catalogues of ICT-standards and interoperability specifications** to guide public procurers and accelerate standards adoption on water markets. Integrating these catalogues into European catalogues would avoid market fragmentation at EU level.

3.1 Vision and underlying principles

New digital technologies in an all connected world (smart sensors and actuators, drones/robots, advanced data analytic models, satellite technologies for earth observation and environmental monitoring,…) will provide detailed data, allowing deeper insights into water availability, quality and use, down to the level of each individual user, intertwining all water processes involved ("**Digital Water**"). A ubiquitous network of smart sensors throughout the water-system from watershed scale up to the smaller "water grid" cycles, will swell the gigabytes of data being generated today by environmental monitoring and utility infrastructures, to thousands of terabytes in the future. Other estimates suggest smart meters could generate around 1,000 petabytes of data a year globally once full rollouts are complete. Therefore, a holistic approach to digital systems applications at various scales (industrial, urban, rural, regional, international river basin) could be exploited by the joint stakeholders to manage our water-system.

Utilities will be reinvented to become big-data related service providers, leveraging on the Open Data and free flow of information paradigms. They will have high-quality forecasting and event diagnosis capabilities, using new data science methods and visualisation applications, with unforeseen levels of real-time knowledge and decision making. This widely diffused network of sensors and metering will

[13] M/441 STANDARDISATION MANDATE TO CEN, CENELEC AND ETSI IN THE FIELD OF MEASURING INSTRUMENTS FOR THE DEVELOPMENT OF AN OPEN ARCHITECTURE FOR UTILITY METERS INVOLVING COMMUNICATION PROTOCOLS ENABLING INTEROPERABILITY

[14] http://ec.europa.eu/growth/content/2017-rolling-plan-ict-standardisation-released-0_en

monitor quality and quantify water flows, while advanced modelling and software systems will support water management and planning in the economy and the environment. This will allow a much smarter, more dynamic and adaptable near real-time water allocation management and governance system that is robust, resilient and less vulnerable against external man-made and natural hazards and climatic extremes. The utility of the future will be defined by the following principles:

- Digital by Default: water operators should deliver services digitally (including machine readable information) as the preferred option (while still keeping other channels open for those who are disconnected by choice or necessity).
- Openness: water authorities should share information/data and enable citizens and businesses to access control and correct their own data; enable users to monitor administrative processes that involve them; engage with and open up to stakeholders (such as businesses, researchers and non-profit organisations) in the design and delivery of services; unique shared digital representations of water-systems will be available in the cloud for management purposes.
- Cross-Sectorial by default: authorities should make relevant digital public services available across sectors and prevent further fragmentation to arise, thereby facilitating information flow within the Digital Single Market for Water Services. Cross-Sectorial cooperation needs to be extended to other types of critical infrastructures and operators (e.g. electricity operators, transport operators…) for alerts, exchange of selected data and combined decisions, if needed.
- Interoperability by default: digital water services should be designed to work seamlessly across the Single Market and across organisational silos, relying on the free movement of data and digital services across the whole water sector and inter-related domains.
- Digital capacity building: training and continuous learning of staff at authorities and private companies is fundamental to achieve digitization goals.
- Trustworthiness & Security: All initiatives should go beyond the mere compliance with the legal framework on personal data protection and privacy, and IT/Cyber-Physical security, by integrating those elements in the design phase. These are important pre-conditions for increasing trust in and take-up of digital services.
- Focus on people: The biggest challenge of water leaders isn't technology - it is the people; it's dependent upon the digital qualifications of the employees who need to roll out digital processes and services, as well as the social awareness and communication with the consumers, using smart phones, specific apps and the social media.
- Appropriate Open Innovation, Open Science and Open Data will have harnessed Europe's global leadership in water technologies enabling the EU to lead in new cost-effective water treatment technologies. It will lead in advanced irrigation and crop-growing technologies that drastically reduce water use in agriculture all over the world. This will also lead to water information systems, for near real-time decision support, and Europe will be exporting its model

for a water-smart society, which combines these new technological solutions with modern inclusive governance practices.

3.2 Boosting Smart Water Technology

In order to engage the interest of utilities, companies and governments, as well as increase citizens' confidence in Smart Water Technology, multiple strategies comprising technical solutions, policy-making, awareness campaign and education are required over the complete water value chain.

The first achievement pursuit is to ensure as much as **possible transparent information exchange and free flow of non-personal data**. Interoperability and data sharing across services (cross-domain services will be a must) will open the pathway to the establishment of Data Analytics layers which improve decision making process. Analytics, as a service, will allow the convergence of water systems (including their actors), together with other relevant industries in the Water-Energy-Land Food-Climate Nexus.

Semantics platforms and model extensions can be an important tool to properly contextualise operational business processes in multiple digital water value chains. Based on full coverage business ontologies and engineering operations, the interrelationship between system parameters inputs |(i.e. process, business, consumer, operation, …) and output parameters (i.e. Key Performance Indicators of Productivity, Energy Efficiency, GHG emissions, Quality/Customer satisfaction, Circular Economy, and many other industry oriented performance factors) will enhance decision making.

Open, secure and robust architectures providing Open Data interfaces and establishing Open Data policies will enable and promote cross-domains knowledge sharing (Water-Energy-Land Food-Climate Nexus). The deployment of data-driven techniques to implement classical and novel signal processing and data mining methods, machine learning and deep learning solutions will boost **Smart Water solutions**. Therefore, real-time data and advanced predictive analytics forecasting models will emerge to improve performance and promote best practices based on objective functions and the true knowledge of the constraints.

Pilot projects, living labs and demonstrators on Smart Water technology will contribute to the establishment of guidelines and best practices for future full digital water value chain implementation, including cross-domain knowledge exchange.

It is important to highlight that, in order to immerse ourselves in this important transformation, it is essential to count with the strong involvement of all the actors in the water value chain. Various stakeholders involved have identified the following responsibilities, as immediate actions supporting this **Smart Water Awareness**:

- For the governing bodies, besides offering the financial support, there should also be promoting legislative upkeep to ensure the security of the data collection, transmission and storing across all domains including ICT supporting solutions in all related water directives.
- For the utilities, operators and industry/rural actors, proposed Smart Water pilot projects should be self-financing within 3-5 years. The pilot projects should start with a small-scale implementation (SSI) carried out within the 1st year of the project. This will enable the utilities to make use of the results of the SSI to learn, optimise and re-engineer the processes in the project for the later phases. In addition, it will serve as a validation checkpoint that will reduce the risks, uncertainties and implementation time of the project.
- For all actors (managing authorities, decision makers, water professionals, entrepreneurs, managers, operators, consumers, citizens, etc.), awareness campaigns should be carried out by the government and operators in all water value chains to ensure better understanding of the value of water and the value of the data.

For the implementation of Smart Water technology to be a success, there should be strong development of cross domain solutions. Both the "inter" systems (like several decision supporting tools) within the water system and the water system itself should not only be able to operate individually within its own set of operational processes, but also interact with other domain systems such as Smart City, Agricultural, Industrial systems, Health, governances, etc.. Recommendations include:

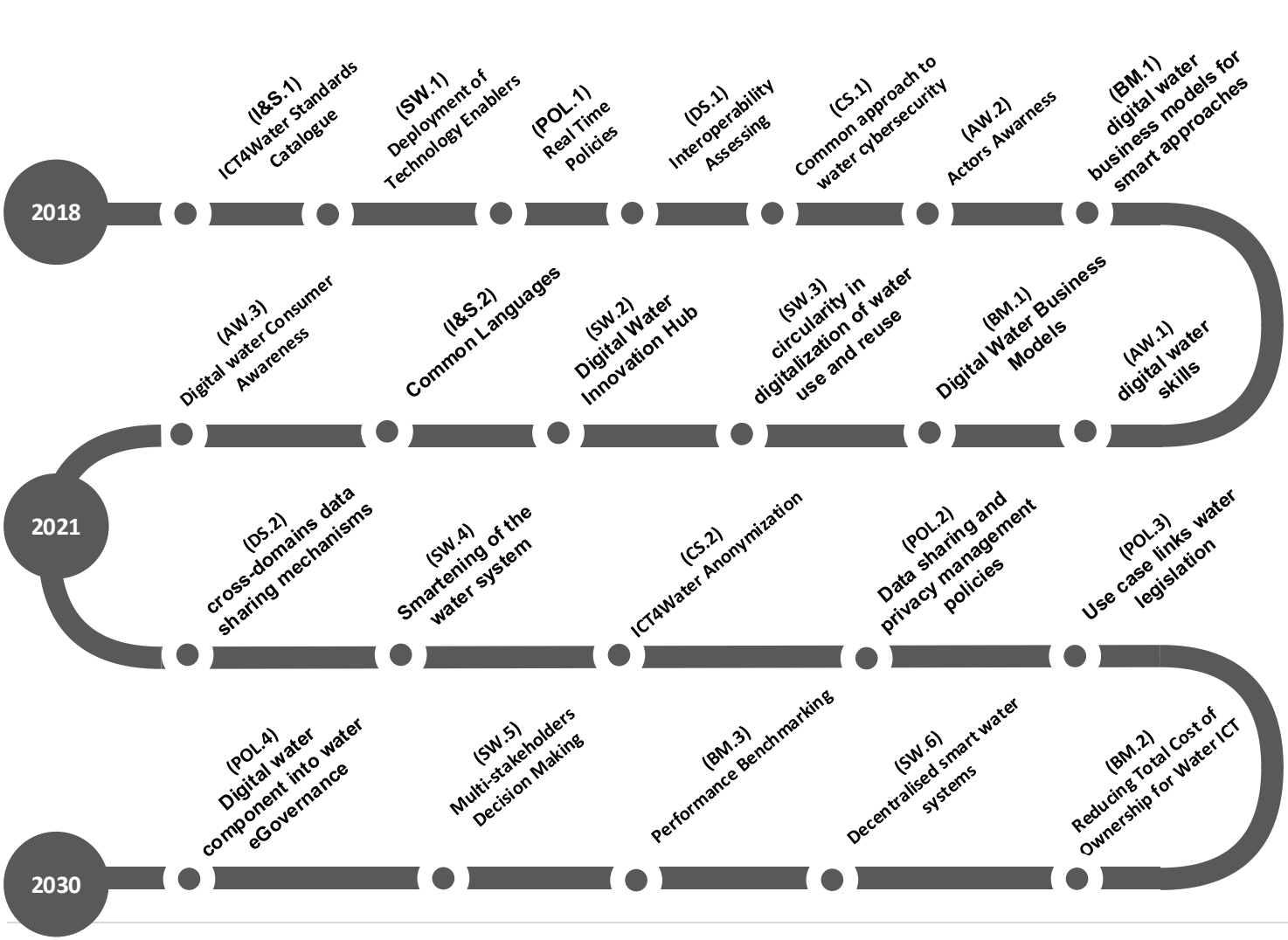
- Definition of the Water Information System for all common business processes models (Water Uses and Services, Environmental Management and Natural Hazards Management) of the water industry, at least at a macro level.
- Contribute to strengthen Open Data initiatives[15] [16] [17], by making Open Data easily accessible to European developers (not only those within the water sector, but also developers at large) supported, with the suitable funds and guided in the development of specific applications and tools.

[15] H2020 Open data pilot

[16] EU Open Data portal (e.g. WISE WFD Database https://data.europa.eu/euodp/data/dataset/data_wise_wfd)

[17] https://www.openaire.eu/what-is-the-open-research-data-pilot

4. The Action Plan



References

INTEROPERABILITY & STANDARIZATION **(I&S)**
DATA SHARING **(DS)**
SMART WATER **(SW)**
CYBER-SECURITY **(CS)**
ACTORS AWARNESS - WATER & DIGITAL **(AW)**
POLICY **(POL)**
BUSINESS MODELS **(BM)**

No.		Action	Activities	Timetable	Implementation Instruments
A. INTEROPERABILITY & STANDARDISATION (I&S)					
1	I&S.1	To develop an European Catalogue of ICT4Water standards and specifications including: Adoption of Priority and Feasibility of integration [18] **IMMEDIATE ACTION**	**Activity 1:** Develop guidelines for the adoption of ICT standards and emerging digital technologies in the water sector. **Activity 2:** Propose good Practices on the implementation of water information generation, collection, processing and exchange standards, and their right portfolio, considering a cross-sectorial interoperability approach and supporting technologies (data management, IoT[19], Cloud[20], LPWAN[21], 5G[22], among others). **Activity 3:** Develop interoperability recommendations and specifications in due consideration of the Communication on ICT Standardisation Priorities for the Digital Single Market[23]. **Activity 4:** Provide guidelines for the inclusion of ICT Standards and public procurements. **Activity 5:**	2018	• Procurement < 15.000€

[18] European Interoperability Framework (EIF) is part of the Communication (COM(2017)134), https://ec.europa.eu/isa2/eif_en

[19] https://aioti.eu/working-groups/

[20] COM(2016) 178 final, European Cloud Initiative - Building a competitive data and knowledge economy in Europe

[21] Low Power Wide Area Networks (e.g. LoRa; Sigfox; NB-IoT; etc.)

[22] https://ec.europa.eu/digital-single-market/en/policies/5G

[23] COM(2016) 176 final, ICT Standardisation Priorities for the Digital Single Market

			Link water standards with the Rolling Plan for ICT Standardisation [24] **Activity 6:** Promote standardisation and interoperability through the deployment and application of standards[25]. Complementary activities on standardisation **(ANNEX-III)**		
2	**I&S.2**	Development of information exchange water standards[26] including common languages to properly contextualise the business processes in the water domain (E.g. SAREF[27], HyFeatures[28], etc.)	**Activity 1:** Identify and develop interface standards essential for the integration of systems. **Activity 2:** Develop specifications for interoperability and data sharing across services (water, energy, assets, etc.) and their infrastructures. **Activity 3:** Promote and accelerate the development on standards and ontologies on data	2019-2023	• Promote in the framework of standardisation bodies • Digital water interoperability award • Dedicated research and innovation actions • Cross European Data-water Association / ICT4Water cluster working group
B. DATA SHARING (DS)					
3	**DS.1**	Develop recommendations ensuring interoperability and data	**Activity 1:** Define, develop, improve, operationalise,	2018-Onwards	• Cross European Data-Water-Standardisation

[24] http://ec.europa.eu/growth/content/2017-rolling-plan-ict-standardisation-released-0_en

[25] M/441 STANDARDISATION MANDATE TO CEN, CENELEC AND ETSI IN THE FIELD OF MEASURING INSTRUMENTS FOR THE DEVELOPMENT OF AN OPEN ARCHITECTURE FOR UTILITY METERS INVOLVING COMMUNICATION PROTOCOLS ENABLING INTEROPERABILITY

[26] M/441 STANDARDISATION MANDATE TO CEN, CENELEC AND ETSI IN THE FIELD OF MEASURING INSTRUMENTS FOR THE DEVELOPMENT OF AN OPEN ARCHITECTURE FOR UTILITY METERS INVOLVING COMMUNICATION PROTOCOLS ENABLING INTEROPERABILITY

[27] https://sites.google.com/site/smartappliancesproject/ontologies/reference-ontology

[28] http://external.opengis.org/twiki_public/HydrologyDWG/ModelRelationships

		sharing across services, making special emphasis on the free flow of non-personal data[29]	maintain and promote interoperable services and tools, standards and specifications following existing directives and initiatives: WFD, INSPIRE, GEOSS … **Activity 2:** Contribute to existing repositories by Improving collection, access and retrieval of coherent water related data. For instance, European Environmental Agency data and maps[30]; WISE[31] portal (Water Information System for Europe is the European information gateway to water issues). **Activity 3:** Engagement with other interconnected domains (e.g. climatology, agriculture, geography, etc.) for multidisciplinary systems with interoperable solutions. To integrate existing European public platforms (e.g. by JRC) and services (e.g. Copernicus by ESA)		Associations working group • H2020 and following Funding Schemas • Current funded activities • European, National, Regional Funding schemas • European-wide water data-sharing regulations
4	**DS.2**	Development of cross-domain data sharing mechanisms (Water-Energy-Food - Land use – Climate Nexus)	**Activity 1:** Develop and provide cross-domain alignment open interfaces and establishing Open Data (or meta data) policies to facilitate the data flow between different systems and domains.	2021-2025	• Dedicated Research and Innovation actions

[29] COM 2017 (495) final, on a framework for the free flow of non-personal data in the European Union

[30] https://www.eea.europa.eu/data-and-maps

[31] http://water.europa.eu/

C. SMART WATER (SW)					
5	**SW.1**	Reinforce better utilisation and effective deployment of new technology enablers	**Activity 1:** Develop effective research and innovation of smart Metering, Smart Sensors, network communications, Big Data, IoT, and Hybrid Infrastructures, including standards and common schemas needed for cross-vertical interoperability. **Activity 2:** Develop quasi-real time data analysis, forecasting, event diagnosis and visualisation technologies for advanced decision support Deployment of tools on various digital water value chains. **Activity 3:** Develop and integrate innovative technologies from machine learning, artificial/ computational intelligence to the operation of water systems, to enhance their monitoring and control procedures. In specific, these systems should provide human-level expertise in detecting and diagnosing events (fault and leak detection, contamination, cyber-physical attacks) and dynamically reconfiguring the system in case of an event.	2018-2022	• H2020 and following Funding Schemas • Dedicated Research and Innovation actions • Stimulate water private sector Investments • European, National, Regional Funding schemas
6	**SW.2**	Promote a Digital Water Innovation Hub	**Activity 1:** Promote data-intensive and cost-efficient water business models, products and services using digital technologies. **Activity 2:** Contribute in advancing the consolidation of the ICT4Water community.	2019-2023	• European, National, Regional funding schema • H2020 and following Funding Schemas • ICT4Water Cluster and other digital water

			Activity 3: Develop and deploy one-stop-shops for digital water services. **Activity 4:** Deploy technology infrastructure (competence center) to provide access to the latest knowledge, expertise and technology, to support the water community with piloting, testing and experimenting with digital water innovations.		working groups
7	**SW.3**	Improve efficiency and circularity in digitalisation of water use and re-use	**Activity 1:** Boosting Smart Cities and Smart Agriculture Linkage, Leakage detection, sustainable reduction of elastic water consumption and water pricing, increased user awareness, usage of grey water and cascade use of water, "promotion of water reclamation and re-use best practices. **Activity 2:** Retrofitting existing water infrastructure creates challenges in terms of how to adapt existing infrastructures with new technologies, which at least can reduce the cost for the community in order to meet current and emerging demands. **Activity 3:** Reinforce public private partnership to leverage risks (including health[32]) and opportunities	2019-2023	• H2020 and following Funding Schemas • Stimulate water private sector Investments • European, National, Regional Funding schemas

[32] EU-level instruments on water reuse Final report to support the Commission's Impact Assessment (2016)

8	**SW.4**	Smartening of the water system	**Activity 1:** Develop, test and deploy autonomous monitoring and control algorithms integrated as part of ICT solutions (system of systems approaches, system models and estimators; predictive control solutions; self-adapting systems…). **Activity 2:** Assess the benefits of implementing these techniques, both at the edge/distributed and at the cloud/centralised. **Activity 3:** Keep increase awareness of the value of the water, and also its key value among the different SDG (sustainable development goals)[33], Paris Agreement[34] and United nation climate conference[35]	2021-2025	• Smart Water awards • H2020 and following funding Schemas • Dedicated Research and Innovation actions • Stimulate water private sector investments • European, National, Reginal Funding schemas
9	**SW.5**	Develop and deploy Decision making tools able to apply new decision schemas considering competing objectives and multi-stakeholder governance models	**Activity 1:** Reduce heterogeneity among decision-making implementations. **Activity 2:** Increase comparability; promote comparison and interoperability of knowledge. **Activity 3:** Develop near/quasi real-time decision support **Activity 4:** Improve evidence-based decision making in water resource management and the system response time; maximize the system efficiency.	2021-onwards	• Dedicated Research and Innovation actions

[33] http://www.undp.org/content/undp/en/home/sustainable-development-goals.html
[34] "Paris Agreement". United Nations Treaty Collection. 8 July 2016
[35] https://cop23.unfccc.int/

			Activity 5: Develop and deploy a knowledge base and ICT tools for resource recovery and recycling **Activity 6:** Develop new methodologies for climate impact analyses and decision-making.		
10	**SW.6**	Develop and deploy decentralised smart water systems including health monitoring;	**Activity 1:** Research on different levels of decentralisation: - Decentralised smart water services at the equipment/sensor level - Decentralised smart water service at an aggregator level; - Decentralised smart water services at a utility level - Decentralised smart water services for wastewater collection and treatment systems - Decentralised smart water services for water supply and distribution **Activity 2:** Research and develop on information decentralization based on **Digital Ledger Technologies** considering the entire water domain (sensing, governance, billing, among others). **Activity 3:** Advance in the development of traceable and trackable products providing a *"Water Story"* as it circles within the nexus of Water-Food-Energy-Land Use-Climate.	2025-2030	• Dedicated Research and Innovation actions

D. CYBER-SECURITY (CS)					
11	**CS.1**	Develop a common approach to water cybersecurity[36].	**Activity 1:** Deploy proactive security by design, provide adequate security certification of products and services, and increase capacity to prevent, deter, detect and respond to cyberattacks. **Activity 2:** Develop secure schemas that permit the trustable sharing of information among sensors and other type of data management services, which fully cover all the data value chain, assuring that security tools arrive to the consumer, **Activity 3:** Fulfil the security faults in the adoption of interoperable open technologies. **Activity 4:** Explore, promote and conduct collaborative work to build common security frameworks together with other sectors (energy, trading, industry, transport, telecommunications...).	2018-onwards	• Cross European Data-Water Associations working group. • Stimulate water private sector investments • European, National, Regional Funding schemas
12	**CS.2**	Contribute in Cybersecurity by developing ICT4Water Anonymization methodologies and procedures	**Activity 1:** Deploy and develop reliable standards, specifications and procedures that anonymise data (regarding the source and the destination) with main focus on supporting secure processing of information from 3rd parties (and cross-domain) for analysis, optimisation, monitoring and control purposes. **Activity 2:**	2021-2025	• Stimulate water private sector investments • European, National, Regional Funding schemas

[36] European Council meeting (19 October 2017), EUCO 14/17

			Develop tools securing the channels and anonymise the data transmitted through the entire ICT platform.		
E. ACTOR AWARENESS - WATER & DIGITAL (AW)					
13	**AW.1**	Define, develop and promote new digital water skills, labour markets and training and education systems to fit for the digital age (in line with the need to invest in digital skills, to empower and enable all Europeans[37]).	**Activity 1:** Foster the transference of applied digital knowledge and experience through all actors in all water value chains. **Activity 2:** Define and develop digital water training programs including best practices and guidelines on Smart Water to promote adoption of digital Water solutions. **Activity 3:** Share success stories trough living digital water labs, pooling resources, and opening to other sectors' approaches and methods. **Activity 4:** Define new digital water roles **Activity 5:** Foster public private partnerships for the development and support of smart water pilot projects, living labs and procurement schemas.	2019-2023	• Stimulate water private sector investments • Data-Water Association/ICT4Water cluster working group • Digital Water Operator Award (Promoted by Water Association) • Dedicated Innovation Actions • H2020 and following Funding Schemas • European, National, Reginal Funding schemas • ICT4Water cluster, WssTP Working Groups and Horizontal Clusters
14	**AW.2**	Raise awareness for water actors, considering cross-actor interactions (managing authorities, decision makers, water professionals,	**Activity 1:** Awareness of the importance of Water Systems interoperability; **Activity 2:** Awareness regarding the benefits of digital water	2018-Onwards	• H2020 and following Funding Schemas • Dedicated Research and Innovation actions • Stimulate water

[37] European Council meeting (19 October 2017), EUCO 14/17

		entrepreneurs, managers, operators, consumers, citizens, etc.).	solutions focusing on the importance of the free flow of data among systems, smartness and open data policies. Promote the value of water data. **Activity 3:** Research in new models on water/health, water/energy/waste, nexuses, water cycles, value of ecosystem services, circular economy, climate impact; etc.		private sector investments • European, National, Reginal Funding schemas • European Digital Water Conference
15	**AW.3**	Progress in digital water consumer awareness	**Activity 1:** Reinforce the value of water. Not only for Smart cities citizens, but also for industrial and agricultural customers. **Activity 2:** Develop smart digital tools to enhance the dialogue amongst water consumers and procedures to understand their motivations; address real needs, and real use cases. Improve product water footprint citizen perception; induce sustainable changes in consumption behavior, and improve social perceptions for water, citizen science, smart engagement and participation in EU programmes and policy making **Activity 3:** Research in new personalised water services (take advantage of digitisation to offer personalised information / services).	2019-Onwards	• H2020 and following Funding Schemas • Dedicated Research and Innovation actions • Stimulate water private sector investments • European, National, Reginal Funding schemas • European policies on water footprint reporting (DGs) • ICT4Water cluster, WssTP vertical clusters

F. POLICY (POL)					
16	**POL.1**	Upgrade policies by considering the inclusion of real-time measurements	**Activity 1:** Supported by technological innovations, e.g. smart sensors and IoT deployment, data is under a big expansion in terms of quantity and diversity. This poses new challenges and offers new opportunities to turn these data into understandable, usable information in real-time for multiple actors within water value chains. Consequently, efficient data quality standards and specifications are required in order to provide information to decision makers in periods not covered by water related directives. Distributed high performance computing infrastructures such as Grids or Clouds appear as promising supporting technologies.	2018-2022	• DGs • Review water directives including ICT experts. • Dedicated Research and Innovation actions
17	**POL.2**	Data sharing and privacy management policies	**Activity 1:** Upgrade legislation providing common sets of terms and conditions to be used. Provide a policy framework to include open data clauses in contracts between local authorities and operators. Furthermore, identify potential privacy risks and propose privacy---preserving solutions (at the technical and policy levels) to facilitate data sharing.	2021-2025	• Cross European Data-Water Associations working group. • DGs
18	**POL.3**	Promote the links with the existing and future water legislation by deploying ICT4WATER use-case(s)	**Activity 1:** Reduction of legislative fragmentation and establishment of clear water governance bodies. Water is a fragmented domain where decision-making legislative responsibilities in some cases are overlapped or unclear; **Activity 2:** Promote a legislative framework for the application of	2021-2025	• DGs • Stimulate water private sector investments • European, National, Regional Funding schemas

			INSPIRE[38] Directive for Geospatial data in digital public services.		
19	**POL.4**	Integrate digital water components into water eGovernance (new or existing urban plans; emergency plans; infrastructures plans; etc.)	**Activity 1:** Develop and deploy data-intensive services for evidence-informed policy-making Initiatives by promoting the usage of effective data management infrastructures including hybrid approaches supporting (i.e. for Water Security Plans). **Activity 2:** Develop and deploy smart water solution to improve management of governance complexity, uncertainty, divergent economic and political interests and cultural discourses.	2025-2030	• Dedicated Innovation Actions • Stimulate water private sector investments • European, National, Regional Funding schemas • WssTP Vertical Clusters
G. BUSINESS MODELS (BM)					
20	**BM.1**	Further developing digital water business models for different smart approaches (Smart Cities, Smart Agriculture, Smart Industry)	**Activity 1:** Definition and development of data driven and service-based business built on digital water value (rural, domestic, industrial regional cases). Further explore options such as: ownership, as a service business models, fix rate... **Activity 2:** Research on optimal solutions for the decentralised exchange of value and creation of digital assets (e.g. Blockchain)	2019-2023	• Data-Water Association/ICT4Water cluster working group • Sector investments • Innovation actions
21	**BM.2**	Reducing Total Cost of Ownership for Water ICT	**Activity 1:** Strengthening research and innovation to deliver: • Cost-effective technical solutions addressing water consumption monitoring and allowing massive implementation of solutions.	2021-2025	• H2020 Funding Schemas • Dedicated Research and Innovation actions • Stimulate water

[38] http://inspire.ec.europa.eu/

			• Technical synergies and business models with energy consumption monitoring, Smart Cities, Smart Home, Smart Agriculture and Smart Industries ecosystems. • Improvement of circular economy business models leveraging the circular characteristics of water.		private sector investments • European, National, Regional Funding schemas
22	**BM.3**	Developing tools for assessing the maturity, costs and benefits of smart water deployments including performance benchmarking	**Activity 1:** Develop, identify and summarize key performance metrics and indicators in order to develop benchmarking framework and assessment methodology of smartness or digitalisation levels (considering already established indicators and Sustainable Development Goals (SDG) as applicable). **Activity 2:** Develop an open access benchmarking tool for assessing digital water implementation status. Develop a process for future updates to the tool and self-assessment process. **Activity 3:** Promote benchmarking and interrelated comparison across water and wastewater operators of smart technologies, considering multiple types of water bodies (urban, agriculture, freshwater and transitional waters)	2021-Onwards	• Cross European Data-Water Associations working group • H2020 and following funding Schemas

5. Delivering the Action Plan

This Action Plan includes actions to be launched between 2018 and 2030. The actions, in their maiority, seek to arrive at their objectives in terms of 5 years, except for those where there is need for a more extended and constant time evolution.

EU implementation instruments such as the EU Framework Programmes, including Horizon 2020, the European Structural and Investment Funds and the European Fund for Strategic Investments can help achieve the objectives. In addition, the EU should also explore ways to set up the appropriate structures and funding to support breakthrough innovation[39]; as well as stimulate water private sector investments and assume them as priorities for Departments and Executive Agencies strategies (e.g. DG CONNECT, DG ENV, DG AGRI, DG CLIMA, DG ENER, DG RTD, EASME, DG GROW, DG DEVCO, EEA).

Additionally, the water sector has a crucial role in the implementation of **The Action Plan for a Digital Single Market for Water Services,** chiefly as main beneficiaries and actors in each of the actions, but also implementing initiatives that allow the realisation of each action, for instance:

Establish cross-domain/cross-sectorial working groups	Involving Cross European Data-Water Associations, ICT4Water Cluster, standardisation bodies
Sponsor prizes and other incentives	Digital water interoperability award Smart Water awards Digital Water Operator Award
Organise conferences	Organise, sponsor and attend events focused on digital water and its intelligent development
Private investments in smart water	Allocate specific resources for research, development and deployment of smart water technologies and digital water training
(the instruments for implementation presented are examples not excluding others that could be proposed in the future)	

Further actions may be needed to achieve the objectives set out within each of the above priorities, in order to adapt to the rapidly changing technological environment. Therefore, new actions may be proposed by the Water Community and the European Commission so as to implement or to initiate new emerging technologies. Stakeholders may also propose actions for implementation under the digital water services Action Plan.

Delivering on the measures proposed in this Action Plan will be possible only through a joint commitment and joint ownership between the Water Community, the European Commission and the Member States, at all levels.

[39] European Council meeting (19 October 2017), EUCO 14/17

6. Conclusion

The Action Plan for a Digital Single Market for Water Services outlines and details necessary steps water actors are taking towards a complete value chain transformation. At the end of this transformation process, successful water/wastewater/agricultural/industrial companies and authorities will become true digital water enterprises, with physical products at their core, augmented by digital interfaces and databased, as well as innovative services. These digital water enterprises will work together with customers and suppliers in industrial digital ecosystems. These developments will fundamentally change individual companies, as well as transform water market dynamics, across a whole range of related industries.

It is noted that just introducing ICT is a necessary but not sufficient measure to achieve these objectives (ICT supported water production may, in some cases, lead to a reduction in the production in order to guarantee sustainability). Water leaders have slowly started digitising essential functions within their internal vertical operations processes, as well as in cooperation with their horizontal partners along the value chain. In addition, they are enhancing their product portfolio with digital functionalities and introducing innovative, databased services. A continued, broader commitment from the European Commission, Associations and all stakeholders concerned will be needed. **The ICT4Water invites the Digital Water community to endorse this action plan and to actively promote its implementation, in close cooperation with all relevant stakeholders.**

Companies that adopt water stewardship strategies should be able to anticipate manage and mitigate a number of risks such as increasing water costs, changing regulatory landscape or disruption of physical supplies. **A Digital Single Market for Water Services is the 21st century opportunity in valuing water.**

This could lead to a new generation of digital services as well as to a new generation of water-related services based on direct collaboration among authorities, providers and citizens. Fast evolution of the cross-domain applications requires a deeper and concrete awareness of the potential correlation among different interrelated domains. All should be considered, in the near future, as **one single complex system to be involved in optimising the flow of information, energy, water, health, food, environment, mobility, etc., as well as managing all the other goods essential for keeping the quality of life as high as possible in the future.**

A meaningful strategy should aim at transforming digital water to provide services to the society ensuring that it can face the future with confidence. To accomplish this broad goal, **further actions will require the support of dedicated advisory and support of dedicated groups** as well as to provide the necessary impetus and review progress regularly. Therefore, the EC and related agencies, the ICT4Water community and new working groups are encouraged reporting regularly on progress for the strategy.

ANNEX I: Background

Large part of worldwide economic activity will depend on digital ecosystems, integrating digital infrastructure, hardware and software, applications and data. As stated during the Tallin Digital Summit[40], this is needed for a stronger and more coherent Digital Europe. Digitization of all sectors will be required for the EU to maintain its competitiveness. Digitization offers unprecedented opportunities to:

- Support the **free flow of non-personal** data as pre-requisite for a competitive data economy within the Digital Single Market.
- Merge both physical and virtual worlds, creating **smart environments** bringing together people, infrastructures and data to solve problems in a faster and more predictive way.
- **Integrate various data sources** and device-agnostic data aggregation for streamlined data management.
- Improve the quality and speed of decision-making throughout the organisation and inter-organisations through **collective decision-making and collaborative philosophies**.
- **Improve trust** in the data and communication security, as well as the protection of intellectual property and personal data.
- **Move towards further automation and technology oriented systems** that provide, cost-benefit affordable and more efficient processes and services.
- Keep increasing the **awareness of the value of water as a link amongst other domains (energy, food, social) and its value as a resilient vector.**
- Support the creation of new products and services.

Despite this promising digital scenario, the planning and integrated management of the water cycle cannot be only accomplished by digital deployment; it is based on a systemic and **interdisciplinary approach that requires the support of a wide range of scientific, economic and social disciplines**. The management of water is also extended throughout, socioeconomic and other environmental resources at the river basin scale, raging across all natural and human-made water cycle. In addition, understanding the interactions of human activities with natural sources and the landscape is critical to effectively managing water and sustaining water availability in the future.

Decision-making in such complex environments requires advanced tools and systems for data collection, information analysis and the generation of the knowledge necessary for an accurate management and governance. At this point, digital ecosystems play a fundamental role. The water industry of the future will be smart and resource-efficient. Networked, intelligent systems will help make better use of energy, avoid unnecessary water losses and minimize the consumption of resources.

[40] https://ec.europa.eu/commission/publications/tallinn-digital-summit-factsheets_en

Urban, rural, industry, environmental, recreation are water uses, which are directly linked to specific activities and processes that are potential targets for deployment of ICT solutions. Across these usages, the water sector needs to implement a range of measures to ensure being at the forefront of developing and exploiting digitalization, automation, sustainable production and processing technologies to serve the integrated water markets of the future across all water usages and value and chains.

Following this major goals and considering all water usages and value chains, the Action Plan for a Digital Single Market of Water services intends to set out a concrete and ambitious strategy to support and deploy a strong industrial base and manage the transition to a smart water services economy that had better address the following needs:

Focus areas	Needs
Operational	• Consolidated asset management for minimizing risk in the water infrastructure. • Improved work force, asset and operational integrated management • Reducing water-wastewater sensors maintenance
Digital Water	• Developing intelligent management of water flow using bi-directional communication in water infrastructure. • Deploying real-time smart decision making and monitoring. • Boosting digitization of the rural water sector. • Advances in autonomous and intelligent sensor capabilities. • Deployment of flexible and scalable data management and analysis services. • Advances in autonomous sensor capabilities. • Advances in research for low cost and reliable sensors/transducers (Physical, Chemical, Biological characteristics). • Creating digital usable representations of water systems.
Environment	• Safeguarding availability of water to sustain lives and livelihoods and protect against threats to and from water. • Developing tools and models of water-cycle resources for more accurate forecast ar impact predictions, leading to enhanced and improved adaptation initiatives to climat change.
Resource efficiency	• Improving energy efficiency in operating and maintaining water infrastructure (legacy adaptation). • Low-cost, affordable or cost-benefit water monitoring solutions.
Standardisatio	• Advances in data sharing and Interoperability • Enabling the free flow of non-personal data • Developing common information exchange standards following a cross-domain approach.

Security an Infrastructu challenges	• Data privacy and security. • Reducing effects of infrastructure age and obsolescence.
Social	• Effective feedback mechanisms to accurately and timely inform consumers for their water consumption and behaviour. • Boosting sustainable behavioural changes in all water actors). • Developing digital change management (new skills, training & technology). • Evolving Water Demand Management (WDM) and pricing strategies.
Governance Policy	• Providing added value to highly detailed water consumption data. • Open EU water directives to online monitoring. • Boosting open access and open data policies. • Enabling integrated governance across sectors.

Water sector challenges and concerns

More than 1.8 billion people worldwide will be living in areas of water scarcity, where more than two thirds of the world's population will face water-stressed conditions in the next decade. Water scarcity, changing demographics and operational efficiency are top issues for the water sector, amplified by the unpredictable impact of climate change. Demand for water is still on the rise, according to the Organisation for Economic Co-operation and Development (OECD). By the middle of the century, water demand will increase by 55 percent compared to 2015 levels[41].

Declining water quality has also grown to be a global concern. It can directly influence the cost of providing water by utilities, reduce the volume of water available for use, and affect human health. Water pollution is mainly attributed to agricultural activities (due to fertilizers or agrochemicals use), domestic sewage and industrial effluents. Moreover, the long-term impact of personal care products and pharmaceuticals (such as painkillers and antibiotics), on water cycles is an emerging area of concern that is rapidly gathering interest among the scientific community; it is expected to result in changes to public policy. At European level, the Water Framework Directive (WFD)[42] and associated water legislation are addressing water protection. A Commission Proposal for a revised Drinking Water Directive (098/83/EC) is scheduled to be adopted in December 2017, and subsequently to be published and submitted to the Council and European Parliament.

A roadmap on the Fitness Check (evaluation) of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC)[43], and a roadmap on the evaluation of the Urban Waste Water

[41] http://unesdoc.unesco.org/images/0023/002318/231823E.pdf

[42] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

[43] https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-5128184_en

Treatment Directive (91/271/EEC)[44] were been published in October 2017. A public consultation on the strategic approach to pharmaceuticals in the environment was launched in November 2017[45].

As part of its plans for a more circular economy, the European Commission is developing tools to help expand the use of safe and efficient water reuse technologies. An EU-wide framework of minimum requirements for water reuse is under development that will reduce pressure on water resources and ensure the best use of this technology in terms of health and safety, environmental protection, and cost effectiveness.

Water managers around the world are dealing with acute water and wastewater infrastructure challenges, often resulting in pipe leaks, sewage overflows and other hazards that not only waste valuable water but may also affect public health and the environment. Infrastructure issues, including water main breaks, sanitary sewage overflows, storm water overflows, and water pipe degradation result in increased costs for households and consumers, due to higher water rates, as well as billion-cost increases to utility costs by 2020[46]. New kinds of infrastructures start to appear (i.e. Managed Aquifer Recharge plants) needing advanced ICT technologies for their every day safe and smart operation. The long-term impact of climate change is uncertain, and planning for its effects is challenging, as historical statistics may not helpful enough in predicting the future. It is widely expected to exacerbate water scarcity and watershed planning, whilst making ageing water infrastructure even more vulnerable to extreme weather conditions. Therefore, risk levels due to climate change are likely to make water cycle, infrastructure and demand management even more complex and costly. The impact of climate change will also vary significantly location wise, thus trapping utility operators to reactive responses, due to the lack of comprehensive data sets and insight into networks infrastructure and water works conditions.

While only a few governments are openly incorporating water-related risks into their plans, a broad coalition of governments, river basin organisations and businesses established the Paris Pact on Water and Climate Change Adaptation at the 2015 Paris Climate Change Conference[47]. The Pact aims to implement individual adaptation plans, strengthening water monitoring and measurement systems in river basins and promoting financial sustainability and new water systems management.

Ultimately, the world needs flexible and resilient water systems that anticipate, monitor and adapt to changed circumstances. We need to implement sustainable management techniques to protect water cycles and reduce the impact of human activity on them. These need to go hand-in-hand with optimising water provision, supply and consumption. They will require closer collaboration between utilities, users and regulators to incentivise water conservation, re-use and recycling.

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[44] http://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-4989291

[45] Public consultation – in 23 languages: https://ec.europa.eu/info/consultations/public-consultation-pharmaceuticals-environment_en; The deadline for responses is 21 February 2018. Targeted stakeholder consultation - in EN only: https://ec.europa.eu/eusurvey/runner/PharmaInEnvTargetedConsultation2017

[46] Koop, S. H. A., Koetsier, L., Doornhof, A., Reinstra, O., Van Leeuwen, C. J., Brouwer, S., … Driessen, P. P. J. (2017). Assessing the Governance Capacity of Cities to Address Challenges of Water, Waste, and Climate Change. Water Resources Management, 31(11), 3427–3443. http://doi.org/10.1007/s11269-017-1677-7

[47] http://newsroom.unfccc.int/lpaa/resilience/press-release-lpaaresilience-1-paris-pact-onwater-and-climate-changeadaptation-announced/

Water & ICT opportunities & challenges

Over recent years, ICT technology has developed greatly and has matured with mass production to allow a wider uptake of methods and devices. After the development phase, digital technologies are now entering an application and implementation phase that is targeting several fields, including the environment. As a relevant example the European Union has defined as a major priority for the next 20 years "ICT for sustainable growth[48]", with the ambition to lead innovation at worldwide scale. In such context, **Digital Water** solutions have the potential to connect water resource management and operations, citizens and authorities with distribution, supply, wastewater, storm water, irrigation and drainage networks and systems, to optimise the holistic treatment and delivery lifecycle of water. XaaS (**Anything-as-a-Service**) solutions can produce operational efficiencies that improve water quality and availability for municipalities, agricultural communities, industrial sectors and consumers worldwide. Using data and analytics (including real-time big data analytics), digital industrial companies can work with water operators and consumers globally to solve the challenges of water supply and distribution, storm water management and wastewater collection and treatment. Governing authorities and water utilities worldwide can use seamless software solution sets built on industrial internet platforms (as they continuing gaining in robustness) to put their data to work, addressing ageing infrastructures, work force constraints, and water resources conservation.

Despite this promising scenario, the **Digital Water** domain is characterised by a low level of maturity concerning the standardisation of ICT solutions, their business processes and the related implementation in the legislative framework. The massive and rapid spread of IoT devices within the society and their application to the industrial sectors is not coordinated[49]. As a result, the relevance for developing these technologies within the water domain has to rely on specific identification of the benefit provided in each business process by the introduction of the new solutions.

Water actors, such as business, operators, associations, technology platforms, authorities and consumers, are key in driving this process. Local, regional and national authorities are enabling the transition, but the EU also has a fundamental role to play in supporting it.

As the impact of climate change and pollution on hydrological cycles is gradually better understood, a number of countries may look to tighten water regulatory standards on the provision of water and sewerage services. With more interest from governments and businesses to adopt water stewardship principles, utilities may also explore innovative financing solutions to fund infrastructure investments. Their aim is to ensure that the right digital water strategy framework is in place.

EU research and innovation agenda has been supporting the development of the ICT for the efficient water resource management since the FP7 Work programme ICT 2011[50]. The ICT aspect has been horizontally integrated in most of the water related topics of the H2020 Societal challenge 5 calls for

[48] http://ec.europa.eu/information_society/activities/sustainable_growth/index_en.htm

49 Black & Veatch (2017). 2017 Black & Veatch strategic Directions: Water Industry Report. https://pages.bv.com/SDR-Water-Industry-DL.html

50 http://cordis.europa.eu/fp7/ict/sustainable-growth/docs/work-programme.pdf#page=77

2014-2020, as well as explicitly target in certain topics[51]. The activities related to ICT and water management contribute to the Digital Single Market Objectives by promoting efficient smart ICT technologies for which open standards and interoperability are essential as well as the free flow of date.

The challenge is to promote the development and adoption of standards that ensure compatibility between systems, data and services across sectors in a joint effort to tackle socioeconomic challenges. Sectors include, among others, the water, eGov, spatial planning, construction, mobility, energy management, and others.

Each decision taken in one area has a direct impact on others, as well as on the life and socio-economic growth of the Smart City. It is essential to address these issues through a cross-sectorial and cross-functional approach to drive common sustainable objectives for Smart Cities.

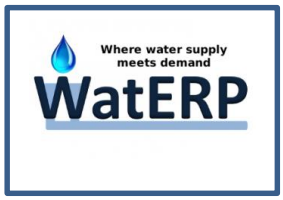
ANNEX II: The ICT4Water Cluster

The ICT4WATER cluster is a hub for innovative activities contributing to strategic views, organising and participating at major exhibitions and scientific events, and disseminating results through major channels. Mainly, it collaborates and contributes in drafting the European Digital Single Market Strategy within the water sector.

Prompted by European Commission (chiefly DG Connect), and EASME since 2015, they have formed a cluster for the alignment in the application of digital technologies in the water sector: the ICT4WATER cluster (www.ict4water.eu). By the date of publication of this Action Plan, 30 EU funded projects have joined this cluster, bringing together over 300 institutions and businesses.

Members:

Founder Members (completed projects):



51 https://ec.europa.eu/programmes/horizon2020/

Completed projects:

Ongoing projects:

Linked EC initiatives:

ANNEX III: Complementary activities on standardisation

- **ACTION 1**: Guidelines for the definition of Smart Water Grids, powered by IoT technologies and standards, which contributes to decentralised bi-directional water and information flow.
- **ACTION 2**: Guidelines and collaborative work among key actors (associations, alliances, SDOs, etc.) for the definition of Water Big Data standardisation frameworks, which contributes to implementing smart water practices. Making special emphasis on key aspects of a big data platform such as integration, analytics, visualisation, development, workload optimisation, security and governance.
- **ACTION 3**: Selection and integration of the best technologies in each class among all the range of suitable standards and ontologies ensuring the interoperability at data and communication level.
- **ACTION 4**: Definition of open models and open data through interoperable platforms.
- **ACTION 5**: Provision of a long term regulatory strategy and advice relevant stakeholders about the adoption of smart technologies
- **ACTION 6**: Incentives for the adoption of Open Data standards, in order to be able to provide information in a transparent and up to date manner

Ongoing water related standards initiatives

Standardisation Body	Short Description and web links
CEN/CENELEC/ETSI	**Functional reference architecture for communications in smart metering systems.** A European standard comprising a software and hardware open architecture for utility meters that supports secure bidirectional communication upstream and downstream through standardised interfaces and data exchange formats and allows advanced information and management and control systems for consumers and service suppliers ftp://ftp.cen.eu/cen/Sectors/List/Measurement/Smartmeters/CENCLCETSI_TR50572.pdf
OGC®	**HY_FEATURES**. Reference model defining real-world water-objects and the way they relate to each other according to hydro-science domain defined by semantics and network topology. http://www.opengeospatial.org/projects/groups/hydrofeatswg
ETSI	**SAREF Investigation for Water** (DTR/SmartM2M-103547) Determining the requirements for an initial semantic model for the Water domain based on a limited set of use cases and from available existing data models https://goo.gl/324EyW
ETSI	**Industry Specification Group "City Digital Profile" (ISG CDP).** That group vision is: • To accelerate the delivery of integrated citizen services and provide a technology road map for city leaders, by promoting the use of standards in a replicable solution stack. • To enable cities to procure smart solutions with confidence that they will be extendable, configurable and interoperable with similar services from other cities. • To lay out a smart city standards roadmap across the whole technology stack, that may be used by city and national leaders to accelerate the deployment of innovative city services. Initial cross domain city applications will include:

	• Health and social care (disability entitlement; housing benefit and rent payment; housing condition, assisted living and vulnerability). • Building management and connected homes • Urban lighting • **Water and waste management and energy** • Transportation and mobility • Environmental issues such as pollution and resource optimization https://portal.etsi.org/Portals/0/TBpages/CDP/Docs/ISG_CDP_ToR_DG_Approved_20171011.pdf
OGC®	**WaterML2.0**. Standard information model for the representation of water observations data, with the intent of allowing the exchange of such data sets across information systems, through the use of existing OGC standards. http://www.opengeospatial.org/projects/groups/waterml2.0swg
INSPIRE	**INSPIRE Directive**. Reference EU architecture for data sets sharing between EU countries. http://inspire.ec.europa.eu
ISO/IEC	**Generic Sensor networks Application Interfaces** (ISO/IEC 30128). International Standard that depicts operational requirements for generic sensor network applications, description of sensor network capabilities, and mandatory and optional interfaces between the applications.
ITU-T	Ubiquitous sensor network middleware, applications, identification (**F.744** standard). Service description and requirements for ubiquitous sensor network middleware.
ISO/TC	**ISO/TC 282**. Standardisation of water re-use of any kind and for any purpose. It covers both centralised and decentralised or on-site water re-uses, direct and indirect ones as well as intentional and unintentional ones. It includes technical, economic, environmental and societal aspects of water re-use. Water re-use comprises a sequence of the stages and operations involved in uptaking, conveyance, processing, storage, distribution, consumption, drainage and other actions related to the handling of wastewater, including the water re-use in repeated, cascaded and recycled ways. https://www.iso.org/committee/4856734.html
PSA	**WITS Standard Protocol.** Standard method dedicated to water industry telemetry control and monitoring. This standard protocol makes interoperable equipment from different manufacturers by using features of the DNP3 protocol to satisfy water industry specific functional requirements. http://www.witsprotocol.org
AIOTI	**High Level Reference Architecture.** Reference ICT architecture and semantic data model based on the ISO/IEC/IEEE 42010 standard for representing IoT entities and services. This reference architecture is transversal to a number of domains including water. https://aioti.eu/wp-content/uploads/2017/06/AIOTI-HLA-R3-June-2017.pdf
W3C	**Web of Thing Working Group.** RDF and Linked Data vocabularies to reduce the fragmentation generated in the IoT devices. Moreover, this group is also focused on providing best practices and corresponding APIs to enable semantic interoperability within the Smart City. **Iot-Schema.org.** Extension of schema.org data model towards modelling IoT entities with focus on energy, transport and water infrastructures.

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