SCOREwater

Smart City Observatories implement REsilient Water Management

DELIVERABLE D8.4

PRELIMINARY POLICY BRIEF

Dissemination level	Public
Type	Other
Issued by	IVL Swedish Environmental Research Institute
Contributing project partners	
Author(s)	Englund, A.
Reviewed by	De Jong, P., Domene Gomez, E. and Evertsson, J.
Keywords	Policy, smart water, sensing technology, scale-up
Number of pages	20
Number of annexes	1
Date:	2022-07-07
Version:	V 2
Deliverable number	D8.4
Work Package number:	WP 8
Status:	Delivered
Approved by coordinator (IVL)	2022-07-07

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

Copyright notices

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

REVISION HISTORY

Version	Reason for changes	Name	Date
1	Original release to EU	Andreas Englund	2022-04-29
2	Addressing the comments of the external reviewer following the review meeting 23 June 2022. The following has been updated: • Section 3.2 paragraph 5 have been updated with clearer description of current state of policy in EU and USA.	Andreas Englund	2022-07-07

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

CONTENT

LIST OF FIGURES

LIST OF TABLES

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

ABBREVIATIONS

Abbreviation	Definition
CAPEX	Capital Expenditures
CKAN	Comprehensive Kerbal Archive Network
ICT	Information and Communications Technology
IoT	Internet of Things
OPEX	Operating Expenses
PCP	Pre-Commercial Procurement
SDG	Sustainable Development Goals
SME	Small and Medium-sized Enterprise

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

PROJECT ABSTRACT

SCOREwater focuses on enhancing the resilience of cities against climate change and urbanization by enabling a water smart society that fulfils SDGs 3, 6, 11, 12 and 13 and secures future ecosystem services. We introduce digital services to improve management of wastewater, stormwater and flooding events. These services are provided by an adaptive digital platform, developed and verified by relevant stakeholders (communities, municipalities, businesses, and civil society) in iterative collaboration with developers, thus tailoring to stakeholders' needs. Existing technical platforms and services (e.g. FIWARE, CKAN) are extended to the water domain by integrating relevant standards, ontologies and vocabularies, and provide an interoperable open-source platform for smart water management. Emerging digital technologies such as IoT, Artificial Intelligence, and Big Data is used to provide accurate real-time predictions and refined information.

We implement three large-scale, cross-cutting innovation demonstrators and enable transfer and upscale by providing harmonized data and services. We initiate a new domain "sewage sociology" mining biomarkers of community-wide lifestyle habits from sewage. We develop new water monitoring techniques and data-adaptive storm water treatment and apply to water resource protection and legal compliance for construction projects. We enhance resilience against flooding by sensing and hydrological modelling coupled to urban water engineering. We will identify best practices for developing and using the digital services, thus addressing water stakeholders beyond the project partners. The project will also develop technologies to increase public engagement in water management.

Moreover, SCOREwater will deliver an innovation ecosystem driven by the financial savings in both maintenance and operation of water systems that are offered using the SCOREwater digital services, providing new business opportunities for water and ICT SMEs.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

EXECUTIVE SUMMARY

Policy issues are highly relevant when digital services to improve the management of wastewater (sewage, stormwater and combined sewage and stormwater water) and flooding events are to be introduced. Policy is a broad topic with many angels. Since scaling up digital services in the water sector is a major challenge, especially when it comes to sensing technology where one is dependent on the advantages of scale to have cost-effective sensors, it is important to focus on policy measures that facilitate diffusion of innovation and scaling. The focus of this policy brief is therefore on policies that could facilitate the scaling of digital services.

The water sector is economically relatively small and, therefore, it is difficult to create a market based exclusively on this sector. Furthermore, the water market is fragmented. 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.

The online monitoring of pollutants is usually not a legal requirement for stormwater and combined sewage systems. There exists, therefore, little motivation for utilities and other actors to invest in sensing technologies for water quality monitoring.

To meet these major challenges, the following policy related actions are recommended:

- Recommendation 1: Set legal requirements for online monitoring of pollutants from stormwater and combined sewage and stormwater systems. Without such requirements, there will be little motivation for utilities and other actors to invest in sensor technologies for water quality monitoring.
- Recommendation 2: Stimulate the creation of a volume market for sensing technologies. As an example, one policy instrument that has successfully addressed upscaling in fragmented markets in other sectors is Pre-Commercial Procurement (PCP).
- Recommendation 3: To further support a volume market, establish guidelines to employ sensoring systems for predictive maintenance and flood control of wastewater systems (sewage, stormwater and combined sewage and stormwater) and start to work with standardization when the market has become more mature.
- Recommendation 4: Create competence development programs on advanced data management for the water sector. This should be directed at both technical staff and management at utilities, urban administration level as well as at data experts in order to raise awareness regarding digital solutions and to attract them to the water sector.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

1. INTRODUCTION

SCOREwater introduces digital services to improve management of wastewater (sewage, stormwater and combined sewage and stormwater water) and flooding events. Policy issues are highly relevant when such services are to be introduced. Policy is a broad topic with many angels. Since scaling up digital services in the water sector is a major challenge, especially when it comes to sensing technology where one is dependent on advantages of scale to have cost-effective sensors, it is important to focus on policy measures that facilitate diffusion of innovation and scaling. The focus of this policy brief is therefore on policies that could facilitate the scaling of digital services.

1.1. GOAL

To analyze the need for policy changes that can facilitate the scaling of digital services to improve the management of wastewater and flooding events.

1.2. METHODOLOGY

The analysis in this policy brief is based on literature studies, a review of other deliverables in the SCOREwater project and a workshop with the stakeholders in the project. Part of the process has also been to participate in the writing of an EU whitepaper (Elelman et al., 2021) on the need for digital water in a green Europe. That whitepaper has been prepared after a process of consultation with members of consortia of about 60 EU-funded projects from the ICT4Water cluster who were asked to complete a detailed questionnaire. After an initial analysis undertaken by an editorial board, individual leaders of specific projects were contacted in order to obtain further, in-depth information.

2. THEORETICALCAL BACKGROUND

The theoretical point of departure for this policy brief is socio-technical system theory (Geels, 2002) and innovation diffusion theory (Rogers, 2003). While socio-technical system theory provides the framework and puts policy, and how it facilitates change, into a macro context the innovation diffusion theory provides the understanding of how change is made on a micro-level.

2.1. SOCIO-TECHNICAL SYSTEMS

The system that is managing wastewater and flooding events could be considered a socio-technical system and could be analyzed by a socio-technical system model. Such a model is considering institutional factors such as:

- technological limitations
- user practices and application domains (market)
- the symbolic meaning of technology
- infrastructure
- policy
- industry structures
- techno-scientific knowledge.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

Geels (2002) has described a model to understand technological shifts. He adopts an institutional perspective and shows that there may be several obstacles to the introduction of new technologies. Institutions are systems of common habits, norms, practices, laws and regulations that govern the relationships between individuals, groups and organizations, i.e. the rules of the game. The model is a map to navigate in the practical innovation work. It explains the challenges faced and puts them in context. Understanding the context makes it easier to find the solutions needed to achieve success. A Socio-technical system model can be used to analyze the best way to apply measures to make them successful. The stability of established socio-technical configurations is the result of links between activities of social groups that reproduce them. People and organizations remember by doing. In different sectors of society people and organizations have similar practices and knowledge. This results in technical development courses as the community is seeking knowledge in the same direction. This creates stability when steering the innovative activities toward incremental improvements along predetermined tracks, i.e. socio-technical regimes. The actors of socio-technical regimes are acting in a larger context that the players in each socio-technical arrangement have difficulty influencing, i.e. the landscape. While the socio-technical regimes tend to generate incremental innovations, radical innovations are generated in technological niches. In these niches, the selection criteria differ a great deal from the selection criteria in the socio-technical arrangements where the technology in the future could have great potential. Because these niches are protected or isolated from the "normal" market selection, they act as incubators for radical innovations. Radical new technologies need such protection because it initially has a relatively low technical performance and is often difficult and costly. Niches are important because they constitute places of learning. Niches also provide space to build social support networks for innovation.

Digital technology in the water sector could be considered radical and is in a need of niche markets that acts as incubators. When it comes to sensing technology, one is dependent on the advantages of scale to have cost-effective sensors. One can therefore not only rely on niche markets to induce change. It is also important to work on changing the institutional factors in the socio-technical systems, such as policy, to facilitate the diffusion of innovation.

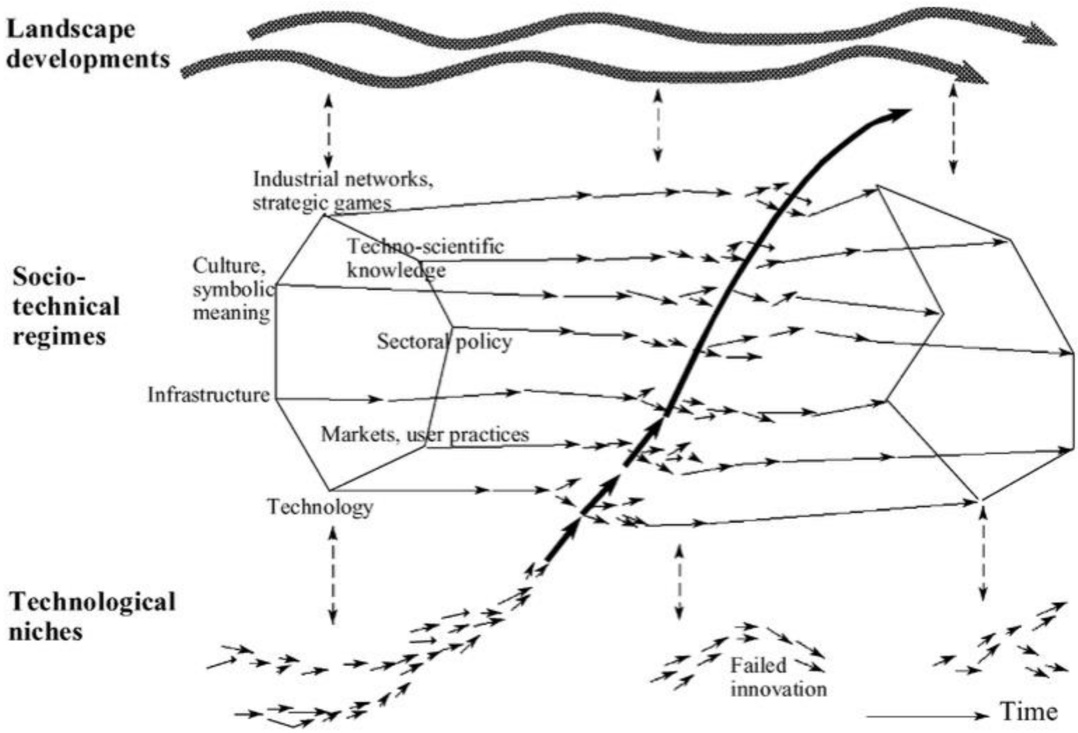

Figure 1. A socio-technical system (Geels, 2002)

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

2.2. INNOVATION DIFFUSION

According to Rogers (2003), four elements control the diffusion of an innovation:

1. the innovation: its relative advantages, compatibility, friability and observability
2. channels of communication: the mass media are the most effective way of disseminating information about an innovation, personal contacts are more effective in influencing decision-making
3. time: an innovation is disseminated over time in accordance with the S-curve
4. the social system: greatly influences the process and creates the stability that enables some sort of prediction of how the different units in the system will react.

Since scaling up digital technology in the water sector is a major challenge, especially when it comes to sensing technology where one is dependent on advantages of scale to have cost-effective sensors, it is important to focus on policy measures that facilitate diffusion of innovation. From an innovation diffusion perspective (Rogers, 2003) one can divide the customers into:

1. innovators (pioneering customers)
2. early adopters (opinion leaders)
3. early and late majority
4. laggards.

First to take on an innovation are usually the pioneering customers, the so-called "innovators". These usually form a few percent of the total market. The pioneering customers are risk-inclined and knowledgeable customers who largely take autonomous decisions independent of outside views. They are often also enthusiasts who have a strong driving force, want to take risks and believe in the new technology. It may be a case of small operators or small units in large organizations. The pioneer customers can also be so-called "niche customers" who have special needs. Meaning that they are willing to pay more for the product, impose requirements on quality different from in the main market and/or take risks in order to gain access to the new technology. The next group to take up an innovation is usually the opinion leaders. This customer group is typically 10-15 percent of the customers. Opinion leaders are often knowledgeable customers who are slightly less risk-inclined. They want to avoid taking unnecessary risks that could damage their position as opinion leaders. After these two groups of customers are customers who may be called the "early and late majority", who mainly make decisions based on peers. The last customer group can be categorized as "laggards" who may even actively oppose being receptive to innovation. In order to stimulate innovations in the early stages, it is important to establish contact between the innovative companies and pioneering customers. This is particularly important when the innovation is more radical and deviates from normal patterns and standards. If rapid dissemination of an innovation is required the opinion leaders should be targeted. The innovation has to be slightly more mature and not too radical, should you target opinion-leading customers.

Policy is often aimed at gaining rapid dissemination of innovation and is therefore targeted towards opinion-leading customers. It is usually the large mature companies that benefit from this, with products that have more or less been finished in their research departments. It is usually possible to establish such a product in the market within a few years. The advantage of this type of policy focus is that a relatively rapid change in the market can take place when other customers quickly follow the opinion leaders.

Working toward opinion-leading customers results in good business development in many cases, but usually not for small companies with radical innovations in the early stages. In order to encourage the smaller companies, there is often a need for a different type of policy approach. In many cases, a small innovative company cannot scale up fast enough to deliver the product volumes that a major market requires. If the product is also under development, the company may need the customer to guarantee to purchase a so-called "limited series production" or demonstration system.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

A limited series is the first series of a new product or system. For customers to have the courage to invest in the production of a limited series often requires substantial support to the customer since it can be risky. The new technology may pose risks that have not been detectable in the evaluation of the tenders - parts can break or the entire new product may need to be replaced. Support for limited series production can also be seen as a premium for the first installations and support for testing the new technology. In order to create good examples of the new technology, investments in demonstration systems are essential, as are other types of pilot projects. Demonstration systems fill an important function to generate credibility with customers. To be genuinely effective, demonstration systems should be developed together with the customer and displayed in a realistic context.

Working with small companies in the early stages usually yields no quantitatively significant results in the question of changed product offerings on the market in the short term. The changes will more likely be seen over 10 to 20 years. In order to constantly push forward the best technology, however, it is important to work with this group of companies.

It can be an idea, in parallel with working with a policy that is targeting opinion-leading customers, to also target special programs to pioneer customers, for example Pre-Commercial Procurement (PCP).

Niche markets are very important for innovations in the early stages, especially in times of technological shifts where radical innovations need to be stimulated. The stability of established socio-technical configurations is the result of links between activities of social groups that reproduce them (Geels, 2002). Often, new technology is more expensive at the beginning of the development process. As the suppliers gradually learn the new technology, they can drive down the costs. The new technology often follows a so-called learning curve in which production price decreases with increased cumulative production volume. Usually, the reduction of costs is significant during the first few years of market introduction. The quality of the product also follows a similar curve and often increases in pace with the time the product has been on the market.

In many cases, it is possible to identify a main market with a great potential for rapid dissemination of the innovation, provided the price and quality are right. Something that often hinders the rapid dissemination is that the price, and sometimes the quality, is not adapted for a large market in the beginning. It is in this situation that niche markets are important for innovation dissemination. In niche markets, customers often have special needs and this means that they are willing to pay more for the product, impose requirements on the quality different from in the main market and/or take risks in order to gain access to new technology. The new technology may grow at a moderate rate in the niche market until it is mature enough for the main market.

3. ANALYSIS

Both the current EU policy instruments in the field of water management and the institutional factors in the socio-technical system that is managing wastewater and flooding events are analyzed. When it comes to the institutional factors the following have been analyzed: technological limitations, user practices and application domains, the symbolic meaning of technology, infrastructure, policy, industry structures and techno-scientific knowledge. The symbolic meaning of technology has not yet been analyzed. It will be further analyzed in the deepened policy brief (D8.5).

3.1. EU POLICY INSTRUMENTS IN THE FIELD OF WATER MANAGEMENT

Papakonstantinou et al. (2020) have mapped the EU policy instruments in the field of water management. The main EU regulatory document in the field is the Water Framework Directive. It constitutes the EU's unified approach to water regulation, and as such, it constitutes its basic legal document. The Water Framework Directive is a document that has remained already 20-years in effect and has been successful in setting up a governance framework for integrated water management for the more than 110,000 water bodies in the EU. Despite its age, a 2019 EU assessment (fitness check) of the EU water legislation (where the WFD holds the major role) established that "the Directive(s) are largely fit for purpose". This finding demonstrates the soundness of the policy options and the provisions of the WFD, that remain relevant after a substantial amount of time has elapsed.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

In addition to the Water Framework Directive, there are several relevant policy instruments. The applicable EU policy instruments in the field of Water Management are as follows:

- Council directive 91/271/EEC concerning urban waste-water treatment
- Council directive 91/414/EEC concerning the placing of plant protection products on the market
- Council directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources
- Council directive 96/61/EC concerning Integrated Pollution Prevention and Control (IPPC)
- Council directive 1999/31/EC of 26 April 1999 on the landfill of waste
- 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
- 2005/646/EC: Commission Decision of 17 August 2005 on the establishment of a register of sites to form the intercalibration network in accordance with Directive 2000/60/EC of the European Parliament and the Council
- Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration
- Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC
- Regulation (EC) No 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EEC
- Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (Text with EEA relevance)
- Communication from the Commission to the European Parliament and the Council – Addressing the challenge of water scarcity and droughts in the European Union {SEC(2007) 993} {SEC(2007) 996}/* COM/2007/0414 final */
- Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing
- Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council
- Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (Text with EEA relevance)
- Commission staff working document accompanying the White paper - Adapting to climate change towards a European framework for action Climate Change and Water, Coasts and Marine Issues{COM(2009) 147 final} {SEC(2009) 387} {SEC(2009) 388}/* SEC/2009/0386 final */
- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An EU Strategy on adaptation to climate change /* COM/2013/0216 final */
- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Next steps for a sustainable European future European action for sustainability - COM/2016/0739 final
- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - The European Green Deal COM/2019/640 final

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

The “The Digital Single Market for Water Services Action Plan” was published by the European Commission in 2018. The document has the objective of contributing to “the Connected Digital Single Market and the Resilient Energy Union objectives by promoting energy-efficient smart ICT technologies in the water sector”. Contributing to this objective, the Action Plan focuses on the following aspects:

- Transparent information exchange and free flow of non-personal data to ensure the data sharing between different services at the cross-domain and also establish data analytics layers to improve decision-making.
- Semantic Platforms to ensure interoperability and data integration between domains providing a context for the information.
- Open, secure and robust architectures providing Open Data interfaces and establishing Open Data Policies to promote and foster the co-generation of data-driven algorithms and knowledge sharing through reliable data sets that finally permit to advance in new decision-making strategies.
- Smart Water Solutions in order to obtain real-time data using different timeframes to improve the monitoring and control and sustain data analytics and decision-making in the water domain.
- Smart Water Awareness to ensure the involvement of all actors across water value chains towards ensuring the digital transformation in the water domain.

Papakonstantinou et al. (2020) conclude: while the robustness and relevance of the basic EU Water Legislation remain beyond doubt, little has been done until today, at least from a law-making point of view, to address the advent of new technologies in the water sector. Essentially, smart water technologies pose new challenges to EU water policy and regulation, that until today have been left unanswered in the relevant specialized legislation, and are therefore currently treated under the general EU regulatory framework of cybersecurity and personal data protection law.

3.2. THE SOCIO-TECHNICAL SYSTEM THAT IS MANAGING WASTEWATER AND FLOODING EVENTS

Sensing technology is essential to acquire data for digital services. It is therefore important to investigate the technological limitations of sensors when analyzing the institutional factors of the socio-technical system that is managing wastewater and flooding events. Large-scale, cost-effective and time-efficient sensing technologies for water quality and quantity monitoring are applied differently in distinct parts of the water sector. The online monitoring of BOD5, COD, TSS, TOC, coliform, N, P and other substances (e.g. pollutants of emerging concern) is fairly widely used in wastewater treatment plants. There are, however, large differences as to how widely-used online monitoring is in different countries and wastewater treatment plants of varying sizes. According to a recent study by IVL (Andersson et al., 2020), the instruments are increasing in presence at wastewater treatment plants and they constitute an important basis for both monitoring and process control. For wastewater treatment plants, commercial sensors are available and there exists the potential to further test systems based on these sensors in new applications. Nevertheless, other parts of the water sector, such as drinking water, the monitoring of surface and groundwater, small-scale treatment plants for dwellings and wastewater systems are still proving slow on the uptake and still rely to a great extent on monitoring by laboratory tests and manual samplings of BOD5, COD, TSS, TOC, coliform, N, P and other substances or even no monitoring at all. However, the market for smart meters continues to be the largest and fastest-growing segment of smart water networks followed closely by leakage management solutions (GWI, 2017). As such, smart meter rollout is expected to dominate the market in the coming years, thanks to the relatively low cost of equipment and the ease of implementation.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

Remote sensing is another technology that is important for the socio-technical system that is managing wastewater and flooding events. Global inland and coastal water monitoring through satellites, as for example addressed by the MONOCLE and PrimeWater projects (Elelman et al., 2021), is now sufficiently mature to deliver key information on biogeochemical cycling which includes the capability to monitor ecosystem response to changing nutrient loads with respect to a 10-15 year baseline. Other remote sensing technologies such as drones for online monitoring of water stress and irrigation needs are under rapid development, as developed by the project WADI70 (Elelman et al., 2021). There is a potential to combine data from remote sensing technologies with onsite sensors to achieve more accurate and cost-efficient monitoring. This is to date an immature field that requires cross-sectoral cooperation.

That a technology is not cost-effective and time-effective is a common technological limitation. Infrastructure could also be a limiting institutional factor. The experience of the INNOQUA project (Elelman et al., 2021) shows that wastewater systems (sewage, stormwater and combined sewage and stormwater) 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 has to be robust enough to require little maintenance, otherwise, a system of many sensors soon becomes costly in maintenance in the wastewater infrastructure, which often covers large geographical areas. Analysis in the SCOREwater project shows that a sensor that has no contact with the water is preferred as biological growth on sensors in water requires regular cleaning increasing costs. Many ongoing research projects are investigating cost-effective and time-efficient sensing technologies for water quality and quantity monitoring. Examples include the projects SCOREwater (real-time contactless turbidity and water level monitoring), DWC (real-time bacterial monitoring) and PrimeWater (advanced Earth-Observation data products integrated with additional data sources and diagnostic modeling tools) (Elelman et al., 2021). Early estimates in the SCOREwater project, made by IVL based on information from Kretslopp vatten (the water utility in Gothenburg responsible for the wastewater network), regarding the case study of Gothenburg suggests that the investment costs of a monitoring system based on sensors for predictive maintenance of wastewater systems in the city could be in the magnitude of one-tenth of the annual maintenance costs. Today, the need for maintenance in wastewater systems is usually identified by manual inspection. This is very costly. If the sensors could have a multiple years maintenance-free lifetime, to ensure that the operational costs do not become excessive, the relatively low CAPEX of the system compared to the relatively high OPEX of maintenance suggests that just a few percent lower OPEX due to more efficient maintenance can make the system profitable. Furthermore, failure to identify clogging and sedimentation on time can lead to odor, overflow and make the impact of flooding events more severe, leading to damage to properties and businesses.

The major challenge is not that the technology *with the potential* to be cost-effective and time-efficient does not exist (with the exception of microbiological pollutants, where there are technical challenges to accurately detect microbes in cost-efficient ways). The real challenge is to scale up such methodologies and ensure that they prove truly cost-effective and time-efficient.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

When it comes to policy as an institutional factor within EU, the online monitoring of pollutants is not a legal requirement for discharge of stormwater and water that overflows from combined sewage systems. Today the Water Framework Directive regulates the monitoring of the status of the recipient while the Council directive 91/271/EEC concerning urban wastewater treatment regulates the monitoring of the discharges from the wastewater treatment plants. These directives are implemented into the laws of each member country. There exists, therefore, little motivation for utilities and other actors to invest in sensing technologies for water quality monitoring in the wastewater network outside the wastewater treatment plants. This challenge has been identified in SCOREwater when addressing the market of environmental monitoring of construction sites. Market analysis shows that the United States, where stricter regulations for monitoring pollutants of stormwater are in place, has a more thriving market and several growth companies commercializing sensing technologies. In the United States the stormwater and water that overflows from combined sewage systems are regulated via the Clean Water Act (CWA). The CWA's National Pollutant Discharge Elimination Sytem (NPDES) Program regulates point sources that discharge pollutants into the waters of the United States. Compliance monitoring under the NPDES Program encompasses a range of techniques, from Discharge Monitoring Report reviews, to on-site compliance evaluation as well as providing assistance to enhance compliance with NPDES permits. To answer if the regulations of the United States could be implemented in the EU would require an extensive analysis by legal experts that are familiar with both the legal systems.

There are market-ready or near market-ready sensing technologies for turbidity, pH and conductivity. To make sensing technologies cost-effective, the sensors have to be produced on a large scale. To analyze if scaling up is possible in the socio-technical system that is managing wastewater and flooding events one needs to look at industry structures as well as user practices and application domains. The water sector is economically relatively small and, therefore, it is difficult to create a market based exclusively on this sector. Furthermore, the water market is fragmented (GWI, 2017). 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 (GWI, 2017). A multitude of companies are specializing in niche applications: equipment manufacturers modifying physical equipment (e.g. pumps) for integration with the smart network; technology companies creating sensors; communications companies transmitting collected data; and data management and analytics firms providing analysis. Such divisions, coupled with a risk-averse culture, make adopting digital solutions an onerous task for many utilities and industry-wide standardization difficult to achieve.

Techno-scientific knowledge in a socio-technical system is an important institutional factor that needs to be considered. Water utilities, especially drinking water utilities (RISE, 2017), many times lack advanced data management skills (GWI, 2017): large-scale sensing technologies are built on 'big data', but the collection of relevant parameters is only part of the equation. Management and analysis of this data leading to meaningful insight are essential to make the sensing useful.

4. RECOMMENDATIONS

To meet the major challenges described in chapter 3, the following policy related actions are recommended:

Recommendation 1:

Set legal requirements on online monitoring of pollutants from stormwater and combined sewage and stormwater systems. Start with some key parameters such as turbidity, pH and conductivity (technically viable and today on the market). Without such requirements, there will be little motivation for utilities and other actors to invest in sensor technologies for water quality monitoring. One interesting area to start with, to create a niche market, could be the environmental monitoring of stormwater from larger construction sites such as infrastructure projects, since monitoring requirements regarding these projects already exist. Online monitoring with low-cost sensing technologies could also lead to the possibility of being obliged to monitor smaller construction sites, which discharge their rain runoff or wastewaters from construction sites into the urban wastewater networks. Currently, these may have only to produce qualitative environmental reports without measurements since laboratory testing is too costly. This would improve urban wastewater network management and the overall water quality of receiving water bodies, in particular, those located in urban areas.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

Recommendation 2:

Stimulate the creation of a volume market for sensing technologies. Policy action needs to focus on this because the upscaling of 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 where the greatest demand could be expected and where the motivation is strongest, for example concerning the optimization of OPEX/CAPEX. Predictive maintenance of wastewater systems (sewage, stormwater and combined sewage and stormwater water) is such an area.

As an example, one policy instrument that has successfully addressed upscaling in fragmented markets in other sectors is Pre-Commercial Procurement (PCP). PCP challenges the industry from the demand side to develop innovative solutions for public sector needs and it provides a first customer reference that enables companies to create competitive advantages in the market. PCP enables public procurers to compare alternative potential solution approaches and filter the best possible solutions that the market can deliver to address the public need.

Recommendation 3:

To further support a volume market, establish guidelines to employ sensoring systems for predictive maintenance and flood control of wastewater systems (sewage, stormwater and combined sewage and stormwater) and start to work with standardization when the market has become more mature.

Recommendation 4:

Create competence development programs on advanced data management for the water sector. This should be directed at both technical staff and management at utilities, urban administration level as well as at data experts in order to raise awareness regarding digital solutions and to attract them to the water sector. Both technical data skills and the management and analysis of data need to be focused on. It is essential that competence development in advanced data management is directed towards drinking water utilities, where data management is far less developed than in wastewater treatment plants, which are more accustomed to handling data from many sensors and instruments in real-time.

5. DISCUSSION

The research undertaken has provided a series of recommendations based on careful investigation and a broad, open exchange of knowledge. There are no simple conclusions. It is extremely important not to underestimate the negative effect that sectoral fragmentation coupled with an aversion to what is perceived as high capital expenditure has had on the incorporation into existing operational systems of much that has been discussed in this paper. The water sector often does not understand the benefits of operational transparency nor the need for enhanced control. Although this is true of many sectors of human activity, water is an issue of such fundamental social, economic, and environmental importance that it demands a rapid and efficient series of solutions. Applications to monitor pollutants from stormwater and combined sewage systems online will not be overcome unless required to do so by law. In the same way, given that the water market is not one of the commercially most attractive due to its small size, a policy is required to ensure that a fragmented market is upscaled.

Many studies are still required, as is the need to further the work of the partnerships whose results have been presented in this paper. This is a preliminary policy brief. It will be further developed in a deepened policy brief (D8.5, in April 2023). Analysis of the wastewater sector according to the socio-technical system theory will be further developed. The interaction between policy and other institutional factors (technological limitations, user practices and application domains, symbolic meaning of technology, infrastructure, industry structures and techno-scientific knowledge) will be further elaborated on. The interaction between the EU-policy level and the national level will be analyzed in greater depth. Also, the tool PCP and its use in the water sector as a means to scale up digital services will be investigated further.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

6. REFERENCES

Andersson, S. L., Åmand, L., Samuelsson, O. and Nilsson, S., 2020. Instrumentera rätt på avlopsreningsverk. IVL Swedish Environmental Institute, Stockholm.

Elelman,R., Wencki, K., Chen, A. S., Englund, A. and Anzaldua, G., 2021. The Need for Digital Water in a Green Europe: EU H2020 projects' contribution to the implementation and strengthening of EU environmental policy. European Commission.

Geels, F. W., 2002. Technological transitions as evolutionary reconfiguration process: a multi-level perspective and a case study, Research Policy, 31, 1257–1274.

GWI, 2017. Global Water Market 2017. Media Analytics Ltd, Oxford

Papakonstantinou, E., Markopoulouy, D. Brekine, A. and Corchero Rodriguez, A., 2020. A holistic water ecosystem for digitization of urban water sector. Project NAIADES. CERTH, Thessaloniki.

RISE, 2017. UDI – SENSATION III - Slutrapportering Steg 3 Följdinvestering. RISE, Göteborg.

Rogers, E.M., 2003. Diffusion of Innovations (5th ed.). The Free Press, New York.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

ANNEX 1– STOCKTAKING

A final Annex of stocktaking was included in all Deliverables of SCOREwater produced after the first half-year of the project. It provides an easy follow-up of how the work leading up to the Deliverable has addressed and contributed to four important project aspects:

1. Strategic Objectives
2. Project KPI
3. Ethical aspects
4. Risk management

STRATEGIC OBJECTIVES

Table 1 lists those strategic objectives of SCOREwater that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable.

Table 1. Stocktaking on Deliverable's contribution to reaching the SCOREwater strategic objectives.

Project goal	Contribution by this Deliverable
SO2. Harmonize and improve interoperability opportunities in the water sector	Recommendation of policy on harmonizing competence.
SO3. Enable the monetization of water cycle data	Recommendation of policy on scale-up
SO5. Identify and mitigate key barriers to implementation of smart, resilient water management	Identifying policy barriers.

PROJECT KPI

Table 2 lists the project KPI that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable.

Table 2. Stocktaking on Deliverable's contribution to SCOREwater project KPI's.

Project KPI	Contribution by this deliverable
13. Organizational barriers and enablers identified and mitigation options demonstrated	2 Organizational barriers and enablers were identified and mitigation options demonstrated
14. Legal barriers identified and mitigation options demonstrated	2 Legal barriers were identified and mitigation options demonstrated

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

ETHICAL ASPECTS

Table 3 lists the project's Ethical aspects and gives a brief explanation on the specific treatment in the work leading up to this Deliverable. Ethical aspects are not relevant for all Deliverables. Table 3 indicates "N/A" for aspects that are irrelevant for this Deliverable.

Table 3. Stocktaking on Deliverable's treatment of Ethical aspects.

Ethical aspect	Treatment in the work on this Deliverable
Justification of ethics data used in project	N/A
Procedures and criteria for identifying research participants	N/A
Informed consent procedures	N/A
Informed consent procedure in case of legal guardians	N/A
Filing of ethics committee's opinions/approval	N/A
Technical and organizational measures taken to safeguard data subjects' rights and freedoms	N/A
Implemented security measures to prevent unauthorized access to ethics data	N/A
Describe anonymization techniques	N/A
Interaction with the SCOREwater Ethics Advisor	N/A

RISK MANAGEMENT

Table 4 lists the risks, from the project's risk log, that have been identified as relevant for the work on this Deliverable and gives a brief explanation on the specific treatment in the work leading up to this Deliverable.

Table 4. Stocktaking on Deliverable's treatment of Risks.

Associated risk	Treatment in the work on this Deliverable
14. There is less interest than anticipated in the uptake of the SCOREwater services	By making policy recommendations the risk that there is less interest than anticipated in the uptake of the SCOREwater services is mitigated.
17. Market demand for the project outcomes is lower than expected and/or take longer than expected to grow.	By making policy recommendations the risk that market demand for the project outcomes is lower than expected and/or take longer than expected to grow is mitigated.

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751

This project hase recieved funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 820751