SCOREwater

Smart City Observatories implement REsilient Water Management

DELIVERABLE D5.1

A FRAMEWORK FOR SPECIFYING HOW TO DEVELOP USER'S NEEDS AND REQUIREMENTS IN AN ITERATIVE PROCESS

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Author(s)	Sanne J., Perjo L., Englund A., Nielsen T., Domene, E., Hwargård, L.
Reviewed by	Corominas L., Rubion Soler E., Lindgren S.
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ABBREVIATIONS

Abbreviation	Definition
CCT	Cancer Clinical Trial
COD	Chemical Oxygen Demand
CKAN	Comprehensive Knowledge Archive Network
Dx.x	Deliverable x.x
DOC	Dissolved Organic Carbon
EUD	End-User Development
FIWARE	Future Internet ware
GA	Grant Agreement
GDP	Gross National Product
H2020	Horizon 2020
ICT	Information and Communication Technology
NCD	Non-Communicable Diseases
OECD	Organisation for Economic Co-operation and Development
PDS	Product Design Specification
SCIM	Chemical Information Mining
SDG	Sustainability Development Goals
SES	Socioeconomic Status
SIM	Sewage Information Mining
SME	Small and Medium Sized Enterprise
SRL	Societal Readiness Level
STS	Science and Technology Studies
UCD	User-Centered Design
UCI	User-Centric Innovation
WHO	World Health Organization

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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.

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SUMMARY

The aim of D5.1 is to provide a framework for the process to specify stakeholders' needs and requirements in WP4 and the collection and analysis of data from the demonstration cases, with regard to organizational and social enablers for development, implementation, use and successive evaluation of SCOREwater technologies and services (WP5 and further to WP6 and WP8).

A framework contains the salient experiences, approaches, theories and perspectives in a field from which prescriptive models and other tools can be built. This deliverable provides more knowledge on four areas with high relevance for the project: a) behavioural, organizational and legal/regulatory barriers/enablers; b) iterative user-expert development processes and relevant standards for end-user development; c) methods and state of the art for sewage sociology; and d) implementation and evaluation research. Together, these focus areas provide a background of principles that guide the implementation of the demonstration cases, in particular in terms of stakeholder engagement and adapting to user needs in WP4 and for an effective implementation of the ICT tools and for their evaluation. In later phases in the project the receiving work packages needs to pick those tools that suits them, based on the analysis for each case study in WP1 and WP4 (and as part of WP6) and adapt them to achieve overall project goals as well as local goals.

The framework is based upon a literature review of state-of-the-art knowledge and best practices, as well as consultation with partners regarding scope and presentation. The review highlights important issues to address and provide approaches to that.

The literature review highlights that water is often managed through a network of public and private actors at different levels, with different perspectives and goals, and different strategies and instruments. There is a need to involve both the users of innovative ICT solutions as well as a broad spectrum of other stakeholders (e.g. municipal and state officials and policy makers) in technology development processes. Different involvement methods need to be chosen based on type of user or stakeholder addressed, but also based on the goals of the involvement action, or the type of knowledge the activity should bring to the process. The literature review provides knowledge on key principles to keep in mind when engaging stakeholders.

Tools and approaches from sewage sociology will be used to design the demonstration case in Barcelona. Sewage sociology refers to the scientific use of biomarkers in waste and waste-water to measure health and environmental characteristics together with known demographic data. The overview in this report shows how sewage sociology is a powerful tool through which urban planning and health authorities should work together to improve citizen's quality of life.

The review also discussed the issues related to implementation and evaluation of the SCOREwater technologies and services. The strategies and approaches for implementation and evaluation needs to be designed beforehand, in collaboration with developers and stakeholders. Implementation of SCOREwater technologies and services in the demonstration cases needs to be both adapted to local context and be able to provide generalizable conclusions for further dissemination and exploitation. It needs to be based upon an analysis of change mechanisms, locally for each case and generic for the water sector. Likewise, the strategy for evaluating the ICT tools needs to be designed beforehand and be integrated into the implementation efforts.

The framework provides more specific advice, based upon the review on various good practices for identifying stakeholders, user groups, their needs and requirements, for an iterative development, implementation, use and successive evaluation of the SCOREwater tools. The framework is supported by a list of resources to be used when designing strategies, to be found in the annexes.

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PART 1: INTRODUCTION

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1. INTRODUCTION

This report constitutes the deliverable 5.1 in the SCOREwater project, as the outcome of task 5.1. This chapter provides the motivation and objectives for the deliverable, and its context in the project. The motivation stems from previous H2020 projects and other experiences with ICT development in areas related to SCOREwater.

A framework contains the salient experiences, approaches, theories and perspectives in a field from which prescriptive models and other tools can be built. Through a literature review this deliverable provides more knowledge on four areas that project partners need in order to carry out the project: a) behavioural, organizational and legal/regulatory barriers/enablers; b) iterative user-expert development processes and relevant standards for end-user development; c) methods and state of the art for sewage sociology; and d) implementation and evaluation research.

Together, these focus areas provide a background of principles that guide the implementation of the demonstration cases, in particular in terms of stakeholder engagement and adapting to user needs in WP4 and for an effective implementation of the ICT tools as well as for their evaluation. The framework aims to provide the toolbox for the design of models to guide further work in WP4 and WP5. The design of these toolboxes needs to be done by those closest to the cases, in collaboration between users and developers. They need to deliberately choose and adapt the tools to their purposes and context.

1.1. MOTIVATION AND AMBITION

One of the distinguishing features of SCOREwater is the explicit recognition that technology and data by itself does not accomplish project goals towards an innovative and effective water governance, achieving policy goals and creating a market for data driven services. Research in the field of Science and Technology Studies (STS) on the co-creation of technology and social structure, organizational processes, professional identities, practices and knowledge, clearly demonstrates that social change in complex systems is not simply accomplished through the replacement of one technology by another (see e.g. Felt et al. 2017).

When developing new technologies in complex systems, it is necessary to understand the relationship between the different actors in the system (OECD 2015). Although data collection through ICT solution can enable better water management, connecting people and infrastructure to sensors and digital services does not in itself provide the requested change. Measuring incredibly complex phenomena with great precision is not enough by itself to improve our ability to predict, anticipate, or modify even obviously destructive human behavior (Stimmel 2016: 20-21). The acquisition of data is not the sole determinant in human decision-making. A wide set of factors play in, including institutional rules, political choices, environmental influences, socio-cultural attitudes, community drivers, and our most individual of behavioral characteristics (OECD 2015). Moreover, it is well known that poor adaption of technologies to existing practices and to users' needs create resistance to use, ineffective work practices, delayed implementation and cost over-runs.

There is a need to create a framework for a business case, addressing barriers and enablers to an effective ICT development, learning from experience. A recent H2020 project (Smart Resilience) addressing identification, visualization and evaluation of resilience in critical infrastructures found that the successful adoption of new technical services by stakeholders requires a proven business case; it must be clear that the new tools provide opportunities to quantify improvements in resilience and track changes over time. Moreover, having an iterative development process where developers and stakeholders meet recurrently over time is crucial to create useful tools that can be adapted to the needs of different users. The Smart Resilience project also shows that for high efficiency, new tools need to complement and be integrated with existing tools, aiming towards reaching existing goals more efficiently.

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Therefore, to create the business case for the SCOREwater tools, four principles will be followed. First, an iterative and collaborative development of the tools that stakeholders will use. Second, that the tools will enable demonstration of benefits for smart water management, adding to their existing abilities to reach existing and foreseen needs and being able to integrate with existing tools and organizational processes. Third, that best practices for developing, implementing and using the tools will be identified as well as how to implement, transfer and upscale these beyond the demonstration cases.

In SCOREwater, technology needs to be developed, tested and proved together with users, and in networks consisting of users and stakeholders such as municipal officers, companies and NGOs. This deliverable provides a framework for identifying salient barriers and enablers and how to address these, based upon best practices identified through previous research. Please note that best practices are to be understood in plural. Any user of the framework needs to carefully choose what suits their situation and purpose.

1.2. OBJECTIVES AND OUTPUT

The objectives for D5.1 were defined in the GA as below:

The deliverable provides a framework for the process to specify stakeholders' needs and requirements in WP4 and the collection and analysis of data from the demonstration cases, with regard to organizational and social enablers for development and use of SCOREwater technologies.

More specifically, it will contribute to the following tasks in WP5:

- D5.2 needs to design and evaluate a business case for the development and use of resilience tools. Thus, it needs to analyse the local needs and requirements, the barriers and enablers to an effective use of these tools as well as how to generalize the conclusions beyond the case study.
- D5.3 will generalize the conclusions from phases 2-4 of the demonstration cases. Thus, it will need to design a framework for evaluation, dissemination and exploitation for these intermediate phases, to support further development of the SCOREwater tools. The framework will need to be designed so that D5.3 can provide relevant knowledge for WP6, WP7 and WP8 (innovation management).
- D5.4 will generalize the conclusions from phases 5-7 of the demonstration cases. Thus, it will need to design a framework for evaluation, dissemination and exploitation beyond the case studies. The framework will need to be designed so that D5.4 provide relevant knowledge for WP6, WP7 and WP8 (innovation management).

Table 1 below summarizes the objectives and the corresponding output, as expressed in the work plan and through the risk mitigation measures in the GA.

Table 1. Summarizing the objectives for D5.1 and its corresponding output.

Objectives in GA	Work plan	Risk mitigation	Output to
The process of specifying stakeholders' needs and requirements in WP4	Ensure that demonstrations are based on users' needs and requirements and respond to those	Providing best practices to design for appropriate means to *develop, test…* the ICT solutions Providing a framework to evaluate the ICT solutions through an appropriate design of the case studies	WP4, D5.2

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The collection and analysis of data (related to organizational and social enablers) from the demonstration cases	Enable analyses of social and organizational enablers in demonstration cases	Providing best practices to design for appropriate means to… *transfer and disseminate* the ICT solutions Providing a framework to design cases as to collect the necessary data *to reach generic conclusions*	D5.3 and D5.4

SCOPE AND OVERVIEW OF THE DELIVERABLE

This deliverable focuses on the following areas:

1.3.

a) *Behavioural, organizational and legal/regulatory barriers/enablers.* This area concerns how stakeholder organizations, within and beyond the project partners can be involved in ICT development in water sector, and its use, dissemination and transfer. This area is specifically relevant for WP4, with relevance for the development process in WP1 as well as providing a framework for generalizing experiences from dissemination, exploitation and innovation management in later stages, through D5.3 (phases 2-3) and D5.4 (phase 4-7). See chapter 2 and 3.

b) *Iterative user-expert development processes and relevant standards for end-user development*. The area regards how individual users or groups of users can be involved in ICT development to ensure that the developed ICT solutions respond to the users' needs with regards to ICT tools. This issue is specifically relevant for WP4, providing a framework for the development process in WP1 through the whole project. See chapter 3.

c) *Methods and state of the art for sewage sociology*. This area provides motivation and background for carrying out and evaluating the Barcelona case study, in addition to the areas above. See chapter 4.

d) *Implementation and evaluation research.* This area addresses the barriers and enablers for how to implement and evaluate the ICT tools developed within the project, through D5.3 (phases 2-3). The area will also contribute to the framework for generalizing experiences from dissemination, exploitation and innovation management in later stages, through D5.4 (phase 4-7). See chapters 5-6.

The report is divided into four parts. Part 2 provides a literature review, on barriers and enablers for ICT development and on stakeholder engagement in the water sector, sewage sociology as well as implementation and evaluation, identifying barriers and enablers that developers need to address to design an effective, iterative development process, to implement the ICT tools into an existing process as well as to support and integrate with existing processes and goals.

Part 3 provides the framework, based upon the literature review, structured according to the implications for further work in WP4 and WP5. The framework specifies how to address the challenges identified in the literature review and provides suggestions for good practices, linking to the resources listed in Part 4. To understand what tools in the framework that might be useful and why, one needs to read the literature review.

Part 4 contains a toolbox of approaches, solutions etc. that can be used when designing strategies for specifying user needs, implementing ICT tools and evaluating services provided by them.

Part 3 and 4 provides the support needed for further work in the project. The next step is for the receiving work packages to pick those tools that suits them, based on the analysis for each case study in WP1 and WP4 (and as part of WP6) and adapt them to overall project goals and local goals.

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METHODS: DATA AND ANALYSIS

The objectives and context with regard to other tasks in the projects, as expressed in the GA, are outlined in the work plan for the deliverable, designed by the team appointed to this and approved by the various partners involved. The deliverable has been carried out through desktop analysis (literature reviews) and through consultation with relevant partners.

IVL:

1.4.

- Leading and coordinating
- Setting goals and framework
- Desktop research & analyses
- Consulting other partners
- Editing and finalizing report

IERMB and BCASA:

- Review of methods and state of the art for sewage sociology

COA, BCASA, CGEA, EUT, CIV:

- Participate in consultation. Consultation through drafting the work plan in May-June 2019 (online and at the project kick-off on May 15-17, 2019), and over the draft report through skype consultation on September 23rd as well as through email communication.

The analysis of data has been governed by the ambitions, objectives and scope set out in the GA and operationalized through the work plan.

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PART 2: LITERATURE REVIEW

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2. BARRIERS AND ENABLERS TO INNOVATION IN URBAN WATER MANAGEMENT

2.1. INTRODUCTION

This chapter addresses the barriers to innovation with regard to stakeholder engagement that will be encountered during the development and testing in demonstration cases and the SCOREwater platform in all phases of the project. The chapter also identifies possible ways forward, that is enablers and how to use these. In the following chapter, more specific challenges related to user engagement will be addressed.

Social scientific research shows that governance, regulatory and behavioural issues, policies and other human and institutional and organisational aspects are equally, if not more, significant hinders to innovation in water management and urban water services than technological problems (see e.g. Cosgrove & Loucks, 2015; Kiparsky et al. 2013; Özerol, de Boer & Vinke-de Kruijf 2013). Organisational innovation studies show that to establish sustainable practices in water utility, changes are needed not only in technologies, structures and processes, but also in behaviour, culture, knowledge and skills (Tanner et al. 2018). In order to support water management innovation, research is needed e.g. on how actors interact to "generate, finance, diffuse and apply water innovations" and how those processes can be supported (Wehn & Montalvo, 2018).

The sections below review existing research on barriers and enablers to innovation in water management in terms of factors related to organisations, institutions and regulations, as well as governance and stakeholder engagement. We have also identified practical tools that can be used in engaging the broad group of stakeholders, see the framework part. Short descriptions of different approaches can be found in Annex 1 and 2.

Please note that the reviewed articles' definition of water sector and water management vary, and they cover a broad variety of different aspects of the water cycle. They provide a broad overview of different kinds of governance issues relevant to the sector as a whole, but not in all cases specifically to ICT in water. A general understanding of the challenges of innovation in the water sector is however needed in order to be able to address those challenges in the SCOREwater demonstration cases.

2.2. ORGANISATIONS, INSTITUTIONS AND REGULATIONS AS INNOVATION BARRIERS AND ENABLERS

Various organisational and institutional challenges and barriers to water innovation have been identified in the previous research that was reviewed for this deliverable. One challenge that is typical to the water sector is the difficulties in predicting the effects of new solutions from a system perspective (Marlow et al. 2013). New innovations may cause unexpected changes in the system and affect costs and performances (Marlow et al. 2013). The difficulty to predict system effects of innovations is identified as a barrier for water-related innovation.

Innovation procurement aims at accelerating market introduction of new technology. The underlying methodology engages different stakeholders on the market in order to develop new and required products and has been successful in satisfying customer needs, resulting in positive environmental effects as well as to stimulate business development. Innovation procurement is definitely a salient component of an innovation strategy for the SCOREwater project (see also Annex 1). However, to make innovation procurement effective towards such secondary goals, there is a need to overcome a number of governance challenges within the water sector, as analysed in the following paragraphs.

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There are practical challenges related to the management of innovative solutions (Marlow et al., 2013). These include increased management complexity, diffuse responsibilities, uncertainty and resistance to change. Institutional and personal bias are also identified as a barrier. When different kinds of actors (e.g. companies, public authorities, universities) develop a solution, they will develop a bias towards the particular solution. This may influence their judgment of the solution leading them to over-estimate its benefits and under-estimate its negative effects compared to other solutions. This is also an example of a behavioural factor that, together with over-estimating ones' own innovativeness as a manager (as illustrated by Kiparsky et al. 2016), may hinder the development and adaptation of most suitable solutions.

Risk aversion and fear of failure are some of the challenges to innovation in water and wastewater management that innovation researchers agree on (see e.g. Farrelly & Brown 2011; Gabrielsson et al. 2018; Kiparsky et al., 2016; Tanner et al., 2018; Wehn & Moltavo, 2018). Public authorities have a key role in water management, and the public sector is traditionally considered to be less inclined to innovation approaches and more likely to have a risk averse organisational culture (Farrelly & Brown, 2011; Kiparsky et al. 2016). The water sector is also considered conservative by nature (Farrelly & Brown 2011), risk aversion as such is seen as typical to the water sector (Wehn & Montalvo, 2018).

Existing research does not provide considerable advice on how to address the issues of risk aversion in relation to innovation in water and wastewater. It is however proposed that risks should be shared between the involved actors, and that more open and transparent working cultures that promote reflection are needed (Farrelly & Brown, 2011). Clarity in risk-sharing between actors can thereby be an enabler of innovation.

Organizational cultures have an import role in innovation Farrelly & Brown shows (2011). Their work studied employees involved in demonstration projects who emphasised the need for promoting good inter- and intra-organisational culture, leadership and commitment. Providing employees with time for reflection and learning were considered by the respondent as important factors for promoting innovation, together with open and transparent communication (Farrelly & Brown 2011). Approaching the experiment as a learning opportunity and labelling them as demonstration projects to create a safe space to experiment is another factor enabling innovative cultures (Farrelly & Brown 2011).

In addition to risk averse attitudes and cultures, limited skills in innovation management and engaging only in short-term planning often hinder adapting innovative solutions (Kiparsky et al. 2016). Kiparsky et al. (2016) studied wastewater managers in California to investigate managers' perceptions to innovation. According to their results, managers see value in innovation, but feel that they should do more to support innovation. The results show that many of the managers believe that they are more innovative than others. The authors note that if managers believe to be more innovative than they are, it can slow down the innovation pace in water and wastewater.

Case studies on wastewater technology adaption (Garrone et al. 2018) show that technological and organizational capabilities and managerial professionalism at firm level function as enablers for adaption of new technologies. At community-level, citizen activism as well as the existence of industries who are dependent on clean environment (e.g. tourism) are drivers to adaption of wastewater technology.

From a regulatory perspective, 75% of the responding water-sector companies in an EU-wide survey from 2017 answered that conflicting requirements of different regulation is a barrier for innovation. SMEs in particular considered sectoral regulations as hinders for innovation. Further, companies developing product or process innovation experienced more regulatory barriers than companies that work with marketing or organizational innovations in water, or companies that are not working with innovation (Peter et al. 2017). Regulations related to labelling and standardization, as well as environmental protection regulations were in turn identified as drivers for innovation by the majority of the respondents. A majority of the respondents considered competition law, procurement rules, product safety regulations and trade agreements as having a neutral effect for innovation (Peter et al. 2017).

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In the SCOREwater project, systemic effects, risk aversion, conservative organizational culture, the potential lack of innovation management skills as well as regulatory challenges within the various regional clusters will be studied and addressed. The barriers identified in this section shall be taken into consideration when the demonstration cases are planned and implemented in WP4, as well as when they are observed in order to draw lessons learned in WP5. It should be further noted that the reviewed studies mainly focus on innovation in technology that require heavy investments, and less on software where often smaller investments are required. Therefore, some of the mentioned challenges may be less pronounced in at least some of the SCOREwater demonstration cases.

2.3. GOVERNANCE AND STAKEHOLDER ENGAGEMENT AS ENABLERS FOR INNOVATION

This section discusses engaging the broad group of stakeholders (e.g. politicians, planners and experts) in a broader governance process context. Stakeholders are in here considered to be all actors that are needed in developing and applying a solution or idea. Different types of stakeholders have access to different kinds of resources that are needed, such as knowledge, competence, contacts or decision-making mandate. In that sense, they have a different level of influence on the possibility to implement the solution. Further, stakeholders are also influenced by the solution to different degrees.

The SCOREwater Grant Agreement defines the project's stakeholders in the following way:

> *SCOREwater has many stakeholders, both internal and external; Internal stakeholders are partners involved in the project: water management companies, municipalities, SMEs and research and innovation partner institutes, while external stakeholders are actors who contribute to the project, are affected by it or receive the project outcome in some way: municipalities, other governmental bodies, water management companies, water utilities, SMEs, Developers/ICT, other businesses, universities/academia and civil society/NGOs. Utilizing the SCOREwater platform will allow different stakeholders to improve their resilience, save costs, make money and become engaged in water-friendly behaviour using the newly available information.*

In research, the concept of water governance is used to describe the complex decision making and goal-definition processes by a range of different stakeholders in relation to water (Wehn et al. 2015). Water management in turn refers to the group of activities to reach the goals set in the water governance processes (Wehn et al. 2015).

In EU countries, water services are regulated at EU level by the Water Framework Directive, the Drinking Water Directive, the Urban Waste Water Treatment Directive and the Bathing Water Directive. These directives are in turn implemented in national legislations (EurEau 2019). EurEau (2019) has mapped the different models for management of water services in EU Member states. They span from direct public management to delegated public management and delegated private management to direct private management. Direct private management systems where all tasks, responsibilities and ownership belong to private operations is however unusual in Europe. EurEau notes that there is a trend where direct public management becomes less common and public and private delegated management becomes more common, although ownership of water infrastructure remains public (EurEau 2019).

The cross-cutting, systemic and infrastructural nature of water management influences the innovation potential and processes in the sector, as a variety of different types of stakeholders with varied interests and conflicting objectives need to be involved at different administrative levels (Wehn & Montalvo 2018; Garrone et al. 2018). The governance challenge is that water is often managed through a network of public and private actors at different levels, with different perspectives and goals, and different strategies and instruments (Özerol, de Boer & Vinke-de Kruijf 2013).

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The Water Framework Directive stipulates that Member States shall encourage active involvement of all interested parties in the implementation of the Directive. Research identifies some main challenges related to networks and stakeholder engagement in relation to water innovation. Grotenbreg & von Buuren (2018) emphasise the need for better coordination capacity among public sector actors who have key roles in water management. Coordination capacity is needed to be able to both coordinate between public actors, and between the various other stakeholders, but also to identify and eliminate possible barriers and working as "boundary spanners" between different actors (Grotenbreg & von Buuren 2018). Coordination capacity in public sector is thereby a key enabler of innovation related to water management.

Also, Gabrielsson et al. (2018) note that the complexity of the water sector calls for knowledge on how different actors can be organised in networks to enable innovation. Systemic approaches to innovation emphasise the need for policy-makers to support the creation of networks that include customers, suppliers, competitors and universities, instead of providing traditional subsidies to individual companies. Systemic approaches to innovation focus on the interplay of network actors as a source for innovation, instead of focusing on the innovativeness of a single company (Gabrielsson et al. 2018).

It is further identified as important to engage all critical stakeholders early and to ensure that there are "champions" and other dedicated individuals who can help to maintain the project momentum (Farrelly & Brown 2011). Water governance needs to take into consideration the complexity of water issues and works in interdisciplinary manner at the level of entire water systems, while also engaging the public (Özerol, de Boer & Vinke-de Kruijf 2013).

In addition to the public authorities' ability to coordinate and eliminate barriers, innovative actions are enabled by clearly and early defining the roles, goals and expectations on each partners' goals and capacities to act (Grotenbreg & von Buuren 2018; Farrelly & Brown 2011).

It is beneficial to capture roles and responsibilities in binding or non-binding agreements (Farrelly & Brown 2011). Case studies by Grotenbreg and von Buuren (2018) illustrate how public authorities may express ambitions and support to stakeholders without taking a leading role in the actual innovation process in a way that has been expected by the private companies who think the public authorities will take the lead, and therefore refrain from acting themselves (Grotenbreg & von Buuren 2018).

Establishing communities of innovation or communities of practice is a method used in EU project such as FP7 BRIDGE and H2020 BRIGAID. The community of practice method may be of interest for SCOREwater demonstrations, as it brings together a variety of actors to regularly discuss and learn from each other's expertise (see more in annex 1).

In the SCOREwater project, the complexity of the water sector, the public actors' abilities to coordinate and eliminate barriers to innovation and to engage stakeholders will all be investigated and addressed in WP4 where we implement demonstration case and draw lessons learned on barriers and enablers observed in them.

2.4. SUMMARY

- Innovation procurement is a useful tool to provide for purchasing tools that can have a beneficial impact on the abilities to manage the water cycle towards SCOREwater goals. However, to make effective use of the opportunities that this tool provides it needs to be complemented through an analysis of the governance challenges in the water sector and through good practices for managing innovation based upon knowledge of these challenges, as outlined below.
- Innovation in the water sector takes place through networks of private and public actors at different levels with different perspectives, sometimes conflicting goals, and access to different strategies and instruments. This makes careful involvement of various actors and stakeholders especially important when developing innovative solutions in this sector. In SCOREwater, this emphasizes the need to identify and involve all relevant network actors early. It is beneficial to see the network of actors a source for innovation, instead of focusing on one company, since various actors (e.g. customers, suppliers, policy-makers) are needed to enable an innovation.

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- The water sector is traditionally risk averse and conservative, and risk sharing between actors and transparent working cultures that promote reflection are needed. Open working cultures that see experimentation projects as spaces for learning enable innovative organizational cultures. The multidisciplinary teams in SCOREwater have good knowledge on the characteristics of the water sector, and the demonstration cases can be designed to contribute to innovative and open organizational cultures and behaviours.
- Behavioural aspects such as bias towards a certain solution or manager's overestimation of their own innovativeness may hinder the development and adaptation of the most suitable solutions. In SCOREwater, it is important to be aware of the possibility of behavioural aspects and biases influencing both the project teams and the stakeholders' actions, to ensure that right solutions are applied.
- Efforts need to be put on identifying stakeholders and ensuring that all stakeholders are aware of each other's roles, responsibilities and mandates. In SCOREwater demonstrations, it is important to clarify these issues early and make sure that all participants have shared understandings of these topics.
- It is important to involve stakeholders with different types of knowledge, competence and mandate. This includes among others different types of expert competences (both technical and social), and often also local knowledge of the inhabitants. It is also important to be transparent about the level of influence the different stakeholders can expect to have on the process and its result. In SCOREwater, we need to ensure the involvement of important actors with both technical and social competences, both in stakeholder organisations and within the project partner organisations (e.g. practical operating technicians in the field).
- The process of involving stakeholders is iterative and should be flexible in order to adapt to changes as new issues to address appear. In SCOREwater, an open and aware attitude and flexibility is required to adapt to possible changes.

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3. HOW CAN USERS BE INVOLVED IN DEVELOPING ICT SOLUTIONS FOR SMART CITIES?

INTRODUCTION

SCOREwater is designed to involve users from project partners in the development, testing and evaluation of the ICT tools to be used in the project, in an iterative process. The sections below present some of the key characteristics of involving users in ICT development processes in smart cities. First, we present the business case for involving users in ICT development in order to prevent "user resistance".

3.1. Second, we review the various concepts used in the field of user involvement in ICT. The aim is to identify their key dimensions and their benefits in order to support the SCOREwater demonstration design processes. Third, we discuss the concept of iterative development that is central to user involvement and emphasizes the need to involve users early and throughout the process. The final part of the chapter summarizes the important issues for SCOREwater.

USER RESISTANCE TO ICT TOOLS

If users are not sufficiently part of the development, the increasing use of ICT can lead to user resistance.

3.2. Smart technology can be welcomed as an enabler of a better society or resisted as a form of 'social engineering' (Stimmel 2016). When considering the urban arena, there is a race amongst the large cities to collect more and more data in order to map different flows and processes in cities. Often technical aspects and data are prioritized over social dimensions, and, thus, more emphasis should be on how the deployment of (new monitoring) technologies affects people's lives.

Mani and Chouk (2016) find the following factors affect consumer resistance to 'smart' products: perceived uselessness; perceived price; intrusiveness; perceived novelty; self-efficacy and; privacy concerns. Many of these factors are an effect of an inadequate business case, based upon incomplete knowledge of user needs, practices and requirements.

Particularly, the issue of privacy has become an important issue, which recent (privacy) cases against tech-giants, such as Google, Facebook, and Twitter demonstrate. As we move further toward a society that is deeply reliant on data-driven systems for its core functions, academics, researchers, industry, and privacy advocates must find agreement about the principles of data privacy and security. "We are shockingly late in addressing the topic of privacy, given the accelerating pace of sensor-based technology deployment." (Stimmel 2016: 8).

Acceptance of technology might also differ on an individual versus community level, here it is important to modify the ICT to different groups (e.g. people with disabilities) or to engage people on an individual level through technology training and peer support (Pang and Schauder 2007).

User resistance is in fact a rational behavior, from the user's perspective. In order to prevent it, there is a need to develop technologies that are perceived useful, have an adequate price etc., given the users current or foreseen needs. To achieve that, there is a need to make a business case for the ICT products

3.3. in the context of their intended use. In the SCOREwater project, we consider this is best done through iterative user-involvement in development and testing. But what dimensions are important to include in an approach to user involvement and what are their respective benefits to the development process?

APPROACHES TO USER INVOLVEMENT

If "user resistance" is a rational behavior, SCOREwater needs to look for useful concepts for how to manage this challenge. This section presents approaches that need to inform the development process in SCOREwater: units of analysis, dimensions to include and drivers to user involvement, providing salient building blocks in the business case for the project.

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Transforming user customer expectations and needs into requirements is a challenging task for many developers. A common approach is Product Design Specification (PDS) (see more details in annex 2). The main concern of requirement acquisition is how to collect reasonable and complete customer requirements and accurately express them. However, from a developer standpoint, different levels of customer statements are not structured with sound logic. In SCOREwater, in order to use such an approach, there is a need to complement it with other approaches, as presented in this section.

Given the state of inter-connectedness of the world today, and the growing number of ICT applications available across all walks of life and on a multitude of devices, it is surprising that relatively few designers incorporate the user in the design process (Kyakulumbye et al., 2018). ICT development projects have historically been driven along the three axes of technological innovation, development programs, or new market creation (Brand and Schwittay 2006). However, a growing number of articles argue that these drivers have to be complemented by a focus on the people served by ICT, and their needs (ibid).

Leminen and Westerlund (2017) empirically studied the innovation processes in living labs. They conclude that using standardized tools lead to predefined incremental innovation outcomes, and that predefined linear innovation processes decreases the complexity of the innovation actions and thereby also lead to more incremental innovation as well. Their conclusion is that iterative and non-linear processes that utilize customized tools are more likely to lead to undefined and novel innovations.

Concepts such as user-centered design (UCD), end-user development, user-driven innovation and user-centric innovation highlight the need to move from techno-centric to user-centric approaches to ICT (see e.g. Pang & Schauder 2007). The different concepts have slightly different perspectives but focus on the need to involve users.

For instance, a key feature of UCD is that 'user' needs should inform processes of information systems design. The concept was inspired by Scandinavian and Japanese examples of how engaging workers in the design of production processes could improve productivity and competitiveness, e.g. at Volvo (Whyte 1986). Key aspects of UCD involves: *Needs analysis* – understanding and analyzing the information needs of users, *Task analysis* - making explicit the specific, essential tasks of users as they interact with information systems, *Individual versus groups as units of analysis* - there is a debate in UCD about the relative importance of focusing on individuals or groups (Pang and Schauder, 2007).

The concept of end-user-development (EUD) sees user involvement as a way to make IT-systems quickly and continuously adapt to change, by involving the end-user in the development process. It takes a 'human-centric' approach to ICT and empowers end-users to perform substantial modifications to IT systems. This is done by using user's specific knowhow (including non-technical) to shape ICT tools (such as measuring technology) to better support users in their daily practices, while at the same time not hampering them in their every-day work (Klann et al. 2006). People will have access to adapt ICT-systems to their individual requirements, and if all actors will be involved the design of IT-systems will find a higher common acceptance (ibid). Limitations include organizational aspects, namely that administration and support services of the software has to deal with a system that is continuously changing, and to find the suitable interface techniques/platforms for EUD's various application domains.

Another concept, which also 'taps' into users' knowledge and experience to improve product and services is *user-driven innovation* (Klann et al. 2006). It presents the use of user involvement and ICT in a more commercial setting, where 'users' provide a key contribution to the development or modification of systems and products of commercial interest (Bjørkquist et al. 2015). Indeed, in user-driven innovation, the developers see a clear financial incentive to apply user-driven innovation as it directly contributes to a project's success by generating new ideas and provides knowledge resources to increase in-depth expertise of market needs (ibid).

That user needs should inform ICT design is a good start, and there are various useful approaches that need to inform their involvement. This section highlights that it is not just users' knowledge of the context of their work and that their know-how that is important to capture in the development process, but equally important to identify also the drivers to the development, as a means to design the business case for the development. In SCOREwater, a salient part of the specification of user needs should analyse their context of work, knowhow and their drivers, as an important source to identifying enablers.

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3.4 INVOLVING USERS IN THE INNOVATION PROCESS

First, user-centric innovation (UCI), is a dimension of open innovation in which the firm encourages or facilitates active participation or involvement by the end-consumer in the innovation process of the product/service/idea developed and offered by the firm (Di Gangi and Wasko, 2009; Faulkner and Runde, 2009). UCI centers on end-user contributions as opposed to business-to-business (B2B) partnerships. Alternative terminology for UCI includes co-creative innovation (Ebbesson, 2012), customer co-creation (Gamble and Gilmore, 2013; Piller et al., 2010), collaborative innovations with consumers (Greer and Lei, 2012) and crowdsourcing or crowd creation (Howe, 2009).

Second, the concepts of co-creation and (urban) living labs have become increasingly popular during the recent decade in development processes in smart cities. Living labs are seen as the frameworks where co-creation between actors take place through different types of co-creational methods to develop and test new innovative solutions . Central to living labs is that the users are seen as co-creators and that all actors are iteratively engaged across all stages, compared to more traditional approaches where users are involved in testing. Co-creational approaches emphasise the need to involve users in earlier phases of development processes in order to make sure that the products and services "fit into the lives of the target groups" (Mulder & Stappers 2009). Please also consult the community of innovation approach in annex 1.

Conclusions from Kristersson et al. (2008) on co-creation in new product development (2008) provides insights that can be useful to take into consideration when implementing the SCOREwater project. They note in successful user involvement, the knowledge generated needs to be derived from users' situation. Users may not always be aware of their needs, but as users are engaged in different activities in their everyday life environments, they become more aware of their needs and new ideas emerge that respond to real experiences. They also note that it is important to involve users with different user roles; that brainstorming activities are not isolated from their everyday contexts; and that users should be motivated by personal benefits. This means that in the SCOREwater project, brainstorming needs to be complemented with an analysis of users' everyday practices and what shapes that.

Third, in addition to the user-development concepts, the service innovation concept is used to shift focus from technological solutions to users. Service innovations are processes developed in close interaction with the customers and innovated in networks rather than labs. Successful service innovation is found in projects with a strong integration with the service providing organization and the external users of the services. Using the example of internet banking, Bygstad and Lanested (2008) argue that the actual service innovation lies not only in the new technology, but in the interplay between the providing organization, the users, and the new technology. They argue that there is no one way to achieve ICT-based service innovation, but that in particular the public sector should be prepared to experiment with alternative project models.

Fourth and forward-looking, Bannon et al. (2018) investigated issues that Participatory Design needs to address as it looks to the future. They asked for research papers that would open up new horizons in Participatory Design, or critically examine successes and failures of the past. Among other issues, the papers argued for the following that is relevant for SCOREwater:

- Stronger, longer-term visions and technologies, and towards educational/formational agendas on, and across, different scales. This connects to the outreach activities in SCOREwater, such as hackathons, immersive experiences and school programs.
- Related research approaches such as Participatory Research and Public Participation in Scientific Research. This also connects to outreach planned in SCOREwater such as citizen science through sensors, apps and the like.
- The connections between citizens participatory activities and the organizational and political levels of civic society and government institutions. See above.
- The local versus global/universal scale. This connects to the need to simultaneously attend to local and universal challenges among demonstration cases in SCOREwater and beyond.

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- The different possibilities and challenges in various parts of the global society. This is important to consider when disseminating the experiences and services provided by SCOREwater.

For example, in one paper the role of citizens in Smart City projects was considered at an urban scale that argued engaging citizens can uncover local concerns that provide a foundation for finding solutions to address citizen concerns. Four key challenges for participatory design at an urban scale were identified; balancing scale with the personal, control of the process, integrating citizen-led work with local authorities (Bannon et al.,2018).

This section relates to section 3.3 when discussing how to create living labs (see also communities of innovation in annex 2) as a means for the actual development processes. This is definitively an important lesson to bring to the development of the ICT tools within SCOREwater. Moreover, the service innovation concept is also salient to the project: it is not the ICT tools by themselves that the project aims at, it is their effective use within the case studies and beyond that are at focus. Finally, the third issue brings important questions to how the development process connects to wider issues within the project concerning citizen engagement, educational purposes, regional differences and exploitation beyond the case studies.

INTERDISCIPLINARY CHALLENGES IN ICT DEVELOPMENT

3.5. As mentioned previously, SCOREwater is by design an interdisciplinary project which brings opportunities for innovative results but also challenges in using those opportunities.

Stewart (2011) identified problems and opportunities of interdisciplinary work involving users and suggested different ways to make interdisciplinary teams successful. Since innovation is always a socio-technical change in society, early understanding of users or looking for new opportunities through users is becoming more important (Stewart, 2011). "Indirect evidence about users", "direct involvement of users and proxy users" and "construction of the user" were presented as sources of users' representations. Challenges with user involvement is that users on the one hand cannot always express their expectations or predict what they need to do with certain devices or applications they have never seen or thought about before. On the other hand, user-research approach can offer researchers stimulus and open new paths of investigations (Stewart, 2011).

When doing interdisciplinary work involving users in speculative research into novel ICT applications we draw on methods mostly used in design, business studies and social science, such as cultural probing, participative observation, conceptual design proposals, intention surveys, creative brainstorms, scenario building with users, long interviews, focus groups, surveys and then used this data to build models, create personas, tell stories, create scenarios, develop theory and extract requirements. These methods have very different time scales – long-term engagement with a community using multiple methods versus an afternoon in the park with a camera (Stewart, 2011).

3.6. That is, interdisciplinary collaboration is necessary for an effective user-involvement process but it also needs to be carefully and purposefully designed. In the SCOREwater project, this will be achieved through a successive iteration of need and opportunities, drawing on methods used in design, business studies and social science.

ITERATIVE USER-INVOLVEMENT PROCESSES

Iterative methods will be used in SCOREwater to increase stakeholder interaction, but also as a means to improve the adaption to user needs and requirements. Iterative development is especially effective for: a) adding to the quality of understanding, b) making the process thorough and more responsive to new information and to changes in the business environment, and c) mitigating the risks associated with integrating the various components of an application system (Eeles et al. 2014; Goodman et al. 2012). In an iterative process, the project adapts with every iteration. This, in theory, minimizes unnecessary development while making products that are more in tune with what people need (Erder and Pureur 2016).

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There are different definitions of iterative processes in the ICT literature, but they share the underlying idea of progressive refinement through cyclical data-driven development (Eeles et al. 2014). For example, design thinking methods are increasingly popular types of iterative processes. The Interaction Design Foundation (2019) defines design thinking as "an iterative process in which we seek to understand the user, challenge assumptions, and redefine problems in an attempt to identify alternative strategies and solutions that might not be instantly apparent with our initial level of understanding."

Piplani et al. (2018) demonstrate how an iterative design process was used to improve the overall user interface and make data entry easier. This included: interaction with the end users, understanding their environment, and analyzing existing methods and parameters used for data entry (ibid).

Goodman et al. (2012) presents three steps in an iterative process:

- *Examination*. This step attempts to define the problems and whom they affect. Questions are raised, needs are analyzed, information is collected, research is conducted, and potential solutions are evaluated. Strengths and weaknesses are enumerated and prioritized. Customers' needs and their capabilities are studied, and existing products or prototypes are evaluated.
- *Definition*. Solutions are specified, e.g. fundamental feature that's missing from the product. At this stage, changes in the product are mapped out with ever-greater detail as additional information about the real needs and capabilities of the target audience is uncovered.
- *Creation*. Solution plans are carried out. Since it's the most expensive and time-consuming phase (taking as much as half of the development time), if the work done in the creation stage is not backed by data collected during the examination phase and by careful planning in the definition phase, much of it could be wasted.

Iterative design thinking methods have become increasingly popular and compared to more traditional development processes in the field of ICT, Lindberg et al. (2010) have identified some central characteristics to design thinking development processes, that could be useful to consider when planning the iterative processes in Scorewater:

- Instead of defining problems based on theoretical hypothesis, formulate those based on observing actually existing exemplary user cases or scenarios.
- Explore several ideas in parallel throughout the process, instead of focusing on one.
- Elaborate and sketch prototype throughout the process on the different ideas to produce tangible and communicative prototypes.
- Instead of involving only technically educated experts, it is also important to ensure strong diversity of disciplines in teams.

3.7. SUMMARY

- Transforming user customer expectations and needs into requirements is a challenging task for many developers. From a developer standpoint, different levels of customer statements are not structured with sound logic. In SCOREwater, in order to use such an approach, there is a need to complement it with other approaches, as presented in this section.
- There is often a lack of end-user involvement, which can lead to lower effectiveness or end-user resistance as the solutions do not respond to end-user needs or fit into their everyday practices. Experiment and brainstorm in real-life contexts to gain insights and ensure that the solutions fit the users' everyday life practices. In SCOREwater, users need to be involved in the development processes. This means for example that operating technicians are involved in the processes in order to decrease the likelihood of user resistance and ensuring that the proposed solutions can and will be implemented in their everyday work as planned.
- The goal of an innovation process should be to find solutions that function in the intersection of technical feasibility, economic viability and user desirability. In SCOREwater, positive environmental impact is a necessary addition to these three.

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- Iterative processes involving users can better ensure that the developed solutions respond to user needs. For example, design thinking emphasizes the need for constantly defining and re-defining the problem to be addressed. Openness in the design process is needed also in SCOREwater.
- It is important to understand people not as technologically inferior but appreciating them as skilled users, as well as to involve users with different types of expertise and competence. From the beginning, development teams need to involve other experts than solely those with technical expertise. This is relevant to keep in mind in SCOREwater when solutions are tested.
- The service innovation concept is also salient to the project: it is not the ICT tools by themselves that the project aims at, it is their effective use within the case studies and beyond that are focused. The business cases developed need to reflect this perspective.
- The development of the ICT tools also brings important questions to how the development process connects to wider issues within the project concerning citizen engagement, educational purposes, regional differences and exploitation beyond the case studies.
- Visualization, games and storytelling are means of simplifying information and helping people understand complex data (Roast et al., 2016, see more in appendix 3). In SCOREwater, we should consider how to use different kinds of data visualization but also prototyping to help users and stakeholders to both understand data and the proposed solutions.
- It is also necessary that the development process is based upon an analysis of users' everyday practices and what factors that shape it such as assignments, budgets, skills etc.

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4. SEWAGE SOCIOLOGY TO IMPROVE HEALTH AND ENVIRONMENT

INTRODUCTION

In this chapter, we will first make the case for sewage sociology, then define it and argue for its value, how it can be used for improving health and environmental conditions and finally how it will provide input to task 4.2.

4.1

Sewage sociology is defined as: "the science of society, social institutions, and social relationships viewed through the eyes of a sewer; specifically: the systematic study of the development, structure, interaction, and collective sewer use of organized groups of human beings" ((Enfinger and Stevens, 2014) adapted from Merriam-Webster's Collegiate Dictionary, (Merriam-Webster Inc., 2003)).

The association between socioeconomic status (SES) and health is widely documented and consistent across countries. The WHO Regional Office for Europe published the evidence on social determinants of health (Wilkinson and Marmot, 2003): (1) the social gradient, (2) stress, (3) early life conditions, (4) social exclusion, (5) work, (6) unemployment, (7) social support, (8) addiction, (9) food, and (10) transport. SES (or sometimes socioeconomic position) is usually measured by education, occupation, employment, income, and wealth (Pampel et al., 2010). The relationship between SES and heath is complex. Much research has been devoted to clarifying the direction of causality.

Population health is worse and life expectancy is shorter in societies where income differences are large, leading to social stratification (Mackenbach et al., 2008; Pickett and Wilkinson, 2015; Wilkinson and Pickett, 2006). A 'social gradient' in health exists increasing education, income and SES improves health outcomes in a dose-response relationship (Arcaya et al., 2015). Research on small areas, in neighbourhoods of cities, further support national and global findings on the negative association between SES and mortality from NCDs and health risk factors (e.g. smoking and obesity) and self-assessed health (Borrell et al., 2014; Marí-Dell'Olmo et al., 2015). Mortality from 14 avoidable causes of death is higher in low-SES neighbourhoods and mortality rate ratios between areas with different levels of deprivation differ between gender and cities from Europe (Hoffmann et al., 2014). About the risk factors, Kinge et al. (2015) provide evidence from 70 countries that obesity increases with GDP, and that in rich countries, obesity is more common among the lower educated, whilst in poor countries, obesity is more common among the higher educated.

Three hypotheses have been tested: (1) social causation (SES --> health), (2) heath selection (health --> SES); and (3) indirect selection (common factors influence both SES and health). Recent studies find support for the social causation hypothesis, namely SES affects health outcomes at multiple points in the life course (Warren, 2009), especially in the transition from working ages to old age (Hoffmann et al., 2018), although prolonged poverty might amply the effects of deprivation in health (Arcaya et al., 2015). On the other hand, low-SES groups show a tendency to adopt unhealthy behaviours, such as smoking, exercising little, poor diet and excess weight.

These respond to social and cultural class traits and are explained by deprivation leading to stress and fewer benefits of investing in health behaviours for longevity, among other reasons (Pampel et al., 2010). Even access to cancer clinical trials (CCTs) is comparatively lower among low-SES groups due to several patient factors (lack of education about cancer and CCTs, fear of participation, poor pre-cancer health) and health-care professional factors (Sharrocks et al., 2014). Thus, health inequalities are caused by material deprivation directly (the purchase of and access to good health) and indirectly (e.g. environmental stress, low education) (Garrison and Rodgers, 2017)

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WHAT SEWAGE SOCIOLOGY CAN ACHIEVE

So far, the term sewage sociology has been used within the frame of studies which analyze hydrographs from sewer flow monitors to record the daily rhythm of people's lives through water and sewer use (Enfinger and Stevens, 2014). In that study, an overview of sewer use patterns is provided for normal weekday and weekend periods. Variations are then discussed based on land use differences. Other events that depart from normal diurnal patterns are also presented – including holidays, religious observances, sporting events, the World Trade Center Attack, the Northeast Power Blackout, and others. Their paper is not a typical technical paper, but rather a collection of interesting observations of human behavior documented through sewer flow monitoring data. The authors performed engineering analysis on data from thousands of flow monitoring locations across the United States, and this paper shows those of general interest, including both serious and light-hearted material. Yet the full potential of information which can be extracted from sewer flows has not been explored, nor the development of algorithms which can automatically ensure the quality of the data (first) and extract useful information from the patterns (second), which can be scalable to any other sampling location.

4.2

The concept of sewage sociology goes beyond the analysis of flows. The analysis of concentrations of chemicals can also provide information about lifestyle habits and health status from communities. This practice is called Sewage Information Mining (SIM) or sewage chemical information mining (SCIM), when the focus is on chemicals. Embodiments of SIM include sewage epidemiology or wastewater-based epidemiology. Sewage water contains everything that goes down through city toilets and therefore it also contains precious data. Daughton (2001) proposed the idea of sampling sewage water to obtain epidemiologic data, including illicit drugs. After that, the research about illicit drugs in sewage water took the lead, with hundreds of published studies based in the analysis of illicit drugs in sewage waters, the application of pharmacokinetics and the estimation of usage per capita based on sewer back-calculations (Daughton, 2018). All those studies about illicit drugs have demonstrated that sewage-water analyses can deliver reliable information about population's health and behaviour (Choi et al., 2018). Later, a few studies started to focus on other compounds such as pesticides, licit drugs, prescribed pharmaceuticals or biomarkers that would reflect exposure, lifestyle habits and overall health status of population (Rousis et al., 2017, van Nuijs et al., 2015, Ryu et al., 2016b, Castiglioni et al., 2015). Chemical oxygen demand (COD) or dissolved organic carbon (DOC) can also give valuable information to understand population movements and social behaviour (Atinkpahoun et al., 2018). SIM is seen as a valuable tool to conduct epidemiological studies because data can be obtained with a high temporal resolution and with full objectivity.

Target measurements of pharmaceuticals can be compared and contrasted with prescriptions, sales and public health data; opening the possibility to develop accurate models for population health and behaviour monitoring. Only a few studies have compared measured pharmaceuticals in sewage with consumption data (van Nuijs et al., 2015). From those studies, it can be learned that the linkage of measured and predicted data is best when the analyzed pharmaceuticals are exclusively prescription-sold, consumed frequently by a big part of the population and with a known urine excretion-pattern (van Nuijs et al., 2015). These compounds, like e.g. beta-blockers, give the possibility to estimate population sizes, to control the quality of other measurements and to assess the general health of a population. The analyses of such compounds can at the same time be compared with the measurements of punctually administrated pharmaceuticals, like antibiotics, which may be used to track disease outbreaks, to assess the vulnerability of different populations to bacterial infections and to estimate non-prescribed intakes.

4.3

SCIM TO FIGHT AGAINST ANTIBIOTIC RESISTANCE AND NON-COMMUNICABLE DISEASES

Based on the previous information, SIM-based tools are valuable to monitor and assess two concerning health problems of modern society: antimicrobial resistance and non-communicable diseases (NCD).

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Even though antibiotics have dramatically changed the fate of patients with infectious diseases and helped the advances in complex surgery and chemotherapy (Friedman et al., 2016), they came with the spread of antimicrobial resistance, which is nowadays an extended problem all over the world (World Health Organization, 2018a). Antimicrobial resistance in the healthcare system is translated to extended hospital stays, isolation wards, stringent infection control measures and treatment failures; therefore public-health leaders should establish a watch-system coordinated at national and international levels with continuous standardized analyses and antibiotic-resistance reporting systems (Friedman et al., 2016; World Health Organization, 2018a). In relation to this, SCIM could be used to monitor antibiotic-consumption within population, which would allow elaborating customized health-care campaigns. These actions could potentially lead to less antibiotic consumption and therefore a decrease in antimicrobial resistance spread.

NCDs, which are the leading cause of death globally, are determined by personal genetics, the lifestyle and the environment (World Health Organization, 2018b). Therefore, urbanization and its implying lifestyle and environment (such as lack of physical inactivity, alcohol intake, unhealthy diets and bad air-quality) is strongly determining the incidence of NCDs (Sachs, 2017). Antimicrobial resistance and NCDs are not completely independent of each other. Some NCDs, like for example diabetes, are going together with susceptibility to infections (Kostova et al., 2017), which may be treated with antibiotics.

SES AND ENVIRONMENTAL BEHAVIOR

4.4. Although the rapid growth on the wet wipe market and their direct relation with the formation of 'fatbergs' in the sewage system, there is still a lack of scientific literature on wet wipes flushed in the toilet and their relationship with SES in households. Articles found the rise of the wet wipes is to its ease of use, hygiene, efficiency, and consumers' environmental perception (biodegradable, dispersible, and compatible with water treatment systems) (Atasagun and Bhat, 2018). Other work mentions a direct relationship between income and their use, together with age and working status (edana.org).

A lack of literature is also present in the residential disposal of fats, oil, and grease on the regional wastewater system. A survey on the recycling of oils and grease developed by the municipality of Cadiz show that 20% of respondents declared that threw the oil out in the sink, or directly into the trash. A survey on determinants of domestic recycling in two municipalities in the Greater Barcelona Region also show that 40% of the respondents did not recycle the oil and grease, with the most possible destination being the toilet. More research is needed to understand the relationship between oils and greases and SES. It is clear that sewage sociology can also be applied to monitor the presence of wet wipes, oils and greases and link to human behavior at households, and ultimately help designing public awareness
4.5. campaigns on the proper disposal of liquid and solid waste.

SUMMARY

Sewage sociology is a powerful tool through which urban planning and health authorities should work together to improve citizen's life-quality and environmental behaviour. In this case, SCIM and BioSCIM could be used to monitor NCDs in different clusters of population and use that information for urban planning and to develop customized NCD prevention-campaigns. The SCOREwater project is designed to use sewage sociology in the Barcelona case study. The case study will also be supported by a framework based upon the other social scientific areas presented in this report.

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5. IMPLEMENTATION

This chapter provide input to the framework for designing the implementation of the SCOREwater technologies and services in the project, thus for WP2, 3 and WP4, in phases 2-4 of the project. The tools need to be implemented in effective ways, adapted to their context but also providing generalizable data and experience for further development of the tools.

A key problem when it comes to implementation of research programs is that often they invest all their time and efforts in understanding problems and their solutions, but place too little efforts in ensuring the implementation of the respective solutions. Pronovost et al. (2004) note that 99% of the medical research budget is devoted to understanding disease biology and developing effective therapies while 1% is devoted to learning how to implement those therapies safely and effectively with patients. They go on arguing that well-researched practices and programs is a good start but the eventual benefits of those practices and programs nationally may rest on understanding how to create functional and hospitable socio-political contexts and effective implementation strategies. Others argue that failure of implementation and systems change are connected to unclear policy outcomes or lack of adequate supervision of the implementation of policy goals (Koontz and Newig 2014).

In this chapter, we will first define what implementation is and present the major approaches as well the implications for SCOREwater. Second, we will present a few good practices for implementation (more support is provided in annex 5).

IMPLEMENTATION: TOP-DOWN OR BOTTOM-UP?

5.1 Up until the 1960s research on change in public and private sector had assumed that implementation was an unproblematic step, which occurred automatically after a central decision had been made (Fernler 2012). However, implementation research case studies demonstrated that local-level implementation of centralised decisions were at least as complex and was not at all automatic. Implementation does not come by itself and it often ends up in unexpected ways. This section highlights two dichotomous approaches (top-down and bottom-up) to implementation, which have received considerable debate in the literature. Each sub-section provides a definition of the approach, what it offers to our understanding of implementation, and its main critique.

5.1.1. TOP-DOWN

The top-down approach provides a hierarchical approach to implementation. According to this understanding, power is situated centrally with the government and public authorities. Policymakers can directly control implementation and do so through clear lines of top-down authority. This can, for example, be in the form of 'soft' laws such as standardization or market-based instruments, which require strict compliance mechanisms on local actors (Fernler 2012).

Here it is assumed that central decisions are followed by a strict local implementation. Central actors (policy elites) determine policy activities by means of political administrative control through policy programs.

To increase the level of efficiency top-down theorists thus demand a clear and consistent statement of the policy goals, a minimization of the number of involved actors, a limitation of the extent of change necessary and to find an institution which supports the point of view of the policy makers in order to guarantee that the implementers sympathize with the new statute (Koontz and Newig 2014; Matland 1995).

The main critique includes that this approach takes policy as a given and does not consider its past history, policy making process, or broader issues – which may influence the implementation process. Thus, it sees implementation as a purely administrative process, ignoring the political aspects. It gives agency mainly to statute framers (central decision makers). It assumes that problems with implementation is mainly a mishandling at the operational (local) level rather than considering the policies themselves.

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5.1.2. BOTTOM-UP

The bottom up approach argues that policies are not so much determined by the statutes emanating from governments and legislative authorities at the centre, but by a multitude of actors who interact at the operational (local) level on a particular problem or issue. The so called 'street level bureaucrats' (Lipsky 1980) and are made up of individual public servants from various agencies, such as schools, welfare departments, health and safety organisations, security agencies, courts, or environmental agencies.

Proponents argue that it offers a more realistic understanding of the implementation process. It highlights the contextual factors policies meets when implemented. Emphasis is placed on the execution of policies from the view of the street level bureaucrats who possess the autonomy and expertise to adapt the policy to local conditions and the target population whom they are in constant interactions with (Matland 1995).

Critiques argue that too much emphasis is given to the autonomy of the local agents and street level bureaucrats. Instead policy control needs to be done by actors whose power to formulate policies are derived by virtue of them being elected representatives (Sabatier 1986). Another critique is the resistance to change of so called 'street level bureaucrats. According to this argument, street level bureaucrats often perceive new ideas or practice in accordance with the belief or practice (routines) they already held. For example, in a study conducted by Cobb et al. (2013), mathematics teachers constructed new ideas to fit within their existing models for mathematics instruction rather than rethinking them.

5.2. DESIGNING EFFECTIVE IMPLEMENTATION STRATEGIES

While the top down approach perceives implementation as the hierarchical execution of centrally-defined policy objectives, the bottom up approach perceives implementation as everyday problem strategies of street level bureaucrats (Lipsky 1980). The top-down approach involves a hierarchical method and emphasises the power of the government and public authorities to determine policy activities by means of political administrative control, while the bottom-up approach involves a non-hierarchical method and draws attention to how a wide range of actors (i.e., the 'street level bureaucrats') are instrumental in affecting both the policy formation and implementation process.

In the SCOREwater project, a mixed approach to implementation will be necessary. Below follows some input to this end. A leading researcher, Fixen (Fixen et al. (2005) characterize different variants of public-sector implementation:

1. *Letting it happen*: Practitioner receives information, but is left alone to interpret and change local routines and practices
2. *Helping it happen*: practitioner receives information and support to interpretation but is left alone to adapt local routines.
3. *Making it happen*: practitioner receives information and support to both interpretation and implementation.

Naturally, SCOREwater needs to support the third variant of implementation. Moreover, Fixen et al. argue that more data on program outcomes alone will not help implement that program. Any implementation strategy needs to be calibrated to both the specific innovation and the organisational context. First and foremost, it is a question of understanding the behaviour you want to change. When you embark on an implementation process, it is a presupposition for success that you understand the behaviour you want to change. The purpose of the assessment is to clarify the potential match between the new practice and the organisational capacity and readiness for change. Thus, in SCOREwater, one needs to analyze the match as part of designing the implementation strategy to achieve the required result.

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There is good evidence that successful implementation efforts designed to achieve beneficial outcomes for consumers require a longer-term multilevel approach (ibid). appropriate support is provided. An intervention must be well defined and carefully evaluated with regard to its effects on its intended consumers (children, families, adults) (Fixen et al. 2005). In accordance with this point, information dissemination alone (research literature, mailings, promulgation of practice guidelines) is an ineffective implementation method, and training (no matter how well done) by itself is an ineffective implementation method. Information dissemination and training must be combined. A multilevel approach is needed for the SCOREwater demonstration cases.

But what kind of support is needed? Fixen et al. (2005) argue that implementation appears most successful when:

- Carefully selected practitioners receive coordinated training, coaching, and frequent performance assessments
- Organizations provide the infrastructure necessary for timely training, skilful supervision and coaching, and regular process and outcome evaluations
- Communities and consumers are fully involved in the selection and evaluation of programs and practices
- State and federal funding avenues, policies, and regulations create a hospitable environment for implementation and program operations.

In addition, in large-scale implementation efforts pilot projects are a valuable source of information about how the implementation process is actually unfolding in varying local contexts. Implementation is a dynamic and often iterative process with different logics. To simplify, you can distinguish between four different phases: exploration, preparation, initial implementation, full implementation. These phases can be aligned with the phases in SCOREwater using the Societal Readiness Scale.

With regard to the innovation process the Societal Readiness Levels (SRLs), developed by the Innovation Fund Denmark) can be used to guide what should be achieved in the various phases of the project. SRL is defined accordingly (innovationsfonden.dk/sites/default/files/2019-03/societal_readiness_levels_-_srl.pdf):

Societal Readiness Level (SRL) is a way of assessing the level of societal adaptation of, for instance, a particular social project, a technology, a product, a process, an intervention, or an innovation (whether social or technical) to be integrated into society. If the societal readiness for the social or technical solution is expected to be low, suggestions for a realistic transition towards societal adaptation are required. Naturally, the lower the societal adaptation is, the better the plan for transition must be. SRL 1 is the lowest and SRL 9 is the highest level.

In Table 2 below we show how the SRL can be used to guide implementation of the SCOREwater technologies and services over project phases:

Table 2. How the SRL can be used as a guidance to the process of successive implementation over project phases.

SRL levels	Implementation levels	Phase, project months
SRL 1 - identifying problem and identifying societal readiness **SRL 2 - formulation of problem, proposed solution(s) and potential impact, expected societal readiness; identifying relevant stakeholders for the project.**	Exploration, preparation	Phase 1, Specification, that is until M6

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SRL levels	Implementation levels	Phase, project months
SRL 3 - initial testing of proposed solution(s) together with relevant stakeholders **SRL 4 - problem validated through pilot testing in relevant environment to substantiate proposed impact and societal readiness**	Initial implementation	Phase 2, Prototype, that is until M12.
SRL 5 - proposed solution(s) validated, now by relevant stakeholders in the area **SRL 6 - solution(s) demonstrated in relevant environment and in co-operation with relevant stakeholders to gain initial feedback on potential impact**	Full implementation	Phases 3-4, Implementation & Testing, that is until M36
SRL 7 - refinement of project and/or solution and, if needed, retesting in relevant environment with relevant stakeholders	Revised implementation	Phases 5-6, Revision & Evaluation, until M42
SRL 8 - proposed solution(s) as well as a plan for societal adaptation complete and qualified **SRL 9 - actual project solution(s) proven in relevant environment**	Refined implementation	Phases 7-8, Extrapolation & Conclusions, until M48

In the SCOREwater project, the ICT tools will need to be implemented in a manner that allows for comparison across the cases but also for drawing generic conclusions in D5.3. In SCOREwater, one needs to assess the potential match between the new practice and the organisational capacity and readiness for change as part of designing the implementation strategy, for each case and across cases. A multilevel approach is needed for implementation in the SCOREwater demonstration cases, including dissemination and training workshops. Moreover, table 3 clearly shows that implementation needs to be divided into different steps but also re-iterated over time.

In appendix 5 a few salient resources to draw upon are provided. It is necessary to understand the behaviour you want to change, to provide an overall plan that attends to project goals but also to adapt it to local goals.

5.3

SUMMARY

- Often implementation efforts are neglected which threatens the success of even the most well-researched programs. Information dissemination (about a new technology, policy, or practice) alone is not enough to guarantee successful implementation. In SCOREwater, the implementation strategy needs to be designed before the actual intervention (the ICT tools and the sensors), based upon an analysis of the conditions for the required change in the local context.
- Implementation is a dynamic and often iterative process with different logics. It is necessary to consider the implications of either a top-down (centralised) or bottom-up (practitioner-based) implementation strategy. Any implementation strategy needs to be calibrated to both the specific innovation and the socio-economic and organisation contexts. In the SCOREwater project, a mixed methods strategy will be designed to allow for adaptation to local context and change logics but also to allow for a comparative evaluation of various factors influencing implementation across and beyond cases (see the next chapter).

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- There is a need to assess the potential match between the new practice and the organisational capacity and readiness for change as part of designing the implementation strategy, for each case and across cases.
- A multilevel approach combining information dissemination and training, based upon the above assessment.
- The implementation strategy needs to be divided into steps that align with project phases, using the SRL model.
- There are several guidelines and toolboxes that can help derive an implementation strategy. The various resources presented can be used differently by the different case studies in SCOREwater, provided that the outcome addresses the project plans and can be compared across cases.

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6. EVALUATION RESEARCH

6.1. INTRODUCTION

This chapter addresses how to evaluate the SCOREwater technologies and services developed and tested in the project, as a means to generate generic knowledge on best practices for development, implementation, use and test, as a basis for further development within the project (phases 4-6). It will therefore provide a framework for the comparative evaluation and generalization of the tests through D5.3 as well as for the generalization of lessons for further development and dissemination of the ICT tools in D5.4. These deliverables in turn provide parts of the data for dissemination and transfer beyond the case studies and innovation management, as part of WP6-8.

Evaluation is the systematic acquisition and assessment of research to provide useful feedback. The generic goal of evaluations is to provide relevant feedback of progress and performance. A similar concept is program evaluation, which is a systematic method for collecting, analysing, and using information to answer questions about projects, policies and programs.

Thus, similarly to implementation, evaluation needs to be designed as an integrated part of the intervention, in ways that adapt to the context but also allows for generalized conclusions.

6.2. APPROACHES IN THE LITERATURE

There are different approaches to evaluation in the literature. A key differentiation lies between top-down and bottom-up. This section outlines a brief description and critique of the two approaches and includes an approach (feedback system) that aims to bridge top-down and bottom-up approaches.

6.2.1. TOP-DOWN

Top-down (conventional) approaches emphasise achieving program effectiveness and practical utility. They remain externally oriented, geared towards enhancing cost efficiency and accountability, and usually require quantitative methods for overall programme assessment. Different types of top-down evaluation traditions include (based on Guba and Lincoln 1989):

- *Measurement orientated*: associated with tradition of educational research and scientific management in business and industry. Tests were commonly used to measure the progress of students in schools or to determine the most productive methods to make working environments more efficient and effective. The role of the evaluator was generally technical, to provide and apply tools or instruments for measurement.
- *Description orientated*: program evaluation based on achievement of objectives and analysis of program strengths and weaknesses, which were utilised to guide refinements and revisions.
- *Judgement orientated*: required the development of (top-down) standards against which to judge a programme.

Criticism of the top-down (conventional) approaches include (based on Estrella and Gaventa 1998): they have proven costly and ineffective in terms of measuring and assessing project achievements. They have failed to involve actively project beneficiaries and others who may be directly affected. Project evaluation has become an increasingly specialised field and activity, conducted and controlled mostly by outsiders and removed from the ongoing planning and implementation of development initiatives. They serve primarily as a tool to control and manage programmes and resources, alienating intended beneficiaries and others involved in programme planning and implementation from taking part in project appraisal. Emphasis on quantitative measures tend to ignore qualitative information which helps provide a fuller understanding of project outcomes, processes and change.

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6.2.2. BOTTOM-UP OR PARTICIPATORY EVALUATION

The bottom-up or participatory evaluation approach emphasize a process of negotiation, incorporating various stakeholders more centrally into the evaluation process. It considers stakeholders' consensual and competing claims, concerns, and issues. It recognises that peoples' diverse perspectives and interests are shaped in a major way by their particular value systems, which in turn are influenced by their specific physical, psychological, social and cultural contexts. Through negotiation, participatory evaluation helps identify a course of action for stakeholders. The evaluator plays a role primarily as a facilitator or 'orchestrator' in the negotiation process with stakeholders, who participate in the design, implementation and interpretation of the evaluation as full partners.

Jacobs (et al. 2010) highlight that it may be difficult to achieve a high level of 'participation' in practice. Certain actors, such as local elites may dominate dialogue and traditionally marginalised people may continue to be excluded. The process tends to be time consuming and expensive. The data generated is often questioned as being subjective, unreliable, and difficult to aggregate or draw general conclusions from.

Authentic participation requires other stakeholders to be willing and able to listen, change and share the power to make decisions, which can be contrary to their immediate interests. Moreover, a significant proportion of the literature on bottom-up (participatory) approaches tend to assume an idealised commitment to participatory practice and that managers have the time and resources to invest in it.

6.2.3. FEEDBACK SYSTEM – COMBINING TOP-DOWN AND BOTTOM-UP APPROACHES

The key differences between conventional and participatory evaluation (Narayan-Parker 1993:12) are highlighted in Table 3 below.

Table 3. Comparing conventional and participatory evaluation approaches.

	Conventional	Participatory
Who	External experts	Community members, project staff, facilitator
What	Predetermined indicators of success, principally cost and production outputs	People identify their own indicators of success, which may include production outputs
How	Focus on 'scientific objectivity'; distancing of evaluators from participants; uniform, complex procedures; delayed limited access to results.	Self-evaluation; simple methods adapted to local culture; open immediate sharing of results through local involvement in evaluation process.
When	Usually upon completion of project sometimes also mid-way	More frequent, small scale evaluations
Why	Accountability, usually summative, to determine if findings continues.	To empower local people to initiate, control and take corrective action.

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The advantages and disadvantages of both conventional and participatory evaluation has led to a mixed approach, grown out of three bodies of work: participatory monitoring and evaluation, social accountability, and customer satisfaction. It has the potential to generate summary data for senior decision-makers (top-down management systems) and also improve practice at the field level by improving accountability and empowering local stakeholders in the project (bottom-up participatory processes). This can be done in the following way: The monitoring data summarises the views of intended beneficiaries, similar to customer satisfaction data in business. The process of collecting data and discussing it at field level can create opportunities to improve projects, strengthen relationships and help achieve development goals. If performance is monitored according to local people's opinions, then field staff have incentives to listen and respond to their concerns and priorities (Jacobs et al. 2010).

6.3. ORGANIZING FOR EVALUATION: AIMS, CATEGORIES AND FORMS

In SCOREwater, a mixed approach to evaluation is needed, accounting for both project goals and local goals, allowing for comparison across cases and extrapolation beyond them (as part of WP5). It needs to be based upon a program approach, that is identifying change mechanisms in the local contexts as well as generic ones. Identifying change mechanisms require a theory-based model that informs aims, categories and forms for evaluation. Further, the evaluation strategy in SCOREwater needs to identify the appropriate aims, categories and forms to include and how they should inform and structure the strategy.

Before conducting an evaluation, it is important to consider:

- Why the evaluation is being done (outcome- or process-based objectives)
- How the evaluation is done (conventional vs. participatory)
- Who is doing the evaluating (external experts or stakeholders)
- What is being evaluated (choice of indicators and criteria)
- For whom evaluation is being done (decision makers, project managers, stakeholders)

More knowledge on how to design an evaluation approach follow below.

6.3.1. AIMS FOR EVALUATION

There are four generic aims, that are all relevant to the SCOREwater project in different phases: a) Gain insights about a project or program and its operations; b) Improve practice; c) Assess the effects and d); Build capacity. Below we suggest how these fits into the SRL levels and the project phases:

Table 4. How the SRL levels can be used to guide the aims for evaluation in different phases of the project.

SRL levels	Evaluation aims	Phase, project months
SRL 1 – identifying problem and identifying societal readiness **SRL 2 – formulation of problem, proposed solution(s) and potential impact, expected societal readiness; identifying relevant stakeholders for the project.**	Gain insights about a project or program and its operations	Phase 1, Specification, that is until M6
SRL 3 – initial testing of proposed solution(s) together with relevant stakeholders	Improve practice (testing how it works)	Phase 2, Prototype, that is until M12.

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SRL 4 - problem validated through pilot testing in relevant environment to substantiate proposed impact and societal readiness		
SRL 5 - proposed solution(s) validated, now by relevant stakeholders in the area **SRL 6 - solution(s) demonstrated in relevant environment and in co-operation with relevant stakeholders to gain initial feedback on potential impact**	Improve practice, preliminary assessment of the effects	Phases 3-4, Implementation & Testing, that is until M36
SRL 7 - refinement of project and/or solution and, if needed, retesting in relevant environment with relevant stakeholders	Improve practice, revised assessment of the effects	Phases 5-6, Revision & Evaluation, until M42
SRL 8 - proposed solution(s) as well as a plan for societal adaptation complete and qualified **SRL 9 - actual project solution(s) proven in relevant environment**	Build capacity	Phases 7-8, Extrapolation & Conclusions, until M48

6.3.2. EVALUATION CATEGORIES

Moreover, Galas (et al. 2018) highlight four categories of evaluation approaches.

a) *Pseudo-evaluation* (invalid because of selectively released or falsified). Not relevant.

b) *Questions and/or methods-oriented evaluation*. This approach can be used for either top-down or mixed approach methods. It is a theory-based approach evaluating the process of an intervention. This approach can be used in SCOREwater to identify good practices and enablers for how to use technologies and services, as part of WP5.

c) *Improvement/accountability evaluation*. This approach is focused on the goals to improve a process or product. This approach can be used in SCOREwater to focus on how the technologies and services provided achieve the intended goals as stated in the GA, as part of WP2-4.

d) *Social agenda/advocacy evaluation*. This approach can be used in SCOREwater to focus on how the technologies and services help stakeholders to improve their practices, as part of WP4-6.

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6.3.3. FORMS OF EVALUATION

Toom (2018) distinguishes between formative and summative evaluation: Formative evaluations strengthen or improve the object being evaluated—this form of evaluation examines the delivery of the program or technology, the quality of its implementation, and the assessment of the organizational context, personnel, procedures, inputs, and so on. This approach is similar to the improvement evaluation above although it also highlights areas to address when designing the evaluation approach in SCOREwater.

Summative evaluations, in contrast, examine the effects or outcomes of some object by describing what happens subsequent to delivery of the program or technology; assessing whether the object can be said to have caused the outcome; determining the overall impact of the causal factor beyond only the immediate target outcomes; and estimating the relative costs associated with the object. This approach is similar to the social agenda approach, and also adding salient areas to address when designing the evaluation approach in SCOREwater.

6.4. SUMMARY

- Consider the why, how, who, what, and for whom questions before conducting the evaluation. In SCOREwater, these questions will need to be addressed by all WPs from their different perspectives. For WP4, it is important that the cases integrate them into their project plans. They also need to be revised when the project progresses.
- Both top-down and bottom-up approaches have their pros and cons. For example, participatory methods engage stakeholders but are costly and time consuming to undertake. In SCOREwater, we will design a mixed methods approach that both allows for local adaptation and for generalising conclusions across and beyond cases.
- The evaluation strategy for SCOREwater needs to identify how different aims for evaluation will be applicable for different phases of the project, through the various stages of SRL.
- The evaluation strategy for SCOREwater also needs to identify what forms of evaluation should be used for different purposes within the project.
- Evaluation will be designed as to provide knowledge about the effects that locally, and beyond the cases, the ICT tools have, and what is needed to further support their successful application.
- The various resources presented in the annex can be used differently by the different case studies, provided that the outcome addresses the project plans and can be compared across cases.

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7. CONCLUSIONS

BEHAVIOURAL, ORGANIZATIONAL AND LEGAL/REGULATORY BARRIERS/ENABLERS

7.1. The research overview shows that the water sector is traditionally risk averse and conservative. Innovation procurement is a useful tool to provide for purchasing tools that can have a beneficial impact on the abilities to manage the water cycle towards SCOREwater goals. However, to achieve its full potential, one needs to analyze governance challenges and how to involve stakeholders and users in an effective way.

The governance challenge is that water is often managed through a network of public and private actors at different levels, with different perspectives and goals, and different strategies and instruments. Risk sharing between actors is needed, as well as promotion of transparent working cultures that promote reflection. Behavioural aspects such as bias towards a certain solution or manager's overestimation of their own innovativeness may hinder the development and adaptation of the most suitable solutions. Open working cultures that see experimentation projects as spaces for learning enable innovative organizational cultures and behaviours. Research on barriers and enablers for innovation emphasizes the need for networked working methods and cooperation with a variety of stakeholders as important enabling factors for developing and implementing innovative solutions successfully.

ITERATIVE USER-EXPERT DEVELOPMENT PROCESSES

7.2. Traditional means such as the PDS methods need to be complemented with other methods and approaches. The review emphasizes the need to involve both the operational users of innovative ICT solutions as well as a broad spectrum of other stakeholders in developing processes (e.g. municipal and state officials and policy makers). Different involvement methods need to be chosen based on type of user or stakeholder addressed, but also based on the goals of the involvement action, or the type of knowledge that the activity should bring to the process.

Efforts need to be put on identifying stakeholders and ensuring that all stakeholders are aware of each other's roles, responsibilities and mandates in the process. Efforts are also needed to identify and map all correct stakeholder with influence or stake. It is beneficial to see the network of actors a source for innovation, instead of focusing on one company, since various actors (e.g. customers, suppliers, policy-makers) are needed to enable that an innovation can be applied.

7.3. There is often a lack of end-user involvement, which can lead to lower effectiveness or end-user resistance as the solutions do not respond to end-user needs or fit into their everyday practices. Iterative processes involving users can better ensure that the developed solutions respond to user needs. For example, design thinking emphasizes the need for constantly defining and re-defining the problem to be addressed. There is a need to experiment and brainstorm in real-life contexts to gain insights and ensure that the solutions fit the users' everyday life practices.

SEWAGE SOCIOLOGY

7.4. Sewage sociology is the scientific use of biomarkers in waste and waste-water to measure health and environmental characteristics together with known demographic data. The overview in this report shows how sewage sociology is a powerful tool through which urban planning and health authorities should work together to improve citizen's life-quality. In this case, SCIM and BioSCIM could be used to monitor NCDs in different clusters of population and use that information for urban planning and to develop customized NCD prevention-campaigns.

IMPLEMENTATION AND EVALUATION RESEARCH

Often implementation efforts are neglected which threatens the success of even the most well-researched programs. Information dissemination (about a new technology, policy, or practice) alone is not enough to guarantee successful implementation.

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Implementation is a dynamic and often iterative process with different logics. It is necessary to consider the implications of either a top-down (centralised) or bottom-up (practitioner-based) implementation strategy. Any implementation strategy needs to be calibrated to both the specific innovation and the socio-economic and organisation contexts.

The review shows that implementation needs to be both locally adapted and being able to provide generalizable conclusions for further dissemination and exploitation. It needs to be based upon an analysis of change mechanisms, locally for each case and generic for the water sector.

Evaluation has traditionally been either top-down and expert-driven or bottom-up and user driven. In SCOREwater, a mixed approach to evaluation is needed, accounting for both project goals and local goals, allowing for comparison across cases and extrapolation beyond them (as part of WP5). It needs to be based upon a program approach, that is identifying change mechanisms in the local contexts as well as generic ones. Identifying change mechanisms require a theory-based model that informs aims, categories and forms for evaluation to include and how they should inform and structure the strategy. Just as for implementation, the evaluation strategy needs to be designed beforehand and to be integrated into the implementation efforts.

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PART 3: FRAMEWORK FOR SPECIFYING HOW TO DEVELOP USER'S NEEDS AND REQUIREMENTS IN AN ITERATIVE PROCESS

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8. INTRODUCTION

Based on the key learning points summarized at the end of each chapter of the literature review, as well as in the previous concluding chapter, this chapter provides a short framework of guiding principles for the implementation of WP4 and WP5 in SCOREwater.

A framework contains the salient experiences, approaches, theories and perspectives in a field from which prescriptive models and other tools can be built. As all the demonstration cases need to be designed in a context-sensitive manner based on local knowledge and available resources, this framework will not provide an obligatory list of steps, but it will instead set out a framework of key guiding principles for the iterative development process together with stakeholders.

8.1. FRAMEWORK FOR WP4

WP4 demonstration cases will draw upon the whole literature review different respects – in terms of providing input for how to develop, implement and evaluate the SCOREwater technologies and services. Consultations between the WP4 leader and the authors of D5.1 were organized already during the process of writing of D5.1, and the results of D5.1 contributed to the Common Guidelines for the workshops in task 4.1 and the identification of stakeholders that took place in connection to that.

The main conclusions from the literature review D5.1. will continue to contribute to guide the demonstration cases in WP4. These are the main framework principles to guide the process of specifying stakeholders' needs and requirements:

- Innovation procurement can be an instrument for innovation in the water sector. In SCOREwater, the opportunities for applying innovation procurement and how this should be designed will be analysed in the three cases, as part of evaluation and innovation management activities (see annex 1). However, to achieve its full potential, one needs to analyze governance challenges and how to involve stakeholders and users in an effective way.
- The PDS methods is a systematic means of collecting, mapping and translating user needs and requirements that is valuable for SCOREwater. In SCOREwater, the PDS will be complemented through other methods and to be used by an interdisciplinary team (see Annex 2).
- In SCOREwater, users need to be involved in the development processes from the start. This means, for example, that operating technicians are involved in development processes in order to decrease the likelihood of user resistance and ensuring that the proposed solutions can and will be successfully implemented in their everyday work.
- Users with different types of expertise will need to be involved, including technical, but also social, organizational or policy-related expertise. Data visualization and prototyping are important tools to promote common understanding among the stakeholders and users with varied backgrounds and competences.
- SCOREwater demonstrations need to involve a broad set of stakeholders, including not only those that are direct practical users, but also other stakeholders whose knowledge, competence and other resources are needed in order to reach successful implementation. SCOREwater demonstrations acknowledge that innovation needs to take place in networks that consists of actors from different sectors and levels of government, as well as different competence categories.
- Practical methods for stakeholder engagement need to be chosen based on the goal of the engagement activity. For instance, web-based surveys may be useful if the aim is to collect large amount of opinions, whereas smaller workshops, focus groups and expert groups may be better when aiming to co-create new ideas and find solutions to complex problems. In SCOREwater, engagement tools will be chosen case-by-case based on the goal of each activity and the knowledge needs.

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- The SCOREwater demonstrations need to be designed so that implementation, evaluation, dissemination and further exploration is both adapted to local context but also comparable across cases and generalizable beyond them. The project plans need to both specific and generic, designed according to a relevant analysis of local mechanisms to allow for an effective implementation but also to identify, evaluation, dissemination and further explore more generic mechanisms.
- Engagement with users and stakeholders in SCOREwater demonstration cases shall take place iteratively throughout the development process. Developers and stakeholders should meet recurrently over time, also ensuring that the new tools complement and can be integrated with already existing tools that are relevant to users and stakeholders.
- Establishing a community of practice/innovation where stakeholder experts regularly meet to discuss specific challenges can be a way to build community and dialogue. Bringing all the local communities of practice together at project level could contribute to transnational learning in the project. In SCOREwater, communities of practice are established in all demonstration cases and the approach is evaluated throughout the process (see annex 1 below).
- Ensuring early and clear definitions of roles, responsibilities and mandates between actors and stakeholders is essential for SCOREwater demonstrations as they engage with a variety of actors. Each partner's goals, expectations and capacities to act in the process should be clarified to all involved and written binding or non-binding agreements should preferably be established.
- SCOREwater demonstration cases need to consider how to promote inclusive, open and experimental working cultures that are able to adapt to changes and provide opportunities for reflection and learning.
- Practical tools for user and stakeholder engagement in SCOREwater demonstration need to be chosen on an individual and on a case-by-case basis.
- Experimenting and brainstorming in real-life contexts with users have shown to be fruitful tools when aiming to gain insights and ensure that the solutions fit the users' everyday life practices.
- In engaging with stakeholders, web-based surveys may be useful if the aim is to collect large amount of opinions
- Smaller workshops, focus groups and expert groups may be better when aiming to co-create new ideas and find solutions to complex problems.
- Toolkits such as the OECD's principles, checklists and indicators can be applied by the demonstration cases to guide the practical implementation of stakeholder engagement (see annex 1).

Main framework principles to guide the process of specifying implementation of SCOREwater technologies in the demonstration cases based upon the analysis of stakeholders' needs and requirements:

- In order to stimulate innovations in early stages, it is important to establish contact between the innovative companies and pioneering adopters in each of the demonstration cases. The analysis of stakeholders in D4.1 can be used to identify potential actors that might be part of an innovation procurement program.
- Implementation needs to be both locally adapted and being able to provide generalizable conclusions for further dissemination and exploitation. It needs to be based upon an analysis of change mechanisms, locally for each case and generic for the water sector. There is a need to assess the potential match between the new practice and the organisational capacity and readiness for change as part of designing the implementation strategy, for each case and across cases.
- The implementation strategy will need to design a multilevel approach combining information dissemination and training, based upon the above assessment.

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- The implementation strategy needs to be divided into steps that align with project phases, using the SRL model, in an iterative process.

Likewise, the evaluation strategy needs to be designed beforehand and to be integrated into the implementation efforts for each case study. Main framework principles to guide the process of specifying evaluation of SCOREwater technologies in the demonstration cases based upon the analysis of stakeholders' needs and requirements

- The opportunities for applying innovation procurement and how this should be designed will be analysed in the three cases, as part of evaluation and providing input to innovation management activities.
- Consider the why, how, who, what, and for whom questions before conducting the evaluation. In SCOREwater, these questions will need to be addressed by all WPs from their different perspectives. For WP4, it is important that the cases integrate them into their project plans. They also need to be revised when the project progresses.
- Both top-down and bottom-up approaches have their pros and cons. For example, participatory methods engage stakeholders but are costly and time consuming to undertake. In SCOREwater, we will design a mixed methods approach that both allows for local adaptation and for generalising conclusions across and beyond cases.
- The evaluation strategy for SCOREwater needs to identify how different aims for evaluation will be applicable for different phases of the project, based on the Societal Readiness Level model.
- The evaluation strategy for SCOREwater also needs to identify what forms of evaluation should be used for different purposes within the project.
- Evaluation will be designed as to provide knowledge about the effects that locally, and beyond the cases, the ICT tools have, and what is needed to further support their successful application.

8.2. FRAMEWORK FOR WP5

The literature review on barriers and enablers for innovation in water sector will also inform WP5, providing the framework for the business cases (including D5.2) and draw recommendations for future development of technologies for water management (D5.3), as well as lessons learned from testing and revising technologies for water management (D5.4).

For D5.3, the literature review will function as a basis for observing and analysing the users' and technical experts' experiences from the development processes, as well as for analysing the innovation management challenges in developing the SCOREwater platform and the resilient management tools.

It will also guide the generation of lessons learned in D5.4. in relation to organizational, behavioural and legal issues that have been identified in the demonstration cases. The research overview guides and provides a framework for the identification of best practices and social and organizational enablers in the SCOREwater demonstration cases, that will further be exploited in WP6 and disseminated in WP7.

For both D5.3 and D5.4, the evaluation strategy will be focused on drawing lessons across and beyond the demonstration cases. The strategy will therefore need to be similar to the one in WP4 but focus more on generic conclusion such as identifying behavioural, legal and organizational barriers for an effective implementation and use of SCOREwater technologies, as outlined in the GA. This provide important input to innovation management.

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PART 4: RESOURCES FOR SPECIFYING HOW TO DEVELOP USER'S NEEDS AND REQUIREMENTS IN AN ITERATIVE PROCESS

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ANNEX 1 – ORGANIZING TO ENGAGE STAKEHOLDERS – RESOURCES

As noted in the overview, the networked character of the water sector makes it particularly important to engage all key actors early in development process, and to early make clear and define all actors' goals, expectations and capacity to act. In this section, we look at general principles to take into consideration when engaging stakeholders in technology development projects in the water sector. We also study and provide examples on how stakeholder engagement has been organised in earlier EU projects that are relevant for SCOREwater. The first of these describes methods developed though innovation procurement, the second how to work with interdisciplinary stakeholder groups, the third how to design an iterative process, and the fourth provides a good deal of practical advice for organizing innovation processes in the water sector, based upon an overview of previous projects.

METHODS WITHIN INNOVATION PROCUREMENT

One field where work has been done on methodological development on identifying customer requirement is innovation procurement. This field is also of importance for innovation in the water sector since it is dominated by public actors and procurement can be an instrument for innovation in this sector.

Procurement of products and services by public institutions—public procurement—is recognized as a major market force. Aside from the primary purpose of public procurement to fulfil the needs and demands of the public administration, policy makers show an increasing interest in utilizing the massive buying power of the public sector as a tool to support secondary goals and policy initiatives, e.g. green and sustainable procurement, support for small- and medium sized enterprises (SMEs), and innovation (Obwegeser and Dueholm Müller 2018).

Innovation procurement, or technology procurement as it earlier has been called, when applied to stimulate environmental technology aims at accelerating market introduction of new technology. The underlying methodology engages different stakeholders on the market in order to develop new and required products and has been successful in satisfying customer needs, resulting in positive environmental effects as well as to stimulate business development. The outcome from an innovation procurement process often leads to a substantial market introduction of the new developed products. Hence, innovation procurement can act as a catalyst for innovations giving direct market effects following the purchase of large product volumes. The need for further development of the concept of innovation procurement in stimulating innovation and technology development has been highlighted in a number of statements and documents from public authorities. Innovation procurement could be used on a systematic basis to contribute to material and energy efficiency as well as the fulfilment of long-term climate mitigation commitments (Dalenstam et al. 2009).

It is in this context different methods for innovation procurement has been identified. UNEP (2014) have developed a method for identifying user needs and a model for collaboration between procurer and supplier that have been further developed by Witjes and Lozano (2016), see Figure 1. The figure shows the procurement process over time where customer demand and product performance successively align until the sourcing stage.

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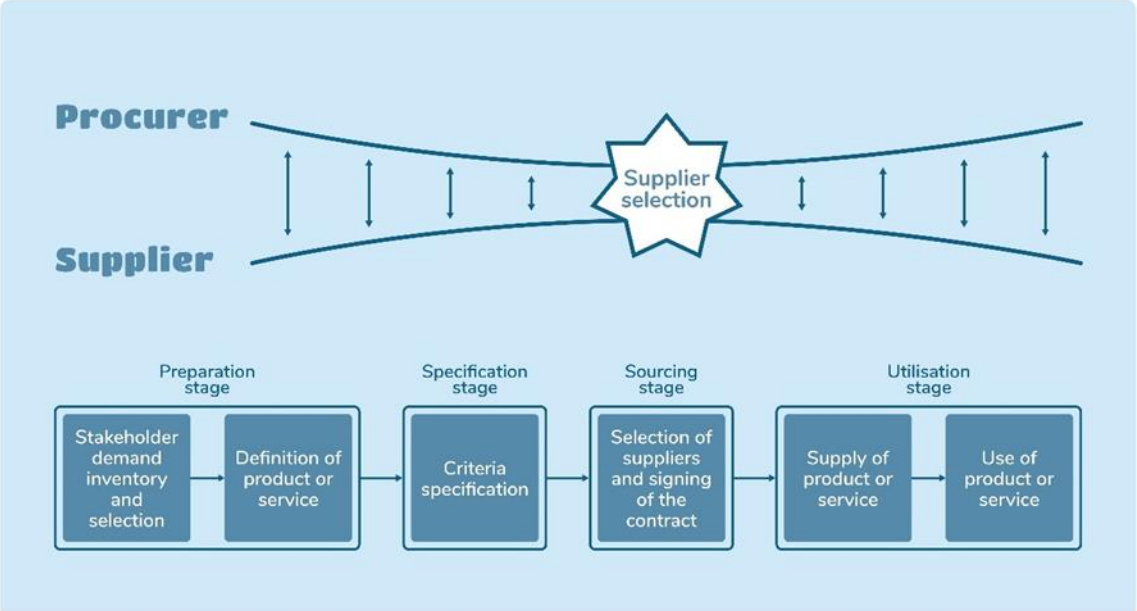

Figure 1. The changing contact between the procurer and supplier during the procurement process showing the different stages from preparation to utilisation (Source: Witjes and Lozano 2016).

Dalenstam et al. (2009) states that most innovation procurements that have been carried out have primarily aimed at gaining rapid dissemination of a new innovation and have therefore been mainly targeted towards opinion-leading customers. It is usually the large mature companies that have won the innovation procurement competitions, 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 innovation procurement is that a relatively rapid change in the market can take place when other customers quickly follow the opinion leaders.

It is argued by Dalenstam et al. (2009) that working towards opinion-leading customers results in good business development in many cases but usually not for small companies with innovations in early stages. In order to encourage the smaller companies, there is often a need for a different type of approach to innovation procurement. In many cases, a small innovative company cannot deliver the product volumes that a major innovation procurement requires. If the product is also under development, then the company may need the customer to guarantee to purchase a so-called "limited series production" or demonstration system.

A limited series production is a first series of the 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 in order to generate credibility with customers. To be 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 offering 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 (Dalenstam et al. 2009).

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COMMUNITIES OF PRACTICE/INNOVATION

Establishing communities of innovation or communities of practice is a method used in EU project such as FP7 BRIDGE and H2020 BRIGAID. The community of practice method may be of interest for SCOREwater demonstrations, as it brings together a variety of actors to regularly discuss and learn from each other's expertise.

In the BRIDGE project, community of practice (CoP) meetings were organized in each of the participating cities. Participation took place both individually through a questionnaire mapping individual perceptions, and in groups in workshops and focus groups that worked on the project's main issues based on pre-defined questions (e.g. what indicators are required to demonstrate that natural resources are protected/improved?).

Later an umbrella CoP meeting was organized at project level where CoP members from all the cities joined together to share knowledge, and an attempt was made to identify the principal objectives that need to be reached to achieve urban sustainability. The aim was to define the shared or common objectives and indicators which are applicable to all the case study cities and for participating cities to exchange ideas and experience of the BRIDGE products on a European level (BRIDGE 2010). This might be relevant for SCOREwater if the consortium wishes to build a common framework from which to compare the three different case studies.

In the BRIGAID project, communities of innovation (CoI) were defined as communities of practice with focus on enabling innovation, consisting of social networks of geographically connected actors, either in one or several different field, with common goals (BRIGAID 2017). The networks in the BRIGAID project included innovators, managers, practitioners, researchers, citizens and decision-makers. Thematically, the CoIs in the BRIGAID project focused on, for instance, exploring potential local actions for climate change adaptation.

THE STAKEHOLDER ENGAGEMENT WHEEL FRAMEWORK

Mott Lacroix (et al. 2016) provide an evaluation of, and lessons learned from three water management engagement processes, and uses this assessment to offer a framework for stakeholder engagement. The Stakeholder Engagement Wheel framework centers on a bridging organization that ensures that the process continues to move forward, and a steering committee that guides and changes activities according to stakeholder interests and concerns. Around the Stakeholder Engagement Wheel are four steps designed to examine iteratively the water management issue driving the engagement process and expand the sphere of interests involved:

- Multiple iterations of problem-solving throughout the process ensure that the problem and goal are robust,
- That ample engagement to understand the problem and to reach the most diverse set of stakeholders possible occurs,
- That actions are developed that meet stakeholder needs.

Steps within the Stakeholder Engagement Wheel

Step 1: Creating a Problem Statement and Goal.

Step 2: Engagement Activities. The aim of this step is to improve understanding of the problem and stakeholder perspectives.

Step 3 and 4: Getting Traction—Developing and Implementing Action Items. Step 3 on the Wheel is to develop action items or next steps. While exploring and synthesizing a problem may help to better understand it and increase the diversity of participants, at some point it becomes necessary to develop concrete actions to address the problems identified in Steps 1 and 2. Having established action items or next steps, the engagement process proceeds to Step 4—implementation of selected action items.

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Step 5: Coming Full Circle—Evaluation of Effectiveness. The effectiveness of the Stakeholder Engagement Wheel approach was evaluated against engagement elements that encourage social learning, i.e., inclusiveness, interactiveness, and flexibility of approach. Each having their own sets of criteria.

THE OECD STAKEHOLDER FRAMEWORK

The OECD report on stakeholder involvement for inclusive water governance (OECD 2015) provides an extensive synthesis of issues to consider when engaging stakeholders in the water sector. Like the research reviewed in chapter 3, the OECD report emphasises the role of stakeholder engagement in water because of the sector's decentralised and fragmented nature with many interdependent actors at different levels.

Because of the complex nature of the sector, it is important to carefully map the stakeholders, and identify core stakeholders (e.g. governments, service providers, river basin organisations, businesses, civil society, legislators, trade unions); newcomer stakeholders who are new to the water sector and require extra attention (e.g. property developers or long-term institutional investors); and underrepresented groups (e.g. women, youth, poor, indigenous users) (OECD 2015)

According to the surveys conducted for the report, the main success factors to take into consideration when engaging stakeholders in the water sector are establishing clear common goals, roles and responsibilities; ensuring that stakeholders are not only involved, but that they also have a real influence on the outcomes; ensuring that sufficient financial and human resources are available; providing high quality and accessible information to stakeholders with different levels of knowledge of the issues on the agenda; and ensuring that sufficient time is reserved for the stakeholder engagement process (OECD 2015).

The report includes a useful list of principles for stakeholder engagement (OECD 2015, p.13):

1. Map all stakeholders who have a stake in the outcome or that are likely to be affected, as well as their responsibility, core motivations and interactions.
2. Define the ultimate line of decision making, the objectives of stakeholder engagement and the expected use of inputs.
3. Allocate proper financial and human resources and share needed information for result-oriented stakeholder engagement.
4. Regularly assess the process and outcomes of stakeholder engagement to learn, adjust and improve accordingly.
5. Embed engagement processes in clear legal and policy frameworks, organisational structures/principles and responsible authorities.
6. Customise the type and level of engagement to the needs and keep the process flexible to changing circumstances.

The report also provides a checklist related to each of the principles. It consists of questions that can guide practitioners in following the principles. As an example, the checklist questions related to mapping stakeholders include questions such as: "Have the core water governance functions and the stakeholders formally responsible for executing them been clearly identified?" and "Have any institutional/organisational bottlenecks that would prevent stakeholder from engaging been effectively diagnosed?".

It also includes indicators that the implementers of stakeholder engagement activities can use to support the mapping activity, such as "stakeholders' motivations and expectations have been clearly identified (e.g. survey, analytical study, report)", and "broad outreach to inform individuals and organisations about the water policy/project process in order for them to decide whether or and/or how they want to be involved". Consulting the checklist and comparing their process to the indicators can be highly useful in SCOREwater demonstrations.

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The OECD report divides water sector engagement methods into formal and informal methods. Formal methods have legal or institutional grounds and stem often from formal agreements. Informal methods are not institutionalised and can be adapted to different needs.

We assess that the informal methods are likely to be advantageous in most SCOREwater cases, as the informal meetings and workshops contribute to deliberation and community-building, as well as bringing together new issues in informal dialogues.

Informal engagement methods in the report (OECD 2015) include:

- Meetings/workshops/fora where people together work on a problem or task.
- Web-based tools used as information sources or fora for input.
- Traditional media to spread information about the project.
- Focus groups for exploratory studies (using issues emerging at focus groups discussions to create e.g. wider questionnaires).
- Expert panel to get specialised input to the project.
- Stakeholder mapping to identify stakeholders.
- Information hotline that provide telephone access to project staff who can answer questions.

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ANNEX 2 – RESOURCES FOR SPECIFYING NEEDS AND REQUIREMENTS

PRODUCT DESIGN SPECIFICATION

Various methods within product development have been developed to identifying user needs. One of the most common methods is Product Design Specification (PDS) that we shortly will describe in this chapter.

Customer expectations and needs can be identified and transformed into requirements for product design with the help of various methods and tools. The main concern of requirement acquisition is how to collect reasonable and complete customer requirements and accurately express them. The requirement analysis mainly focuses on some useful approaches and methods to realize the mapping of customer requirements to PDS. Customer expectations and needs can be identified and transformed into requirements for product design with the help of various methods and tools (Zhang et al. 2013). Over the last two decades, an increasing number of methods and tools have been used in the field of customer requirement modelling along with many endeavors in industrial applications (Ma et al. 2017).

The demands on the product are formulated in a document that is known as a PDS (Product Design Specification). The PDS can be in the form of a list of demands. Once the list of demands has been drawn up, criteria can be graded on a scale and then weighted. PDSs can vary greatly in different contexts. They must be adapted to suit the complexity of the system or product that is under development. They must also be adapted to suit the environment in which they are to be used.

The PDS is an important element in a product development project because it defines the target to be met. One requirement on the PDS is to articulate and communicate the aspects, which makes the product attractive seen from the users' viewpoint. In the design methodology literature, we find guidelines and methods to compile a PDS. The contributions are based on the common underlying assumption that the only feasible approach to interpret the result of a needs analysis into a set of technical specifications, which express the customers' needs and perceptions of value (Hansen and Andreasen 2004).

However, from a developer standpoint, different levels of customer statements are not structured with sound logic. The PDS should be used with the understanding of these limits. It is important to agree on a broad basis about the demands the solution must fulfil and to consider as many aspects of the solution as possible. The most important aspect is the user demands on the solution, and these must be well documented in the PDS. They are the basis of a commercial success. It can be helpful to formulate the PDS in collaboration with potential users, if this is possible. The PDS should be comprehensive and sufficiently detailed to be used as a management document in the development work. If it is to fulfil this function it is also important to up-date it if the conditions change, as more knowledge and understanding are gained, or major decisions are made within the project.

With the increasing complexity of products, it is necessary to involve multidisciplinary design teams. However, the traditional customer requirements modelling for a single discipline team may become difficult to apply in a multidisciplinary team and project. This, since team members with various disciplinary backgrounds may have different interpretations of the customers' requirements. They may employ different sets of context and discipline-specific languages to express the customer requirement based on their own knowledge and disciplinary background. Those differences in understanding, semantics and terminology will impair the ability to convey requirement information effectively from customers to designers and obstruct the communication between different disciplines, resulting in a PDS which is incomplete, ambiguous, or inconsistent. It can lead to problems during the design process and require unnecessary design iterations which results in increased design time and cost (Ma et al. 2017).

The PDS method is a systematic approach to map, collect and translate user needs and requirements into specification. It is a useful tool for SCOREwater in the progressive translation from users to developers. It should be used alongside other methods and tools presented in this report, such as how to include users in the design process, to organize interdisciplinary design teams and an iterative process that allows user needs and requirements to be successively defined in response to offered solutions.

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INVOLVING USERS – A GOOD EXAMPLE

In an Internet of Things-based project for smart water and energy management Curry et al. (2018) argue that user engagement plays a critical role for successful resource management. The method was used to develop IoT-enabled applications within a smart home, school, office building, university, and airport, where the goal had been to engage a wide range of users to increase water and energy awareness, management, and conservation (ibid). The gained insights of applying the method was:

1. Minimize cognitive overload with clear and focused applications and visualizations
2. Understand your users' needs and their journey
3. Social influence and interaction are strong motivators
4. Close the feedback loop with personalization
5. Bring your "Humans in the Loop" of the smart environment
6. Careful use of targeted alerts and notifications.

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ANNEX 3 – RESOURCES FOR DESIGNING AN EFFECTIVE IMPLEMENTATION

SUCCESSFUL IMPLEMENTATION TOOLS

Implementation is not only an analytical task. You should also involve practice experience through facilitating discussions and focus groups among administrators, practitioners, end-users, and perhaps experts with knowledge about the new practice and implementation. The following examples of analytical tools and frameworks to guide implementation can be found in Osterse, J. & D. Graff (2017):

- Consolidated framework for advancing implementation science (CFIR)
- Promoting Action on Research Implementation in Health Systems framework (PARIHS)
- The Behaviour Change Wheel, www.behaviourchangewheel.com
- Organisational readiness to change assessment (ORCA)
- The Evidence-Based Practice Attitude Scale (EBPAS).

Moreover, one can also use the following resource to help identify components in an implementation strategy: www.cfirguide.org/tools

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ANNEX 4 – SEWAGE SOCIOLOGY

EXAMPLES OF BIOMARKERS OF LIFESTYLE HABITS AND OVERALL HEALTH STATUS CAN BE MEASURED TODAY IN SEWAGE

Biomarkers are biological compounds that can be measured and evaluated to indicate normal biological processes, pathogenic processes or responses to therapeutic interventions of exogenous substances (Atkinson et al., 2001). The measurements of biomarkers can potentially produce the most reliable and useful data, allowing the prediction, prevention and detection of almost any health aspect (Daughton, 2018). However, the scientific community is struggling to choose the right biomarkers in sewage water analyses because they need to accomplish a list of conditions. Biomarkers have to be produced exclusively from human metabolism, undergo extensive urine excretion and in high concentrations, have molecular stability, be excreted in quantities that change linearly depending on population health status and be minimally influenced by pharmaceuticals intake (Daughton, 2018).

Table 5. Biomarkers already measured within SIM; * these are examples of all possible references.

Group of indicators	Class	Biomarker	Refs*
Lifestyle habits	Illicit drugs	Benzoylecgonine (cocaine), amphetamine, methamphetamine, MDMA, THC-COOH (Cannabis)	(Baz-Lomba et al., 2016; Bijlsma et al., 2016; Ort et al., 2014; Thomas et al., 2012; van Nuijs et al., 2011)
	New psychoactive substances	Synthetic cannabinoids, Synthetic cathinones, Phenethylamines, Piperazines, Ketamine and phencyclidine-type substances	(Andrés-Costa et al., 2017)
	Alcohol	Ethyl sulphate (EtS)	(Baz-Lomba et al., 2016; Rodríguez-Álvarez et al., 2015; Ryu et al., 2016a)
	Tobacco	Nicotine, cotinine, etc.	(Baz-Lomba et al., 2016; Castiglioni et al., 2015; Lai et al., 2017; Ryu et al., 2016c)
	Caffeine	1,3,7-trimethylxanthine	(Baz-Lomba et al., 2016; Senta et al., 2015)
	Artificial sweeteners	Acesulfame	(Kokotou et al., 2012)
	Soya	Phytoestrogens	(Kang and Price, 2009)
	Stimulant beverages	Caffeine	(Rico et al., 2017; Senta et al., 2015)

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Group of indicators	Class	Biomarker	Refs*
Health	Pharmaceuticals	Atenolol, carbamazepine, etc.	(Rico et al., 2017; Thomaidis et al., 2016)
	Oxidative stress	isoprostanes	(Gago-ferrero et al., 2015; Ryu et al., 2016c, 2015)
	Serotonin	5-HIAA	(Rico et al., 2017)
	Obesity	Microbiome diversity	(Newton et al., 2015)

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ANNEX 5 – RESOURCES FOR DESIGNING EFFECTIVE EVALUATIONS

SUCCESS FACTORS FOR EVALUATION

Based on a literature review of interdisciplinary and transdisciplinary research Klein (2008) provides seven generic principles to base a coherent framework for thinking about evaluation:

1. **Variability of goals**: Interdisciplinary and transdisciplinary research are not driven by a single goal therefore sensitivity to context and flexibility are fundamental for evaluation procedures.
    a. Variances: size, scope, scale, level and subsystem, degree of integration in multidisciplinary–interdisciplinary–transdisciplinary environment
    b. Multiple goals: for example, epistemic or methodologic forms, product development, pragmatic problem solving
    c. Range of stages: ex ante, intermediate, ex post
2. **Variability of criteria and indicators**: questions of who performs the evaluation and the weighting of criteria. Two major approaches to quality assessment: conventional metrics; indirect, field-based, and proxy criteria vs primary or epistemic measures of warranted interdisciplinary knowledge in the substance of the work
    a. Expanded indicators: for example, experimental rigor, aesthetic quality, new explanatory power, feedback to multiple fields, enhanced research capabilities, changing career trajectories, new public policies and treatment protocols, long-term impacts and unforeseen consequences
3. **Leveraging of integration**: attention should be given not only to outcomes but also to the quality of the process.
    a. Key factors: balance in weaving perspectives together into new whole, reaching effective synthesis, antecedent conditions for readiness
    b. Criteria for leveraging and evaluating integration: organizational, methodologic, and epistemological components; strategies that promote communication and consensus; generative boundary objects
4. **Interaction of social and cognitive factors in collaboration**: Evaluation is defined as a collaborative and discursive learning process. Individuals first address questions by themselves, and then arrive at a common plan together, rather than imposing a priori a universal scoring method.
    a. Requirements: for example, calibrating separate standards, managing tensions among conflicting approaches, clarifying and negotiating collaboration differences among all stakeholders, compromising, communicating in ongoing and systematic fashion, engaging in mutual learning and joint activities
5. **Management, leadership, and coaching**: evaluation must consider how well the organizational structure fosters communication, including networking among subprojects. The organizational chart and task distribution must allow time for interaction, joint work activities, common instruments, and shared decision making. Repeating the process ensures that reviewers gain the necessary competence and a communication base over time, facilitated by the empowerment of applicants and the enforced interdisciplinary learning of reviewers.
    a. Requirements: managing tensions in balancing acts, consensus building, integration, interaction, common boundary objects, shared decision making, coaching the process
    b. Categories of leadership tasks: cognitive, structural, and processual.
6. **Iteration in a comprehensive and transparent system**; A quantifiable benchmark, though, can be set for each indicator in consultation with researchers and policymakers. Scores are plotted on a radar-like graph that represents variegated activities.

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a. Requirements: attuning a pluralism of values and interests, iterative work to ensure collaborative inputs, transparency to include common stakeholders, feedback to the mission in a dynamic framework, mobility of participants, interaction and communication patterns

7. **Effectiveness and impact:**
    a. Expanded indicators: sensitivity to a variety of goals in Principle 1 and variety of criteria and indicators in Principle 2; inclusion of unpredictable long-term impacts, returns on investment, value-added.

GENERIC METHOD STEPS OF EVALUATION

1. The conceptualization and measurement of the objectives of the program and other unanticipated relevant outcomes
2. Formulation of a research design and the criteria for proof of effectiveness of the program, including consideration of control groups or alternatives to them
3. The development and application of research procedures, including provisions for the estimation or reduction of errors in measurement
4. Problems of index construction and the proper evaluation of effectiveness; and
5. Procedures for understanding and explaining the findings on effectiveness or ineffectiveness.

(based on Hyman et al. 1962 in Galas et al. 2018)

SWOT ANALYSIS

The evaluation of the H2020 project PATHAYWS included a Strengths (S), Weaknesses (W), Opportunities (O), and Threats (SWOT) analysis (Galas et al. 2018). In this case: Strengths refers to work inside the project such as capabilities and competences of partners, whereas weaknesses refer to aspects, which needs improvement, such as resources. Opportunities and Threats are considered outside factors and uncontrollable. Opportunities are maximized to fit the organization's values and resources and threats are the factors that the organization is not well equipped to deal with.

The PATHWAYS project members participated in SWOT analyses every three months. They answered four open questions about strengths, weaknesses, opportunities, and threats identified in evaluated period (last three months). They were then asked to assess those items on a 10-point scale. The sample included results from nine evaluated periods from partners from ten different countries.

PARTICIPATORY APPROACHES

Participatory monitoring and evaluation methods vary considerably depending on operating context (based on Estrella and Gaventa 1998):

- Participatory rural appraisal (PRA) e.g. from group walks to matrix scoring.
- Audio-visual tools: include storytelling and use of videos.
- Quantitative tools: more 'conventional' methods such as local stakeholder surveys.
- Tools from the 'anthropological' tradition: oral testimonies and participant observation.

Example of participatory evaluation (Gariba 1995 and Jackson 1995 in Estrella and Gaventa 1998):

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Data was collected through interviews with households and key informants, focus group discussions, and field observation. Rural residents provided feedback on collected data. The major stakeholders – who include village representatives, implementing agencies, the donor and other allied agencies – participated in the process of allocating scores (ranging from one to five) on each of these indicators to the villages under study. The scoring process facilitated dialogue and consensus building among the various stakeholders, with village representatives providing feedback on the findings of the VDCI scoring exercise. Scores on the VDCI for each village can then be used by monitoring teams to track changes and impacts over time to assess progress.

WORKSHOP EVALUATION

Sufi (et al. 2018) offer 10 simple rules for measuring (evaluating) the impacts of workshops:

1. *Setting goals effectively*: WSH goals - output (what you want to produce), and outcome (what difference you hope it will make). These goals can be set in collaboration with participants, for example pre-workshop questionnaire.
2. *Balancing time, effort and costs*: it is important to consider the cost of a WSH, in terms time, effort, money when measuring impact, e.g. number of participants, duration, venue, price to the individual, resources available, stand-alone event or a part of a series.
3. *Create metrics purposefully*: not only easily measured metrics, but what helps answer our research questions. It is important to answer questions that will elicit useful responses. Types of matrices: scoring, categorisation or free-text responses.
4. *Understanding bias*: confirmation bias, sampling bias, social desirability bias. To control for bias, consider which biases will most likely affect the results of your study and determine strategies to counteract those biases to the best of your ability.
5. *Design your surveys well*: Pitfalls when designing questions e.g. compound questions, leading questions, complex questions, multiple-choice questions, choice of wording, open-ended questions.
6. *Ask about participants 'confidence'*: A common question that you can ask both at the start and end of a workshop is "How confident are you about <workshop topic>." This question allows you to gauge the participants' change in confidence and analyse whether the workshop changed the level of confidence about a particular subject, or technique, or ways of working together.
7. *Ask about specific skills*: Examples of specific skill questions are: "I understand the purpose of"; "I can describe the"; "I can apply the to my work": "I have a firm plan for how I am going to introduce what I have learned from this workshop into my work".
8. *Gather feedback before, during and after*: Before (demographic information, learning expectations, what they hope to discuss), During (how well the event is meeting its objectives, whether participants change their goals), at the end (ask how they want to use what they have learned, or how they would like to change some aspects of their current practise as a consequence of attending the workshop, or what their action plan is), after (online survey), much after (e.g. Interviews).
9. *Harness gamification to test participants' skills*: Using a game to assess if people have learned a particular skill from your workshop.
10. *Measuring those who did not attend*: impact of WSH beyond participants e.g. mentioned on twitter etc. if people that attend next WSH were recommended to participate.

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