SCOREwater

Smart City Observatories implement REsilient Water Management

DELIVERABLE D5.2

LESSONS FROM ADAPTING RESILIENCE TOOLS TO FLOODING AND STORMWATER MANAGEMENT

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Author(s)	Sanne, J,M., Chesa Marro, M.-J., Moldan, F., Rahmberg, M., Hubers, E.
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ABBREVIATIONS

Abbreviation	Definition
AI	Artificial Intelligence
BCASA	Barcelona Cicle de Aigua
CIV	Civity
CKAN	Comprehensive Kerbal Archive Network
COA	City of Amersfoort
DCL	Dynamic checklist
EUT	Eurecat, Centre Tecnològic de Catalunya
Gryaab	Göteborg wastewater treatment
ICRA	Catalan Institute for Water Research
ICT	Information and Communications Technology
IoT	Internet of Things
IVL	IVL Swedish Environmental Research Institute
OECD	Organisation for Economic Co-operation and Development
SCI	Smart Critical Infrastructure
SDG	Sustainable Development Goals
SHS	Swedish Hydro Solutions
SME	Small and Medium-sized Enterprise
SWW (KoV)	Sustainable Waste and Water, Göteborg city department
Trafikverket	The Swedish Transport Administration
TP	Talkpool

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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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EXECUTIVE SUMMARY

This deliverable reports on the activities conducted as part of Task 5.2.The objective is to identify social and organizational enablers for the development and effective use of technologies for digitalization of water management through an illustrative example. For this purpose we used tools developed for identifying, visualizing and evaluating/acting upon data addressing resilience in critical infrastructures, defined and quantified through indicators.

The framework for the deliverable is based upon a) a previous H2020 project regarding the design, implementation and added value from using the tools as well as b) findings from the SCOREwater deliverable D5.1 regarding issues of stakeholder engagement, user involvement and implementation/ evaluation (focusing on the two former). Through an iterative design process, we created a baseline with a scenario with regard to resilience against the release of insufficiently purified water from a worksite in the West link construction project in Göteborg. Based upon the baseline we created a business case for what we wanted to measure and improve through the tools. We created two checklists for measuring and acting upon data on resilience addressing the business case. Finally, we identified a few best practices for stakeholder engagement as well as examples of how to make best use of the technologies and services to be developed and deployed in the SCOREwater project.

The deliverable provides a process description of the successive iteration we carried out. We show half-finished checklists for resilience measurement, describe stakeholder feedback from these and a successive development of the business case and the checklists. The process illustrates that the tool is useful for this context and provide a beneficial illustration for how to create useful checklists that stakeholders benefit from to increase knowledge about resilience and how to improve resilience. The best practices for introducing and adapting the resilience tools were to do “homework” properly (that is to identify the relevant baseline) and to interact intensively to identify and define stakeholder issues such as:

1. What is the regulatory context setting the rules of the game?
2. Who are the relevant actors, their responsibilities and their possible contributions?
3. What are their problems and motivations (pains and gains)?
4. What added value can the tools provide?
5. How can the purpose of using the tools best be aligned with and add to the overall project/case study objectives?

Similarly, the replication of the tools in Amersfoort and possibly Barcelona require doing the “homework” and engaging in identifying baselines and business cases as well as how to implement them into existing practices.

The Göteborg municipal environmental board saw the tools as an opportunity to develop methods for early warning, such as enabling mitigation of negative environmental impacts on recipients from the release of stormwater and process water from construction sites. Construction companies saw that the tools provided potentials for improving knowledge of resilience of their water management as well as potentials to improve their resilience.

The barriers and enablers identified in the deliverable are easily generalized beyond the West link project. Compared to many other construction projects the project provides relatively good opportunities for good practices and learning over time as it is relatively large, lasting long and carried out with good expertise. The problems with regard to resilience to disturbances related to adequate water management encountered there will certainly be present also in other construction projects.

The social and organizational enablers identified to make best use of the technologies and services to be developed and deployed in the SCOREwater project were related to the communicative and organizational abilities to react to and make use of the improvements in sensor technology and AI solutions. Stakeholders stressed that if the organizational capacities to make use of the data and services provided by improvements in sensor capability and AI solutions are not improved, overall resilience would not be improved.

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1. INTRODUCTION

1.1. Purpose and background

The overall objective of SCOREwater is to develop tools, services and best practices to strengthen cities resilience with regard to challenges from urbanization and climate changes. This deliverable reports on the activities conducted as part of Task 5.2. The objective is to identify social and organizational enablers for the development and effective use of technologies for digitalization of water management through an illustrative example. For this purpose, we used tools developed for identifying, visualizing and evaluating/acting upon data addressing resilience in critical infrastructures, defined and quantified through indicators. The tools were developed in a previous H2020 project (Smart Resilience 2016-2019) to identify, visualize and evaluate/act upon data (defined and quantified through indices) addressing resilience in critical infrastructures, among them drinking water production and distribution.

1.2. Content and process

The tools have been used to measure the current resilience in the SCOREwater Göteborg case study for managing water from the West link construction sites (the West link will be an eight-kilometer-long train tunnel in central Göteborg including three commuter stations, built during 2018-2026, 2 billion Euros) and reflections have been added on its potential value for the Amersfoort and Barcelona case studies.

The deliverable describes how we carried out the task:

1. How we used the resilience measurement to provide a baseline for the current resilience of the construction site. The baseline provided the grounds for designing a business case for the use of the resilience tools, as valued by the stakeholders.
2. How we used and evaluated the Smart Resilience tools in the Göteborg case study. This description was used to identify best practices for adapting and using the tools as well as salient social and organizational enablers for strengthening resilience through these tools.
3. How the tools might be used tools in Amersfoort and Barcelona.

1.3. Context in the project

The deliverable is based upon conclusions from a) the Smart Resilience project regarding the design, implementation and added value from using the tools as well as b) from the SCOREwater deliverable D5.1 regarding issues of stakeholder engagement, user involvement and implementation/evaluation.

The deliverable provide implications for best practices on the use of the tools, for replication on using the tools in Amersfoort and Barcelona, and a baseline for assessing improved resilience through the technologies and services to be developed in the project.

1.4. Report structure

In chapter 2, we describe the Smart Resilience project, the tools and how they were used. In chapter 3 we will report on the workshops and meetings used to specify the task, define scenarios and specific purposes for how to use the tools. Chapter 4 starts with an analytical framework based upon the Smart Resilience project as well as from D5.1 regarding social and organizational enablers. Then we describe the process for defining a scenario and to adapt the tools to the Göteborg case study as well as partners and stakeholders reflections on their usefulness. The chapter concludes with findings regarding the baseline assessment as well as regarding the best practices and salient social and organizational enablers for strengthening resilience through these tools in this particular instance. Chapter 5 reports on the feedback and reflections on possible uses in Amersfoort and Barcelona while chapter 6 conclude with overall findings and implications for further work in the project.

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2. SMART RESILIENCE: CONCEPTS, METHODS AND IMPLICATIONS

2.1. Introduction

The EU H2020 Smart Resilience project (see www.smartresilience.eu-vri.eu/) started from the recognition that in an increasingly complex and interdependent world, it becomes ever more difficult and costly to identify and protect systems, communities or organizations against all possible threats (e.g. Thekdi & Chatterjee, 2019). Resilience approaches, however, provide capacities or abilities to respond to hazards and threats beyond existing scenarios and associated response plans, as well as learn from these disturbances and improve performance. Therefore, resilience approaches provide increased capabilities for strengthening systems, communities or organizations beyond traditional risk, crisis and business continuity approaches (e.g. Øien et al., 2018). For these reasons, resilience approaches are increasingly adopted in both research and practice across the globe (e.g. Australian Government, 2010; OECD 2019; Wilson & Wilson, 2018;). However, while promising, resilience approaches also poses a number of challenges, in terms of conceptualization and operationalization (e.g. Doorn, 2015) as well as in terms of contextualizing the measures to be used. Contextualizing includes here to identify variables that represent salient components of resilience in specific cases, enabling a relevant measure and for taking action that achieves required objectives (e.g. Hernantes, Rich, Lauge, Labaka, & Sarriegi, 2013), while also applying a coherent and conceptually appropriate approach across cases (Beccari, 2016).

The Smart Resilience project developed a modular, indicator-based decision support to identify, visualize and assess risks to Smart Critical Infrastructures (SCIs), tested in eight different infrastructures in different European countries. The methodology is a mixed approach (Doorn, 2015), with a generic approach to be used by everyone (top-down) permitting benchmarking and aggregation, although allowing for adaption to specific uses and users (bottom-up). Thus, all the applications depart from a shared definition of resilience, a specific design of the resilience cycle and the tools used to identify and assess resilience. However, simultaneously, users can design and choose their own indicators and they can aggregate indicators on a chosen level, depending on their purposes.

The methodology was based upon previous indicator-based projects, defining five successive phases over the resilience cycle in relation to a threat or disturbance (Øien et al., 2019: p. 14):

> The ability to anticipate possible adverse scenarios/events (including the new/emerging ones) representing threats and leading to possible disruptions in operation/functionality of the infrastructure, prepare for them, withstand/absorb their impacts, recover from disruptions caused by them and adapt to the changing conditions.

Based on this definition, the project derived the following five phases of the resilience cycle: 1) understand risks; 2) anticipate/prepare; 3) absorb/withstand: 4) respond/recover; and 5) adapt/learn. In addition, five dimensions of resilience were defined as heuristics to prompt the development of a multi-dimensional approach: 1) system/physical; 2) information/data; 3) organizational/business; 4) societal/political and; 5) cognitive/decision-making (see Figure 1).

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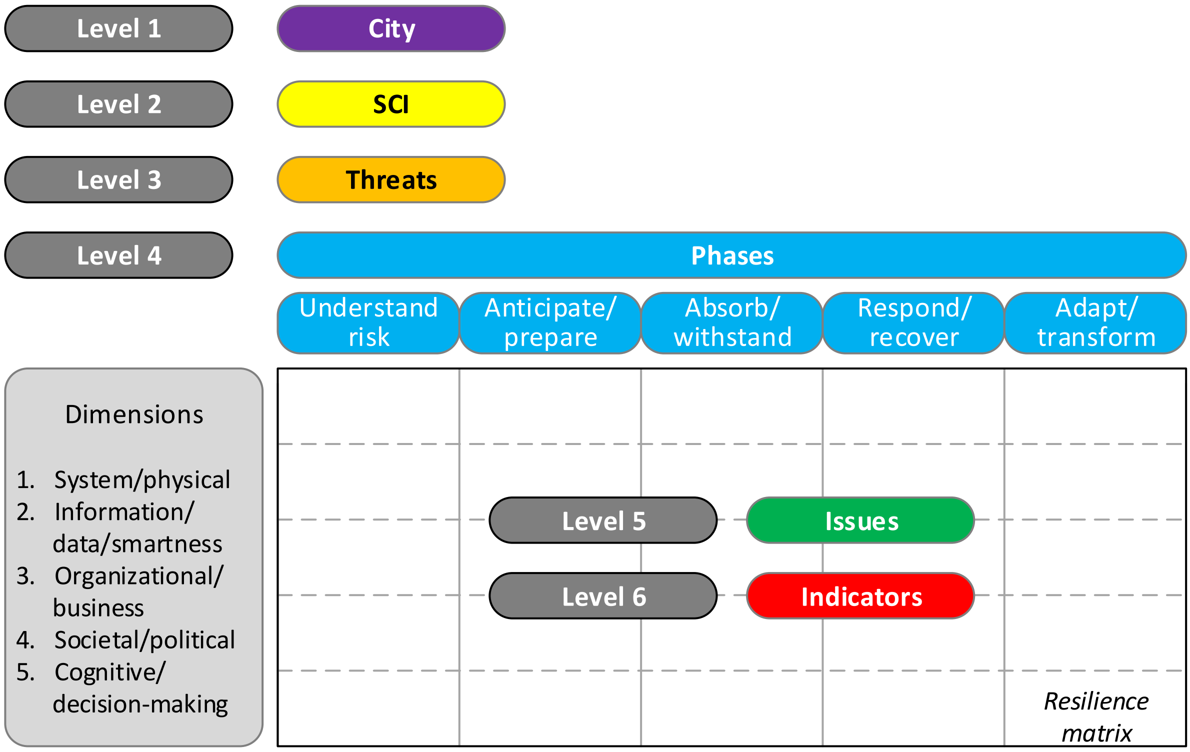

Figure 1. The five phases of the resilience cycle and the five dimensions of resilience. The figure also illustrates further levels of aggregation that are possible. Reprinted with permission from EU-VRI.

The Smart Resilience project involved iterative collaboration over the development processes with a range of stakeholders from eight different critical infrastructures, in different countries: finance (UK); energy distribution (DE); healthcare (AT); airport security (HU); oil refinery (RS); drinking water production (SE/FI); flooding (EI) and; underground coal storage (FI).

An important finding early in the Smart Resilience project (Buhr et al. 2019) was that while many innovation projects have an intensive collaboration between developers of various decision support systems and concerned stakeholders/users, there is very little documentation on the actual process and methods used, and even less so, identification of problems and best practices for doing so. Thus, here we will provide some of the main findings in this respect.

2.2. Indicator criteria

The basis for the methodology in Smart Resilience was grounded upon using issues (or functional elements) to define anything (factors, conditions, functions, actions, capacities, capabilities, etc.) that is important in order to be resilient against severe threats such as terror attacks, cyber threats and extreme weather. Issues are allocated to one of the five phases in the resilience cycle: e.g., it can be 'training' performed in the anticipate/prepare phase. To measure the issues, partners and stakeholders constructed indicators, assigning one or more to each issue. The indicators were assigned a scale from 0 (worst) to 5 (best). The methodology was used to develop several tools, serving different purposes, such as:

1. Following up the development of the own organization over time (trending) and analyse status.
2. Comparing with others (benchmarking).
3. Providing overview of strengths and weaknesses and point at improvement needs.
4. Evaluating various improvement options.

An indicator was defined as a way to operationalize/quantify an ability ('issue'), ideally with a value from 0-5. Seven criteria for designing useful indicators were used, based upon prior research (Øien et al., 2017):

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- Measurable with available knowledge, methods and instruments
- Possible to influence through the decisions and processes over which the organization has control
- Provide sufficient data to be used to control processes and make decisions
- Controllable – can be validated
- Individually valid and together sufficient coverage of the topic
- Easy to understand, simple and unambiguous
- Easy to find data for staff (preferably automatic generated)

2.3. Engaging stakeholders and designing a business case

The indicators used in Smart Resilience were designed through dialogue with stakeholders in the relevant case studies. These efforts were guided by common protocols for how to identify stakeholders, what questions to ask in interviews, how to identify relevant regulation, how to design indicators, how to conduct and evaluate workshops etc., based upon an 'actor analysis' approach, allowing for a coherent approach across the case studies but also allowing for adaptations to local context (Buhr et al., 2019, Sanne et al., 2020).

Most of the work was carried out in close collaboration with stakeholders. The interviews were made using relevant ethical requirements, such as informed consent procedures. We learned early that the drinking water sector in Sweden was not familiar with resilience concepts. This was also the case, to varying degrees, for the other infrastructure practitioners in the project. Therefore, we needed to do some 'homework' to learn what was already in place and how the resilience concept and the project tools could add to existing practices and tools within risk analysis, crisis management and business continuity processes.

First we identified stakeholders challenges, needs and requirements in assessing resilience (Buhr et al., 2019), that is a baseline assessment for the project, predominantly based on qualitative methods, consisting of semi-structured individual or group interviews with key stakeholders in critical infrastructures, carried out desktop studies of secondary material, searching in databases and through a literature review. Second, we conducted a review of the legal and knowledge base for assessing and improving resilience in critical infrastructures (Vollmer et al., 2018). Third, we identified a number of salient threats and assessed resilience for them, through setting up preliminary scenarios (Walther, 2017). Fourth, we used an eclectic approach to design a database of appropriate indicators, drawn from our "homework' and through workshops with experts and practitioners as well as suggested from previous resilience engineering and research, providing a theory-base for the methodology (Øien et al., 2017). Fifth, we iterated scenarios for various disturbances and useful Dynamic Checklists (DCLs) to address these scenarios through repeated workshops with practitioners (e.g. Sanne, Matschke Ekholm, & Rahmberg, 2019a). The scenarios were used as examples of disturbances, causing consequences for which the different infrastructures need to be resilient. DCLs are designed using the common methodology but adapted to the specific infrastructure and to a specific use (see more below). Six, we fine-tuned indicator development procedures, tips and guidance (Sanne et al., 2020a).

2.4. Conclusions and implications from Smart Resilience

The findings from Smart Resilience suggest that: (a) indicators should be developed with an appropriate end-user in mind; (b) indicators should be developed in dialogue with end users to increase the likelihood that they cover relevant areas and; (c) indicators should be developed in line with the end-users' organizational processes. In this way, the indicators can be designed according to a relevant 'business case' (Lee et al., 2103). Through collaborative scenario-building and the construction of tailored DCLs, the Smart Resilience approach has proved an added value over existing tools and approaches used in the critical infrastructures and can be used integrated with existing processes for improving resilience (compare to calls by Bialas, 2016). Through exercises and workshops, stakeholders validated the index values to a certain extent (compare Beccari, 2016).

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The project used a modular approach to operationalize indicators, assigning sets of DCLs within four groups (Core, Recommended etc.). This allowed for using a generic approach while also adapting to various uses and users (compare to Beccari, 2016). It also allowed for sharing indicators across infrastructures. The generic approach also allows for learning and fine-tuning over time, thus addressing calls for how to design a model covering various phases over the resilience cycle (Wilson & Wilson, 2018) and continuous improvement (Bialas, 2013) as well as how to quantify and test indicators for various uses (Beccari, 2016).

The project developed several tools that can be applied at a chosen level of aggregation for various purposes: resilience level assessment, stress-test, multi-criteria decision support etc, and for tailoring these to individual users and uses (Beccari, 2016). This answered to calls for various levels of analysis and the way it was carried out validated several business cases for the tools (Lee et al., 2013).

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3. METHODS AND DATA

The barriers and enablers identified in the deliverable are easily generalized beyond the West link project. Compared to many other construction projects the project provides relatively good opportunities for good practices and learning over time as it is relatively large, lasting long and carried out with good expertise. The problems with regard to resilience to disturbances related to adequate water management encountered there will certainly be present also in other construction projects.

The deliverable is based upon data from workshops and meetings with partners and stakeholders, as specified in the work plan. Work was led by IVL, and the following partners and stakeholders participated.

IVL:

- Leading and coordinating
- Suggesting goals and framework
- Leading the work with the dynamic checklists
- Coordinating partners and stakeholders
- Editing and finalizing report

CGEA:

- Providing data and experiences: historical data and previous stormwater management practices
- Setting goals for calculations: calculate value for different measures or the resilience of current stormwater management practices
- Contribute to specification of outcomes and objectives: purpose of the use of the tool in this task
- Iterative consultation: evaluating value of checklists or calculations
- Proving the business case: the added value to existing assignments for stormwater management

TP:

- Contribute to specification of outcomes and objectives
- Iterative consultation

EUT, CIV, ICRA:

- Contribute to specification of outcomes and objectives
- Iterative consultation

COA:

- Contribute to objectives
- To dynamic checklists
- Specification
- Iterative consultation

SHS (through task 4.3)

- Contribute to objectives
- To dynamic checklists
- Specification
- Iterative consultation

Stakeholders beyond partners: NCC, Skanska (construction companies), Gryaab (Göteborg wastewater company), SWW (Göteborg city, department of environmental services)

- Participating in workshops
- Providing data and experiences
- Setting goals for the calculations

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- Contribute to specification of outcomes and objectives
- Iterative consultation
- Proving the business case

The task was carried out through an iterative process with extensive partner and stakeholder engagement in the following steps (see Table 1):

Table 1. The iterative design process leading to the business case, the baseline and the final checklist.

Activity	Time	Goal	Partners and stakeholders
Agreeing on the work plan, through emails and an online meeting	October-November 2019	Agreeing on what to do and by whom	All involved partners
Start meeting in Göteborg	December 13th, 2019	Setting a scenario and goals for the measurement of resilience	IVL, CGEA, KoV
Setting up a preliminary checklist	February 2020	Setting up on a preliminary checklist with relevant issues and indicators (resilience assessment), preliminary business case	IVL
Workshop to discuss the preliminary checklist	March 10th, 2020	Adjusting the checklist	IVL, CGEA, SWW, SHS
Presentation of the resilience tool to stakeholders	April 2nd, 2020	To engage and involved relevant stakeholders	IVL, CGEA, SHS, TP, NCC,UNI, Skanska, Gryab, Trafikverket
Improving first checklist	May 2020	To improve after first workshop	IVL
Workshop with stakeholders	May 20, 2020	Discussion on the improved checklist, preliminary baseline, improved business case	IVL, CGEA, SHS, NCC, Skanska, Gryab,
Iterative consultation with partners	May 26, 2020	Update on progress and feedback from partners	IVL, EUT, CIV, SHS
Designing a second checklist	May-June 2020	To do a stress-test based upon a real event	IVL, NCC, Skanska
Workshop with stakeholders	June 18th, 2020	Discussion on second checklist (stress-test), refining business case and baseline	IVL, SHS, NCC, Skanska, CGEA (water management agency),
Iterative consultation with partners	June 23th, 2020	Update on progress and feedback from partners	IVL, EUT, CIV, SHS
Further workshop with stakeholders	June 24th, 2020	Further refining checklist and baseline	IVL, NCC, Skanska,

The data consists of two checklists and partners and stakeholders comments and feedback on the resilience testing. Through an iterative design process, we created a scenario with a business case, two checklists and a baseline for the resilience with regard to the release of insufficiently purified water from a worksite in the West link project.

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4. HOW THE TOOLS WERE USED IN THE GÖTEBORG CASE STUDY

4.1. Analytical framework

The analytical framework for analyzing the adaptation and use of the Smart Resilience tools in the Göteborg case study is based upon the Smart Resilience project as well as from D5.1 regarding social and organizational enablers (Sanne et al. 2019b).

The Smart Resilience project 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 to a disturbance 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.

Therefore, to create the business case and relevant checklists for the resilience task in SCOREwater (Task 5.2), three principles were 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 (e.g. to do your homework properly, identifying a relevant baseline problem). Third, that best practices for developing, implement and using the tools will be identified as well as how to implement, transfer and upscale these beyond the demonstration cases.

The framework for analyzing social and organizational enablers in D5.1 was divided into four categories: a) stakeholder engagement, b) user involvement, c) implementation and d) evaluation. This deliverable has mainly included stakeholder engagement, to some degree user involvement and only touched upon the two latter categories. This is for natural reasons: we engaged stakeholders new to the tools and we only engaged in the first rounds of iteration regarding their adaptation. We aim to return to the other issues with regard to the resilience tools in later stages of the project when we have more data on them.

In sum, previous experience suggests that the Smart Resilience tools provide opportunities for various users and uses in various contexts but that their successful adaptation require creating a business case proving their added value through iterative collaboration with relevant stakeholders.

4.2. First meeting: defining a scenario and exploring regulatory demands

At the first meeting, December 13th, 2019, IVL met with Göteborg city (both CGEA, the Environmental Administration, and the Water processing company, SWW) to determine the objectives in more detail and to set a time-plan. We decided to create a scenario based upon resilience against the release of insufficiently purified water from the West link construction site, threatening to reach the recipient, as a means to align with the overall objectives for the case study.

Large construction sites that are either water-related or otherwise require an environmental permit are regulated by decisions from the Land and Environment Court (Mark- och miljödomstolen, 2018). The developer is the operator and the actor responsible for managing the construction within the limits set in the permit (that is the regulatee). Together with the County Administrative Board the CGEA carry out the supervision of the project, a role that includes to further define some of the safeguards that needs to be taken as regards to water protection.

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CGEA describes the generic problem and the regulatory demands for a developer like this. In connection with construction work, discharges of process water, stormwater or bilge water need to be in line with the decisions from the Land and Environment Court. Emissions are checked via the operator's self-monitoring activities and reported to the supervision authority. For the most part, sampling is done manually and the analysis is done in laboratory. The sampling results are usually reported on a weekly or monthly basis. CGEA adds that improvements to the self-monitoring activities would be preferable. Although samples are taken regularly, a more efficient method of detecting an emission may enable an earlier detection and thus enable a limitation of the negative consequences of the emission.

According to CGEA, a worrying scenario could be that the sedimentation plant/sludge separation for the process water on a larger construction site stops working, so that elevated turbidity values are detected using sensors in the stormwater network or the recipient and enables early detection and mitigation of negative environmental impacts on such as, for example, the impact on migratory fish, destroyed spawning grounds and other environmental values.

To prevent this from happening, developers often have their own automatic turbidity sensors at the building worksite. Some of the water released from the construction sites within the West link project is purified using mobile stations before being released to the stormwater system and then led to the recipient, for some sites minor streams and for some the larger river, Göta Älv. The SCOREwater partner SHS is the company responsible for the pilot on-site water purification at the West link construction site Central station. However, the flows from construction sites that are discharged to the recipient via SWW-pipes are the responsibility of SWW and are not further treated by SWW. At present time both CGEA and SWW can only react on a possible high pollutant discharge due to failing treatment after the reporting from the construction operators has come in, which can be too late to handle these flows. Therefore, a live-alarm system operated by both construction operators and the City of Gothenburg would be much more effective for acting on high pollutant levels before it reaches a recipient. Some contractors use various alarm systems but these are not used for warning other stakeholders.

Thus, CGEA sees SCOREwater as an opportunity to develop methods for early warning, enabling mitigation of negative environmental impacts on recipients from the release of stormwater and process water from construction sites. Thus, using the tools for this purpose will be used as an example of what can be done to measure and increase resilience with regard to release of insufficiently purified water from a construction site.

Trafikverket (the Swedish Transport Administration) is the procurer and developer for the West link, and thus the legal operator. Trafikverket has been approved an environmental permit regarding water management to carry out the West link, which includes a number of conditions. The permit also requires Trafikverket (as regulatee) to set up an extensive control programme, i.e. activities concerning water management (Trafikverket, 2019). The control programme is important in the dialogue with the supervision authorities, according to CGEA. Control programs have two purposes: 1. Describe how the regulatee checks that permit conditions or other authorities' decisions are followed. 2. Provide a basis for supervision.

In addition to what is set in the environmental permit the control program (Trafikverket, 2019) further define the emission limits for various substances or measurements allowed in the water to be released from the site, over longer time and over shorter intervals, when actions need to be taken etc. In the case of the West link the control program constitutes the limits to emission values set for the constructors and subcontractors procured for the construction work. We decided that the control programme should set the conditions for the resilience measurement for the deliverable.

Thus, in terms of social enablers, this first meeting and the subsequent communication involved doing the "homework", finding out the legal context, the relevant value chain for the adaption and the possible added value to existing practices. Still there is no business case though.

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4.3. First workshop: introducing the resilience tool

In February 2020, IVL designed a first checklist, for a resilience level assessment, and during the first workshop on March 10, IVL met with Göteborg city (both CGEA, the Environmental Administration, and SWW) and with SHS to present the checklist for assessing resilience levels and to get feedback on how to improve it.

As presented before, the resilience level assessment measures the resilience for each of the five phases of the resilience cycle: understand risks, anticipate/prepare, absorb/withstand, respond/recover, and adapt/learn. The basis for the methodology is based upon using issues (or functional elements) to define anything (factors, conditions, functions, actions, capacities, capabilities, etc.) that is important in order to be resilient against severe threats such as terror attacks, cyber threats and extreme weather. Issues are allocated to one of the five phases in the resilience cycle: e.g., it can be 'training' performed in the anticipate/prepare phase. The indicators are assigned a scale from 0 (worst) to 5 (best). This means that the resilience level is composed of the value assigned to the indicators, assessed issue by issue, or for each phase or for the whole system. The first checklist contained 25 issues and 34 indicators (most issues had only one indicator while a few had two or more). Table 2 below contains the issues.

Table 2. The issues presented at the first workshop.

No of issue	Name of issue	Phase
1	Event reports	**Phase 1 - Understand resilience**
2	Failure data gathering	
3	Discussion of risk/safety/resilience issues in regular meetings	
4	Risk/safety/resilience performance requested by senior management	
4	Communicating risk/resilience at all levels in the organization	
6	Contamination risk of water	
7	Water quality	
8	Risk/hazard identification	**Phase 2 - prepare, anticipate**
9	Emerging risks	
10	Early warning systems	
11	Information within organization	
12	Competence of personnel	
13	Assessing Barrier status	
14	Water microbiological quality	
14	Coordination between external actors (at various levels)	**Phase 3 - absorb, withstand**
15	Communication between actors	
16	Separation of wastewater and stormwater Urban storm water treatment systems.	
17	Water Chemical quality	
18	Water Physical quality	
19	Communication	**Phase 4 - recovery**
20	External support	
21	Monitor effects and adapt (shift of attention)	
22	Evaluation of emergency planning	

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23	Implementation and follow-up of recommendations for adaptation/ improvement	**Phase 5 - learn, improve**
23	Emergency response operation reporting including lessons learned	
24	Implementation and follow-up of lessons learned	
25	Feedback and learning from successful operations	

The checklist was based upon IVL's experience from using the resilience tools for drinking water production and most of the workshop time was used to "translate" it into the context of environmental regulation and wastewater/stormwater management as well as the realities of a construction site. The participants were keen to "translate" or connect the issues mentioned into actual activities and responsibilities for various actors in relation to the regulatory system, the environmental limits for various water recipients or the control programme for the West link construction site, that is contextualize them. The participants divided the system clearly in two parts: at the construction site until release and in the network beyond that. There are currently no means to mitigate any dangerous releases from the construction site as the water continuous flow without further measurement, purification or containment before it reaches the water recipients. This makes it difficult to identify a suitable business case for using the resilience tools at this moment.

CGEA stressed that the environmental limits constitutes the overall considerations that govern their regulation for all releases of impurified water. As mentioned, CGEA saw opportunities for early warning technologies and SHS engaged in finding ways to accommodate that at the worksite. The representatives from SWW expressed an interest in placing sensors in the stormwater network and connecting these to an early warning system that could be used for improving treatment or containing stormwater before release to a recipient, a system for which a resilience assessment could be made. Another major advantage of a warning system is that it would enable KoV to act proactively to prevent environmental damage which is about to take place. This would mean a major improvement relative to present situation, when KoV only can act retroactively when various failures occur and are brought to the attention of the KoV personnel, quite often by communication from concerned citizens. It would also increase resilience since acting proactively most often requires less resources than containing an ongoing failure. In that case would resistance increase since the existing resources would be capable to handle (potentially) more damaging situations than at present.

Information from the worksite is currently only provided from phase 1 (risk analysis before activities), 2 (regular updates to improve resilience) and from phase 5 (event reports from contractors). The environmental concession and the control program was seen as mostly concerned with what to do to prevent releases, that is phase 2. Phases 3-5 are left to the developer and its contractors, for their work with self-assessment. There are no routines for real-time warning should a release take place, except for major releases that require the attention of the emergency services, such as major releases of oil and other dangerous substances. Thus, mitigation of most events is limited to the worksite resources. These expressions of interest are also in line with the early use cases designed for the Göteborg case study. That is, the major contribution of the resilience assessment is as a tool for strengthening contractors' self-assessment.

At this workshop, the possible added value was further specified, and the tool was adapted to some extent to the context and practices regarding stormwater management.

4.4. Second workshop: engaging stakeholders

On April 4th, the deliverable objectives were presented to a stakeholder meeting for the whole Göteborg case study. In this meeting, all the Göteborg case study partners (IVL, TP, SHS, CGEA, UNI) participated, as well as the water treatment plant (Gryab), SWW, the West link developer (Trafikverket) and representatives for the construction companies NCC and Skanska. The resilience tool was met with great interest, further "translation" into the realities of construction and suggestions as to the added valued were made, as well as how it should be designed so as to provide a baseline for further improvements in sensors and AI solutions to be provided through the SCOREwater project.

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It was stressed that sensors and measurements do not provide the full picture of the resilience by themselves. Using a resilience tool could provide a fuller picture, for example through using indicators from continuous measurements as proxies for other variables that are not currently measured continuously. AI tools can be developed to strengthen such correlations. Moreover, the resilience tool can also be used to measure other important parameters that determine resilience, such as communication at the construction site.

For the latter reason, it was decided to use a disturbance indicated by high turbidity as an example for the resilience measurement. Turbidity indicates the level of particles and therefore also indicate other kinds of contamination. At the meeting, it was decided to focus the resilience measurement on the part of the system at the construction site, because of a large interest among the construction companies. The purpose would be to measure resilience with regard to keep within the limits set by the control program, which in turn are related to environmental limits for certain substances in specific recipients. Moreover, it was decided to focus on false alarms, provided that turbidity sensors provide too many false alarms and that AI solutions could be developed within the SCOREwater project to reduce those alarms.

At this workshop, the interdisciplinary competence among the participants helped to define a clear and attractive business case for the construction companies: a) the future possibilities to use AI to increase the value of proxy indicators and b) the possibilities to combine technical and organizational enablers to provide a better picture of resilience and possibilities for improvement.

4.5. Third workshop: adapting the checklist

In the third resilience workshop on May 20th, 2020, IVL presented a checklist for a resilience assessment developed from the discussions (and translated into Swedish) at the first workshop on March 10, as well as based upon the feedback at the April meeting. The other participants represented CGEA, SHS, SWW, NCC, Skanska, Göteborg Energy and Gryaab. At this workshop, it was clarified that the purpose of using the checklist is to protect the water recipients but that it needed to be further adapted to the user. IVL clarified that to make it useful to the stakeholders it should be adapted to the West link project. The construction companies expressed a large interest in participating in continuous work with the resilience tool because they thought that a) because of the size of the West link project it is possible to have a significant environmental focus and b) because of the length of time and expertise in the project it is possible to make changes and improve over time due to experience. SWW considered that a continued work focusing on the construction site would be interesting for them to follow but that their network did not need to be covered at the moment.

Both CGEA and the construction companies appreciated that the checklist highlighted organizational and communication issues in addition to technical issues addressing measurement of substances or particles. A lot of the mistakes and mishaps at a construction site, they argued, were due to these issues. There are instances where reports do not reach the appropriate receiver, who need the information and can take actions. Workers might miss the training required to manage issues. One of the major risks with large construction project lies in the very long chains of subcontractors on different levels, causing inadequate skills unclear division of responsibilities that cause release of insufficiently polluted water. There are challenges in communication along the chains, e.g. regarding what kinds of water to be pumped where and how to use a pump (lowering it too much in a pond may result in water too dirty to be released or to be purified). CGEA suggested that a historical event (a release of insufficiently purified water released from a construction site) could be used to see if the involved companies had secured that it would not happen again. The construction companies agreed with this idea and it was decided to arrange a fourth workshop to this purpose.

At this workshop, the business case grew further as it was considered that the West link project provides good opportunities to try out the tools and to make improvements. More details on the organizational enablers for using the sensors and AI technologies were provided, adding to the checklist issues.

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4.6. Fourth workshop: stress-test

For the fourth workshop on June 18th,2020, IVL and NCC designed a stress-test based upon an actual event where insufficiently purified water was released from one of the construction sites within the West link project. The stress test measures whether the loss of functionality due to an event (i.e. the consequences for the system's performance) is less than required throughout the resilience cycle. Present at the workshop were also representatives from Skanska, SHS and KoV. The stress-test was based upon a release of water with high turbidity from the Korsvägen construction site in central Göteborg (part of the West link project). For a stress-test, the Smart Resilience tool uses functional elements to define important functional elements, a kind of performance dimensions with regard to the consequences of an event, each with a number of indicators, over the whole resilience curve (see Figure 2).

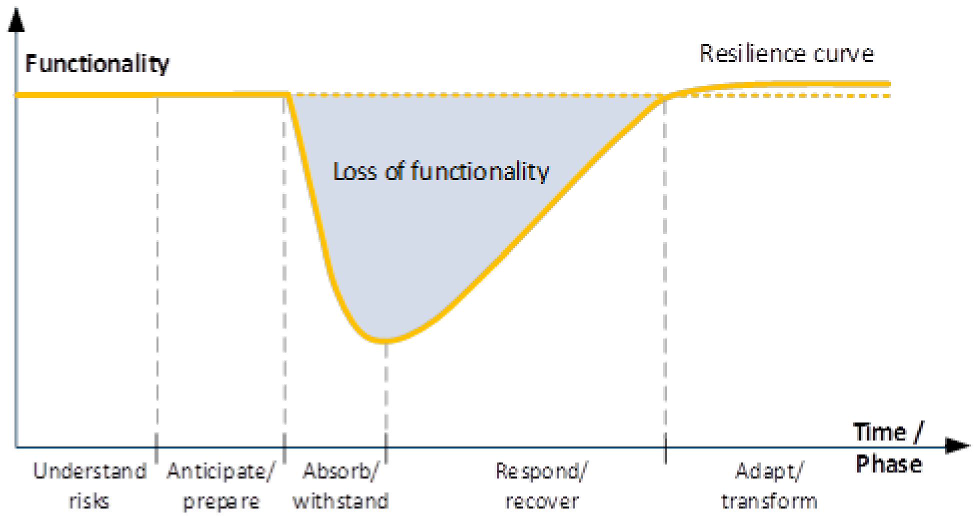

Figure 2. The resilience curve expressed as loss of functionality (performance) and elapsed time for each phase. Reprinted with copyright with permission from EU-VRi.

In this case, IVL and NCC defined the following functional elements: a) water quality out from the site; b) communication ability; c) organizational abilities; and d) sensor and IT functionality. The workshop revised a few of the suggested indicators, deselected some of them and commented on the others. On June 24th, IVL, Skanska and NCC met again to further revise indicators and to define the gradings on the six-grade scale (from 0-5) for the indicators. This was very valuable in further specifying the checklist so that it represents the resilience of the actual construction site (for the final checklist please see Table 3).

Table 3. The final checklist for the stress-test.

Functional element	Indicator	Phase 1 - Understand resilience	Phase 2 - prepare, anticipate	Phase 3 - absorb, withstand	Phase 4 - recovery	Phase 5 - learn, improve
Functionality level for whole system		78%	80%	43%	68%	88%
FE 1 - Water out		68%	76%	52%	60%	68%
	Turbidity	5	5	1	3	5

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	What is the effect of stopping construction?	5	5	0	2	5
FE 2 - Communication ability		90%	90%	65%	80%	90%
	How well do we communicate within the subcontractor?	5	5	4	4	5
	How well do we communicate with other subcontractors and the main contractor?	5	5	2	4	5
	How well do we communicate with external parties?	5	5	4	5	5
FE 3 - Organizational abilities		80%	80%	0%	60%	100%
	How fast can we stop production?	4	4	0	3	5
	How fast can workers stop production?	4	4	0	3	5
FE 4 - Sensor and IT functionality		73%	73%	53%	73%	93%
	To what extent can we trust sensors?	4	4	3	4	5

Water quality: Only two indicators were retained to focus on the particular event being analysed. Only the turbidity indicator was relevant and there were no possibilities to contain impurified water as a mitigation measure, only to stop production. So, the indicator measured the ability in time to stop impurified water to be released from the site as an effect of stopping production. For water quality, the grades concerned how often turbidity was measured and the time taken to stop production with the effect on absorption and recovery phases.

Communication functionality: The issue of communication to external stakeholders was discussed. It was argued that if there was an event that required the emergency services to act, such as an oil spill, real-time communication to 112 would take place. However, there is a risk that events not perceived as a matter for the emergency services won't be managed properly – there is no procedure and contact for semi-urgent events. There is currently no procedure for that, nor any persons or functions to contact. After the fact, the construction company will report the event. Communication was graded to address time to contact relevant persons, but also the scope of communication. e.g. how many relevant external stakeholders that were contacted and with sufficient information.

Organizational functionality: There is a need for a well-functioning routine that contains the following: there needs to a person or function that receives a warning, who knows what to do depending on the situation and whom to contact to stop production. For the actual event, it took four hours to stop production. The routine was measured in terms of existence, scope, dissemination and training as well as if it had been successfully designed and tested. This indicator might be separated into several.

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IT and sensor functionality: The turbidity indicators measured can be considered reliable but can be improved. However, turbidity measurements are also known to provide lots of false alarms due to sensors going dry, placed to deep, etc. For this indicator, the degree of certainty as an effect of false alarms was considered an appropriate grading scale. There are also limited opportunities to continuously monitor water quality parameters, often sensors only signal when limits are passed. This indicator was graded according to the number of parameters measured and whether they are measured automatically.

Currently, there are also limited capacities to predict future water quality, as it depends on both the quality of incoming water to the construction site and the specific construction process at the time. For this indicator, the degree of certainty as an effect of error sources was considered an appropriate grading scale. Stakeholders expressed that they would like SCOREwater to help improve these capabilities. Still though they also stressed that if the organizational capacity did not improve, these improvements would not improve the overall performance.

During the workshop, stakeholders also assessed the values for the various indicators, as average values for each phase (as seen in the last five columns in Table 3) . In Figure 3 below, the resilience curve for the whole system, aggregated for the four functional elements is shown.

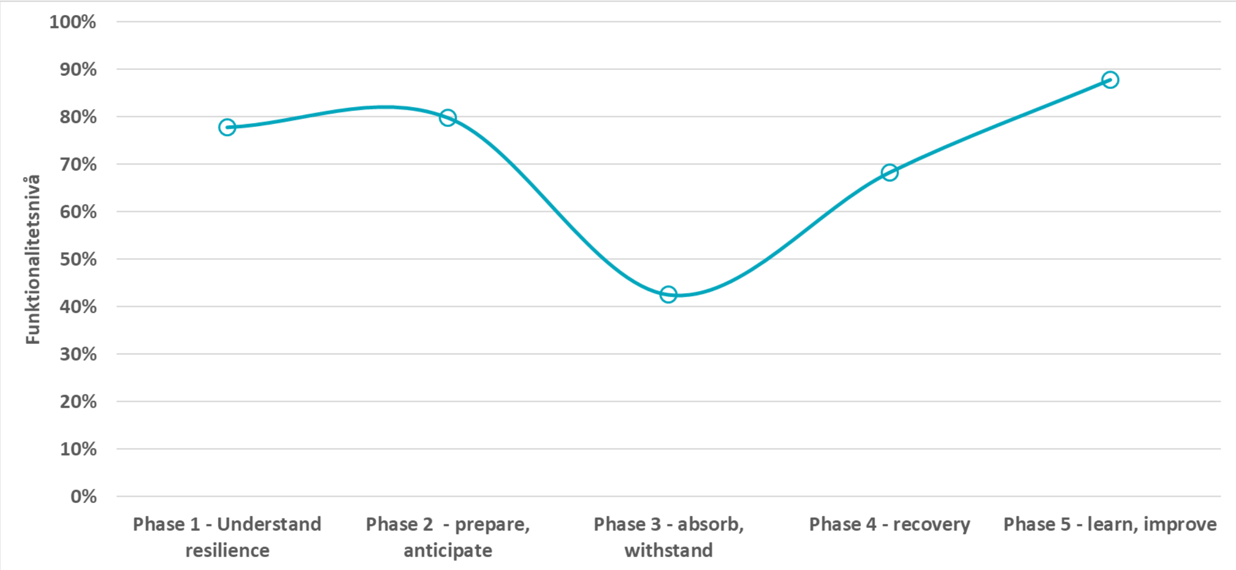

Figure 3. The resilience curve from the stress-test of the incident at Korsvägen construction site. Authors' copyright.

The stakeholders were asked what was most important to improve, the drop in performance (water quality and the abilities to manage it) after the event, that is in phase 2, or the time taken to resume acceptable performance, that is how to shorten phase 3 and 4. They all agreed that time to resume was more important to decrease than the drop in actual water quality.

In sum, at the final workshops, the choice of a stress-test provided a very good opportunity to adapt the tools to real circumstances at a real construction site. Thus, the stress-test constitute a good baseline for assessing possible contributions through sensors and AI solutions but also to identify the necessary social and organizational enablers needed to make these technologies useful.

4.7. Conclusions from the Göteborg case study

The best practices for introducing and adapting the resilience tools were to do "homework" properly and to interact intensively to identify and define:

6. What is the regulatory context setting the rules of the game? Here: environmental regulation and specifically certain objects with impact on water quality. The need for a permit from the Land and Environment Court, the control programme specifying limits and controls.

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7. Who are the relevant actors, their responsibilities and their possible contributions? Here: the Land and Environment Court, the city environmental board, the County Administration as regulators, Trafikverket as regulatee and the contractors governed by the control program
8. What are their problems and motivations (pains and gains)? The regulators are worried about late warnings and late response during a release, the contractors have inadequate routines for warning and acting from sensors warnings.
9. What added value can the tools provide? Here: provide a holistic picture, assess and improve resilience.
10. How can the purpose of using the tools best be aligned with and add to the overall project/case study objectives? Through focusing on turbidity and organizational abilities:

The baseline assessment identified troubles with e.g. false alarms but also the opportunities for an improvement of resilience through AI solutions to strengthen correlations between proxy indicators and other impurities that are not continuously measured.

The social and organizational enablers identified to make best use of the technologies and services to be developed and deployed in the SCOREwater project were related to the communicative and organizational abilities to react to and make use of the above-mentioned improvements. In fact, stakeholders stressed that if the organizational capacities to make use of the data and services provided by improvements in sensor capability and AI solutions was not increased, overall resilience would not be improved.

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5. POTENTIAL USES IN BARCELONA AND AMERSFOORT

5.1. Barcelona

The analysis of wastewater to infer the quality of life of the population that produces it, the SCOREwater study case of Barcelona, cannot be of greater relevance. The SARS-CoV-2 pandemic has highlighted this fact. Globally, the presence of the virus in wastewater is being used to provide an early warning system for the pandemic (Medema et al., 2020). Health authorities, research centres, universities, companies and water operators, are joining forces in the face of this difficult situation caused by the pandemic and increasing our resilience as a society.

The contribution of the SCOREwater project in the Barcelona case, if it was very attractive in its initial formulation as a platform to increase public awareness of a good use of sanitation, is now with the situation caused by the viral pandemic, most relevant in the area of health and individual commitment to increase the resilience of our cities, and our own lives.

The SCOREwater project will help us to raise awareness of the ONE HEALTH concept: "an interdisciplinary approach to planetary health" (Deem et al., 2019). The project will be an invaluable tool for obtaining date on wastewater quality, and thus explaining the need to avoid pollution at source. Cities need the commitment of all to make good use of the water cycle. We need tools to avoid the discharge of improper products, such as wet wipes, oils, fats, medicines to the toilet. Industries and commercial business must also increase their environmental monitoring to minimize the water cycle pollution. It is necessary to count on the whole of society to increase respect for the environment to guarantee our own health.

For the Barcelona City Council and BCASA, the public operator of the water cycle in the city, the project will provide us with information on the quality of wastewater in three different neighbourhoods. With this data, we could have a better monitoring and control of polluting discharges by companies. It will also help us quantify improper discharges into the sewer system at the domestic level. With this date we will be able to better carry out the governance of the city and be able to stablish communication and awareness campaigns to revert the increase discharge of wet wipes and oils to the sewer network of the last decades. On the other hand, wastewater quality indicators can also help us to deal with new emerging risks, such as other bacterial and viral diseases, with can be detected through the analysis of fecal waters.

5.2. Amersfoort

We have two possible cases in Amersfoort that we would like to explore for the resilience tool:

1. Replacement or repair of sewerage pipes
2. Testing of pumping station in case of flooding (for example Malesluis)

End users are the water board and the municipality (in both cases).

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6. FINDINGS AND IMPLICATIONS FOR FURTHER WORK

6.1. Introduction

The deliverable describes the process of using the Smart Resilience tools in the Göteborg case, applied to resilience with regard to the release of insufficiently purified water from a construction site, through the creation of a relevant scenario with a baseline, a business case and two dynamic checklists, as well as stakeholders feedback and valuation of these. The deliverable summarizes findings with regards to:

1. A baseline for the current resilience of the construction site to be compared with the improvements that will be made possible through the sensors and AI solutions.
2. Identifying best practices and salient social and organizational enablers for the implementation, adaptation and use of these tools.
3. The potential use in Barcelona and for the replication in Amersfoort in task 6.3.

Moreover, it also describes the implications for a number of future tasks within SCOREwater.

To create the baseline, business case and relevant checklists for the resilience task in SCOREwater (Task 5.2) three principles were 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 (e.g. to do your homework properly, identifying a relevant baseline problem). Third, that best practices for developing, implement and using the tools will be identified as well as how to implement, transfer and upscale these beyond the demonstration cases.

6.2. Baseline

The West Link project is a large project, going on for long time and with good expertise (and being watched closely by citizens, media and opposing NGOs), providing good opportunities for good practices and learning over time. The problems encountered there will certainly be present also in other construction projects, thus the barriers and enablers identified will easily be generalized.

The issue of communication to external stakeholders was discussed. It was argued that if there was an event that required the emergency services to act, such as an oil spill, real-time communication to 112 would take place. Currently, both Göteborg city's environmental board and the waste and water operator can only react on a possible high pollutant discharge due to failing treatment after the reporting from the construction operators has come in, which can be too late to handle these flows. However, there is a risk that events not perceived as a matter for the emergency services won't be managed properly – there is no procedure and contact for semi-urgent events. There is currently no procedure for that, nor any persons or functions to contact.

Some contractors use various alarm systems but these are not used for warning other stakeholders, often insufficient also for use at the worksite due to insufficient routines for acting upon these, insufficient practices for containing contaminated releases, unclear responsibilities among contractors, insufficient training among workers for how to measure and manage contaminated water.

The baseline assessment also identified troubles with e.g. false alarms but also the opportunities for an improvement of resilience through AI solutions to strengthen correlations between proxy indicators and other impurities that are not continuously measured.

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6.3. Business case: adding benefits

A live-alarm system operated by both construction operators and the Göteborg Environmental Board would be much more effective for acting on high pollutant levels before it reaches a recipient. Thus, the Environmental Board saw the tools as an opportunity to develop methods for early warning, enabling mitigation of negative environmental impacts on recipients from the release of stormwater and process water from construction sites. Using the tools for this purpose will be used as an example of what can be done to measure and increase resilience with regard to release of insufficiently purified water from a construction site.

The interdisciplinary competence among the participants helped to define a clear and attractive business case for the construction companies: a) the future possibilities to use AI to increase the value of proxy indicators and b) the possibilities to combine technical and organizational enablers to provide a better picture of resilience and possibilities for improvement.

6.4. Best practices for iterative development

In Smart Resilience it was discovered a lack of method descriptions and identification of barriers and enablers to collaborative design of decision support systems and other technologies in H2020 projects, preventing the identification of behavioral and social barriers and enablers for managing these. Task 5.2 shows that the best practices for introducing and adapting the resilience tools were to do “homework” properly (that is to identify the relevant baseline) and to interact intensively to identify and define:

1. What is the regulatory context setting the rules of the game?
2. Who are the relevant actors, their responsibilities and their possible contributions?
3. What are their problems and motivations (pains and gains)?
4. What added value can the tools provide?
5. How can the purpose of using the tools best be aligned with and add to the overall project/case study objectives?

This deliverable has provided (through sections 4.2-4.6) a process description of the successive iteration. We show half-finished checklists, describe stakeholder feedback from these and a successive development of a "business case". This is what contextualization as a verb is about. It does not matter then, that we only created one "business case". What matters is that the process and the analysis of the process illustrates an important conclusion. The important result here is not the final checklist but that the tool is useful for this context and how one can do (provide a beneficial illustration) to create useful checklists that stakeholders benefit from to increase knowledge about resilience and be able to improve it.

6.5. Social and organizational enablers

The social and organizational enablers identified to make best use of the technologies and services to be developed and deployed in the SCOREwater project were related to the communicative and organizational abilities to react to and make use of the improvements in sensor technology and AI solutions. In fact, stakeholders stressed that if the organizational capacities to make use of the data and services provided by improvements in sensor capability and AI solutions, overall resilience would not be improved.

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6.6. Implications

As an input to the further development of machine learning and AI solutions in WP2 and WP4, it is important to remember that stakeholders stressed that if the organizational capacities to make use of the data and services provided by improvements in sensor capability and AI solutions are not improved, overall resilience will not be improved. This means that this development needs to focus on solutions that are supported by a business case for which users need to value suggested solutions based upon their willingness, competences and abilities to improve organizational capacities to match these solutions, that is their organizational readiness for change. Thus, highlighting the importance of developing business cases and continue the iterative collaboration between users and developers. Similarly, the replication (or transfer) of the tools in Amersfoort and possibly Barcelona require doing the “homework” and engaging in identifying baselines and business cases.

These conclusions are also relevant for the further work with social and organizational enablers in WP5, as well as the work with value proposition, business model, market and stakeholders analysis in WP6. For example, there is a need to further analyze the specifics of organizational readiness for change among stakeholders (to be done in Task 5.3). This might also require an analysis of the policy changes (such as sharpened environmental regulation) that might be necessary to provide the incentives for investing in improved sensors, AI solutions and associated organizational capacities beyond the case study (that is upscaling beyond the project). This will be an issue for the policy briefs in WP8. Moreover, the baseline developed in this task can be used to evaluate the improvements to resilience from contaminated water that the tools and services developed and tested in the Göteborg case study will bring.

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ANNEX 1 – STOCKTAKING

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

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

STRATEGIC OBJECTIVES

Table 4 lists those strategic objectives of SCOREwater that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable.

Table 4. Stocktaking on Deliverable's contribution to reaching the SCOREwater strategic objectives.

Project goal	Contribution by this Deliverable
Ambition 3a: identify social & organisational enablers	Through an iterative development process with partners and stakeholders we have created a proven business case for the tools adapted to resilience against release of contaminated water from construction sites, and we have identified social and organizational enablers that are needed to make sensors and AI solutions useful to stakeholders (organizational routines and responsibilities to react to sensor data and AI support).
Expected Impacts, Strategic Objective 5	We have identified some of the necessary barriers to a successful use of SCOREwater sensor and AI solutions

PROJECT KPI

Table 5 lists the project KPI that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable.

Table 5. Stocktaking on Deliverable's contribution to SCOREwater project KPI's.

Project KPI	Contribution by this deliverable
11	Behavioral barriers and enablers identified and mitigation options demonstrated (#15) • Workers are not trained to identify or prevent release of contaminated water (#1) • Workers are not trained how to measure contaminated water properly (#1)
13	Organizational barriers and enablers identified and mitigation options demonstrated (#10) • Barriers and enablers identified - lack of routines and responsibilities at the worksite to warn and act when sensors show a risk for contaminated water; lack of warning to external stakeholders; unclear responsibilities and coordination at the worksite might prevent actions taken from such warnings (#3) • Mitigation options - introducing routines and responsibilities at the worksite to warn and act upon warning; issuing early warnings to SWW when contaminated water risks to reach recipients; improved responsibilities and coordination at the worksite might prevent actions taken (#3)

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Project KPI	Contribution by this deliverable
	• Insufficient regulation provides too little incentives to invest in technology and organizational routines to prevent the release of contaminated water (#1)

ETHICAL ASPECTS

Table 6 lists the project's Ethical aspects and gives a brief explanation on the specific treatment in the work leading up to this Deliverable. Ethical aspects are not relevant for all Deliverables. Table 6 indicates "N/A" for aspects that are irrelevant for this Deliverable.

Table 6. Stocktaking on Deliverable's treatment of Ethical aspects.

Ethical aspect	Treatment in the work on this Deliverable
Justification of ethics data used in project	N/A No need for personal data
Procedures and criteria for identifying research participants	Managed through stakeholder and partner arrangements in other WPs
Informed consent procedures	Managed through workshop arrangements in other WPs
Informed consent procedure in case of legal guardians	N/A
Filing of ethics committee's opinions/approval	N/A
Technical and organizational measures taken to safeguard data subjects' rights and freedoms	N/A - no personal data collected
Implemented security measures to prevent unauthorized access to ethics data	N/A
Describe anonymization techniques	N/A
Interaction with the SCOREwater Ethics Advisor	N/A

RISK MANAGEMENT

Table 7 lists the risks, from the project's risk log, that have been identified as relevant for the work on this Deliverable and gives a brief explanation on the specific treatment in the work leading up to this Deliverable.

Table 7. Stocktaking on Deliverable's treatment of Risks.

Associated risk	Treatment in the work on this Deliverable
7 Unacceptable quality of results (L/M)	Reasonable quality of results - somewhat vague feedback on the usefulness in the other cases: to provide more specific feedback requires more extensive involvement in the creation of checklists (see also below)
9 The solutions developed are too case specific (L/M	Taken care of through feedback for the potential value of the tools beyond the case from partners beyond the case, addressed in the implications and conclusions chapter

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Associated risk	Treatment in the work on this Deliverable
15 Stakeholders outside the project are not interested (M/L)	Varying interest in participating in the task but sees opportunities for future use of the resilience tools
16 Low interest from local stakeholder to participate in demonstration cases. (H/M)	Great interest from many local stakeholders to participate in the demonstration case - see also above

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