Digital Water .City

PERCEPTION, ACCEPTANCE AND USE OF DIGITAL SOLUTIONS

Final version

-2nd DRAFT-

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Deliverable N°3.5	Perception, acceptance and use of digital solutions
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Deliverable lead	Gabrielle Bouleau
Author(s)	Gabrielle Bouleau, Gaële Rouillé-Kiélo, Ulf Stein, Benedict Bueb, Fausto Favero, Stephan Gensch, Francesco Fatone, Adriano Mancini, Enrico Marinelli, Serena Radini, Sofia Housni, Linda Rath, Alexander Sperlich, Christoph Sprenger, Jean-Pierre Tabuchi
Contact for queries	gabrielle.bouleau@inrae.fr
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Abstract	See executive summary

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X	PP	Restricted to other programme participants
	RE	Restricted to a group specified by the consortium
	CO	Confidential, only for members of the consortium

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Executive summary

The objective of the report is to identify enabling and hindering factors for the uptake of ICT solutions to water governance, through the analysis of the process of development and the introduction of three digital applications in three different contexts of water management.

This final deliverable builds on a preliminary (deliverable 3.4) for WP3 which was submitted in November 2020. The report applies the structure proposed in the Guiding Protocol (Deliverable 3.1).

This document is a draft version. A final version will be submitted in May 2022.

The report first describes the general case context of Berlin, Paris and Milan before turning to the assessment of the digital water governance system in the three case studies. In a second step, the social context of the use of the digital solutions will be evaluated.

As such, collected findings in this report are still preliminary and, so far, not every hypothesis defined in the Guiding Protocol has been inquired thoroughly. Nevertheless, current research has reached good progress, reflected in the current status of this report. The first sets of stakeholders' interviews and community of practices were conducted and allowed to delineate the structural configurations of water governance specific to the different case studies. They expose elements that might prove to be factors and conjunctions that affect – positively or negatively – the uptake of digital solutions and the coordination among involved actors.

The process of development of the three applications – ICT solutions – in Berlin, Milan and Paris proceeds in parallel to the sociological research on the respective systems of water governance. Thanks to regular communication and exchanges, digital solutions will be developed accordingly with the study cases' own specificity, to ensure that, once finalized these will be effectively used by people and will thus support a digital and sustainable transition of the water systems.

Note: the preparation of this report has been impacted by the COVID pandemics. In consequence, a previous draft version was delivered in November 2020. The present document represents the second draft version, and compared to the previous version it brings additional input regarding:

- information on the COPs and the collection of the public opinion in Paris.
- Introduction to section 3 "governance assessment".

In addition, the introductive sections of the deliverable have been amended. It has been agreed that the final version is due end of May 2022.

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1. Introduction

1.1. Objective of WP3

The use of integrated, real-time information and communication technology (ICT) solutions, such as sensors, monitors, geographic information system (GIS) and satellite mapping and other data sharing tools in urban water management, is believed to contribute to social, environmental and economic sustainability (Bjornlund et al., 2018). However, factors that enable or hinder the uptake of innovative ICT solutions aiming at greater sustainability in urban water management as well, as the risks of greater reliance on ICT solutions, are still poorly understood.

Against this backdrop, the digital-water.city project (DWC) pilots the development of 15 innovative ICT solutions for water management in the five cities Berlin, Copenhagen, Milan, Paris and Sofia. WP3 focuses on overarching societal and ecological factors whereas WP1, WP2 and WP4 deal with technical aspects.

In particular, WP3 explores enabling and hindering factors as well as risks of ICT solutions to water governance. It does so by closely analysing the development and uptake of three of the piloted ICT solutions aiming at fostering public involvement in water management: (1) an early warning system of bathing water quality in Paris with a public app to inform on bathing site opening, (2) an Augmented Reality (AR) mobile application for groundwater visualisation in Berlin and (3) a 'serious game' to raise awareness of water reuse in Milan. The key question is how to ensure that innovative ICT solutions for water management are not only well developed, but are also successfully implemented and actually used by end-users ('uptake') in the long-term. To analyse barriers to and enablers of such sustainable innovation, DWC analyses which governance modes hinder or encourage end-users to take up innovative ICT solutions ('innovative governance' and 'innovation friendly governance'). Therefore, WP3 analyses both governance structures and ICT solutions in the local setting of each case study to give policy recommendations. Moreover, it provides practical inputs for the co-development and successful uptake of the solutions

The question is approached from two angles within WP3. Firstly, based on case studies, 'lessons learnt' about the sustainable uptake of ICT solutions of the DWC project to governance are drawn out (Project Deliverables 3.4 and 3.5). Secondly, a policy matrix (Deliverable 3.2) maps existing political and legal structures on water governance and ICT governance to shed light on their intersections and resulting opportunities and problems.

1.2. Objective of this document

This deliverable entails lessons learnt from case-studies on water governance and sustainable uptake of ICT solutions. It identifies barriers or enablers for ICT uptake.

Table 1 summarises the difference between the previous deliverable 3.4., this draft version is still very much based on and the final version.

Sections 2 and 3 of this report are based on the structure outlined in the **Guiding Protocol** for the Assessment of Digital Water Governance Systems (D. 3.1). Section 4 lays out a specific methodology to investigate end-users needs in relation to the **design thinking method**.

The guiding protocol serves as an overarching framework to link the methodologies and results of the different WPs and to allow for comparability between different case studies conducted within WP3.

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To facilitate research on digital water governance systems in urban areas, the guiding protocol introduces a 'Governance Assessment Framework'. This framework helps identify non-technical factors that enable or hinder the uptake of information and communications technology (ICT) solutions to sustainability issues in the water sector. Enabling and hindering factors can include different aspects such as the degree of fragmentation of the governance system, existing ICT as well as data protection regulations, interoperability aspects, congruent ICT ontologies and cybersecurity (Knoblauch et al. 2019).

We conducted interviews in each city (4 for Paris, 3 in Berlin, 4 in Milan) in order to gather this preliminary information and the right questions to ask in each site. Further interviews and investigations will also be carried out subsequently to collect all the answers to these questions and conclude on what must be taken into account for the development of the applications. Between these two stages, regular exchanges between the social science team carrying out these interviews and the technical team in charge of developing the applications will be organised. The technical team benefiting from our discovery of social and managerial concerns without waiting until the end of November 2021.

Step 3 of the guiding protocol also refers to the recommendations. They will be completed in D 3.5, section 3, after each table documenting the reflexion on hypotheses.

Section 4 describes initial findings on end-users of digital solutions, which needs to be documented in order to feed the **design thinking method**. This is an addition to the structured analysis prescribed by the guiding protocol and aims to shed light on results of the interviews, CoPs and focus groups **not related to governance** (and thus not addressed by assessment framework proposed in the guiding protocol). It describes how different people relate to water and digital apps.

With this report, the social science team will get a better understanding on the level of development of the apps. Thus, this report is also an attempt to **foster co-production** between different disciplines involved in the project.

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Table 1 Comparison of Deliverable 3.4. and 3.5

	Deliverable 3.4 (Previous version)[1]	Deliverable 3.5 (Final Version, May 2022)
3.3 Description of the general case study context	✓	✓
3.4 Digital Water Governance Assessment of the case studies	Translation of guiding protocol into place-based contextualised questions, preliminary findings based on selected interviews without comprehensive assessment of hypotheses	Comprehensive findings based on additional interviews, desk research and focus group meetings
3.4 Recommendations for practical development and uptake of the digital solutions	App development is supported by sociological knowledge of the WP3 experts	Comprehensive recommendations for the apps from the focus groups. More general recommendations will published in D3.5.
3.5 Evaluation of the social context of the use of digital solutions	Better definition of the end-users	Comprehensive findings of end-users needs based on additional interviews, desk research and focus group meetings
Appendix. Technical description of the apps for public involvement	Description is based on early versions	Description will be based on comprehensive testing and later versions.

1.3. Methods

The following sub-sections briefly present the panel of available tools: individual interviews, CoPs, focus groups, participatory observation, and the use of written sources.

1.3.1. The analysis of written sources

Before going to meet stakeholders for interviews and collective meetings (focus group or Community of Practice (CoP)), it is important that the investigators document themselves on the mandates of each organisation based on official information on the web and on current issues concerning the water issue in relation to the envisaged application as reported by the press and blogs. Part of this work was done for the policy matrix. It continues with the monitoring of the regional press and blogs identified through automatic alerts.

[1] The current draft document of D3.5. is to a large extent still based on D3.4.

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Table 2 Analysis of written sources

Cities	Legal and official information	Grey literature, studies	Press and blogs
Berlin	IT-Sicherheitsgesetz (IT-SiG/BSI-G) IT Security Act describing Security Requirements for Public Infrastructure Umweltinformationsgesetz (UIG) (Act on public access to environmental information) defines responsibilities of water utilities and public administrations to provide environmental data to the public Smart City-Strategy Berlin	German Water Partnership[2]: Water 4.0.	Regional press
Milan	Legge 5 January 1994 n. 36 (Legge Galli) on water system reform Decreto Legislativo 3 Aprile 2006, n. 152. on Environmental protection regulations	Corte dei conti Report Banca d'Italia Report ARERA resolution Parliamentary documentation Scientific publications	Regional press
Paris	Circulaire DGS/EA4 n° 2009-389 describing bathing profiles according to 2006/7/CE Policy and metropoly modernisation law (MAPTAM n° 2014-58) New territorial organisation law ((NOTRE – n° 2015-991) aquatic environments and flood prevention law (GEMAPI n° 2017-1838)	ARCEAU reports Bathing comity reports	Regional press, open waters twitter accounts, google alerts, TV documentaries on bathing in the Seine.

[2] https://germanwaterpartnership.de/wp-content/uploads/2019/03/gwp_water_40_2019.pdf

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1.3.2. Individual interviews

Such interviews aim at identifying the **variety of stakeholders** engaging with water in each case-study and at highlighting their **different perceptions** of water, water governance, digital water governance and ICT solutions.[3] They reveal information on feelings, fears, conflicts, oppositions, misunderstandings that are poorly voiced in public.

Individual interviews are conducted with local residents, managers, bathers, boatmen, farmers, decision-makers, water utilities, guides in museums who have different levels of concern and engagement with the project. Their expertise or practical knowledge of water, water use, water governance and ICT solutions can be useful for developing the applications. It helps us to answer the hypotheses raised in the **D.3.1 DWC guiding protocol and its DWC governance assessment framework** and give further information on end-users need in order to feed the **design-thinking method**.

The interviewees are not mentioned with their names in this report to ensure their anonymity.

Table 3 Individual Interviews conducted so far

Cities	Interviews
Berlin	Berliner Wasserbetriebe (Berlin Water Utility): Scientic staff member and tour guides Museum guide for future innovations Interview with trade union representative initially conducted for DWC Work Package 5.
Milan	Consumer's association: Altroconsumo Federation of Utilities: Utilitalia River basin authority: ADBPO Farmer association: CIA Lombardy Environmental consultancy: AmbienteItalia University of Udine: Uniudine + Bocconi Consultancy: REF richerche Italian Regulatory Authority for Energy, Networks and Environment: ARERA Regional irrigation association: ANBI Lombardia
Paris	ICT developer : SIAAP Sanitary authorities in Paris region : Health Regional Agency Bathing promoters : Syndicat Marne Vive; Conseil Départemental du Val de Marne ; Ville de Paris ; Outside Paris region bathing promoter : EPIDOR (bathing already in place)

[3] Please refer to Section 3.1 for a clarification of relevant key terms.

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1.3.3. Community of practices (CoP)

CoPs main objective is to accelerate internal innovation by integrating stakeholder knowledge in product development and building the trust of external stakeholders in the future use of the digital solutions. The goal is to have actors in charge of or related to the development of the apps **learn from each other**, for the benefit of the ICT solution development, use and uptake. CoPs are collective meetings bringing together water managers in charge of taking decision in relation to the apps to discuss common management difficulties. CoP members also have a representative function for DWC that serve as multiplies and “door openers” within their respective community. CoPs aim at confronting views on what the app should incorporate, what is useful, what works and what does not and how it can be fixed. The method used for moderating CoPs rely on encouraging each participant to speak from his/her experience through open questions, reformulation and benevolence towards each participant. CoPs **raise issues** that will be further addressed in focus groups.

In DWC project, CoPs are organised and steered by each city partner supported by ICATALIST. Their planning in Paris was late because it took time to convince participants it was worth sharing knowledge in 2021 even if bathing would be allowed after 2024. But once launched, these COPs were very much appreciated by participants and they were useful for social learning.

Table 4 Community of Practices held so far

Cities	CoP
Berlin	4 meetings: September 2019, February 2020, November 2020, October 2021
Milan	5 meetings: July 2020, November 2021, March 2021, next one planned for December 2021
Paris	5 meetings : November 2021, December 2021, January 2022, February 2022, one planned in March 2022.

1.3.4. Focus groups

The focus groups main objective is to come up with a common understanding of very specific (focused) issues. As CoPs, they are also collective meetings and the method used to moderate the meetings is the same (benevolence with all participants, reformulation, open questions). Yet, they bring together people chosen for their specific expert knowledge or user experience, in relation to **one aspect** of water management or ICT solutions. Those expects are not necessarily the end users of the apps. Focus groups pick up specific questions that have been raised in the CoPs and the research process. This method enables to make implicit knowledge explicit. In DWC focus groups are organised by the WP3 site-leader. Each focus group gathers members of the specific targeted public who may use the app. Focus groups can include specific app users, such as teachers, guides or those officials from public authorities, tourists, boat-owners, that have not been involved in the technical side of app development.

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Table 5 Focus Groups

Cities	Focus groups
Berlin	1. Target group: Berlin senate staff, guides, BWB communication staff), date: September 2021 2. Target group: Pupils age xxx, date: planned for early 2022
Milan	1. December 2021.
Paris	1. Target group: young bathers, boat-owners, date: May 2021 2. Target group: riparian associations Nov 2021 3. Target group: Bathers and riparians April 2022

1.3.5. Participatory observation

Participatory observation consists in sociological observation of social interactions while actively participating as a member in meetings or outdoor activity. It enables to see a difference between what people have in mind when they are interviewed and what they really do in practice. Participatory observation has been implemented as an additional research method in Paris.

Cities	Participatory observation
Paris	6 expert meetings in 2021 dealing with bathing risks 2021 “big Jump” public event in the Marne;

1.4. Structure of the report

The report is structured as follows.

Part 2 corresponds to the general case study description with the presentation of intended ICT solutions (step 1 of the guiding protocol).

Part 3 synthesises the findings of the governance assessment (step 2 of the guiding protocol). The next draft of this deliverable will complete this part with practical recommendations (step 3 of the guiding protocol).

Part 4 documents what we know from the social context in which ICT solutions are to be used and what are users’ expectations, in order to feed the design-thinking process.

Annex presents a detailed account of each digital solution.

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2. Description of the case studies and ICT solutions

This part presents key social, environmental and economic characteristics of each case study (e.g. size, population, etc.), and its main challenges (e.g. in particular those related to innovation uptake).

It shortly displays the ICT solution and its key purposes (e.g. water quality improvement, water scarcity, flood risk reduction). More details are to be documented later according to the table in the Annex.

It illustrates technical barriers to its uptake (e.g. mismatch with existing infrastructure, complexity of technology) before turning to non-technical factors in the governance assessment (in chapter 3).

The design process for the ICT solution follows the "design thinking" methodology (Brown 2008), a process that is divided in different phases. This phases do not represent orderly steps to follow in sequence, but rather moments of different activities – understand, empathize, define, ideation, prototyping, testing - that feedback into each other in a continuum of innovation, of redefinition of what the problem is and which solutions could solve it.

Design Thinking is a strategy that allows multi-stakeholder teams to find creative solutions to complex challenges. Developed at Stanford University, Design Thinking offers the opportunity to identify user needs, form relevant insights and generate innovative ideas. The main focus here is on experiencing a new way of working. The triad of "invite, engage, enable" opens up a learning and opportunity space in which participants can experience a creative work culture with interactive working methods. Methodically, strategies and approaches from the field of design, such as Human Centered Design, are used, which put the human being at the centre of strategy or project development. The different aspects of the process of co-creation are illustrated in the figure below.

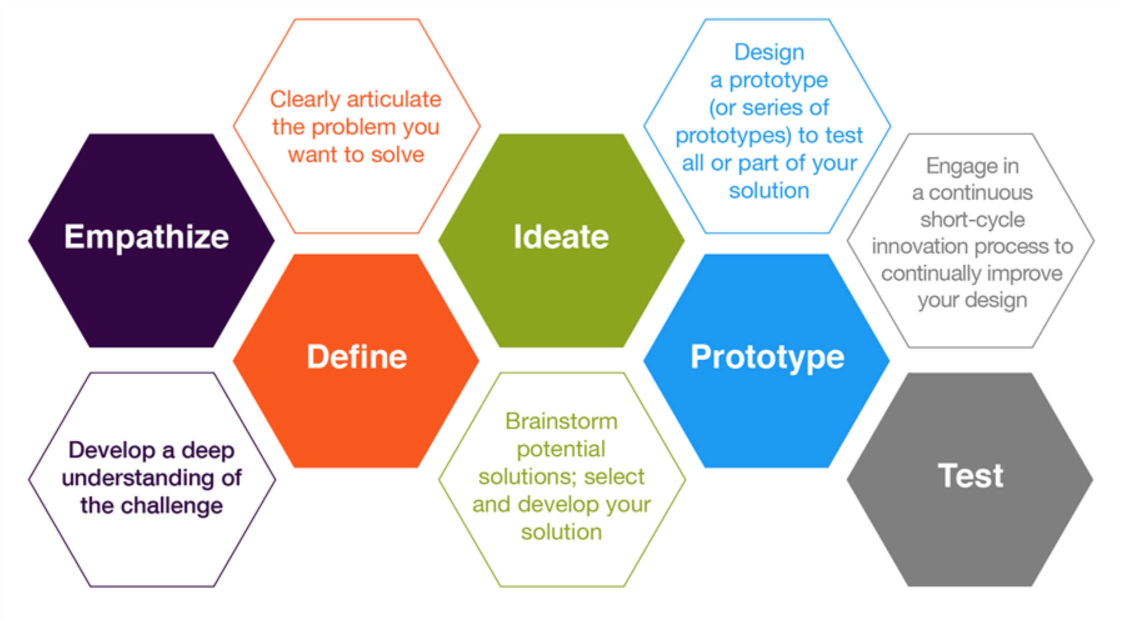

Figure 1 Design Thinking Work Process (Illinois CITL, 2020)

Before detailing each case, the following table provides an overview of all ICT characteristics. The distinction between target group and user group only makes sense for the Berlin case study. There, the target group (expert communicators, environmental educators) are the ones that demonstrate the app to the user group (general public). In other cases, the users of the app are the target group.

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Table 6 ICT Solutions

Features of the ICT solutions		Berlin	Milan	Paris
Description of the ICT solution		An AR app visualizing geology and groundwater and highlighting their relevance as drinking water resource	A serious game providing information about treated/reused water nexus complexity that aims at raising awareness and promotes the implementation of sustainable solutions such as sensors for improved water quality monitoring.	1) a smartphone or web application informing the public on the status of the bathing site 2) a web platform informing bathing site managers with water quality
Technology used		OBJ 3D models[4] from MODFLOW data MODFLOW simulations of scenes	Online web application based on JavaScript and frameworks as angular/react. Serverless approach with basic API.	Statistical modelling, Machine Learning; app not yet decided
Partner involved		Vragments, BWB, KWB	CAP, UNIMI	KWB, SIAAP, SU
Communication	*Target Group*	General public (e.g. teachers, pupils from secondary school upwards, students); no experts	General public, environmental NGOs, local governments, water authorities, water utilities, water reclamation managers, irrigation infrastructure operators	1) General public (anyone who might be interested in the bathing app: local residents, boat owners) + 2) Bathing site managers
	User Group	Expert communicators and environmental educators, e.g. at water utilities (Berliner Wasserbetriebe or partner utilites) and authorities or NGOs who conduct guided tours or participate in further training for teachers		
	Aim	Answering the following questions: Where does the drinking water come from?	Provide information about economic and technical efforts to address systemic improvement, thus raising awareness and	1) Providing information on bathing authorization and additional information on sites (access, affluence, algae…)

[4] OBJ Wavefront is one of the common 3D data formats. This is completely independent of AR/VR and is also relatively well supported by Unity (the platform used to develop the AR app).

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Features of the ICT solutions		Berlin	Milan	Paris
		How does the water get into the wells? How is the water cleaned during infiltration?	willingness to invest in more sustainable solutions.	2) providing information on water fecal contamination
Implementation		Off-site (on-site at later stage)	Off-site + on-site	Two different versions to balance/address accessibility and complexity

2.1. Berlin

2.1.1. Case-study characteristics and main challenges

The Berliner Wasserbetriebe (BWB) is the central water utility in Berlin, which owns and operates approx. 11,000 km of sewer and pressure mains, six wastewater treatment plants (WWTPs) and nine waterworks with about 650 drinking water abstraction wells. The groundwater pumped from the wells is composed of naturally formed groundwater (approx. 30%), enriched groundwater (approx. 10%) and bank filtrate (approx. 60%). In Berlin the urban water cycle is partially closed and intensively challenged by competing uses and pressures such as drinking water production, discharges of stormwater and treated wastewater, combined sewer overflow (CSO), and recreational purposes. Hence, minimizing river impacts and increasing the efficiency of the existing infrastructure by e.g. cost-effective monitoring tools, interoperable data exchange with stakeholders such as the Berlin water authority (SenUVK), automated data processing and visualisation are major goals in integrated water management.

2.1.2. ICT solution and key purposes

The Augmented Reality Application "Grundwasser sichtbar machen" (Making groundwater visible) intents to visualise geology and groundwater and highlight their relevance as drinking water resource and "hidden part" of the water cycle. The application will be used for different communication purposes (tourism, education) and generally aims to increase awareness about the origins of drinking water and communicate the importance of groundwater for water supply in the city. Thus, the application addresses three central questions: 1) Where does the drinking water come from? 2) How does the water get into the well? and 3) How is the water purified during the soil-aquifer passage?

The design process that has been used to lead the app development follows design thinking principles and is visualised in

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Table 7 for the Berlin case study.

The Design Thinking Method was applied to generate a prototype for the tool in a co-creation process with different stakeholders. Table 1 illustrates this process that started in October 2017 with co-design workshops.

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Table 7 Design Process for the Berlin App

Understand	Empathize	Define	Ideation	Prototyping	Testing
Collecting communication goals; Collecting information on groundwater & geology; Collecting sources for content & visualization;	Interviews with BWB personnel and further experts; Requirements of visitor groups and problems with user apps	Define the target group(s) pupils/ students/ public; Overview scenario for introduction of the topic Scenarios for detailed questions	Design and concepts for the presentation of contents "Berlin overview" with base map, geology, legends, groundwater Scenarios as 200x200m blocks	Berlin overview and UX for showing/ hiding layers geometry/ animations for scenarios groundwater bodies from simulation data; Visualization of geology and groundwater in AR	Deployment of visualization mockups; Feedback rounds with BWB personnel; Focus Groups with potential users

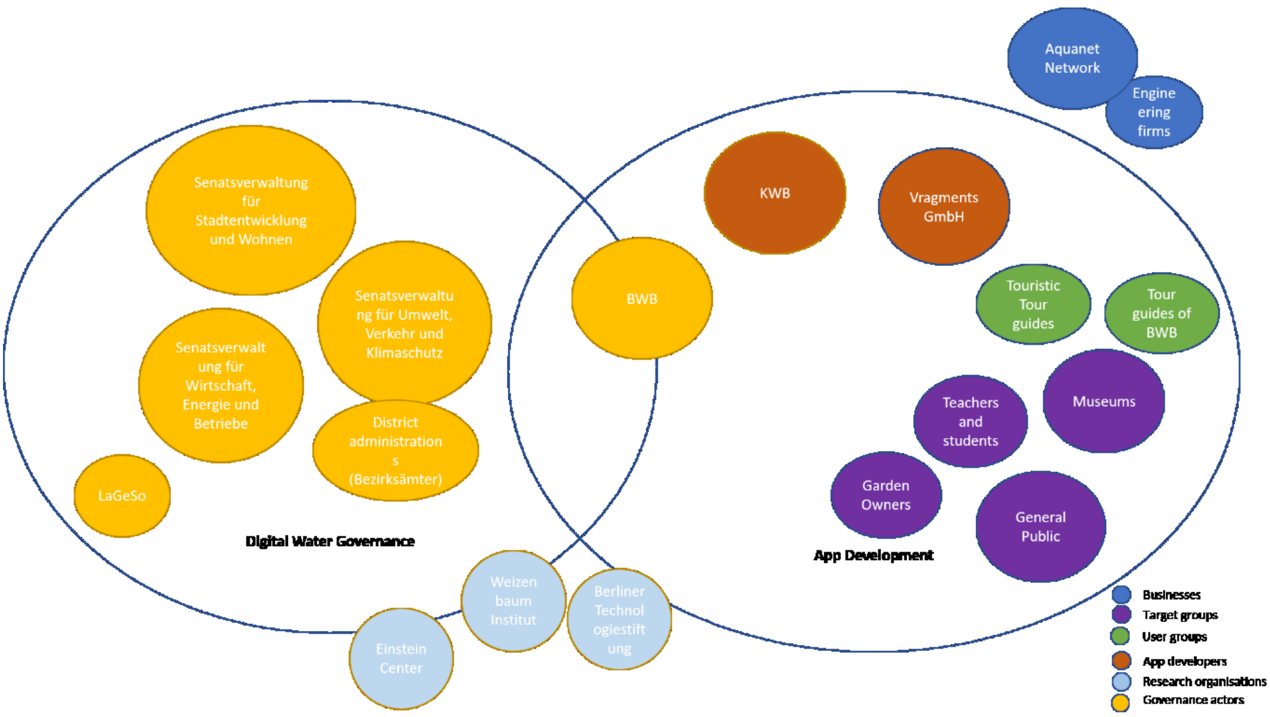

Figure 2 Stakeholder Map for the AR Application "Making Groundwater Visible" in Berlin

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2.1.3. Technical barriers to its uptake

Not identified yet, to be added in final version of the Deliverable 3.5.

2.2. Milan

2.2.1. Case-study characteristics and main challenges

Gruppo CAP, the utility that is responsible for water management and service in the peri-urban area of Milan, aims at improving the nexus between the management of the water, food and energy sectors by enhance water reuse in rural areas, in particular for irrigation purposes. Gruppo CAP manages around 60 wastewater treatment plants across the province of Milan. Many facilities could reach the new EU 741/2020 standards for water reuse in agriculture, with proper technical optimization. A set of digital solutions are considered to improve wastewater treatment, water performance and process control, ultimately allowing higher percentages of reused water in agricultural activities in Milan.

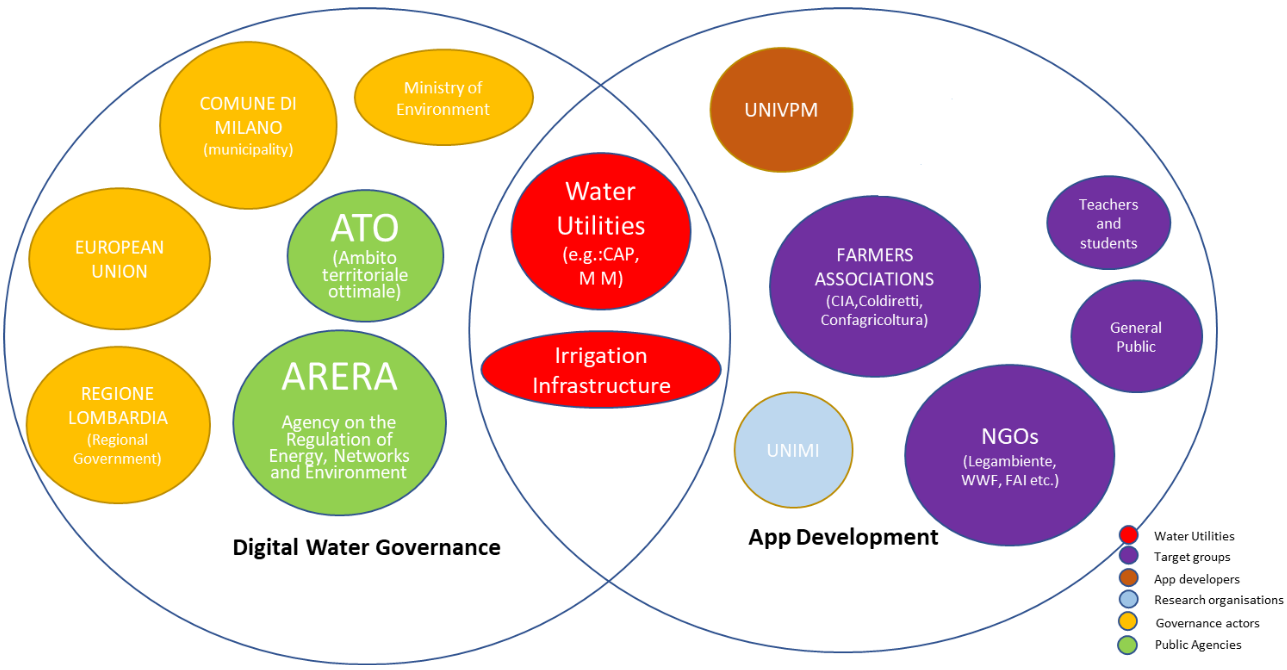

Figure 3 Stakeholder map for the serious game application for wastewater reuse in Milan

2.2.2. ICT solution and key purposes

The serious game on water reuse, carbon, energy, food and climate nexuses is a simulation-based management videogame whose aim is to engage a wide public (aged 16-99 years) and raise awareness on issues surrounding water reuse, ultimately overcoming social and economic barriers to its effective implementation. The game structure has at its core scientifically validated wastewater treatment and crop growth data driven models and validated data, but both the gameplay and the visualization tool were designed to vehicle the complexity of trans-sectoral nexuses and real-life issues to both relevant stakeholders and citizens in such a way that key implications of policy decisions and the benefits of water reuse in terms of impact on energy footprint, carbon emissions, food availability and social aspects could be understood.

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Table 8 Design Process for the Milan App

Understand	Empathize	Define	Ideation	Prototyping	Testing
Review of literature and of previous projects on trans-sectoral nexuses Research of previous serious game on environmental sustainability	Regular interaction with stakeholders, participation to webinars and other events, test other serious games to identify with future users.	Define target audience. Define the data that allow to correctly measure and assess the nexus. Define crop and soil sustainability/foot printing models.	Evaluate water, energy and carbon footprint indicators, based on tools developed or (possibly) data-driven models. Consider different urban water infrastructure configurations and peri-urban fields configurations	Two different versions to balance/address accessibility and complexity. Proof of Concept with "micropolisJS", the open source version of SimCity Classic	Beta version to test engagement and acceptance of the community (through CoP).

2.2.3. Technical barriers to its uptake

Not identified yet, to be added in final version of the Deliverable 3.5.

2.3. Paris

2.3.1. Case-study characteristics and main challenges

Paris area is strongly committed to provide permanent and safe bathing sites in the urban river as a legacy of the Olympics and Paralympic games 2024. This challenging objective is supported by SIAAP, the greater Parisian Sanitation Authority that transports and treats wastewater for nine million people in and around Paris. Many efforts have already been done aiming at reducing drainage system impact on rivers.

The map below shows the location of the bathing candidate sites as well as the two wastewater treatment plants in the area of the project. This map also shows the location of outlets of storm water networks and the existing combined sewer overflows.

The average daily flow of the 2 WWTP are about 450 000 m^3/d for the largest one (Seine-Valenton) and its discharge point is located on the right bank of the Seine river. A disinfection treatment will be implemented. The second WWTP, Marne-Aval, is located on the Marne river. Its average daily flow is about 46 000 m^3/d. Its discharge point into the Marne river is located far away downstream in order to protect a drinking water supply abstraction point.

The largest stormwater discharge point can reach a flow rate of 50 m^3/s.

The Seine river dry weather flow during summer is about 100 m^3/s and the Marne river flow is around 35 m^3/s.

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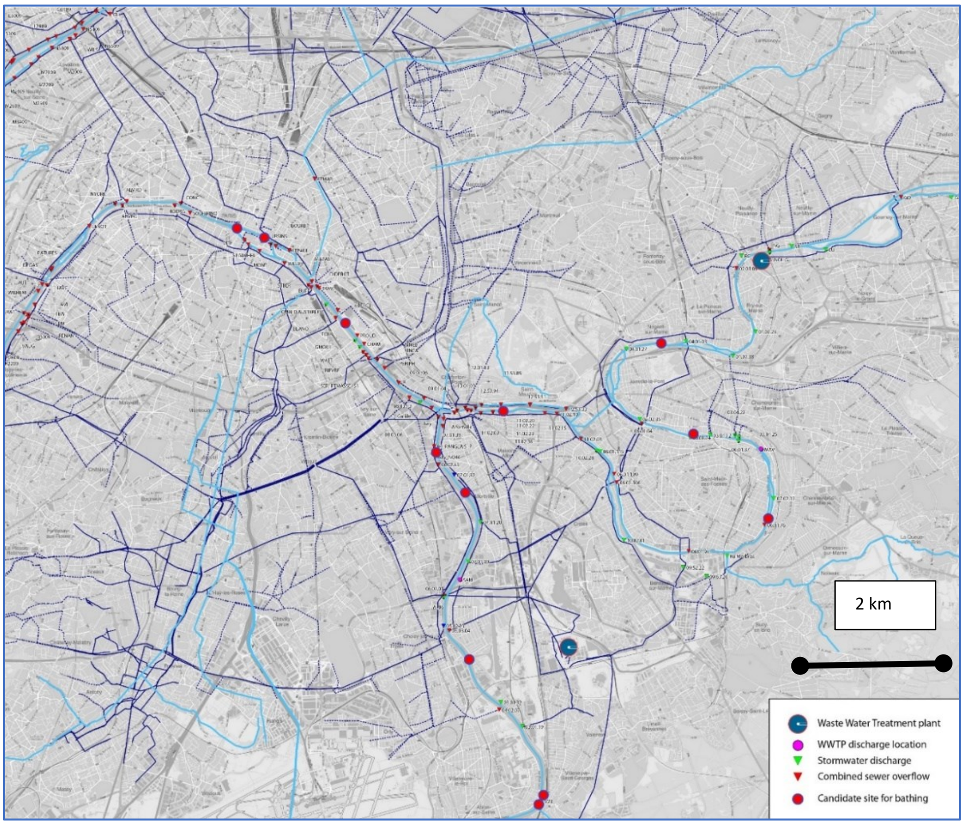

Figure 4 Map of Paris region with main sewers, CSO and WWTP and candidate bathing sites

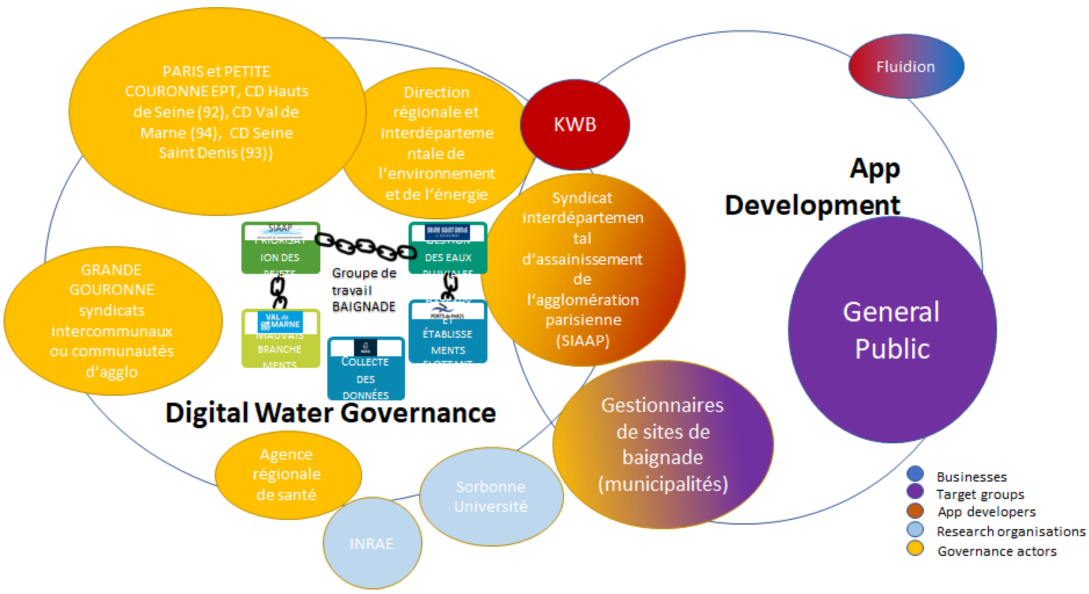

Figure 5 Stakeholder map for the application on bathing quality information in & near Paris

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2.3.2. ICT solution and key purposes

Two ICT solutions are to be developed in Paris.

- An "Expert interface" where a responsible (preferably the manager of the bathing site) will be able to get the information about the water quality, decide to open or close the bathing site and then transfer it to the public.
- A "Public" application that will provide information about water quality to the public.

Table 9 Design Process for the Paris App

Understand	Empathize	Define	Ideation	Prototyping	Testing
Communication goals SIAAP and ARS collected Sources of pollution understanding (sewerage, boats) Legal requirements and concerns for site managers Research for early warning systems	Interviews with SIAAP personnel and ARS Interviews with bathing sites managers (in Paris and in existing sites in France) Interviews with boat owners Interviews with general public	Define the target group(s) managers/public Define the people involved with the development of the EWS in terms of governance of the data collected and shared Overview scenario for introduction of the topic Scenarios for detailed questions	Design and concepts for the presentation of contents "Seine & Marne overview" with map, bathing profiles	Prototypes of the two apps will be developed. These will be used to test the system it self and to start the fine adaptation process to meet expert app users expectations and also the ones of the general public app. in an iterative process,	Deployment of visualization mockups Feedback rounds with SIAAP personnel Focus Groups with potential users CoP with bathing sites managers

2.3.3. Technical barriers to its uptake

The most technical barrier today is the lack of existing bathing site on the Marne and the Seine. Target groups (managers and public) need to imagine their use in a context where this use is yet to come. We did not identify specific barriers to ICT uptake given the high level of ICT development in public services in France in general, but rather technical barriers to bathing site implementation in the first place.

Another technical barrier is the uncertainty concerning the apps' manager in the future.

Yet we overcome this difficulty by convening experts from existing bathing sites in other places in France and have them tell their experience and expectations towards ICT. This helped managers-to-be to visualise their future situation and needs. They were able to imagine their use and to specify their needs.

Our findings are that the uptake of ICT tools rely on :

- Including contextual information about bathing sites not directly linked to water quality such as access with public transportation, affluence, algae presence, water temperature,

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- Including the possibility for public to report information to the managers through the app and including a FAQ page
- The possibility to include yet-to-come new alerts in the design of the expert app.

3. Governance assessment

This section provides empirical description of each case. These descriptions and more details given in interviews are then used in the cross-case comparison to inform the relevant variables identified in the guiding document.

3.1. Definitions

These definitions are taken from the Guiding Protocol (Deliverable 3.1) that has established definitions of relevant key terms to ensure a congruent use of these terms throughout the project.

Governance

Governance can be defined as the various institutionalised modes of social coordination to produce and implement collectively binding rules, or to provide collective goods (Börzel and Risse 2010, p. 114).

Governance Modes

Governance modes refer to the various forms through which governance can be realised. One widely used classification is the distinction between bureaucratic hierarchies, networks and markets as the main governance modes. They may be understood as ideal types in the Weberian sense since, in reality, any individual mode will rarely occur in isolation (Pahl-Wostl, 2009). An operationalisation of how these governance modes manifest in different governance contexts makes them amenable to empirical investigation (Pahl-Wostl, 2015).

Hierarchical Governance

In hierarchies, coordination is achieved through top-down orders based on legitimate authority (Pahl-Wostl 2015). Using a top-down approach, the focus is on the setting of objectives and rule-making, the allocation of tasks and responsibilities, and on lines of control (Bouckaert, Peters et al. 2016). Prototypes of hierarchical governance are bureaucratic organisation and firms (Bouwma, Gerritsen et al. 2015).

Market Governance

Market governance relies on prices to coordinate exchange between self-interested actors (Bouwma, Gerritsen et al. 2015, based on williamson 1985). Markets are based on a combination of formal and informal institutions and non-state actors are dominant (Pahl-Wostl 2015).

Networked Governance

Networks are based on informal institutions and states as well as non-state actors (Pahl-Wostl 2015). In networks, coordination is achieved through interactions “between actors whose interorganizational relations are ruled by the acknowledgement of mutual interdependencies, trust and the responsibilities of each actor” (Bouckaert, Peters et al. 2016, p. 36). Networked governance integrates distributed capacities for problem solving and policy-making by making use of governance networks that can self-organise within bounds to help support certain policy-making functions (Huppé, Creech et al. 2012).

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Hybrid Forms of Governance

Hybrid forms of governance are a combination of governance modes. Most governance settings in the real world are characterised by such hybrid forms of governance (Pahl-Wostl 2015).

Digital Water Governance

Adapting a water governance definition by Pahl-Wostl (2015) to the specific context of digital innovation, we define digital water governance here as the social function that regulates the management of water resources and provisions of water services by the means of ICT solutions at different levels of society. It comprises all actors, processes, regulations, structures and ICT solutions involved. Thus, what sets it apart from water governance is its specific analytical focus on innovation uptake and the role of ICT solutions in forming the water management context as soon as these solutions are being deployed in the sector.

Water Governance

Water governance is the social function that regulates development and management of water resources and provisions of water services at different levels of society. It comprises all actors, processes and structures involved. Good water governance guides water use towards a desirable state and away from an undesirable state (Pahl-Wostl, 2015).

Water Management

Water management refers to the activities of analysing and monitoring water resources, as well as developing and implementing measures to keep the state of a water resource within what has been negotiated as desirable bounds (Pahl-Wostl, 2015).

3.2. Epistemic use of the guiding protocol hypotheses

The guiding protocol raised 12 hypotheses (12 Guiding Protocol Hypotheses, GPH) on the relations between governance settings and ICT solution uptake based on literature. Such hypotheses identify risks for low uptake in different situations. Since developers are currently working on ICT solutions, the final uptake will only be known at the end of the project at the soonest.

Social science hypotheses relate to potential causal relations that are neither necessary nor sufficient. They are **interpretations of causality**. For example, governance fragmentation may hinder ICT uptake, but there are cases of ICT uptake despite fragmentation and there might be obstacles to uptake that do not relate to fragmentation. **Hypotheses help to clarify the reasoning, more than mere questions.** Social science explanations cannot be invalidated through one observation or one case study, but rather through confrontation with other causal explanations. In addition, governance fragmentation is a qualitative social science concept, which cannot be measured quantitatively. There is some leeway for interpretation in considering that governance is or is not fragmented. This qualitative characterization makes more sense in comparison between cases than in absolute. Moreover social actors have a learning capacity to constantly react to social science statements. Therefore, the relevance of social science relies in its **social transformative power**.

(In)validating hypotheses with qualitative means is not possible, thus it is important to note that the 12 GPH are primarily meant to *structure* the assessment of governance rather than to provide a set of hypotheses which are to be tested like quantitative science is doing. To facilitate the linking and structuring of different research areas, which are engaged with digital water governance but are yet to be merged, the hypotheses offered in this guiding protocol are deliberately left broad.

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Instead of testing the validity of the 12 GPH, WP3 aims at informing ICT developers of the specific barriers, enablers and risks each case governance assessment allows us to identify, so that developers, CoPs and focus groups can address these risks and collective decisions can be taken accordingly. Such risks are presented in each table summarizing cross-case findings.

3.3. Broad description of governance in each case

In the following subsections, the governance in each case study will be broadly described with a focus on key policies, actors and the state of digitalisation in the water sector. Further aspects of governance will be described in the cross-case comparison in section 3.4.

3.3.1. Berlin

In Berlin, the water policy framework is largely coherent and comprehensive (Knoblauch et al. 2020). The Berlin Senate Department for Environment, Transport and Climate is the key actor in water policy-making. The first law on water protection, the German Water Management Act (Wasserhaushaltsgesetz), was in 1957, introducing the principle of sustainable water management. The 2005 Berlin Law on Water (Berliner Wassergesetz) implemented the 1957 law on the city level. Over time, the German as well as Berlin's regulatory environment adjusted to European legislation, particularly the WFD, the Quality of Water Directive and the Urban Wastewater Directive. Transposition of European norms has not been limited to the water sector: The 2005 Environmental Information Law (Umweltinformationsgesetz) set up the legal framework for free access to environmental information for reporting bodies, in compliance with the 2003/4 Directive.

In order to enhance digitalisation in numerous aspects, the city government of Berlin has passed several policy documents and strategy papers (e.g. the 2015 Berlin Smart City Strategy). The 2030 Berlin Energy and Climate Plan (*Berliner Energie- und Klimaschutzprogramm 2030*) constitutes the ultimate climate plan for the city of Berlin. Smart solutions are integrated in specific practices of optimised resilience and adaptation. However, a specific focus on deploying ICT technologies in water management is lacking in these strategic documents, leaving the potential of digital solutions to water management largely untapped for now.

As novel ICT solutions are increasingly applied in the Berlin water supply infrastructure sector, also new requirements regarding their cyber security arise. On the national level, the 2015 IT Security Act (IT-Sicherheitsgesetz) obliges the operators of critical infrastructure facilities or facilities themselves to establish IT security systems according to the state of the art. By definition, critical infrastructure also includes sewage disposal and drinking water supply, which also encompasses other water management facilities, e.g. dams, if they are used for drinking water supply.

3.3.2. Milan

Milan is an open, innovative European city where participative, multispatial and smart solutions are being increasingly explored in the governance of many sectors. The Italian configuration for water governance is largely based on the 1994 comprehensive reform for water service, whose primary goal was to address the strongly fragmented character of water service management. The resulting institutional setting separates functions of planning and control, assigned to Regions and basin level authorities, from those of management, which can vary from one municipality to another. About half of the population is served through models of delegated public management, 36% relies on Public-private partnerships (PPPs) and the remaining share of population is provided with water services by either private companies with a concession or from their municipality.

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Significant autonomy is left to the local level, by allowing local regulatory authorities (AATOs) to reorganize and overwatch over their water system, but this also translates into high level of heterogeneity of approaches across the country. Entrusted water utility companies, owners of service delivery and responsible for the implementation of the necessary infrastructure, are the actors through which the digitalization of the water system can be enhanced, as in the case of Milan's water utilities Gruppo CAP and MM (remote monitoring, webGIS etc.). The high degree of fragmentation and decentralization for water service management gave the opportunity to some to opt-up and implement innovative approaches when managing water, but in multiple instances the lack of support and guidance from the higher levels of governance led to stalemates and missed opportunities of cooperation between actors. Lack of incentives and guarantees, legal and normative gaps, the low level of awareness of citizens on current issues are all factors that, if addressed correctly, could allow to speed up the process of digital uptake that is unfolding in water management and service in Milan.

3.3.3. Paris

Generally speaking, governance in Paris region is fragmented into many administrative levels and water-related responsibilities. Each local authority has its political assembly, which is fully responsible in its fields of competence, which are changing from one level to another. The State administration has both centralised and decentralised offices. In that system, for the sanitation management, there is no single authority formally in charge of the coordination between local authorities. This role is partly endorsed by State authorities in charge of implementing and controlling regulation, and they generally consider that SIAAP should secure the good functioning of the whole sanitation system, although it is not responsible for upstream sewerage operation. Municipalities have the responsibility for collecting wastewater and rainwater in small sewerage systems that flow into larger infrastructures managed at supra municipal level. *Départements* (French administrative subdivision) are responsible for wastewater transport (*collecteurs*) and SIAAP is responsible for final transport to WWTP with the largest sewers (*émissaires*) and sewage treatment. What would happen in case of a lack of compliance upstream resulting in problems downstream is an open question. SIAAP has reputational incentives to make the whole system works; yet it cannot be legally charged beyond its downstream sewerage mandate.

In that frame, the action plan to improve the bathing water quality relies mainly on the good will of each actor to work together. For the moment the common objective of Olympic and Paralympic games acts as a federative project. Getting the bathing water quality as a legacy of this event is generally seen as a project that meets the social expectation regarding a new water use. Water managers also consider that it gives a new revival to the sanitation policy, notably that of rainfall drainage management, but with little involvement of the large public in the decision making. In order to reach this objective, a coordination platform with an executive board (groupe de pilotage baignade) and several technical ones (groupes de travail baignade) were setup on behalf of the City of Paris and the State authorities to develop the bathing water quality action plan. This organisation has gathered, step by step, all the involved parties to develop a high performance level for sanitation.

Bathing opening and closing is the responsibility of bathing site manager, generally the municipalities. Yet bathing site managers are not knowledgeable about water pollution in real-time. Small public sewerage may carry contamination due to non-compliant households' waste-water connection in separate systems.

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Improving connection compliance requires huge public and private costs (several k€ per individual house[5]). Risks of water contamination are better known and managed by supra municipal organisations. Both *Départements* and SIAAP have the knowledge and they have budget to invest for preventing bathing sites contamination from the larger collective infrastructures.

The DWC project is setup in that frame and will be a place where end users, (bathing sites managers and swimmers) will be involved in the design of their tool. One app is dedicated to the decision making of opening or closing bathing sites for managers and the second one will target to inform the large public whether bathing is possible.

Paris' challenge is to open the Seine and the Marne Rivers to bathing, whereas both rivers receive irregular wastewater discharges due to CSO and non-compliant sewerage connections from separates sewer systems. Today the Seine meets the bathing water quality standards in Paris between 20 and 30% of the time in summer.

Recent legislations on water policy and governance have challenged the pre-existing water governance in the Paris Region. Incumbency regarding the communication of water quality is not yet defined. Health authorities do not take decision on bathing site opening or closing, they only check compliance of bathing sites with the regulation and perform quality tests and report them to the EU. They may intervene at last resort in case of enduring health risks.

Three related stakes are opportunities for ICT development. The first one is a need for a reliable water quality prediction in order to optimise bathing opening duration. The second one is to inform the population on the bathing status and bathing facilities so that they value the investments made. A third stake emerges from internal discussion with SIAAP. The public app could also gather observations from the public to inform managers about users' concerns on sites.

3.4. Cross-case comparison

This section describes the results of the interviews following the guiding protocol.

3.4.1. Levels and Scales

Levels and scales are hydrological scales (e.g. catchments, water bodies, rivers, lakes, surface run-off, sub-surface flows, reservoirs, pipes, drains, tanks, gutters, houses, gardens, parks) and administrative levels (i.e. municipal, regional, national, European) relevant to digital water governance in the particular case study context.

The guiding protocol raised the following hypotheses:

- H1: *centralisation* of the water governance system limits opportunities of public involvement in urban water management
- H2: *fragmentation of tasks and powers across multiple organisations* limits the uptake of the ICT solutions.

[5](https://eau-iledefrance.fr/baignade-en-banlieue-paris-est-marne-et-bois-met-le-paquet-sur-lassainissement/#more-12228)

Berlin case study

Experts interviewed as part of this deliverable have pointed out that there is only a limited number of actors involved in digital water governance. The dominant level in shaping water policy is the federal state level with the Berlin Senate Administration for Environment, Transport and Climate as the central actor. As the water utility in Berlin, the Berliner Wasserbetriebe are also key in pushing forward innovation in the water sector. According to the expert form the Berliner Wasserbetriebe they have been for a long time the initiator of digitalising the water sector, e.g. by kicking-off new data sharing concepts with the Berlin Senate. Another important actor is the Berlin State Office for Health and Social Affairs (LAGeSo) who is responsible for water quality monitoring. The influence of European policies on the practice of water policy in Berlin is rather low.[6] In addition, linkages of the Berliner Wasserbetriebe with national or European policy level actors are limited. The German Association of Energy and Water Industries (BDEW) has a major role as an actor that links the German water utilities with the national and European levels and articulates their needs and demands to policy actors on these levels.

Digital water governance as opposed to traditional water governance is not a distinct policy area and thus, decision-making authority in this field is dispersed mainly across two Departments of the Berlin Senate (see stakeholder map, Figure 2). Not only the Senate Department for Environment, Transport and Climate is thus involved in this field but also Senate Department for Economics, Energy and Public Enterprises that is central in shaping the city's innovation policy. As a result, policy fragmentation exists that might be one explanatory factor why a proactive digital water governance agenda is still lacking. This fragmentation clearly limits the uptake of ICT solutions, e.g. the development of interface to automatize data reporting of the water utilities on the local level to supervisory agencies on higher levels. One interviewee expressed that it would not be cost-efficient to set up such an interface that would allow national or European level actors to directly access data.

Milan case study

The territory where Milan is located is characterized by a natural hydrologic network, whose main elements are the rivers Ticino, Adda, Lambro and Olona, and a dense system of artificial channels that resulted from the advanced agricultural and industrial development in the area[7]. On top of this, a fundamental supply of water, especially for agricultural purposes, comes from groundwater sources, while Milano Nosedo is one of the largest EU WWTPs delivering water for agricultural reuse. The consumption of water for agriculture puts the ecological balance of the hydrological system under pressure, in particular in those territories along the river Ticino and on the southern side of the province[8].

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[6] The limited influence of European and national policies on digital water governance in Berlin will be researched on in more detail and additional findings will be included in the final version of this deliverable (D.3.5.)

[7] Provincia di Milano Assessorato all'Ambiente, Politecnico di Milano (1995) – Le risorse idriche sotterranee nella provincia di Milano vol. 1: lineamenti idrogeologici http://www.risorsa-acqua.it/PDF/le%20risorse%20idriche%20sotterranee%20nella%20Provincia%20di%20Milano%20lineamenti%20idrogeologici.pdf p. 33

[8] Provincia di Milano Assessorato all'Ambiente, Politecnico di Milano (1995) – Le risorse idriche sotterranee nella provincia di Milano vol. 1: lineamenti idrogeologici http://www.risorsa-

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In Italy the water infrastructure is public, yet its management is delegated to utilities (mostly publicly owned, but also private ones, with anyway major public shareholders obligatory by law). In certain cases, and under specific conditions, water services can be directly managed by municipalities, in what is known as "in house" management[9]. At the national level, the agency ARERA (Agency on the regulation of energy, networks and environment) sets water tariffs and defines technical standard for water services which are finally impacting on the tariffs. According to the water tariff regulation in Italy water reuse is highly promoted by direct impact on possible incentive with the tariff policy framework. Among the main actors for water management we find the AATO (authority for the operational territorial scope) which have competences over a territory that is defined by the Region (Lombardy) following coherent hydrological areas. One of the most important role of AATOs is to identify the utilities that will be entrusted with the management of water services in their territorial scope[10].

Despite the fact that the introduction of AATOs in 1994 was specifically conceived to limit the historically persistent fragmentation of water management in Italy[11], today there are still 92 AATOs and more than 700 utilities that are responsible for services[12]. Since there is not a single model of management, public, private and hybrid utilities coexist throughout the national territory, alongside municipalities that opted for the "in house" management. This amounts to a considerable degree of fragmentation which prevents the achievement of a desirable configuration in terms of industrial efficiency and economic equilibrium.

Because of the deep territorial digital divide that exists between different regions in Italy, especially between the industrial north and the lagging south, regions appear to be the most suitable level to lead the digital transition. The need of a multilevel coordination for the digitalization of public administration and public services is a known problem to the national legislator, but to date the results of coordination actions appear limited, with fragmented interventions, duplications, poor interoperability and integration of the services developed[13]. The governance for a digital transition has often ignored the potential of information systems to build synergetic networks, offloading the responsibility of initiative to individual entities in a weak governance context at central level[14].

Paris case study

France is a centralised country with a low public participation in comparison to other European neighbours. Yet some innovations in the Paris region encourage public participation to water issues.

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acqua.it/PDF/le%20risorse%20idriche%20sotterranee%20nella%20Provincia%20di%20Milano%20lineamenti%20idrogeologici.pdf p. 107

10 Gazzetta Ufficiale della Repubblica Italiana (2006) Decreto Legislativo 3 aprile 2006, n. 152. Art. 148. https://www.gazzettaufficiale.it/dettaglio/codici/materiaAmbientale

11 Gazzetta Ufficiale della repubblica Italiana (1994) Legge 5 gennaio 1994, n. 36, art. 8. https://www.gazzettaufficiale.it/eli/id/1994/01/19/094G0049/sg

12 https://www.gruppohera.it/gruppo/com_media/dossier_acqua/articoli/pagina25.html Retrieved on 28.10.2020.

13 Corte dei Conti (2019) Referto in materia di Informatica Pubblica https://www.corteconti.it/Download?id=64ba98bf-b6b5-4a67-b132-2cb87010ed36 p. 31.

14 Banca d'Italia (2016) L'e-Government in Italia:

situazione attuale, problemi e prospettive https://www.bancaditalia.it/pubblicazioni/qef/2016-0309/QEF_309_16.pdf pp. 30ff.

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The perspective of future bathing in the Seine is one of them. A large audience documentary film on this promise and related issues was scheduled on TV in July 2021. In addition, ICT is widely developed for public services (i.e. FranceConnect).

Fragmentation in water governance is important in France. Especially in Paris Region. Yet in the Paris Region between 2014 and 2019 the number of organisations in charge of water management has decreased by 54%. Following a long dispute over the odour nuisance from the Seine-Aval wastewater treatment plant, the management of the sanitation master plan for the central zone of the Île-de-France region was recentralised and entrusted to the State authority in charge of the environment (DRIEE) and driven and funded by the Water Agency and with the involvement of the regional council and SIAAP. Scenario C in 1997 of this general sanitation plan calls for the implementation of an integrated real time management system, enabling 500,000 m^3 of storage to be saved by optimising the networks management. SIAAP developed the system and commissioned the Emissary Management Support Model (MAGES). The master plan endorsed the political decision to deconcentrate wastewater fluxes: The capacity of Achères wastewater treatment plant (Seine-Aval) has been decreased from 2.7 Mm^3/d to 1.5 Mm^3/d. Waste waters were rerouted to other WWTP upstream Paris (Seine-Amont, Marne-Aval, …) and new WWTP were build (Seine-Centre, and Seine-Grésillons and Seine-Morée). This results in a distributed system of WWTP and CSO upstream and downstream Paris, controlled in real-time by SIAAP.

Wastewater collection from households and medium-size sewerage are not managed by SIAAP, as shown in Figure 5. In Paris and its closer outskirt, Etablissements publics territoriaux (local groups of municipalities) are responsible for collecting wastewater, then departments are responsible for wastewater transport, combined sewerage and rainwater drainage. This results in **fragmentation** of incumbencies. Yet, since the decree of 21 July 2015 (UWWT directive implementation), the SIAAP shall report to the State authorities on the performance of the entire system from collection to purified discharge. The water agency requires this reporting to pay the SIAAP 100% good treatment incentives (around 50 million euros). Wastewater discharge during dry weather may result in 10, 20 o 30% reduction of incentives.

In the larger outskirt of Paris area, since the MAPTAM law, municipalities have gathered in intermunicipal organisations who are in charge of collecting wastewater and rainwater. Municipalities have merged in agglomerations who took responsibility of wastewater. Some syndicates were suppressed yet competences are not yet transferred to agglomerations. This creates a standby situation.

Our findings through participatory observations and interviews show that despite this fragmentation, technical staff in each organisations share similar values and common understanding of data uncertainty. A framework for sharing digital water-related data already exists and professionals trust each other. This factor seems to offset the obstacle of fragmentation for ICT uptake.

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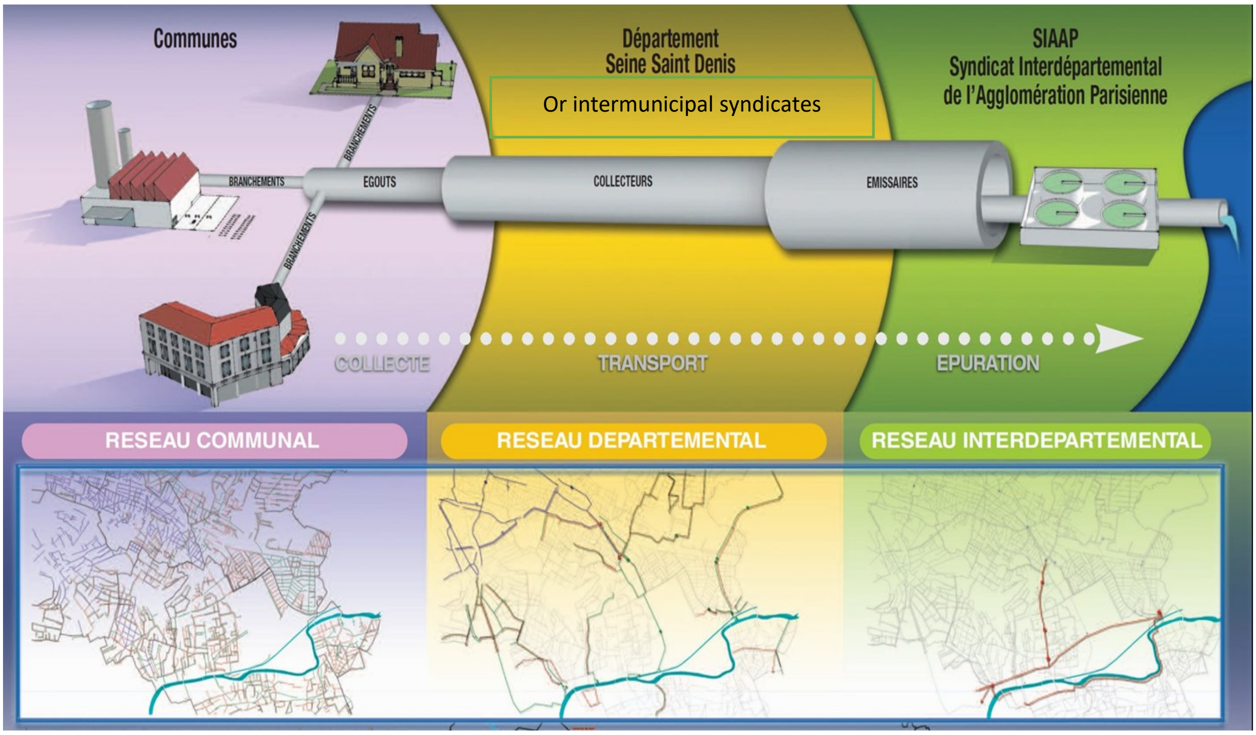

Figure 6 Waste-water incumbencies in Paris region (Source: SIAAP).

Table 10 Summarizing findings on levels and scale

Cities	Fragmentation	Decentralisation	Temporary conclusion on the validity of the guiding protocol hypotheses
Berlin	Fragmentation in water management is low but fragmentation exists as water governance and digital governance are partially overlapping.	High degree of decentralisation at the national level in terms of water management but high centralisation at city level.	H1. Favourable context for public involvement H2. Unfavourable uptake of the ICT solutions due to the lack of articulation between digital and water governance
Milan	Despite structural reforms to stem the problem, fragmentation is still very high.	Wide territorial differences on digital infrastructure and capabilities resulted in a decentralisation of roles and responsibilities.	
Paris	Used to be high, in reduction due to recent laws	New incumbency given to state services and SIAAP in favour of recentralisation	H1. Risks of low public involvement due to recentralisation offset by public interest for bathing.

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			H2. Favourable context for digital uptake due to ICT development in public services, the reduction of fragmentation and professional shared culture of digital data

3.4.2. Actors, Networks and Communication Channels

Actors and networks include the range of public authorities, private companies, civil society organisations, political activists and other stakeholders, and the inter-organisational structures (e.g. fora), involved in, benefiting from or impacted by the digital water governance system.

The guiding protocol raised the following hypotheses on factors influencing ICT uptakes

- H3: positive effect of community of practice
- H4: negative effect of digital divide
- H5: ICT deployment fosters public involvement in water management which may change behaviors towards more sustainable use (effect on behavior to be addressed in part 4.2)

Berlin case study

In Berlin, a range of public authorities, private companies, civil society organisations, political activists and other stakeholders exist that are engaged in enhancing urban water management.

lists key actors in the realm of digital water governance in the city. Relevant public authorities, these include three senate departments with the Berlin Senate Administration for Environment, Transport and Climate as the central actor. In addition, the Berlin State Office for Health and Social Affairs (LAGeSo) is responsible for water quality monitoring. As the water utility in Berlin, the Berliner Wasserbetriebe are also key in shaping digital water governance by deploying innovation in the water sector and fostering a steady exchange with relevant authorities. At the district level, the district administrations are further important players that are responsible for granting authorisations regarding water usage and the handling of substances hazardous to water.

In addition, a vivid research environment exists in the city, particularly in the field of digitalisation. Examples include the Einstein Center, the Weizenbaum Institute and the Technologiestiftung Berlin. The Kompetenzzentrum Wasser Berlin is researching mainly water-related issues, however, with an increasing focus on digitalisation issues. Moreover, several research institutes for environmental policy, such as the Ecologic Institute, the Oeko-Institut or Adelphi are complementing the research environment.

One prominent example of a civil society organisation active in promoting sustainable urban water management is the initiative "Flussbad Berlin" that aims to improve the water quality in the river Spree so that it can be used by the public as a bathing site. In the specific area of digital water governance, the role of civil society organisations remains limited mostly to requests for the provision of water data. Although BWB is not collecting nor using sensitive personal data and despite this collection being strictly limited by law, one interviewee expressed that mistrust among civil society actors with regards to the collection and use of data becomes visible.

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Within the population, there thus seems to be a lack of information on the strict regulatory limits that exists for BWB and other utilities to collect personal data. Currently, the BWB website provides public to access environmental data, e.g. on water quality. The “Making Groundwater Visible” application is not intended to provide access to new or more data but instead to visualize data which is already available. In addition, a digital bathing water quality app already exists in Berlin, something that will be developed for Paris within DWC.

Milan case study

In the Milanese context, through the years more and more actors were involved in the governance of water. Civil society – intended here as both specific stakeholders and end users at large – as well as agricultural and industrial representatives have been progressively involved in the decision process of public administrators as a way to avoid resistance of local users from the start, favoring an effective management and monitoring at later stages while at the same time reaching wider social targets such as integration and public awareness. Innovation, sustainability and the exchange of best practices are pursued through the contribution of Universities, research institutes and the digital private sector. Having said that, two publicly owned utilities coexist in Milan: Metropolitana Milanese (MM) is responsible for the Urban area, while the metropolitan area is attributed to Gruppo CAP. Users in the two different areas have different needs and perceptions and because of that the management in the rural area is more participatory and inclusive than in the urban context, where water management is rather top-down and communication tools for citizens to interact with service providers are limited. Despite the efforts of the municipality of Milan and the Lombardy region to raise awareness on water issues and the benefits of innovation, citizens living in the urban area still take water for granted without understanding wider implications and are skeptical about potential connection with the process of digitalization, as change is feared to bring additional costs or more accurate means of control over consumption. Initial user consensus is also rare as relatively low levels of digital alphabetization among users represent an obstacle for the involvement of them in the initial stages of development for digital solutions.

Most of the times, administrative bodies and utilities are in good relations between themselves and with other stakeholders, and cooperation is reached with ease. Nevertheless, in certain situations, especially during periods of crisis, conflicts arise and the role of mediator is taken by public authorities, i.e. either by the Region or basin level authorities. Cooperation then is not guaranteed; the lack of protocols or mechanisms to solve disputes may potentially lead to stalemate and missed opportunities of synergies.

Paris case study

Given the lack of existing authorized bathing sites for the moment, the need for the apps is not yet perceived by most bathing site candidates. The first COP gathered 23 participants among which were 6 bathing site candidates, 4 waste-water managers, funding agencies and regulators, who were willing to be involved until the end of the project. They agreed on participation and decision rules for the COP, including

- the leading role of the SIAAP
- the requirement of an official demand for participation
- the possibility to be granted passive or active role in COP
- one voice is granted for each organisation
- decisions are taken with the ⅔ majority rule

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- the possibility to postpone individual decisions after one COP
- the validation of minutes by each participant is made at the next COP

They were willing to contribute to the design of the app and agreed to structure the discussion process around the following decisions to be taken:

- the type of app to be developed: responsive, downloadable or progressive web application.
- the possibility to allow other ICT platforms to have access to and display the bathing sites informations on their site
- the possibility to bill this service
- the information content to be shared in the app for each bathing site, including a questionnaire for the public feedback

Then 4 other COPs took place and help to address the guiding protocol questions:

- Which actors are actively involved in the uptake of the digital solution? And why?

For the moment only water and bathing sites managers, regulators and funding agencies are actively involved in the uptake of the digital solution because they will be responsible for deciding which information will be available in the app. End-users will be involved through focus group in spring 2022.

- Which actors are affected and why?

The development of bathing sites may affect some actors, but the development of the app itself is not perceive as a threat by any actor. Participants were granted voting power in the COP and this helped to build trust and confidence in the app development process. The disclosure of information which could affect some actors will be decided on a case-by-case principle and bathing sites managers will have the decision power on this.

- How would you describe the interactions and opposition between actors?

There are currently no opposition between actors. The transparency on decision taking rules and the fact that the app is one among possible other tools prevent the rise of oppositions.

Another reason for constructive interactions between actors is the long history of coordination and/or cooperation between actors for water management, which already relies on digital tools.

The existing interaction between science and local communities has long been a breeding ground for innovation. For more than 30 years, a scientific community, with a scientific research program (PIREN Seine), has been interested in the quality of water in the Seine and has developed quality modelling tools (PROSE,...). The NGO ARCEAU Idf [15] was created in 2013 and fosters research transfer between academia, elected officials and water practitioners. This association has launched several studies on bathing and its reports and activities are an important source of both shared technical knowledge and social learning. Eau de Paris and SIAAP have important research departments with laboratories that have well-developed measurement techniques and competent staff. For example, in 2003 Sedif, Eau de Paris and the Faculty of Pharmacy had launched a study on emerging microbiological pollutants (viruses, ...) in the Seine et Marne. SIAAP has developed and operates a real-time control of water discharges of WWTP and CSO (Mages).

[15] http://www.arceau-idf.fr/.arceau-idf.fr/

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Wastewater and sanitation operators have been **using digital tools since 1974**, for real-time management. The Seine St Denis department has been a driving force by investing first in automatic management systems for retention basins. They have also contributed to the development of models to transform radar data into rainfall heights, notably thanks to funding from the State services (DDE). In 1984 they were among the first to invest in sanitation system supervision. In 1992 they moved from remote monitoring and remote control to remote management. Between 1984 and 1992, all the constituent departments of the SIAAP (Paris (75), Hauts de Seine (92), Val de Marne (94), Seine Saint Denis (93)) were all equipped with remote management, with independent systems. In Seine St Denis, it was to combat flooding. In the Hauts de Seine, it was to limit discharges from storm overflows. This created an emulation. At the SIAAP, remote management made it possible to store effluents during the day and purify them at night, optimising Achères' purification capacity. D**ata openness is not widespread among administrations.** Data exchange requires contractualisation. COPs will smooth this process. .

Bouleau et al (2020) demonstrate that "water quality in the Seine Basin is not the environmental issue that most engages the population; of greater concern is air pollution. There is more concern about groundwater, especially when it is used as a water supply and particularly when the concentration of nitrates exceeds drinking water standards (…)." Yet the objective of bathing in open waters is getting more and more salience in the media.

Some groups of actors show strong motivation; these include environmental protection associations (Ile de France Environnement, for example), or the local authority of Val-de-Marne, which is crossed by two large rivers, the Seine and the Marne. The "Big Jump" initiative, which promotes bathing in the Marne River may garner some attention in the future. At the basin level, the water agency commissioned a questionnaire-based consultation of the population in 2008. Among the 1437 people surveyed in the Seine-Normandy Basin (by a quota sampling method), less than 5% returned the questionnaire; of these, more than 92% said they were "aware of environmental issues". A consultation was undertaken in 2019 with the public and with institutional stakeholders in order to identify the issues and the means that would make it possible, within the framework of the future SDAGE 2022-2027, to achieve good ecological status. Out of 18.5 million inhabitants only 881 responded. Compared to the 2008 survey, the 2019 survey showed that the issue of climate change and its consequences has come to be seen as a major challenge."

Table 11 Summarizing findings on actors, networks and communication channels

Cities	Did the community of practice change actor network (H3)	Who suffers from digital divide (H4)	What is the current level of public involvement in water management that could foster sustainable use (H5)
Berlin	*To be added in final version.*	Employees of the water utilities that cannot cope with pace of digitalisation and automatisation	Limited public involvement
Milan	*To be added in final version.*	A strong push for digitalization in managerial practices is not matched by the public administration which is sparsely digitalized.	Low citizens interest and awareness on current issues of water public service, especially in the urban area.

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Paris	The COPs strengthened interest and trust between actors for sharing knowledge and data.	Water managers have been digital since 1974 Bathing site candidates managers are now involved in COP. France is widely using ICT for public services online. Elderly and rural populations are the most vulnerable to digital divide. They are not the targeted group for the app.	Poor public involvement (Bouleau, Barbier et al. 2020) except for bathing activists and public respondents in focus groups

3.4.3. Problem Perceptions, Narratives and Goal Ambitions

Problem perceptions, narratives and goal ambitions are, in the context of DWC, the different perceptions and positions of relevant stakeholders towards digital water governance and their relevance for enabling/constraining innovation in urban water management. Goals, and their definitions, depend largely on the perceptions of the problems at hand

The guiding protocol raised the following hypotheses on factors influencing ICT uptakes:

- H6: user involvement in developing ICT solutions fosters user benefit of the solution.
- H7: yet it limits innovativeness.
- H8: when relevant governance actors are open to learning processes it facilitates the uptake of innovative ICT solutions.

Berlin case study

Major actors recognise the potential benefits of digitalising the urban water sector. Within the Berliner Wasserbetriebe, the main water utility, digitalisation and, even more, automation, are embraced as processes with a high potential to reap efficiency gains. Automation allows to decrease the number of tasks that require intense manual labour and thus can contribute to increasing workplace attractiveness of water utilities.

In addition, they can help to reduce complexity for employees in the water sector. An interviewee expressed that the work environment is becoming increasingly complex in the water sector and at some point a limit is reached as to what a human being can simultaneously process. To optimise different processes with sometimes conflicting goals digitalisation is perceived as providing huge benefits. Nature protection and energy efficiency were mentioned as an example by the interviewee for areas, that often have conflicting goals, e.g. when it comes to the optimal water level of water bodies. In this case, the interviewee emphasized, digital tools can facilitate optimising water levels by taking into account the requirements of these different sectors.

Another issue raised by the interviewee was the fact that as more data is being collected large “data cemeteries” might be created. Thus, the interviewee perceives that digitalisation in the form of collecting more and more data on water infrastructure and the environment could lead to a misconception of achieving greater control of processes. The interview emphasized that collecting data would also require careful process understanding and operation of the water infrastructure to be able to analyse the data collected effectively.

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Digitalisation, the interviewee expressed, thus still requires to check regularly for the plausibility of the data collected as well as to calibrate sensors etc. This in turn, requires many resources, and in turn leads to a relocation of workplaces, as more experts are needed for issues like data monitoring and sensor calibrating. In addition, collecting and storing increasing amounts of data also requires high standards of data security to cope with potential cyber security threats. This, the interviewee expressed, has to be considered when praising the efficiency gains that come with digitalisation.

Also, civil society organisations are voicing concerns regarding the collection of data through utilities and their "data sovereignty" as they fear that utilities are not fully transparent when it comes to environmental damages. Here, the interviewee highlighted, it is, however, important to work in trust building and increasing transparency by providing data to an extent current regulation allows.

Major concerns have been voiced by representatives of German trade unions. An interviewee expressed that if the decision goes that AI will be used to control a wastewater treatment plant, then jobs will actually be lost if no other opportunities are brought about. In this sense, there exists a real job loss risk. However, the interviewee also expressed hope that fields of work will change, but no job has to be completely eliminated by digitalisation. The interviewee highlighted, however, that there are further risks in public services. In the case of a water extraction service controlled by AI, serious consequences fall back on society as a whole, for example if sewage networks run full. That is why someone must be there to constantly monitor the system. AI can help to makes proposals, referring to which experts make decisions.

Milan case study

With the interviews conducted so far, we are not able to answer all the questions of the guiding protocols. To what extent do views/arguments/positions support each other, and to what extent are they in competition? This question will be answered in D3.5.

All actors seem to recognize the potential benefits that digitalization could bring in terms of efficiency gains, improved performance and reducing environmental impact. Nevertheless, different actors perceive a series of risks or drawbacks that might put a hold on digital transition.

A first obstacle that is transversely acknowledged by different categories is the persistence of an outdated legal framework that does not address innovation uptake and leaves normative gaps, for example in data management for customized services. In the agricultural sector, the main doubts regarding digitalization have to do with the implementation of technology, the use of sensors, as well as the definition and sharing of responsibilities. These issues affect cost-effectiveness and are therefore taken into consideration in risk assessment and risk management. The lack of incentives supporting digital uptake places most of the economic burden on the shoulders of private farms. For example, farmers lament a lack of incentives and economic support for the implementation of underground water meters: among other functions, these are useful to reach targets of water and food safety, which is of course an improvement that serves a public interest and that in itself farmers would welcome. However, the opposite is true, as the costs for the installation of water meters are currently borne by private farmers for the lack of public economic support.

Similarly, legal risks are not adequately shared with farmers when digital solutions are implemented. As an example, improvement in water reuse shares are held back because it is not clear who should be responsible for risk management (e.g. the utility, the irrigation infrastructure manager, the farmer or a third contractor) and to which extent, as system boundaries and the definition of roles have so far not been dealt with.

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From what emerged during the most recent CoP, major interest of utilities, reclamation managers and farmers converged to the data science for dynamic risk management and minimization by early warning systems. In short, we can assess how most stakeholders share a rather optimistic stance on the digitalization of the water system, as they believe that it will bring benefits on water related activities in terms of efficiency and sustainability. At the same time, contrasting views appear when the discussion turns towards economic and legal risks connected to the introduction of novel digital solutions.

The ambition of water utilities is to grow more digital. For instance, by using digital twins, analytical tools and machine learning, their ambition is to better predict network behavior and prevent technical and environmental issues. With such a mindset, Gruppo CAP has promoted the largest network of utilities in Lombardy through a digital hub connecting 450 municipalities in the Region. The involvement of potential users into the processes of development and evaluation of digital solutions is common practice, as their interests and feedbacks are collected in CoPs.

Paris case study

Digitalization of water management in the Paris region as such is not discussed in the public space. The perception of digitalization in the water management can be related to the current perception of water issues.

Water managers perceive two types of problems. The first one concerns public infrastructures and is mainly technical. SIAAP decided to equip WWTP with disinfection (Seine-Valenton and Marne-Aval) and to invest in a large reservoir in Paris to store rainwater (near hôpital de la Salpétrière). Both decisions encountered some criticism in the media, based on their cost and their potential environmental impacts.

The second one concerns non-compliant households connections in case of separate system. It is perceived as a huge effort to be made (35000 connections/year), with a significant share of the cost on households (several k€), only some of them will benefit from bathing site proximity. It is perceived as potentially much more conflictual.

Table 12 Summarizing findings on problem perceptions

Cities	Gains from user involvement (H6) Previously unseen user problems (revealed by WP3)	Drawbacks from user involvement (H7) Reluctance to innovativeness	Observed learning processes that facilitate the uptake of innovative solutions (H8)
Berlin	*To be completed in final version.*	*To be completed in D3.5*	*To be completed in D3.5*
Milan	*To be completed in final version.*	Increase of service costs; economic and legal responsibilities for risk assessment and management are not defined.	The serious game is specifically designed to trigger and support a learning process regarding water-food-climate nexuses.
Paris	WP3 revealed the public's expectation for :	no reluctance to innovativeness was observed.	COPs served as a learning platform for future bathing site managers.

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	- a users-to-managers feedback menu in the app - a FAQ page - additional information on access, affluence, Temperature, and algae presence.		Future managers notably learned the technical possibilities of early warning systems and their costs. They also learn about organizational issues with chemical labs.

3.4.4. Strategies and Instruments

This part addresses regulatory, economic and voluntary forms of policy action influencing the uptake of innovative ICT solutions in the urban water sector.

The guiding protocol raised the following hypotheses on factors influencing ICT uptakes:

- H9: Existing standards which give preference to low(est) cost offers and proven technologies hinder innovation uptake.
- H10: High risks and uncertainty around adopting new management practices make innovation uptake in urban water management less likely.

Berlin case study

The gain of productivity seems to be the main driver, yet the role of policy instruments will be further documented in D.3.5.

Small-sized firms have a higher and faster rollout potential, and they can be the real forerunners in the digital transition. Large utilities like the Berliner Wasserbetriebe that operate in the whole of Berlin are facing enormous investments when it comes to automatizing processes, such as central operation of drinking water treatment plants and wastewater treatment plants. On the other hand, there are enormous gains in productivity due to automatization and digitalization and this is why Berliner Wasserbetriebe strongly focuses on the digitalization of its work processes. A regulatory framework that requires automation of such processes as well as major financial incentives from the Berlin Senate to implement ICT solutions are absent, which might also slow down the deployment of ICT solutions in the sector.

As water infrastructure is critical infrastructure, any introduced new technology needs to have a proven record of being safe and not putting secure operation of the water infrastructure at risk. This is a hindrance to the use of emerging digital technologies, which might not yet have reached this stage. Risk aversion of managers in water utilities is another complicating factor, especially because funding for innovation has still to take into consideration both sunk and running costs.

Data security was mentioned as another important challenge that comes with increased digitalisation in the sector. Current legislation relevant to the sector aims at protecting personal data.

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Most information can be, however, provided to the public in accordance with the Environmental Information Law without disclosing information on critical water infrastructure. A high degree of data security as those posed by the German Federal States can further limit the portfolio of available digital technology on the market and thus its application. As the water market is small compared to other markets, there are few incentives to offer tools which provide both data security and functionality. One interviewee proposed to have a central data protection guideline applicable to innovations in the water sector.

Milan case study

In Italy today there is a national energy and climate plan, as well as a national directive for water, but a national digital strategy is still missing. The lack of national coordination hinders the establishment of a much-needed multilevel governance for digitalization, which is currently pursued mainly by leaving utilities free to opt-up autonomously. This typically happens within the scope of projects that are funded by programs of the European Union. In this context, a valuable strategy to push for innovation that was successfully implemented by water utilities operating in Lombardy is the initiative "Water Alliance – Acque di Lombardia"[16]: Utilities collectively aim at ambitious objectives – modernization, efficiency, sustainability of water service - that are meant to be achieved through industrial synergies based on open innovation and the sharing of knowledge and competences with the stakeholders of the sector. Key tools of the alliance include a shared WebGis digital platform, laboratory network and smart meters[17]. This success story exposes how within a fragmented structure of governance, farsightedness in water resource management is possible, but it is conditioned to the free initiative of local actors to merge operations and to pool resources and expertise, which inevitably limits interactions and opportunities of development.

One issue that was raised by public authorities is the lack of coercive instruments for local and regional actors to comply with national requirements of ATO, and how this typically results in missing data. These deficiencies make it more challenging to set accurate rates and make decisions on tools and approaches.

Paris case study

Given the significance of pollution sources reaching the Marne and the Seine River during rainfall events, bathing is not possible without ICT tools to secure early warning systems. In this sense, the combination of the Bathing directive which states water quality requirements and the JOP agenda are together the strategy and the policy instruments driving the uptake of ICT tools.

The funding for developping the app is secured by SIAAP. Yet the funding needed for innovations to become implemented (municipal digital equipments, staff training) is not discussed yet. The implementation of the bathing policy will cost between 1 and 1.4 billion Euros but there are discussions about the dedicated parts to achieve the bathing quality standards. States authorities are considering that more than 80% of this amount is related to reach compliance with regulation.

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[16] http://www.wateralliance.it/chi-siamo/ Retrieved on 29.10.2020.

[17] Acque di Lombardia (2019) Acqua, sviluppo e innovazione alla base delle strategie più competitive per far crescere il territorio Lombardo http://www.wateralliance.it/comunicato-stampa/acqua-sviluppo-e-innovazione-alla-base-delle-strategie-piu-competitive-per-far-crescere-il-territorio-lombardo/ Retrieved on 29.10.2020.

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The cost of innovation is marginal in relation to the overall bathing policy. First costs of development will be covered by SIAAP.

In the city of Paris, wastewater is carried in combined sewer and the price of water is 3.42 Euros, one of the lowest prices in the area. Beyond the city limits, in the near outskirt, water prices are much higher. Achieving bathing quality in the Marne and the Seine Rivers requires that more rainwater be infiltrated and household connections be compliant with the separate system requirement. Both efforts are to be made in the outskirt although infiltration is easier in less densely populated area, therefore outside Paris. The financial support rules from the Seine-Normandy water agency was changed toward more equity between Paris and its outskirt and this should enhance public support for this policy.

The existing bathing directive imposes water to be of sufficient quality for 90% of the time. Given the risk of rainfall during the bathing season, the cost of securing bathing quality during these events is very high. Modelling and early warning systems provide a reliable information for closing sites so that the public has no health risk. Yet it does not secure that sites will be open 90% of the time. Without flexibility in the bathing directive interpretation, bathing sites managers may be encouraged to close permanently bathing sites instead of relying on innovations.

Table 13 Summarizing findings on strategies and instruments

Cities	Existing standards hindering innovation (H9)	¨Perceived risks and uncertainty that may hinder innovation uptake (H10)
Berlin	Lack of regulatory incentives and a digital water governance framework is hindering innovation	Data security risks, general risk aversion of water managers
Milan	To be completed in final version.	Legal uncertainty and cost-effectiveness are two factors that discourage actors from implementing digital solutions.
Paris	Innovation costs are marginal compared to the overall bathing policy. Bathing directive demanding standards may encourage bathing sites managers to close permanently bathing sites instead of relying on innovations.	Remaining uncertainties on the sanitarian quality of water (once BIF are desinfected in WWTP) may hinder bathing practices, and by consequences the use of the public app.

3.4.5. Responsibilities and Resources

Responsibilities and resources are the allocation of tasks, powers and capacities within the digital water governance system influencing innovation uptake in urban water management. It describes the mandates of each stakeholder when it comes to innovation uptake.

The guiding protocol raised the following hypotheses on factors influencing ICT uptakes:

- H11: Centralisation of decision-making reduces the speed of innovation uptake
- H12: A lack of funding in the water sector hinders the uptake of ICT solutions.

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Berlin case study

More information is to come in D3.5 with later interviews notably concerning the mandates of different departments of the Senate.

Decision-making in urban water management is highly centralised, with the Berlin Senate for Environment, Transport and Climate as the central policy actor and the Berliner Wasserbetriebe as the major implementing agency. When it comes to digital water governance, however, responsibilities are not clearly assigned to a single actor only but rather dispersed a range of actors. These include different branches of the Berlin Senate (the Senate Department for Environment, Transport and Climate on the one hand and the Senate Department for Economics, Energy and Public Enterprises) that are central in shaping the city's innovation policy. This decision-making authority of the different Senate Departments in most aspects related to digital water management is, however, not necessarily accompanied with sufficient funding to design a regulatory framework that facilitates the uptake of digital solutions in the water sector. Such a lack of funding has been mentioned by several interviewees as a main obstacle that hinders innovation uptake in the water sector. It needs to be distinguished between *a)* a lack of funding at regulatory agencies to design and implement policies that stimulate innovation, such as the Berlin senate and *b)* a lack of funding among water utilities to design and implement innovative ICT solutions. In the water sector, change takes place at a slow pace and the management model relies on long-term plans with long investment cycles. Thus, these findings in the Berlin case support hypothesis H12 which sees a lack of funding as a hindrance to the uptake of ICT solutions.

Milan case study

Financial resources are allocated at the national level. AATOs assign the provision of water service to utilities, but the framework of contract as well as minimum standards for the service are determined by ARERA[18]. Innovative initiatives are usually taken at the local level by utilities and private sector, funding for digitalization comes mainly from the supranational level.

Paris case study

The tasks within the digital governance are to be decided in COPs. SIAAP was granded an official mandate in october.

[18] Fracchia, F. & Pantalone, P. (2018) The governance and independent regulation of the integrated water service in Italy: commons, ideology and future generations, Federalismi.it 11/2018 p. 12;

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Table 14 Summarizing findings on responsibilities and resources

Cities	Centralisation of decision which could reduce the speed of innovation uptake (H11)	Funding issues which may hinder the uptake of ICT solutions (H12)
Berlin	Dispersed between different Senate Departments on the regulatory level and the Berliner Wasserbetriebe on the operational level	Lack of funding in regulatory agencies and in water utility
Milan	*To be completed in final version.*	*To be completed in final version.*
Paris	Decisions are not centralised but discussed in cops under the leardership of SIAAP. This has slowed down the process in the beginning but secured stronger level of involvement and trust in the long term	No. Innovation costs are low in comparison to those for achieving bathing quality.

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4. Social context of ICT solutions use and expectations of the targeted public

The objective of this section is to present the results of the interviews, CoPs and focus groups for issues related to end-users needs (in order to feed the design-thinking method). It deals with how different people relate to water and digital apps.

4.1. Berlin Case study

4.1.1. The context in which the targeted public is supposed to use the app (in line with design-thinking)

We expect that the context in which the targeted public is supposed to use the app must be taken into account.

4.1.2. How the app could change the representation of the targeted public

Better understanding of groundwater flows and sources and increased awareness the importance of groundwater for water supply in the city.

4.2. Milan Case study

4.2.1. The context in which the targeted public is supposed to use the app (in line with design-thinking)

While planning agricultural practices or making decisions on farming inputs; training of stakeholders (from water utilities, reclamation facility operators, irrigation infrastructure, to farmers)

4.2.2. How the app could change the representation of the targeted public

Better understanding of water reuse and safe water reuse, increasing awareness and willingness to support more sustainable solutions.

4.3. Paris Case study

In this section, we focus on end-user and large public. The expert-targeted app in Paris is not addressed in this section.

4.3.1. The context in which the targeted public is supposed to use the app (in line with design-thinking)

We expect that the context in which the targeted public is supposed to use the app must be taken into account: Residents in Paris region planning a weekend? Europeans planning vacation in Paris area? Residents taking a bike during summer? Our first findings tend to identify end-users as middle-class residents close to the river. In spring 2022 we will ask more questions on the intended practices of future users:

- As individuals or in a group? When encouraged by a community-manager or by themselves?
- Do they use mobile phone during this practice or a computer?

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4.3.2. How the app could change the representation of the targeted public

- The project aims to identify the current representations of water by the targeted public and to understand how it could change with the development of the app.

We assume that the information displayed on the app concerning biodiversity and water pollution sources may contribute to change the general public understanding of water. Our first focus group confirmed a lack of knowledge in water pollution sources and the existence of flora and fauna in the river.

5. Conclusion

5.1. Barriers

The only barrier identified in Paris is the EU water quality standard for bathing that is hard to achieve more than 90% of the time in Paris urban rivers and that may encourage bathing site managers to close sites instead of relying in ICT tools.

5.2. Enablers

In Paris, supposedly disfavourable factors to ICT uptake were actually offset by ICT development in public services, a common culture of digital water-related data sharing among water professionals, and by the good development of COPs.

5.3. Key learnings

Setting up participating and voting rules in COPs helps develop engagement and trust among participants. When participants have a lack of practice, like future bathing site managers, COPs may nevertheless be useful if experienced professionals are invited to tell their feedbacks.

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6. Annex: Technical description of the apps for public involvement

The following annex describes the technical specifications of the apps developed in the three case studies. **Please note that the descriptions of the app do not reflect the current state of the app development. Thus, some sections will be updated and completed in the final version of this deliverable.**

6.1. Berlin Case study

6.1.1. Design of the tool

Objective and benefits

The objective of the app is to help end-users answer the following questions:

- Where does the drinking water come from?
- How does the water get into the wells?
- How is the water cleaned during the soil passage?

How will the tool improve public involvement?

The mobile application will be developed for visualizing geology and groundwater and highlighting their relevance as drinking water resource. Both off-site and on-site mode aim to be used in training and learning environments to increase the level of users' immersion and to create an added value by visualizing the "hidden part of the water cycle".

Target group

General public (e.g. teachers, pupils from secondary school upwards, students); no experts

User Group

Employees of Berliner Wasserbetriebe (or generally in the partner utilities), who conduct guided tours or participate in further training for teachers

Where is the tool used?

The use on site/ off site has to be specified through further interviews

User requirements (e.g. are trainings needed?)

Functional description of main features

The mobile application is targeted for modern smart phones that are capable of displaying augmented reality content using the smart phone camera. The application will operate in two modes: off-site and on-site. Both modes will need no additional data or synchronization with external data. The off-site or table-top mode can be used anywhere. It displays specific areas of Berlin to highlight groundwater processes in a diorama-like fashion. The on-site mode is designed for specific places, only to enhance an existing site with digital augments. The on-site mode actually mixes virtual characters (i.e. geology, groundwater flow, well information) with the actual world (i.e. landscape, well lids) (Figure 1).

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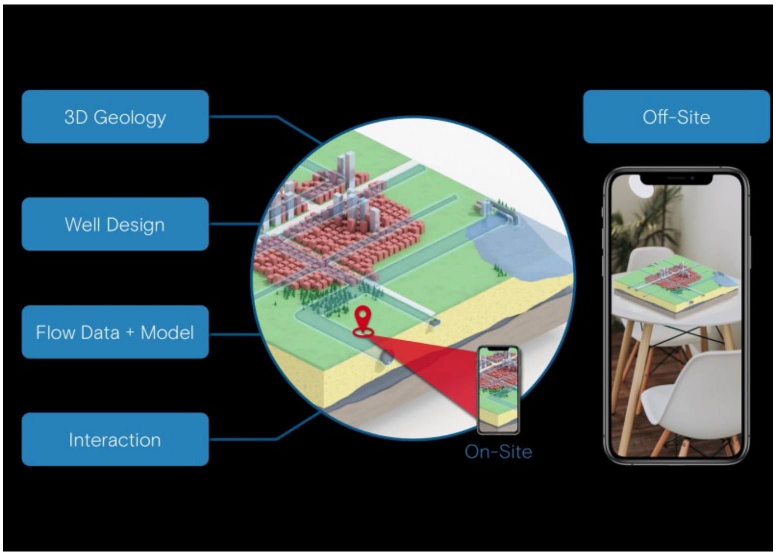

Figure 7 Overview of main features of mobile VR/AR applications

User interface (mock-up and structure)

The user interface will consist of a main menu to select various scenes of content. A skippable introductory scene is planned to be played at first use to introduce new users to the app and AR technology.

- Main menu (Introduction)
- Berlin overview scene
- Scene Riverbank filtration
  - at Berlin Beelitzhof
- Scene Groundwater augmentation
  - at Berlin Spandau

How does the user interact with the GUI (including input of data)?

Users interact with the app through a straightforward menu system that allows them to select the desired content. To place AR models, the app is using standardized means of user interaction and guidance, e.g. to localize a plane, to place an object, to resize or to rotate it.

Non-standard interaction will occur with the models itself. The interaction design is planned to be natural and self-explanatory by using 3D elements instead of named 2D buttons. To make sure, this process meets user demand, user testing will be conducted from the initial model prototypes onward. The off-site mode will allow the user to interact with

- groundwater flow direction
- groundwater flow velocity
- well function (total depth, filter screen, abstraction rate)
- display function of time (real-time and acceleration function)
- geological layers and supporting information on genesis and function

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What information/data is required?

The required data for displaying groundwater flow are obtained from numerical simulations of the scenes. Simulations are conducted by standard software product MODFLOW. Simulated data are then displayed in a virtual three-dimensional (3-D) environment on mobile terminals. The data from numerical simulations is parsed and processed by a newly developed, stand-alone component. This will take different MODFLOW output files and generate 3D model files suitable for the AR/VR environment. The process will initially support the OBJ-format.

What is the purpose of the processing done by the product, including use of models?

The purpose is to develop an AR/VR-based app as training and educational material and to create tools and software routines to link numerical software output data to AR/VR applications.

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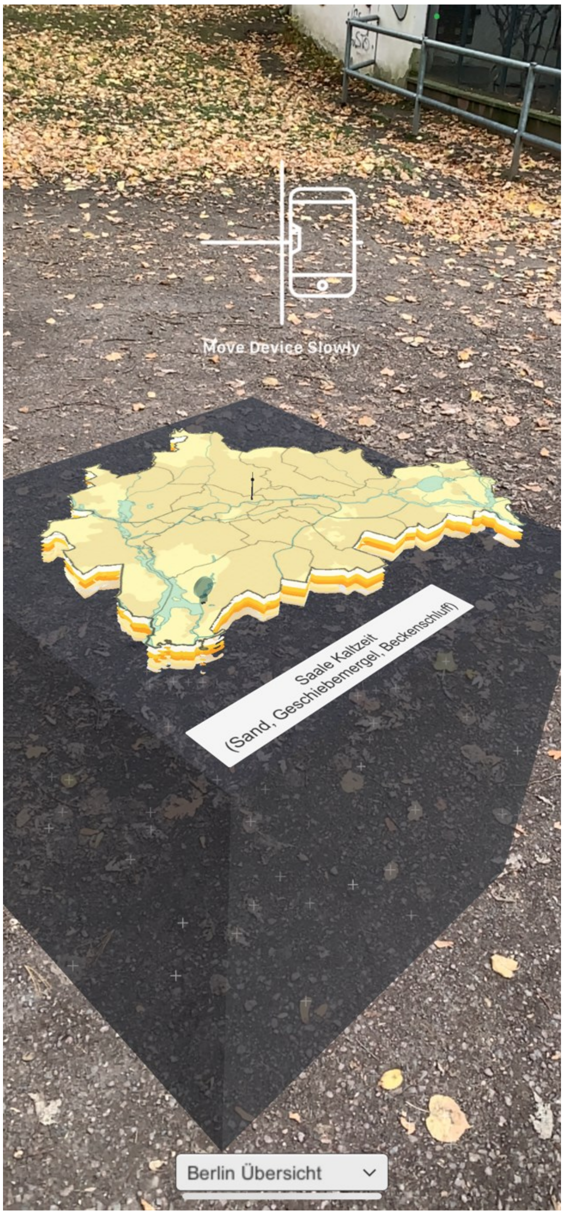
What are the results? How are the results visualised?



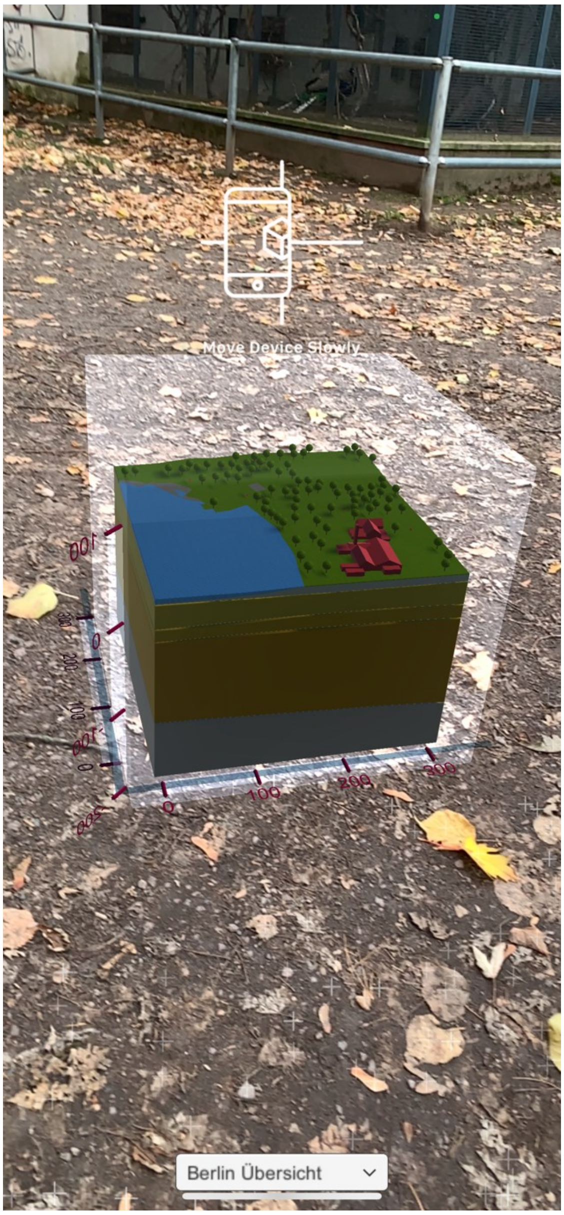


Figure 8 Overview scene of Berlin geology and topology *Figure 9 UX sample of scene detail*

6.1.2. Technical description of the tool

The product in its environment (relation to external systems and services)

In Berlin, a Beta versions is already out and is currently being tested. The development process and the products environment include the following entities (see Figure 1):

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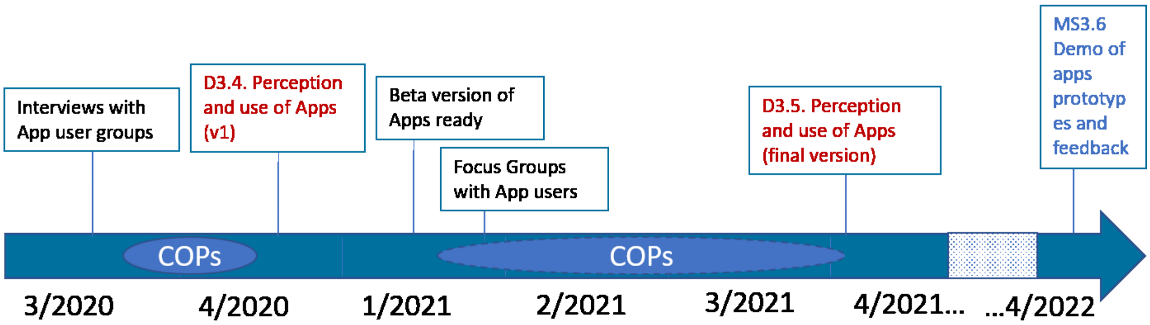

Figure 10 Timeline of development for the "Grundwasser Sichtbar Machen" App in Berlin

What are the software components for the product?

- Unity 3D AR mobile application for Android and iOS
- Elixir conversion tool for MODFLOW to 3D format OBJ

How are these components implemented?

The AR application is using Unity AR Foundation framework as a baseline to easy cross platform development. This provides a basic set of classes for plane detection, AR camera setup and wraps specific native AR libraries of Android and iOS to create AR applications. This framework is extended by own models, scripts (programmatic behaviour), and designs. The conversion of MODFLOW results (text files) into 3D models in OBJ format is done via a small Elixir toolkit that consists of a parser to read and internalise MODFLOW documents and a generator to create valid OBJ files. This will be a command line tool that could be integrated into a small web service later on.

Which (open) data sets (including formats; resolution, source, copyright) are used?

- Geology dataset (Berlin 3D, x3d)

Which data sets (including formats) are produced?

- OBJ-formatted 3D models from MODFLOW data
- MODFLOW simulations of scenes

What is the operational environment (servers, firewall, operating system)?

There is no specific operational environment for the app. It will be published on Google Play Store and Apple App Store[19] and compatibility lists for devices will be available on the store pages.

[19] It is important to note that although the app will be available in the Google Play Store and Apple App Store, it is still not directed at the general public as a target group but as a user group. From a technical point of view, the app should be easily usable on all devices of the target group and available for download. It should also be self-explanatory. This means that the needs of the target group determine the development of the app (previous knowledge, UX, ...). Nevertheless, the user group is important for the distribution and acceptance of the app which is another argument why the app is publicly available.

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6.1.3. Quality attributes

What are the availability requirements?

- Google Play Store
- Apple App Store

What are the performance requirements?

Modern smartphone (exact compatibility list will be available after builds are done and published in the app stores)

What are the security requirements?

No requirements other that needed for AR (camera)

What are the usability requirements?

- Android
- iOS

What are the modifiability requirements?

Updates will be served through the playstores

6.2. Milan Case study

6.2.1. Design of the tool

Objective and benefits

Engage a wide public on issues surrounding water reuse, ultimately overcoming social and economic barriers to its effective implementation. Benefits include increased awareness and willingness to support more sustainable solutions.

How will the tool improve public involvement?

The serious game will provide on-field verifiable and fit-for-audience information about economic and technical efforts to address systemic and nexus improvement, letting them understand the nexus complexity and put hands-on urban and peri-urban (treatment and reuse) water systems that are improving nexus footprint.

Target user group

General public (e.g. teachers, pupils from secondary school upwards, students, consumers), environmentalist NGOs, local governments, water authorities, water utilities, water reclamation managers, irrigation consortia. Entities at the European Union level could also be targeted: European Water Regulators (WAREG), EurEau, Water Europe, Irrigants d'Europe, CoPA-CONGECA, European Commission (DG Environment, DG agriculture and rural development).

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Where is the tool used?

The application will run on an online web application and it is designed to be used during different training or learning events.

User requirements (e.g. are trainings needed?)

Citizens should be able to play the game without specific technical background knowledge. Nevertheless, users will be assisted along the gameplay, with information and suggestions about challenges and indicators.

Functional description of main features

The user interface will consist in a main menu where various section of the serious game can be selected.

- In the main page an introduction and contextualization of the game can be found.
- In the configuration section some of the parameters (area size, type etc.) that will affect the gaming experience can be regulated.
- the interface dedicated to the game itself will allow to add/modify/remove a number of layers (soils, crops, WWTPs etc.) which represent the different intervention that the player can make as a decision maker to impact on the nexus. Furthermore, different aspects (cultivation, irrigation, digitalization) can be linked or unlinked between different areas, affecting the final results.
- A last section is dedicated to the evaluation of the final results and the optional share of these with other users.

How does the user interact with the GUI (including input of data)?

User interacts using typical UI components of a web application, such as list and text inputs.

What information/data is required?

Population; industrial area size, Wastewater simplified description, WWTP configuration, Water quality, Energy footprint indicators, Water footprints indicators, Carbon footprint indicators, Nexus indicators, field properties (soil configuration, water demand, crop productivity etc.)

What is the purpose of the processing done by the product, including use of models?

According to the set-up parameters selected by the user, different scenarios will be created based on a real-data-based simulation. Set-up parameters include wastewater infrastructure’s performances and costs, irrigation systems, digitalization of the field, weather conditions and will have a final impact on carbon, water and nexus footprint indicators.

What are the results?

The gaming experience will result in an evaluation of how different strategies of urban wastewater, peri-urban irrigation and agricultural management have an impact on carbon, energy, water and nexus footprint indicators.

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How are the results visualised?

A first version of the application will visualize the gameplay results through plots and canvas. The components will be inspired by the material design.

6.2.2. Technical description of the tool

The product in its environment (relation to external systems and services)

In Milan, a first release (beta) is scheduled for the end of January 2021. To date, a first proof of concept (PoC) was developed, together with the general structure, the required data, the assumptions/models/simplifications to be used and expected outputs.

The development process and the products environment include the following entities

1) Urban wastewater infrastructure configuration and sustainability indicators such as catchment drainage, treatments, water-energy-carbon and nexus footprint indicators, effluent quality indicators;

2) Peri-urban field configuration (season, rains, cultivated crops, soil characteristics, irrigation techniques).

Once these inputs are set and the level of water quality to be achieved is established (according to the A-D water quality scale included in the EU regulation 741/2020), water-energy-carbon and nexus footprint indicators will be displayed, expressed in relation to the volume of water that was used or to the amount of agricultural products.

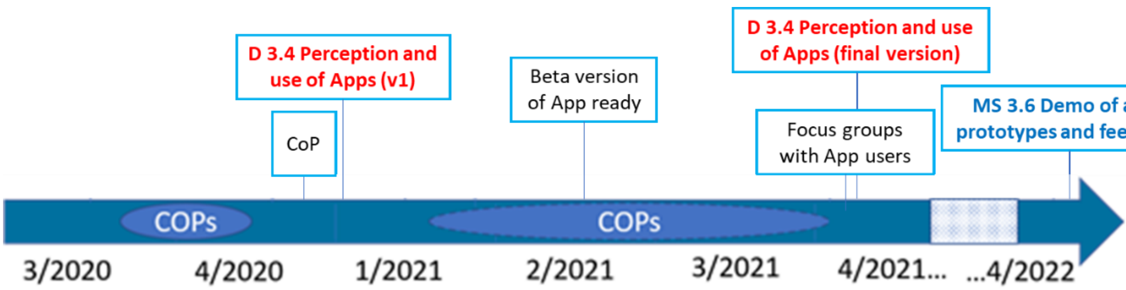

Figure 11 Timeline for the serious game app in Milan

What are the software components for the product?

Front-end: modern approach to web development based on JavaScript and frameworks as Angular / React.

Back-end: based on serverless approach with basic API to update the game according to the user's input.

How are these components implemented?

Agile development with strong interaction with cloud services trying to use as much as possible a serverless approach.

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Which (open) data sets (including formats; resolution, source, copyright) are used?

Open access software for environment simulation are used to process agronomic data, while carbon footprint models are self-developed and use data provided by the WWTP.

Which data sets (including formats) are produced?

Only for internal use. The majority of data sets will be stored as JSON.

What is the operational environment (servers, firewall, operating system)?

Serverless architecture with an API gateway that provides access to internal services developed as lambda function. Database will run as a service in a dedicated instance.

6.2.3. Quality attributes

What are the availability requirements?

The serious game will be public; registration will be required in order to play with the game. Since the game is a web application it will be accessible through a range of devices: computers, tablets, smartphones.

What are the performance requirements?

Standard Notebook / Desktop / Table able to open a modern rich web UI with internet access enabled.

What are the security requirements?

Basic user information will be collected, including name, surname, gender, instruction level, current occupation, country and email. Data will be used internally and will not be used or shared by third parties. The use profiling is limited to the gaming setup purposes.

What are the usability requirements?

Browsers that are based on Chromium will grant the optimal experience. Nevertheless, the application will be tested also on Firefox and Safari and there will be no dependency to any operating system.

What are the modifiability requirements?

The application will not be modifiable.

6.3. Paris Case study

6.3.1. Design of the tool

Since the design of the apps is still open to definition by CoPs, only minor information are given here and the coming year will be used to further develop the design of the apps.

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Objective and benefits

Two apps are to be developed. One aims at informing bathing site managers with water quality indicators so that they can take a decision for opening or closing sites. The other aims to inform the public on the status of bathing sites (open or closed) and other useful information. It could also be used by the public to send observations to bathing sites managers.

How will the tool improve public involvement?

The app will give public more information about their environment and could be used for the public to send observations to bathing sites managers,

Target user group

App 1 Bathing site managers

App 2 Bathers, riparian residents, boat owners

Where is the tool used?

App 1 in bathing site managers offices

App 2 anywhere

User requirements (e.g. are trainings needed?)

App 1 training required

App 2 no training required

Functional description of main features

User interface (mock-up and structure)

How does the user interact with the GUI (including input of data)?

What information/data is required?

What is the purpose of the processing done by the product, including use of models?

What are the results?

How are the results visualised?

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6.3.2. Technical description of the tool

The product in its environment (relation to external systems and services) –

The development process and the products environment include the following entities

What are the software components for the product?

How are these components implemented?

Which (open) data sets (including formats; resolution, source, copyright) are used?

Which data sets (including formats) are produced?

What is the operational environment (servers, firewall, operating system)?

6.3.3. Quality attributes

What are the availability requirements?

What are the performance requirements?

What are the security requirements?

What are the usability requirements?

What are the modifiability requirements?

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