PERCEPTION, ACCEPTANCE AND USE OF DIGITAL SOLUTIONS

Final version

digital-water.city
digitalwater_eu

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Deliverable N°3.5	Perception, acceptance and use of digital solutions
Related Work Package	WP3
Deliverable lead	Gabrielle Bouleau
Author(s)	Gabrielle Bouleau, Ulf Stein, Benedict Bueb, Gaële Rouillé-Kiélo, 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
Grant Agreement Number	n° 820954
Instrument	HORIZON 2020
Start date of the project	01 June 2019
Duration of the project	42 months
Website	www.digital-water.city
License	
Abstract	See executive summary

Dissemination level of the document

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

Versioning and contribution history

Version*	Date	Modified by	Modification reasons
D1	30/11/2021	Ulf Stein, Gabrielle Bouleau, Benedict Bueb	Preparing draft version of final deliverable
S1	30/11/2021	Hella Schwarzmüller	Internal review and pdf creation
S2	20/03/2022	Ulf Stein, Gabrielle Bouleau, Benedict Bueb	Addressing some reviewers' comments to the draft version.
D2	13/04/2022	Benedict Bueb, Ulf Stein	Inclusion of additional research results into cross-case comparison and conclusion
D3	28/04/2022	Stephan Gensch, Massimiliano Sgroi, Sofia Housni, Alexander Sperlich	Addressing acomments from the COM to the draft version.
D4	16/05/2022	Ulf Stein	Addressing reviewer's comments.
V	31/01/2023	Benedict Bueb	Final edits following external review

* The version convention of the deliverables is described in the Project Management Handbook (D7.1). D for draft, R for draft following internal review, S for submitted to the EC and V for approved by the EC.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Table of content

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

List of figures

List of tables

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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).

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, inquiring the hypotheses defined in the Guiding Protocol concerning governance factors enabling and hindering ICT uptake in each context. Then we evaluate, the social context of the use of the digital solutions. Finally, conclusions regarding barriers, enables and key lessons learned are drawn based on the cross-case governance analysis.

These lessons learned are the following:

- The general public hardly knows about water infrastructure and water main sources of pollution. The information displayed on the apps may contribute to change the general public understanding of water.
- On the contrary, water managers tend to overlook other sources of risks not directly linked with water.
- In terms of regulatory issues and standards, there is a clear need to **establish standards** for data harmonization. Related to this, a central **data protection and security guideline** applicable to innovations in the water sector could be a way forward to decrease risk aversion and uncertainties around data protection issues that often hinder innovation in digital water management and governance. As the water market is small compared to other markets, there are few incentives to offer tools which provide both data security and functionality, thus balancing data security risks and attractiveness to technology developers and utilities is important.
- Employees' support for digitalization is key for ICT uptake, in addition to end-user participation to the design process.
- Due to the high degree of governance fragmentation and the cross-sectoral character of digital water governance challenges *within* cities, harmonised and effective governance approaches that enable the uptake of ICT solutions are needed. Here, **intersectoral working groups**, bringing together utilities, technology developers but also representatives of different public authorities can be a way forward to enhance harmonised and effective governance. Such working groups organised by a lead actor can meet regularly to identify regulatory gaps and challenges, develop and discuss new standards and policy recommendations and develop strategies that give incentives the uptake of ICT solutions.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

- In a similar manner and to overcome fragmentation *across* governance levels, working groups on digital water governance bringing together national and sub-national authorities are very useful. In Berlin, comparable working groups already exist that can be taken as potential examples.
- 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.
- In the absence of regulations or strategies that aim for greater digitalisation in the urban water sector, stricter water quality regulations set by authorities at national and city level enabled ICT uptake in Berlin and Milan.
- A lack of public funding has been mentioned by several interviewees as a main obstacle that hinders innovation uptake in the water sector. Private funds could partly compensate for the lack of public funding available for ICT solutions in the urban water sector in these cities. In Paris, digitalisation of the water sector was entirely publicly funded.
- Governance fragmentation has been a barrier in particular in Berlin and Milan, where the cross-sectoral character of digital water governance challenges harmonized and effective governance approaches that enable the uptake of ICT solutions. Intersectoral working groups, bringing together utilities, technology developers but also representatives of different public authorities can be a way forward to enhance harmonised and effective governance. In Paris governance fragmentation is offset by a professional community of engineers across organizations already sharing digital tools and information.
- Since water infrastructure are critical infrastructures, managers express strong reluctance to fully automatize key water management processes. Water managers keeping control on critical decisions remain key to ICT solution acceptance.
- Preexisting digital culture and tool usage among water managers enables ICT uptake. Otherwise, ICT uptake develops incrementally as trust is being built among a community of practice. Co-creation platforms such as CoPs, are well suited to support digital use cases on municipal level.
- A timing paradox became visible in Paris and Berlin. If there is little public involvement, people will know little about how they can contribute to urban water management practices and what stake they have in the relevant processes. However, developing appropriate digital solutions requires that end users are involved in planning as early as possible and make decisions without knowing much about the broader context.
- Focus groups with potential future users of digital solutions helped define an approach that takes into account users' expectations of information (both information provided by technical managers and information that users communicate to managers). The organisation of these focus groups also revealed which part of the public felt affected or excluded by the digital solutions, as well as the potential of the digital solutions to inform the public.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

- In Berlin, different focus groups were held with both water management practitioners and school children. While the focus group with water professionals helped to improve the user experience, the focus group with school children provided valuable insights into the interaction of another main target group of the app.
- A high level of digital literacy among the children was a crucial factor for using the app, confirming the importance of digital literacy, which was also observed as a facilitating factor in Paris. The playful introduction to groundwater flows in Berlin was positively received by the children and could potentially be integrated into the curricula of local schools.
- Central data protection and security guideline applicable to innovations in the water guideline could be a way forward to decrease uncertainties around data protection issues that often hinder innovation in digital water management and governance.
- Due to the social digital gap, most people still get water-related information from classic media (press, TV, radio) rather than digital apps. Apps targeted the large public may actually be used by a limited part of the population. Digital apps informing on water are more likely to be used by young middle-class users. Apps must be developed so that links with popular websites can be easily set and updated. Digital solutions supporting social awareness can be an integral building block within sustainable urban water management and infrastructure development.

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 are developed accordingly with the study cases' own specificity, to ensure that, once finalized these are 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:

- the cross-case comparison of the governance assessment.
- information on the COPs and the collection of the public opinion in Paris.
- introduction to section 3 "governance assessment".

In addition, the introductory sections of the deliverable have been amended. See table 1 for more details. Following external review, the findings were detailed. The executive summary and conclusion have been expended with key information and conclusions for each city as well as for cross-comparison.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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.

This cross-case comparison conducted in this deliverable tries to generalise findings about the introduction of ICT solutions in digital water governance and management in general in Berlin,

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Paris and Milan, beyond the specific ICT solutions for public involvement developed in the DWC project and described in the annex of this deliverable.

Table 1 summarises the difference between the previous deliverable 3.4.

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. 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, 5 in Berlin, 8 in Milan) in order to gather this information and to test public reaction to thequestions tin each site. Further interviews and investigations were then 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 were organised. The technical team benefiting from our discovery of social and managerial concerns .

Section 3 identifies non-technical factors that enable or hinder the uptake of digital solutions.

Section 4 is a focus on the three apps for public involvement. It describes the context in which end-users will use digital solutions, which were fed into the **design thinking method**. It describes how different people (stakeholders, social groups, end-users categories) relate to water and digital apps, and how this may impact the ICT uptake.

Step 3 of the guiding protocol also refers to the recommendations. These are given in **section 5** of these reported, distinguished by barriers, enabling factors and key lessons learned for the uptake of ICT solutions in urban water management

Thus, this report is also an attempt to **foster co-production** between different disciplines involved in the project.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Table 1 Comparison of Deliverable 3.4. and 3.5

	Deliverable 3.4 (Previous version)	Deliverable 3.5 (Final Version, May 2022)
2 Description of the general case study context	✓	✓
3 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 Cross-case comparison	App development is supported by sociological knowledge of the WP3 experts following the themes identified in the guiding protocole	Comprehensive comparison and lessons learned for the apps from the focus groups.
4 Social context of ICT solutions use and expectations of the targeted public	Better definition of the end-users	Comprehensive findings of end-users needs based on additional interviews, desk research and focus group meetings
5 Conclusion	No detailed conclusion	Findings are summarised in detail
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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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.

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[1]: 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 DECRETO MINISTERIALE 12 giugno 2003, n. 185 on technical regulation for wastewater reuse	Corte dei conti Report Banca d’ Italia Report ARERA resolution Parliamentary documentation Scientific publications	Regional press

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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Cities	Legal and official information	Grey literature, studies	Press and blogs
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.

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.[2] 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.

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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Table 3 Individual Interviews conducted so far

Cities	Interviews
Berlin	Berliner Wasserbetriebe (Berlin Water Utility): Staff member Museum guide for future innovations Trade union representative initially conducted for DWC Work Package 5. Staff of Hydrology Divison at Senate Department for the Environment, Urban Mobility, Consumer Protection and Climate Action (SenUVK) Staff at Engineering Firm Sieker
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 and environmental authorities in Paris region: Health Regional Agency; DRIEE Bathing promoters : Syndicat Marne Vive; Conseil Départemental du Val de Marne ; Ville de Paris ; Métropole du Grand Paris ; Open Swim Stars ; Laboratoire des Baignades Urbaines ; Association La Seine en Partage ; Sewerage managers : SIAH Croult ; Département de Seine Saint-Denis ; HAROPA ; EPT Grand Est ; Elected officials and employees in candidate riparian cities : Saint Maurice ; Ile Saint Denis ; Ivry ; Choisy ; Vitry Outside Paris region bathing promoter: EPIDOR (bathing already in place); ERN;

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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	4 meetings: July 2020, November 2021, March 2021, 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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Table 5 Focus Groups

Cities	Focus groups
Berlin[3]	1. Target group: Berlin senate staff, guides, BWB communication staff), date: September 2021 2. Target group: Pupils age 10-12, date: July 2022
Milan	1. Target groups: farmers, water utilities, governors, representatives of farmers association, representatives of water utilities association, environmental protection agencies, date: December 2021 2. Target groups: high school students and teachers, date: April 2022
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.

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

[3] In addition to the two focus groups, one workshop was conducted on the occasion of the World Water Day on March 22, to present the groundwater app and gather feedback from an interested audience.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Section 3 synthesises the findings of the governance assessment (step 2 of the guiding protocol). Section 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.

Section 5 presents conclusions drawn from the cross-case governance comparison (section 3).

Annex presents a detailed account of each digital solution.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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. These 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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

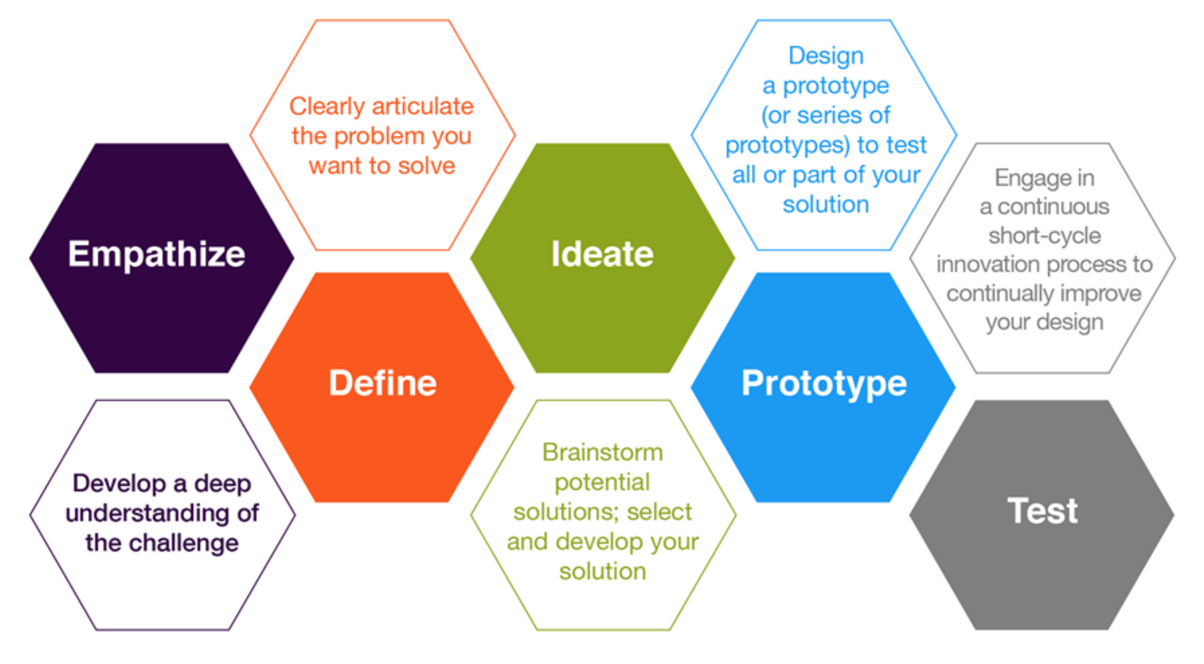


Figure 1 Design Thinking Work Process (Illinois CITL, 2020)

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.

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

digital-water.city
digitalwater_eu
digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Features of the ICT solutions		Berlin	Milan	Paris
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	UNIVPM, CAP	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, citizens, students	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	1) Providing information on bathing authorization and additional

[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).

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Features of the ICT solutions		Berlin	Milan	Paris
		How does the water get into the wells? How is the water cleaned during infiltration?	raising awareness and willingness to invest in more sustainable solutions.	information on sites (access, affluence, algae…) 2) providing information on water fecal contamination
Implementation		Off-site	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

Berliner Wasserbetriebe (BWB) is the public 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 approximately 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 Senate Department for the Environment, Urban Mobility, Consumer Protection and Climate Action (SenUVK), automated data processing and visualisation are major goals in integrated water management. First digitalisation initiatives in the city’s water sector date back to the 1990s and included projects on rainwater management jointly conducted by the Berlin Senate, BWB and engineering companies like Sieker.

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 (education, tourism) and generally aims to increase

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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 wells? 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 Table 7 for the Berlin case study.

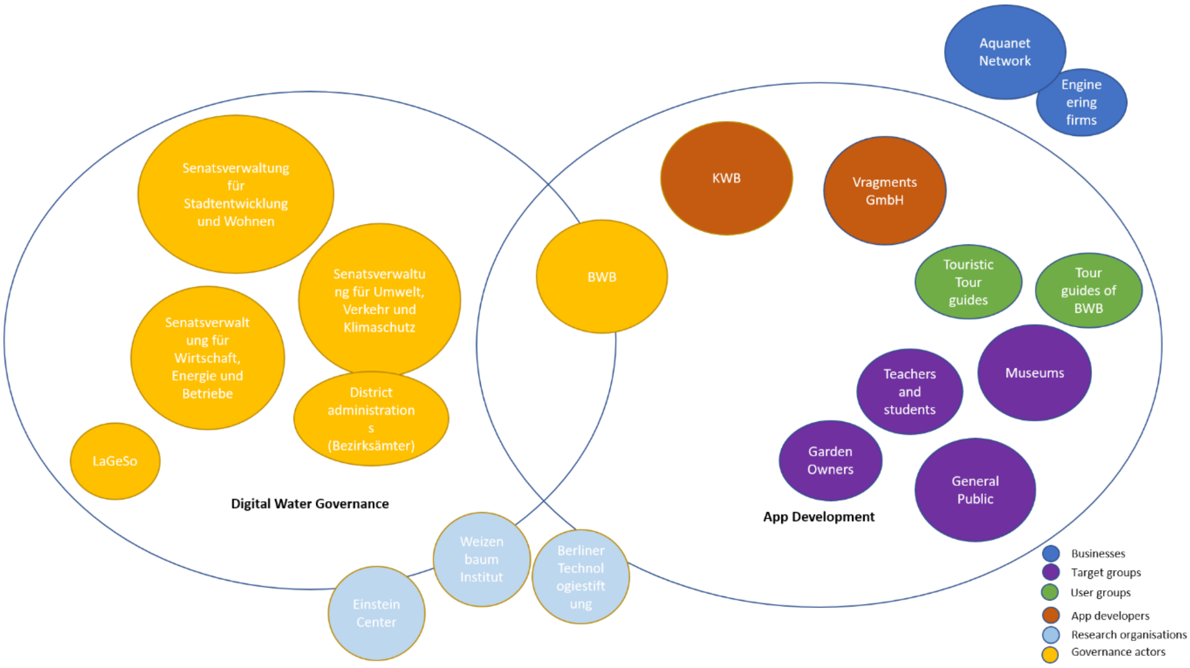
The Design Thinking Method was applied to generate a prototype for the tool in a co-creation process with different stakeholders. Table 1 illustrates this process that started in October 2017 with co-design workshops.

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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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



2.1.3. Technical barriers to its uptake

While AR applications are increasingly available on modern smartphones, general uptake is limited to people owning AR capable devices. This current shortcoming can be expected to be decreased in the future, as AR capabilities become increasingly available due to technical advance and further innovation that create news business cases drives widespread adoption.

A second limitation is the current bottleneck in manual processes to generate groundwater flow visualisations. The data source is using MODFLOW 2005 and additional scripts to prepare the data for app ingestion. This work is done by KWB and needs to be prepared for every scenario to be displayed. The refined data is ingested by VRAG using a developed Unity tool and then added manually to a scenario.

2.2. Milan

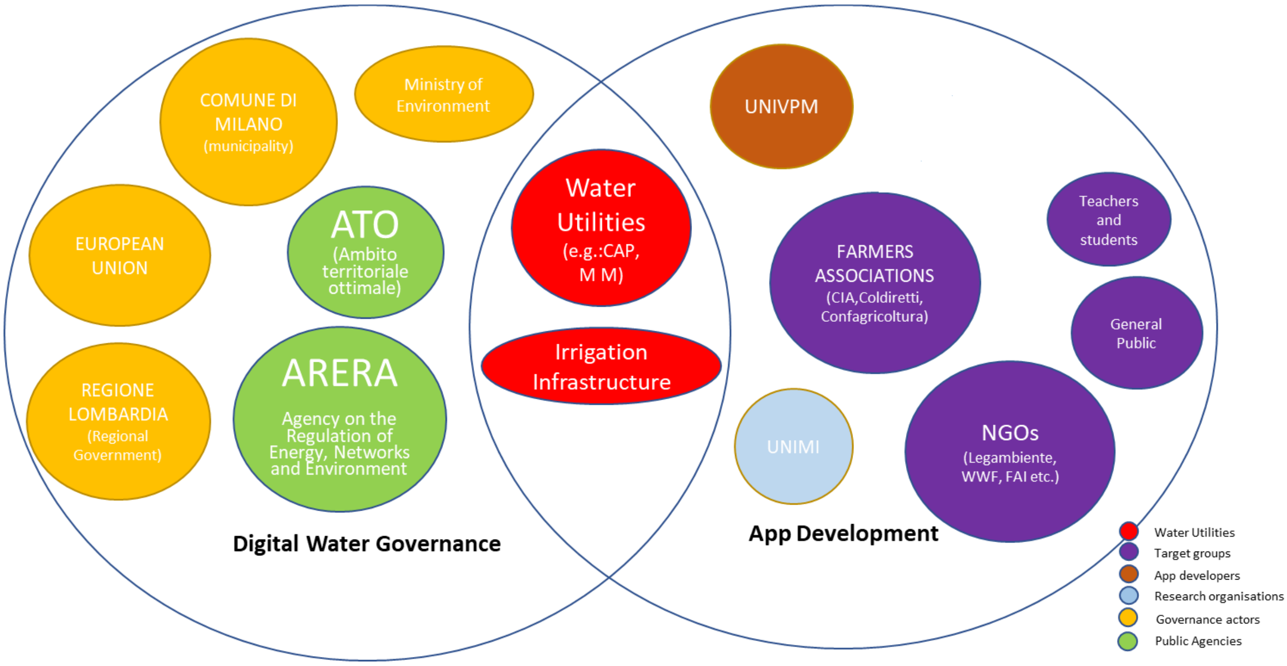
2.2.1. Case-study characteristics and main challenges

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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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, 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, nutrients recovery and social aspects could be understood.

The design process that has been used to lead the app development follows design thinking principles and is visualised in Table 8.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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 energy and carbon-foot printing models.	Evaluate water, energy and carbon footprint indicators, based on tools developed or (possibly) data-driven models. Consider different, wastewater treatment processes, irrigation infrastructure and peri-urban fields configurations	Two different versions to balance/address accessibility and complexity.	Beta version to test engagement and acceptance of the community (through CoP). Feedback from project partners. Focus Groups with potential users

2.2.3. Technical barriers to its uptake

The developed "Serious Game" application is very versatile and can be easily applied to wastewater treatment plants and peri-urban areas of different region of Europe. To do so, data for energy audit and carbon footprint evaluation of the selected wastewater treatment plant should be shared by the water utility in charge of its management as well as basic data on crops cultivation in the region.

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

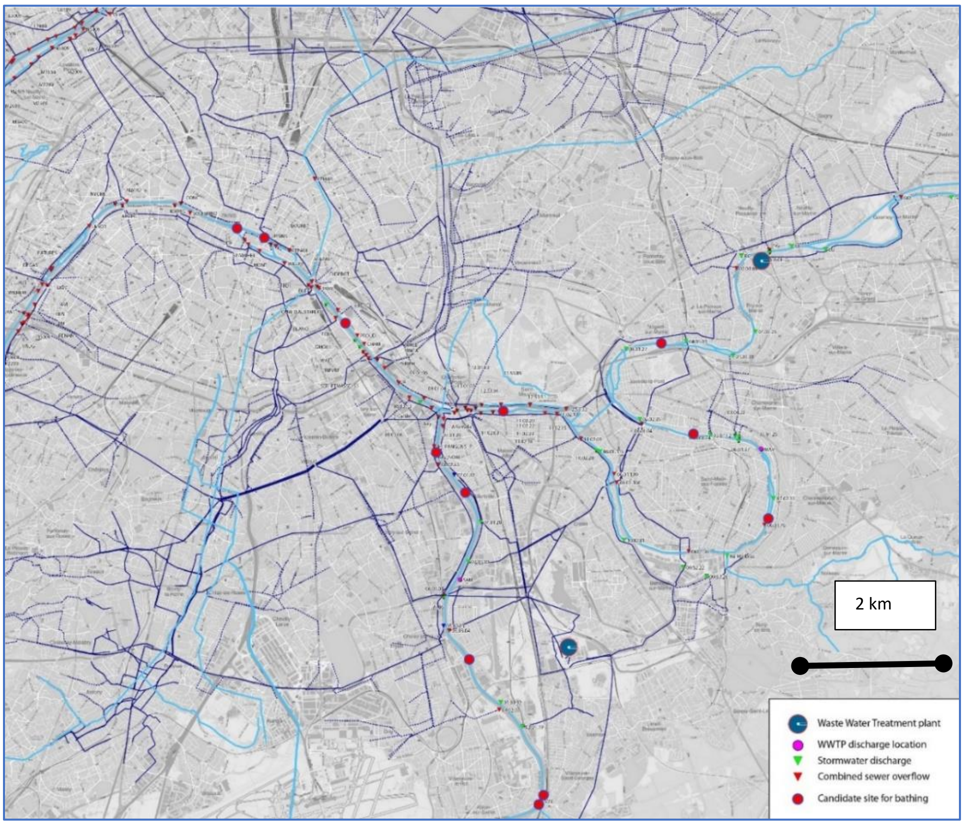
digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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.

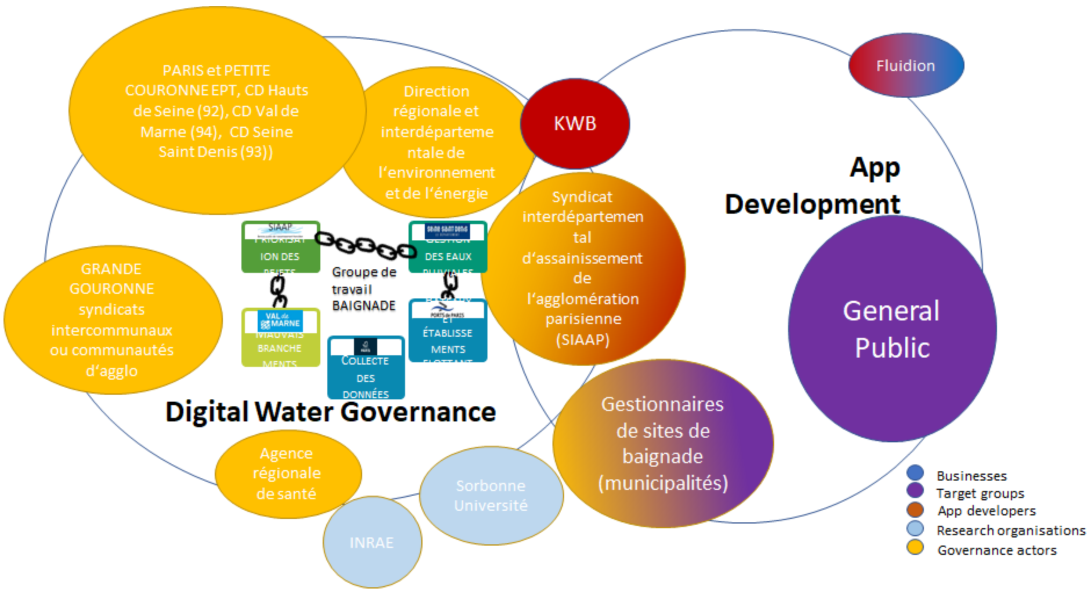
The Seine river dry weather flow during summer is about 100 m^3/s and the Marne river flow is around 35 m^3/s.

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



digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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



digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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 relevant 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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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,
- 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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

3. Governance assessment

This section provides an empirical description of each case. These descriptions which are based on the interviews and focus groups conducted in each case study are then used in the cross-case comparison to inform the relevant hypotheses identified in the guiding document. The following definitions of key terms used in the governance assessment will help to guide the reader.

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,

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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).

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. We discuss them according to social and governance investigation results. 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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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. 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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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. The water governance system is articulated on three levels: there is ARERA at the national level, the utilities and in between the local authority (Ente di governo dell'ambito). The latter examines the planning in detail, and therefore holds an important role within the transposition of the tariffs and can actually control and monitor in greater detail the operations of the utility.

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. Significant autonomy is left to the local level, by allowing local regulatory authorities (AATOs) to reorganize and monitor 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 provided 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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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. Our observations show that water professionals have a common ambition for bathing and share a common worldview which sthreghtens collective engagement. 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. 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

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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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.

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. With regards to the public authorities involved, digitalisation in the water sector in Berlin mainly includes initiatives to enhance data sharing on water management issues between relevant actors. 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

digital-water.city has received funding from the European Union’s H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Wasserbetriebe are also key in pushing forward innovation in the water sector. According to the expert from 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 differs according to the specific (sub-)topic of urban water management. Apart from the Water Framework, the Floods and the Drinking Water Directives, the INSPIRE Directive is of cross-cutting importance and plays a key role in providing the regulatory framework for spatial information infrastructure. Despite of that, linkages of the Berliner Wasserbetriebe (BWB) 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 different 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. In addition, the Berlin Senate Department for Inner Affairs as well as the Senate Department for Urban Development are relevant authorities. At operational level, the Berlin Water Authority (Wasserbehörde) is another relevant actor in digitising internal processes. The Berlin Senate also coordinates with authorities from the surrounding state of Brandenburg with regards to questions of regional, cross-boundary importance. Path dependencies and historically grown differences in the governance settings and administrative structures of the individual states complicate a coordinated approach to digital water governance so far, as one interviewee emphasized.

The actor setting is complemented by national-level actors that are responsible for the maintenance of the city’s waterways which is reflected in data sharing between sub-national and national levels. Overall, however, the federal state level plays a subordinate role in pushing digital water governance forward, as two interviewees noted. In particular, the federal state level has its own fragmentation challenges as well with different authorities and ministries pursuing different agendas and goals. As a result, policy fragmentation exists that might be one explanatory factor why a proactive digital water governance agenda that builds on public involvement is still lacking. Another one may be that all key actors are fulfilling their respective roles as prescribed by the regulatory framework, which is, however not designed to spur innovation through public involvement in the urban water sector. These two aspects clearly limit the uptake of ICT solutions, e.g., the development of an 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. Nevertheless, examples for digitalisation initiatives exist. With regards to flood risk management, a platform for inter-state coordination (Länderübergreifende Hochwasserportal, LHP) has been set up relying on

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

data from the different states. The platform has been significantly improved after the severe floods in Western Germany in July 2021.

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[6]. 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[7].

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). The national level has most regulatory functions setting requirements, with ARERA being the central authority. Often national regulatory prescriptions are based on EU regulations, that operators are required to meet. Local authorities are then responsible to monitor the compliance with these standards and regulations. In certain cases, and under specific conditions, water services can be directly managed by municipalities, in what is known as "in house" management[8]. 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[9].

---

[6] 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

[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. 107

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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Despite the fact that the introduction of AATOs in 1994 was specifically conceived to limit the historically persistent fragmentation of water management in Italy[10], today there are still 92 AATOs and more than 700 utilities that are responsible for services[11]. 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 efficiency and viability in the water sector. However, fragmentation is not as present as in Berlin, as in Italy, municipalities must associate at a supra-municipal level. The process has not been completed, insofar as here and there management realities survive at municipal level, but the direction traced by the 1994 reform is clear. The sub-regional dimension with a single manager remains the objective that is being approached. 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[12]. 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[13].

Apart from the EU regulatory prescriptions transposed to Italian national law, the direct influence of European Policies on local water management in Milan is limited and mainly involves soft governance measures such as the circulation of best practices, awareness raising campaigns, etc.

Public involvement in Milan water management is still limited. However, one interviewee expressed that some water managers are now seeking for less technocratic approaches in the drinking water sector that takes into account priorities of citizens. Thus, attempts are made by water utilities to involve users in the development of "Water Safety Plans" to analyze the risks of water contamination in drinking water systems.

10 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

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

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

13 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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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. 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 or 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.

digital-water.city
digitalwater_eu
digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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

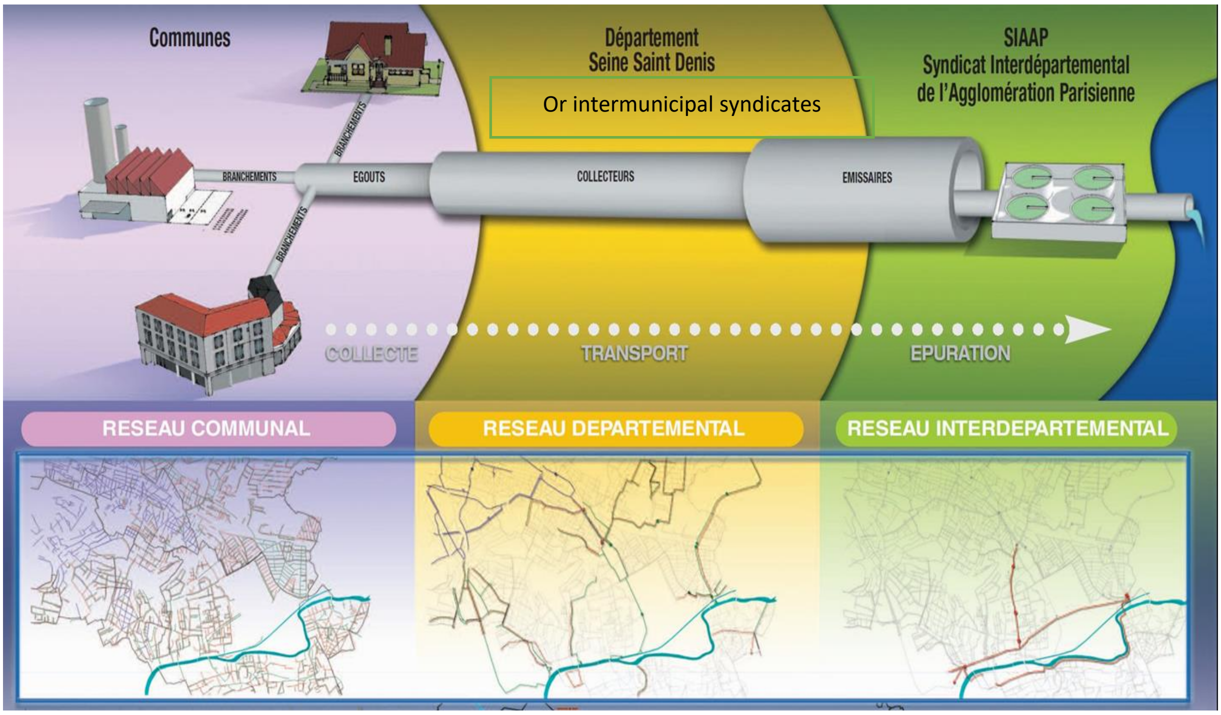


Table 10 Summarizing findings on levels and scale

Cities	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.
Berlin	High degree of decentralisation at the national level in terms of water management but high centralisation at city level where a few actors possess most decision making power. Only selected initiatives building on public involvement to spur innovation exist, thus no link between centralisation of governance and opportunities of public involvement could be established.	Fragmentation in digital water governance is high as water governance and digital governance are partially overlapping. High governance fragmentation does also exist also between the city and surrounding state of Brandenburg.
Milan	Greater extent of centralisation observed than in Berlin due to strong position of supra-municipal level. However, wide territorial differences	Despite structural reforms to stem the problem, fragmentation is still very high.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

	on digital infrastructure and capabilities resulted in a decentralisation of roles and responsibilities.	
Paris	New incumbency given to state services and SIAAP in favour of recentralisation	Used to be high, in reduction due to recent laws

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: Communities of practices enhance the openness of relevant stakeholders to innovative and innovation-friendly modes of digital water governance in urban water management.
- H4: The digital divide challenges the potential of ICT solutions to contribute to resource-efficient and sustainable water management
- 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. Figure 2 lists key actors in the realm of digital water governance in the city. Relevant public authorities, these include different 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 Digital Future, the Weizenbaum Institute and the Technologiestiftung Berlin as well as the three large universities in Berlin. The

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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.

The CoPs in Berlin played an important role to support the development of the App development. From the beginning the relevant actors where aware of the development process and supported it actively. Thereby, the CoP's inputs for the app development reach much further than just merely awareness raising. The kick-off of this co-creation process started on 18.02.2020 where the app development was announced for the first time. Following COPs, especially the ones on 11.06.2020, and 14.11.2021, reported on the progress and collected expectations on the app and suggestions for further use cases for the AR technology in the water sector. (cp., Figure 7)

Figure 8 Mentimeter slide from CoP Berlin on June 11, 2020 ("How suited is the AR app idea, to make knowledge on groundwater in Berlin visible? Scoring 4,1 out of 5 points (4 = "well suited", n = 14))

The first focus group and the webinar that requested specific feedback on the UI and UX of the AR app where a direct spin-off of the CoP process, bringing together a subgroup of the COP especially interested in the app development. All in all, we can summarize that the CoPs played an important role for the AR app development in Berlin. Digital transformation proceeds at the speed of trust on personal and technological level. To get sufficient acceptance and to promote the benefits of digital solutions, they must be communicated in clarity and detail to the potential end-user. Co-creation platforms such as CoPs, are well suited to support digital use cases on municipal level.

Frequently partnering with research foundations or universities as well as BWB and the Senate, engineering firms (e.g. Sieker and others) who are specialised in rainwater management bring digitalisation initiatives in the city forward. These projects range from the

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

control of decentralised water storage systems to watershed models that can provide runoff predictions using forecast-driven models. Purely private initiatives also exist, such as a project in which retention green roofs are developed and implemented that are controlled based on precipitation forecasts. 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 also strictly limited by law, one interviewee expressed that mistrust among civil society actors with regards to the collection and use of data becomes visible. 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 access to 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.

The digital divide plays a major role in the uptake of ICT solutions, not only in the general public, but also in utilities and relevant public authorities. One interviewee made clear that in the authorities reluctance towards the automation and digitalization of processes exists, especially among staff that has been working with specific processes for years. Here, clearly a digital divide exists between new, or younger staff and older staff.

There is no instutionalised regular exchange taking place in Berlin between these relevant digital water governance stakeholders. Exchange forums do exist at river basin level, such as the Arbeitskreis Flussgebietsbewirtschaftung Spree Schwarze Elster that includes the states of Berlin, Brandenburg and Saxony or the Flussgebietsgemeinschaft Elbe with several working groups on flood risk management and modelling. These working groups comprises water management and public actors including experts from the German Meteorological Service (DWD). However, there is no exchange at city-level taking place ad-hoc. Against this background, the CoP provided a good starting point for a regular exchange between relevant actors. In terms of the “Making Groundwater visible” app in Berlin, the app was not designed to increase citizen participation but rather to inform and educate citizens about Berlin’s groundwater flows. Whether the app can render citizen involvement more sustainable if not accompanied by further measures has to be questioned.

On the contrary, the process of the app development was highly participatory, as different user and target groups (guides, ordinary citizens, students) were asked in the focus groups to provide their feedback on the app. This feedback was then taken into account into the further development of the app.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Milan case study

In the Milanese context, through the years more and more actors were involved in the governance of water. Water utilities, technology providers, research institutes and universities as well as public authorities can be considered the main actor groups. Relevant public authorities include both the regional and national government institutions, but also the sector authorities (ARERA and area government bodies). Civil society – understood 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 literacy 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. Between utilities, local authorities and ARERA the dialogue is fully structured. Utilitalia, the national federation of Italian utilities providing public services in the sectors of environment, water and energy for example gather a large number of utilities at the national level. Also, in recent years so-called “water alliances” have emerged, where a number of utilities that are geographically close to each other clusters to exchange experiences and create common joint call for tenders with greater bargaining power. This solution resulted in greater levels of efficiency. On top of that, the CoP established by Gruppo CAP provide an important forum for exchange between relevant stakeholders, as one interviewed participant of the CoP confirmed.

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.

One challenge specific to the Milan context is that many inhabitants living in shared building do not receive an individual water bill and thus no information about efficiency improvement

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

issues. Consequently, the sensitivity with regards to water-related topics is often limited. Digital meters could provide a way forward to increase awareness among end-users but to date, the most suitable technology for smart meters in Italy has not yet been identified. Currently, technology providers are the ones pushing for relevant initiatives and strategies, rather than national or regional authorities as one interviewee stated.

Four CoP were organized by Gruppo CAP to communicate to potential users and to governors the benefits of the digitalization of the water sector. Particularly, all target groups participating at the organized events have shown interest for the proposed digital solutions and seemed to have understood, at least at conceptual level, benefits that can arise from digitalization of the wastewater reuse practices. However, effective acceptation of the proposed solutions still needs to face barriers as costs for their actual implementations and presence of professionally formed operators.

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
- 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 information 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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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 [14] 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).

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.

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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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. **Data 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 12 Summarizing findings on actors, networks and communication channels

Cities	Positive effect of community of practice (H3)	Challenges of digital divide (H4)	What is the current level of public involvement in water management that could foster sustainable use (H5)
Berlin	The COP provided a very valuable platform for relevant stakeholders involved in the digitalization of the water sector to exchange information and also provided important feedback during the development process.	Employees of the water utilities that cannot cope with pace of digitalisation and automatisation	Limited public involvement, no regular exchange between relevant stakeholders

digital-water.city
digitalwater_eu
digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Milan	The CoP had the role to get together all the actors that can be involved in the digitalization of the water sector highlighting possible common benefits.	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.
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

In addition to our initial hypotheses, we notice that employees support to digitalization is a a key factor to reduce path dependency and risk aversion. In Berlin, they ave mix perceptions about digitalization.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Major actors recognise the potential benefits of digitalising the urban water sector (which is favorable to ICT uptake according to H8). 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. 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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

monitor the system. AI can help to makes proposals, referring to which experts make decisions.

As mentioned previously, in the authorities reluctance towards the automation and digitalization of processes persist, especially among staff that has been working with specific processes for years. Thus, the openness to learning is limited among key actors.

The development of the Berlin app was done involving potential users throughout the development process. Feedback from two user workshops conducted in the reporting period and discussions within the team have resulted in the implementation of several suggested improvements of the user experience (e.g., step-by-step approach to better illustrate the groundwater passage). Yet, the innovativeness of the app was not seriously compromised as its main features remain included in the app.

Milan case study

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 actors 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.

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

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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.

In relation to H6, user involvement helped designing a FAQ section in the app addressing questions that are the most debated in public space in relation to water. It did not limit innovativess (H7). Strong participation of releveant governance actors in CoPs fostered the co-construction of the apps and is favorable to their future uptake.

Table 13 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	Major user experience improvements where made based on user feedback.	Innovativeness was not compromised as a result of the feedback received from users.	Reluctancy among relevant staff of authorities and utility regarding the automation and digitalization of many processes.
Milan	Some of the feedback received from users were very useful to improve the serious game. Particularly:	The users' feedback did not limit the innovativeness of the serious game. Generally, received feedback were very	The serious game is specifically designed to trigger and support a learning process regarding water-food-climate nexus.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

	- an introductory part of the game was added to explain role of the player, structure and aims of the game - since different configurations and reuse options can be selected during the game, a final page was added reassuming the outcomes of all the performed selections to highlight differences - better explanations were provided in the game about energy consumption by using different technologies for irrigation and related water saving efficiencies - conversion factors to obtain NexusCOIN were included to explain impacts quantification	positive and appreciative of the tool	
Paris	WP3 revealed the public's expectation for : - a users-to-managers feedback menu in the app - a FAQ page - additional information on access, affluence,	no reluctance to innovativeness was observed.	COPs served as a learning platform for future bathing site managers. Future managers notably learned the technical possibilities of early warning systems and their costs. They also learn about organizational issues with chemical labs.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

	Temperature, and algae presence.		

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

In many areas, new regulatory standards introduced by the authorities steer digitalisation initiatives in the city. However, while some of these initiatives primarily aim for digitalisation in the sector, others address different goals but still spur digitalisation as a side effect. Senate specifications on water inlet restrictions in both the mixed and separated water systems has driven different digitalisation initiatives as one interviewee stated. 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. However, within Berlin's Smart City strategy, there is a smart water project planned under the auspices of the Berlin Senate to increase the coordination as well as risk communication between involved authorities and Berlin Water Works.

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. In a project, one interviewee worked on, a water pump was equipped with a vibration sensor that causes the pump to be turned off once the sensor triggers a vibration. This provides a potential security threat when harmful forces can gain control of the sensor system. 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. As one interviewee stated, in terms of introducing new digital tools or software, it is

digital-water.city
digitalwater_eu
digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

often times rather the governance fragmentation (e.g., between authorities of Berlin and neighboring Brandenburg) and a lack of qualified staff than risk aversion of relevant authorities that hinders the introduction of new ICT solutions. At the same time, many path dependencies exist that hinder digitalisation initiatives which result from the specifities of the Berlin mixed water system. Consequently, changes occur incrementally rather than in an encompassing manner. This is backed by the statement of another interviewee who emphasized that abrupt and encompassing automation of processes in water management is associated with risks like data unreliability.

Due to a high degree of fragmentation in IT security of urban water governance, main challenges evolve around establishing a comprehensive and reliable IT security infrastructure while ensuring interoperability and close collaboration between relevant actors. In Berlin, with the online portal "Wasserportal"[15] a one-stop-shop has been established for public water data but standardization issues remain. While the portal includes an API, requested data comes in different formats resulting in resource and time-consuming data harmonization. In this regard, one interviewee highlighted the lack of standards in terms of data formats and means of data sharing and the importance of introducing respective guidelines or regulations.

When it comes to the publication of water data, most data can be 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.

Data protection 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. This can be of hindrance, for example, when it comes to the publication of risk areas of intense precipitation based on user data. SenUVK has started an initiative that also in future, this data will remain publicly available. An example on how this can work is provided by the DWD Warning App, where citizens can enter weather-related warnings based on their observations anonymously.

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

[15] https://wasserportal.berlin.de/

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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. A researcher interviewed highlighted that, as in the Berlin case, digitalisation impulses often result from stricter regulations on water quality or water system performance defined by AEREA at national level that local operators have to comply with rather than from digitalization initiatives as such. This strategy to promote digitalisation via targets is actively communicated by AEREA. They opted for a technical quality control system which relies on purely output-based objectives. Goals are set and their achievement is measured on a yearly basis and associated with these is a system of rewards and penalties. For certain management aspects (e.g., reduction of leakages, monitoring of wastewater treatment etc.), a successful achievement of the objectives is dependent on a management system that improves its performances through digital means, as one interviewee stated. Therefore, the goals set de facto incentivize the adoption of innovative digital means.

The creation of an authority at two levels (local and national) was a strong political choice that gave impetus against the fragmentation and towards efficiency as well as the infrastructural renewal and therefore also digitalization.

As in Berlin, encompassing changes of the water governance system towards embracing digitalisation are constrained by path dependencies which result from the particularites of the Milan water system, especially in fields like suburban irrigation. This stresses the potential of investing in these structures in order to modernize them and make them consistent with the possibilities offered by recent technologies, while certainly maintaining the historical and cultural value that they represent.

[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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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 developing the app is secured by SIAAP. Yet the funding needed for innovations to become implemented (municipal digital equipment, 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. 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 14 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 a digital water governance framework is hindering innovation. However, tighter national and local regulations spur new ICT solutions as a side effect.	Data security risks and fragmentation as main hindrance, general risk aversion of water managers less relevant in comparison to fragmentation of water governance system

digital-water.city
digitalwater_eu
digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Milan	Lack of overarching national strategy for digitalization in the water sector is hindering. Goals set by regulators de facto incentivize the adoption of innovative digital means.	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 disinfected 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

Berlin case study

Decision-making in urban water management is highly centralised, with the Berlin Senate Department for Senate Department for the Environment, Urban Mobility, Consumer Protection and Climate Action (SenUVK) 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 as previously described. 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. 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. However, also private companies and technology developers invest in relevant ICT solutions when being equipped with funds from private investors as one interviewee highlighted.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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. While public funding issues surely persist in Berlin, a larger problem is a lack of trained IT personnel in the Senate Departments that can design and implement relevant digital water policies. One interviewee emphasized that only single experts working on these issues are employed at relevant authorities like SenUVK.

Milan case study

As previously described, decision making in Milan is dispersed across three actors (national authority, utilities and local authorities). The centralisation of decision-making authority at national level has resulted in stricter regulations on water quality and other issues. This has been described as an important driving force for digitalisation initiatives at local level, thus increasing the speed of innovation uptake, which supports H11.

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 the national regulator 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.

The water system in Italy still has rather fragile financial foundations and financial institutions are still weak. However, it must be recognized that the national regulator attempted to create the conditions for investments to resume resulting in considerable improvements over the last 10 years.

Funds provided by ARERA are limited as they solely collect fee-based resources that do not leave much room for encompassing financial support of digitalisation initiatives. As in Berlin, one interviewee stated that a lack of financial capacities and personal resources in relevant utilities hinders the implementation of innovative ICT solutions. Another related issue is that of authorizations. In Italy, the system of permits and authorizations is a time-intense and bureaucratic process. The funds provided by the PNRR (National Plan for Recovery and Resilience) were not allocated so much in the water sector because the above-described problems conflicted with the temporal requirements set by the European Commission for the realization of the investments.

[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;

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Paris case study

The tasks for the future digital governance are to be decided in COPs. SIAAP was granted an official mandate in October.

Table 15 Summarizing findings on responsibilities and resources

Cities	Centralisation of decision making reduces the speed of innovation uptake (H11)	Funding issues which may hinder the uptake of ICT solutions (H12)
Berlin	Dispersed between different scales (city and national scale), senate Departments with SenUVK as major actor on the regulatory level and the Berliner Wasserbetriebe on the operational level. Fragmentation of decision-making system reduces speed of innovation uptake.	Lack of funding in regulatory agencies and in water utility is partly compensated by private funding resulting from stricter water quality regulations.
Milan	Decision making is dispersed across three levels but centralised within each of these levels. Centralisation of decision-making authority at national level resulting in stricter regulations has been an important driving force for digitalisation initiatives at local level, thus increasing the speed of innovation uptake.	Lack of funding in regulatory agencies and in water utility is partly compensated by private funding resulting from stricter water quality regulations.
Paris	Decisions are not centralised but discussed in cops under the leadership 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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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 imagine their future use of 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

Through the focus groups conducted in Berlin, the research team gathered insights on the context potential users envision to use the groundwater app. In interactive Mentimeter polls, users listed diverse contexts, that can be broadly grouped into two clusters. First, some users responded that the app could support urban land use and water planning or in the planning of retention sinks (water expert perspective). Second, users identified environmental education and awareness-raising on groundwater issues as an important context, e.g., as part of communication campaigns or high school curricula (environmental educator perspective).

In the second focus group (March 2022), in which the app was presented to the interested public, the app received positive feedback and 10 out of 13 participants indicated that they would download the app once available. Participants highlighted that the app provides a good example for using digital tools to raise awareness on groundwater issues in a playful manner.

Also the third focus group (July 2022) conducted with school children resulted in overall positive feedback. the focus group with school children provided valuable insights into the interaction of another main target group of the app.

A high level of digital literacy among the children was a crucial factor for using the app, confirming the importance of digital literacy, which was also observed as a facilitating factor in Paris. The playful introduction to groundwater flows in Berlin was positively received by the children and could potentially be integrated into the curricula of local schools.

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

The app can contribute to a better understanding of groundwater flows and sources and increase awareness on the importance of groundwater for water supply in the city. By highlighting the importance of this hidden resource, the awareness of the targeted public rises. In the mid- to long-term this will positively enhance the public's opinion on measures to protect groundwater (such as maintaining groundwater protection zones) and support of groundwater protection and water management in general. For the water utility and water authorities, the app allows outreach to the citizens and communication on the benefits of water management including not only the provision of drinking water and the treatment of wastewater, but also additional valuable services such as the protection of surface and

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

groundwater ecosystems, the treatment of rain and surface water in order to protect the drinking water resource.

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)

The developed "Serious Game" tool aims at informing and engaging the widest public as possible to raise awareness and overcome social and economic barriers to water reuse. The "Serious game" has been designed to allow citizens easily to interact with local data and support the understanding of the complexity of the nexus of water availability, carbon emission, energy consumption, and resource (i.e., nutrients) recovery for crop production. It aims at communicating the benefits of water reuse in terms of impacts on each aspect of the nexus. Main targeted groups of the developed application are water utilities and citizens, and particularly high-school and university students living in urban and peri-urban areas. Other target groups include farmers, governors, technicians and engineers, staffer of environmental protection agencies and so on.

For water utilities, the tool may represent a promotional instrument to disseminate to customers and citizens the benefits related to water reclamation and reuse fostering a better image of the company. Game simulation events can be planned during conferences or meetings organized by the company for promotion purposes. Furthermore, the app may be promoted by newsletters and on the website. By sharing data on energy consumptions and plant management, the app can be customized for every wastewater treatment plant managed by the water utility.

The "Serious Game" is first of all a didactic tool and can be used during high-school or university lectures to explain the concept of water – energy – food – climatic nexus to students. Particularly, many data are provided concerning energy consumption, greenhouse gas emission, amount of treated wastewater and nutrient concentrations. Standard methodology such as ENERWATER and UNI EN ISO 14064-1:2019 are used to calculate energy consumptions and carbon footprint. Hence, the "Serious Game" represents an important tool to make citizens and students able to interact with real and scientific data related to local areas. In a similar way, dissemination events can be organized to explain the benefits of water reuse to other stakeholders, which may have also economic and governmental interests (e.g., farmers, governors, engineers and technicians, etc.).

The "Serious game" can be also played independently by a sole end-user. Indeed, many illustrative windows and link to reference documents can guide the players step by step in his/her play.

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

The end users of the "Serious Game" tool are citizens, and main goal of the app is to raise awareness and overcome social and economic barriers to water reuse. By explaining the

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

benefits of water reuse in terms of impacts on each aspect of the water – energy – food – climatic nexus, the developed app aims to increase the general consent to public investments for the water sector, including its digitalization. Hence, the "Serious Game" will help to increase awareness and willingness to support more sustainable solutions in the water management sector.

4.2.3. Enhanced public awareness on water reuse

Raising public awareness will in turn feed back into increased public acceptance regarding the implementation of policies promoting the sustainable use of urban water and foster the public involvement in urban water management. In this context, the "Serious Game" app has been developed to support the understanding of the complexity of the nexus of water availability, carbon emission, energy consumption, food crop productivity and climate variability within a peri-urban system. To reach this objective, the developed tool has been promoted during different dissemination and communication events and actions in the Lombardy Region and in Italy, which are listed in Table16.

Table 16 Events and actions to reach citizens in the Lombardy Region and in Italy

Event/Action	Date	Number of reached citizens	Source/proof
CoP in Milan	July 2020	6	check participants list
Ecomondo – Italian exhibition group event	October 2021		check participants list
CoP in Milan	November 2021	35	check participants list
Sostenibilmente Event (Ancona)	November 2021	150	
CoP in Milan	March 2021	39	check participants list
CoP (Focus Group) in Milan	December 2021	13	check participants list
Promotion of the Book "Pensare e fare economia circolare" by CAP in Milan	March 2022	20	check participants list
Focus group in Milan	April 2022	14	Number of students involved in the event. Check participants list and

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

			presence of students at school
Seminars in secondary school in the Marche Region (Ancona and Jesi)	April 2022	61	Presence of students at school
IWS Italian Water Tour – Webinar Live at ACQUE VERONESI	?	?	
Number of accesses in the "Serious Game" web app	January 2021 – April 2022	?	

4.3. Paris Case study

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

a. the expert app

During CoPs, future expert app users inform the app developers that they will take one decision per day and not more, since closing an affluent bathing site is unpopular, so **the app should support a decision robust enough for 24 hours**.

The context of decision making is broader than bacteriological concerns. Information concerning water temperature, algae, users feedback were further integrated as useful contextual information for expert app users.

CoPs also reveal the importance to take into account the fact that other risks and alerts may emerge in the future and require further development. Such development was not included in the app, but may be in the future as needed.

b. The public app.

Since bathing sites do not exist yet, people feel it hard to imagine the context in which they will use the app.

Observations on future sites and focus groups reveal that the end-users of the public app will probably be middle-class residents close to the river. The digital gap is still important in the society and only young educated people are likely to search information online for their leisure activities. Other bathing sites users may get their information from more classical mass media such as the press, the TV, and the radio.

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

- The public hardly knows about contamination risks. People are generally not aware of the existing organization of water infrastructures such as combined sewer overflows

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

(CSO) and unitary systems. They generally imagine that chemical sources of pollution are the main impacts on biodiversity.

- The information displayed on the app concerning biodiversity and water pollution sources may contribute to change the general public understanding of water. Focus groups confirmed a lack of knowledge in water pollution sources and the existence of flora and fauna in the river.
- Unexpectedly the development of the app also changed the current representations of water managers regarding bathing risks

Whereas water managers currently focus on bacteriological risks, focus groups reveal other sources of risks to be taken into account, like collision with boats, drowning risks due to currents and possible risk of conflict due to resident perception of nuisances from bathing activities.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

5. Conclusion

In the following, conclusions are drawn based on the cross-case comparison of the Berlin, Paris and Milan cases. These conclusions refer to the introduction of ICT solutions in digital water governance and management as such and not to the specific ICT solutions for public involvement developed in the DWC project and described in the annex of this deliverable.

5.1. Barriers

For each urban water management system, path dependencies, both of technical but also of political nature, exist that constrain and influence digitization initiatives. Consequently, changes occur incrementally rather than in an encompassing manner. The Berlin case shows that **employees' support for digitalization can be key** for ICT uptake, **in addition to end-user participation to the design process**. In particular, employees concern for "data cemetery" that is the production of non-used data, shall be addressed.

Governance fragmentation has been a barrier in particular in Berlin and Milan, where the cross-sectoral character of digital water governance challenges harmonized and effective governance approaches that enable the uptake of ICT solutions.

In Berlin and Milan, **legal uncertainty** and **cost-effectiveness** are two factors that emerged as discouraging actors to invest in and implement digital solutions. In Milan, an obstacle 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.

The characteristics of water infrastructure as critical infrastructure was identified as another general barrier that aim to automatize key water management processes. In Paris, the engineers acceptance of the ICT solution relies on the fact that they are merely decision support systems with water managers **keeping control on the final decision.** Potential security risks occur if harmful forces gain control over these solutions.

A high degree of **data security** as posed by the German Federal States can however limit the portfolio of available digital technology on the market and thus its application. Connected to this, **risk aversion** of water managers can be a complicating factor, especially if paired with **limited openness** to learning of these managers. In addition, to the limited openness of water managers and relevant authorities, relatively **low levels of digital literacy** among users represent an obstacle for the involvement of them in the initial stages of development for digital solutions. Another barrier identified, in particular in Berlin, was that **standards** for water data harmonization at subnational level are lacking, leading to time- and resource-intensive harmonization processes at relevant authorities.

The main barrier identified **in Paris** for the expert app 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**. Another barrier concerns the digital gap for the public app. Most people declare that they would not use digital app to get information on bathing. **Only young and highly educated people are keen on**

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

looking on the web to find information for their leisure activities. In Berlin and Milan on the contrary, it could be observed that often, stricter regulations at EU and national level incentivize digital innovation at city level. At the same time, overtly bureaucratic standards can hinder the development and uptake of ICT solutions.

Finally, a lack of public funding has been mentioned by several interviewees as a main obstacle that hinders innovation uptake in the water sector.

5.2. Enablers

The growing data availability and democratised access to AI tool enable ICT uptake in society in general.

In Paris, supposedly unfavourable 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.

In the absence of regulations or strategies that aim for greater digitalisation in the urban water sector, **stricter water quality regulations** set by authorities at national and city level have been an important de-facto enabler of ICT uptake in Berlin and Milan. The centralisation of decision-making authority at national level has resulted in stricter regulations on water quality and other issues. This has been described as an important driving force for digitalisation initiatives at local level, thus increasing the speed of innovation uptake. Private funds could partly compensate for the lack of public funding available for ICT solutions in the urban water sector in these cities. In Paris, digitalisation of the water sector was entirely publicly funded.

5.3. Key learnings

Several key learnings emerged from the cross-case comparison.

The general public hardly knows about water infrastructure and water main sources of pollution. The information displayed on the apps may contribute to change the general public understanding of water.

On the contrary, water managers tend to overlook other sources of risks not directly linked with water.

In terms of regulatory issues and standards, there is a clear need to **establish standards** for data harmonization. Related to this, a central **data protection and security guideline** applicable to innovations in the water sector could be a way forward to decrease risk aversion and uncertainties around data protection issues that often hinder innovation in digital water management and governance. As the water market is small compared to other markets, there are few incentives to offer tools which provide both data security and functionality, thus balancing data security risks and attractiveness to technology developers and utilities is important.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Path dependency is a strong hinderance for change but can be addressed through incremental change and building interpersonal trust among actors. E**mployees' support for digitalization is key** for ICT uptake, **in addition to end-user participation to the design process**.

To ensure adequate uptake and promote the benefits of digital solutions, they need to be explained to the user in full clarity and depth. Innovative digital engagement techniques such as serious gaming, augmented reality, virtual reality can promote stakeholder engagement, education and policy communication in the water sector.

In Berlin, different focus groups were held with both water management practitioners and school children. While the focus group with water professionals helped to improve the user experience, the focus group with school children provided valuable insights into the interaction of another main target group of the app.

A high level of digital literacy among the children was a crucial factor for using the app, confirming the importance of digital literacy, which was also observed as a facilitating factor in Paris. The playful introduction to groundwater flows in Berlin was positively received by the children and could potentially be integrated into the curricula of local schools.

A timing paradox became visible when working in the three case studies. If there is little public involvement, people will know little about how they can contribute to urban water management practices and what stake they have in the relevant processes. However, developing appropriate digital solutions requires that end users are involved in planning as early as possible and make decisions without knowing much about the broader context.

Due to the high degree of governance fragmentation and the cross-sectoral character of digital water governance challenges *within* cities, harmonised and effective governance approaches that enable the uptake of ICT solutions are needed. Here, **intersectoral working groups**, bringing together utilities, technology developers but also representatives of different public authorities can be a way forward to enhance harmonised and effective governance. Such working groups organised by a lead actor can meet regularly to identify regulatory gaps and challenges, develop and discuss new standards and policy recommendations and develop strategies that give incentives the uptake of ICT solutions.

In a similar manner and to overcome fragmentation *across* governance levels, working groups on digital water governance bringing together national and sub-national authorities are very useful. In Berlin, comparable working groups already exist that can be taken as potential examples.

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.

Water engineers are more prone to accept ICT solutions when water managers **keep control on the final decision concerning risks.**

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Digital apps informing on water are more likely to be used by **young middle class users** when other social groups get information from more classical media. Apps must be developed so that **links with popular websites can be easily set and updated**.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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.

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

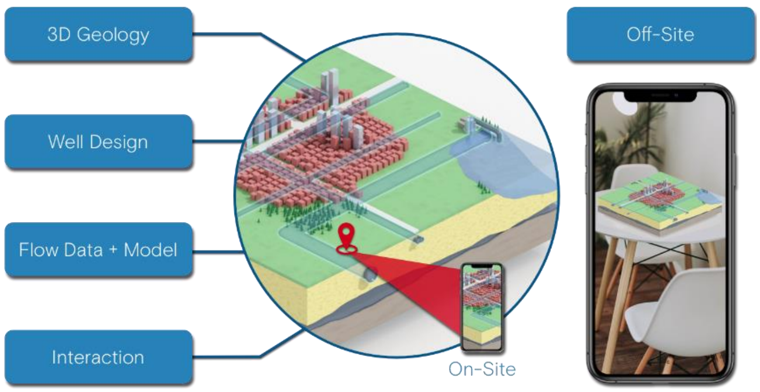
digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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).

Figure 9 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)

The main introduction includes a short paragraph that sets the context of the app for the users. When hidden, the regular menu appears.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

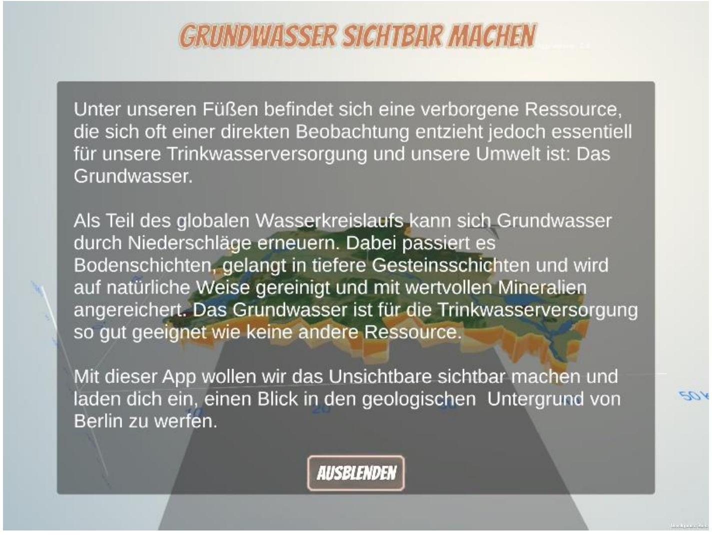


Figure 10 - Welcome screen of the app.

The regular menu appears next, displaying the overall Berlin area, waterworks and geological structures. There is a button to access general information about the app, and a help section.

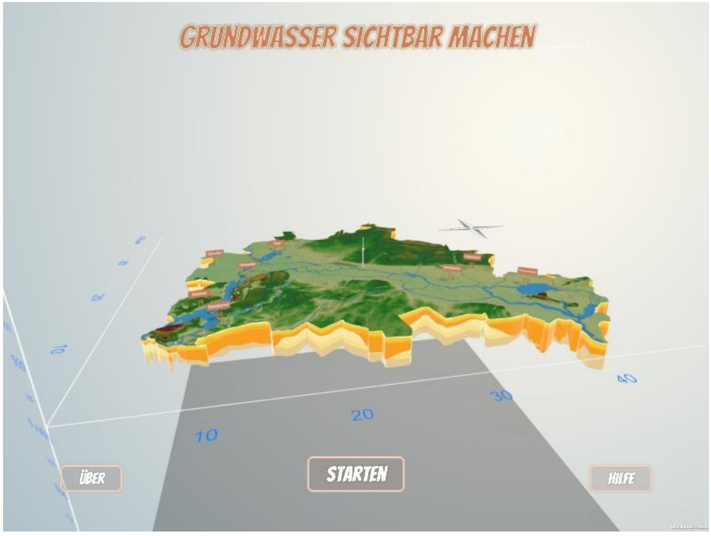


Figure 11 - Menu scene of the app.

Berlin overview scene

Upon pressing start, the app guides the user to place the AR model.

digital-water.city
digitalwater_eu
digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

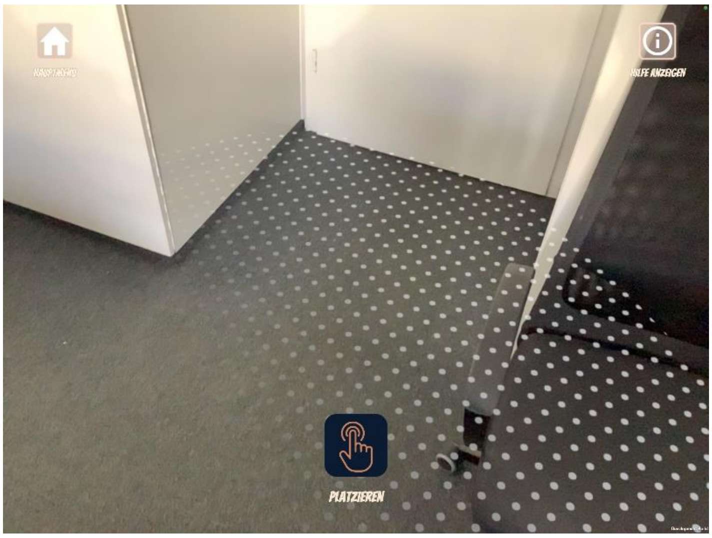


Figure 12 - Placement interface that allows users to place the AR model in their environment

Once, the model is placed, a cube appears to show translation of movement and resizing or rotating the placed model.

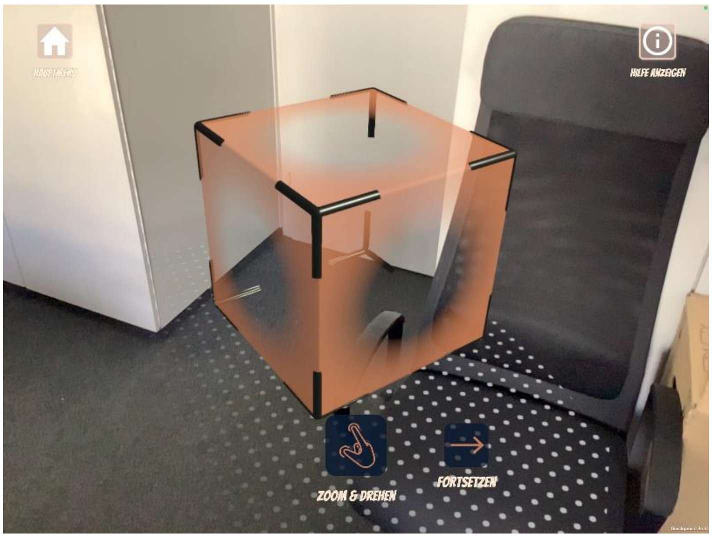


Figure 13 - Placement cube to demontrate manipulation of an AR object

When pressing "Fortsetzen" (continue) the placement cube is replaced with the actual Berlin Overview scene model. It allows users to explore the geology and the groundwater top layer. The water works can be accessed and additional information unlocked, when moving closer to one of them.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

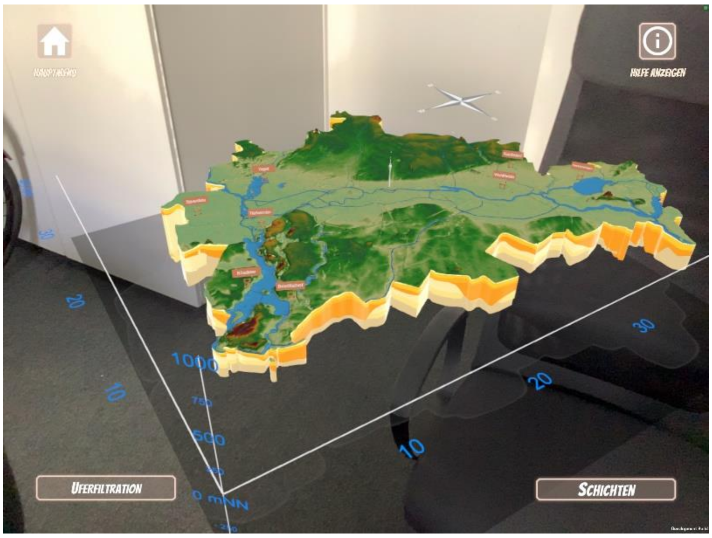


Figure 14 - Overview model

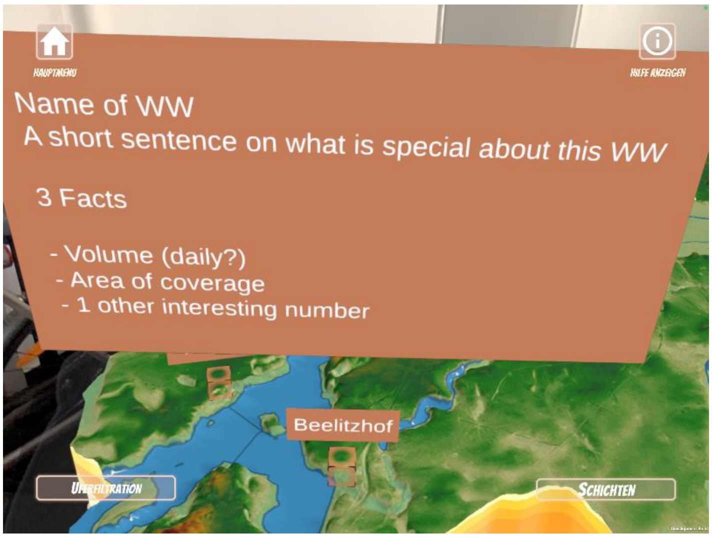
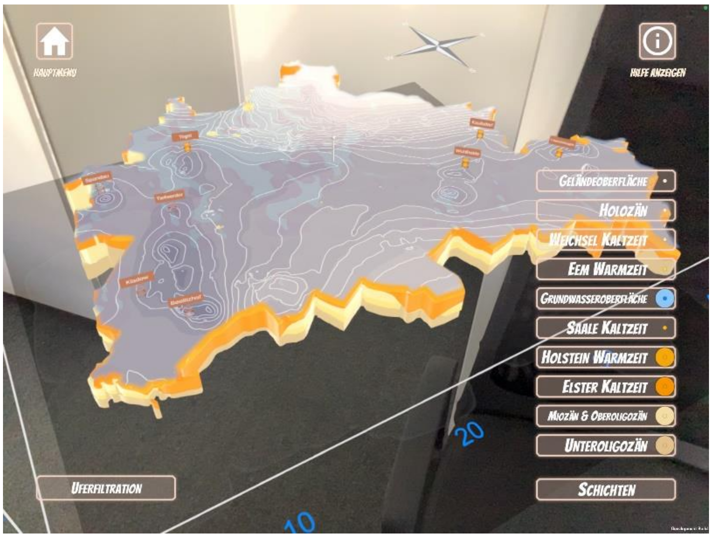


Figure 15 - UX concept of accessing detail information on proximity

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.



Pressing "Uferfiltration" (river bank filtration) accesses a specific scenario - a series of animated blocks that tell the specific story of river bank filtration and functionality of a drinking water well.

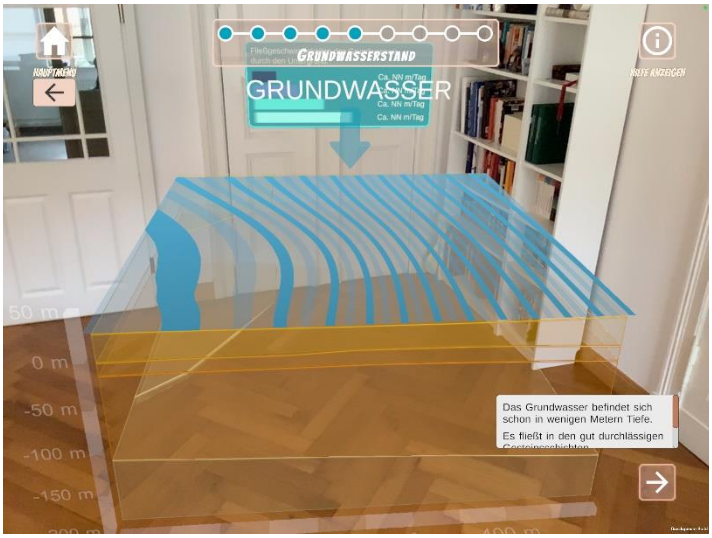


Figure 16 - Scenario stage displaying the groundwater level

The scenario explains several aspects of the location and specifics in geology and hydrogeology.

Scene Riverbank filtration

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Figure 17 - Display of groundwater flow with an activated well.

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

- An overview model of Berlin to toggle geological and hydrological layers
- A scenario that explains step-by-step the aspects of river bank filtration
- Access of geological layers and supporting information on genesis and function

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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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.

What are the results? How are the results visualised?

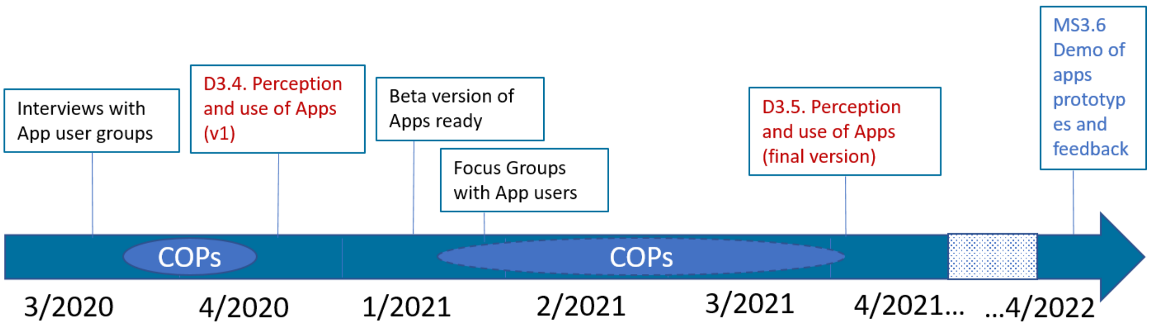
See section on User interface and mocks for impressions from the app.

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):

Figure 18 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
- Unity 3D ingestion and conversion tool for MODFLOW to 3D texture and virtual effect.

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 an effect visualisation takes place using a

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

toolset that is developed for the project. It is able to parse several modules and generate usable data, such as 3D models and 3D textures (an three dimensional, normalised RGBA data array) The 3D textures are used as an input for visual effects graphs that render particle flows based on the characteristics of the RGBA values (color determines direction and alpha determines normalized speed).

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

- Geology dataset (Berlin 3D, x3d)

Which data sets (including formats) are produced?

- Internal 3D meshes from MODFLOW data
- MODFLOW simulations of scenes
- Visual effect graphs for particle systems
- Various 3D models imported as FBX from Autodesk 3DS Max

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. The minimum target version for iOS is 13.

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)

[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.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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 platform app stores.

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, citizens), 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).

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, or even independently by a sole user.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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 sections 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 modify a number of features (source of water, crops, upgrade of WWTPs, irrigation technology etc.) which represent the different intervention that the player can make as a decision maker to impact on the nexus. Furthermore, different aspects (cultivated crops, size of the district, wastewater treatment processes) 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, Wastewater simplified description, WWTP configuration, Water quality, Energy footprint indicators, Water footprints indicators, Carbon footprint indicators, Nexus indicators, field properties (cultivated crops, crops water demand, 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, energy consumption, irrigation systems, cultivated crops and will have a final impact on carbon, water and nexus footprint indicators. Standard methodologies such as ENERWATER and UNI EN ISO 14064-1:2019 are used to calculate energy consumption indicators and to evaluate the carbon footprint

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

What are the results?

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

How are the results visualised?

During each selection step real and scientific data are shown to highlight impacts on carbon emission, energy consumption, saved water and recovered nutrients (Figure 11). All these impacts will be monetized by NEXUS COINS. Thus, at the end of the game the saved Nexus Coins are calculated compared to the scenario of non-water reuse (Figure 12).

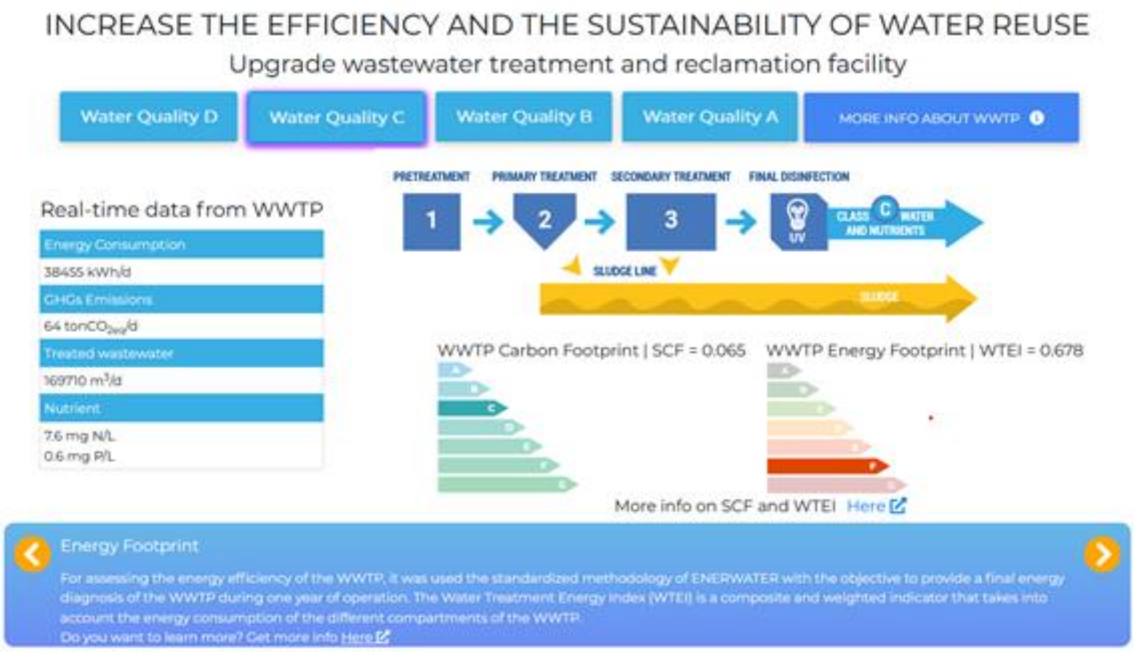


Figure 11 Layout with scientific data shown within the “Serious game”

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Figure 12 Layout of the "Serious game" showing the final results

6.2.2. Technical description of the tool

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

In Milan, a first (beta) version of the "Serious Game" was released at the end of January 2021. Comments and feedback by users on the beta version were used to improve the tool. In the final version more wastewater treatment plants located in different geographic areas of Italy and different crops were introduced.

The development process and the products environment include the following entities

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

2) Peri-urban field configuration (cultivated crops, irrigation techniques, district size, demands of crops for water and nutrients).

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 for agricultural irrigation during one year.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

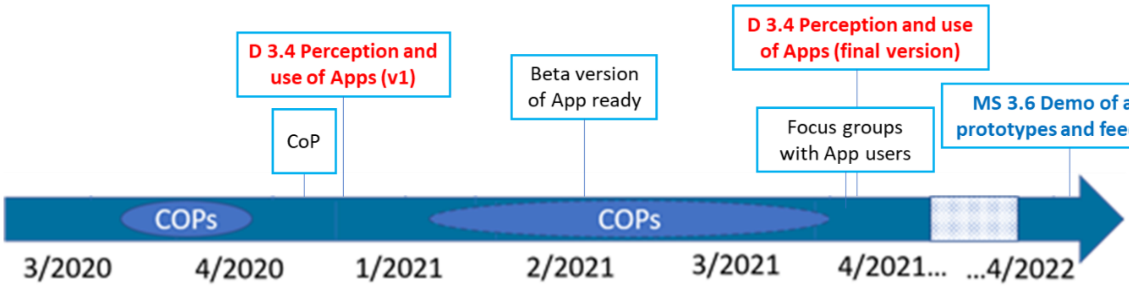


Figure 19 Timeline for the serious game app in Milan

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.

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

Standard methodologies such as ENERWATER and UNI EN ISO 14064-1:2019 are used to calculate energy consumption indicators and to evaluate the carbon footprint using data provided by the WWTP.

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. Since the game is a web application it will be accessible through a range of devices: computers, tablets, smartphones.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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?

No user information will be collected. The game experience will be anonymous

What are the usability requirements?

The application will be tested in different browsers, including Chromium, Firefox and Safari and there will be no dependency on any operating system.

What are the modifiability requirements?

The application can be customized to include data from any WWTP

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.

Objective and benefits

In the Paris region case, the choice has been made to create a community of practice that gather all the relevant actors that are involved the Seine and Marne River water quality recovery for bathing use, or in the future for the implementation of bathing sites. These bathing sites are one of the legacy of the 2024 Olympics and Paralympics games.

Two main end-users of these apps are targeted: the bathing sites managers and the general public. These are two very different kinds of users. For the bathing site manager, the tool must be efficient and it has to gather relevant information and be ergonomic. Concerning the public, there was a need to have a good assessment of their expectations in terms of the required information. The provided information must be relevant, clear and credible without bringing fears.

The organisation is the following one: the apps are commissioned by the SIAAP. The bathing sites managers are gathered in the CoP and the public is met in focus groups organized by INRAE.

Because, no bathing sites currently exist, the future bathing site managers had no experience in that field. So, it has been decided to invite experienced managers from four bathing sites

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

from other regions of France. They were invited to share their experience and to express their point of view regarding the specifications for the digital tools that are developed in DWC.

The main idea was to co-design the specifications of the applications with the future end-users. With that objective, the SIAAP has invited the provider in charge of the development of the apps to participate to the CoP meetings. The first meetings were used to determine the specifications of each app (technical, content and design), it was the conception phase. The following phase was the development of both applications based on all the feedbacks gathered from the CoP.

Thanks to this organisation the SIAAP expects to meet the expectations of both the future bathing site managers and the public.

How will the tool improve public involvement?

The app will give to the public more information about their environment and could also be used to send observations to bathing sites managers from the French citizens. As a bather, the public should pay more attention to the river and its quality. There is the hope that this will raise interest on water policy management as well as ecofriendly behavior in order to improve water quality.

For example, one of the issue that one have to cope with is the question of wrong connection in separate sewer system. Thanks to the information gathered in the app, the user can be redirected to a dedicated website on wrong connections where the user will learn about this issue.

Target user group

The first app called the “Expert” app aims at informing bathing site managers with water quality indicators so that they can take a decision for opening or closing sites. These data are compiled into a dashboard. It will depend on the local organization but this app may be open even to the mayor of the city that own the bathing site.

The second app called the “Public” app aims to inform the public on the status of bathing sites (bathing authorized or forbidden) and other useful information through a Q&A section or thanks to links to other websites. It could also be used by the public to send observations to bathing sites managers.

Where is the tool used?

It was decided by the CoP that both applications should be able to be used on a computer and via a cell phone. The technology is called a Progressive Web Application (PWA). This will allow both end-users to be able to use the apps anywhere (work, home, transportation…)

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

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

Both applications have been designed so that their use can be done the easiest way possible.

No training is required to use either of the applications. However, considering that the data available on the "Expert" app is quite technical, the person in charge of analysing it and making the final call about the bathing site status will have to beknowledgeable in water quality management.

Functional description of main features

"Expert" app

The "expert" app possess multiple features that have been chosen by the members of the CoP such as:

- Dashboard reuniting the last data of each parameters selected by the CoP (FIB concentration, rainfall, flowrates…)
- The ability to manage multiple bathing sites using one interface
- A menu that gives access to each of the parameters in detail allowing the user to see the data on a much longer period that the last day
- A map that shows all the other bathing sites with the last quality measurement and status
- A procedures page where all the info on "how to make a decision" and the availability of the people are gathered
- A phone book with the contact of all the necessary people (bathing site managers, health authorities, emergency…)
- A page where the decision about the status of a bathing site can be taken (authorized, forbidden)

"Public" app

The "public" app possesses multiple features that have been chosen by the members of the CoP such as:

- A map of all the bathing sites and their status appearing in bright colour
- A list of all the bathing sites
- A specific page for each bathing sites containing specific information such as:
    - General info: address, bathing site manager, status and European ranking…
    - Pictures
    - Technical info: water quality, type of bathing site…
    - Practical info: weather, hours of opening and closing, activities available, local biodiversity…
    - A form to fill in case of an issue at the bathing site

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

User interface (mock-up and structure) How are the results visualised?

<u>"Expert" app</u>

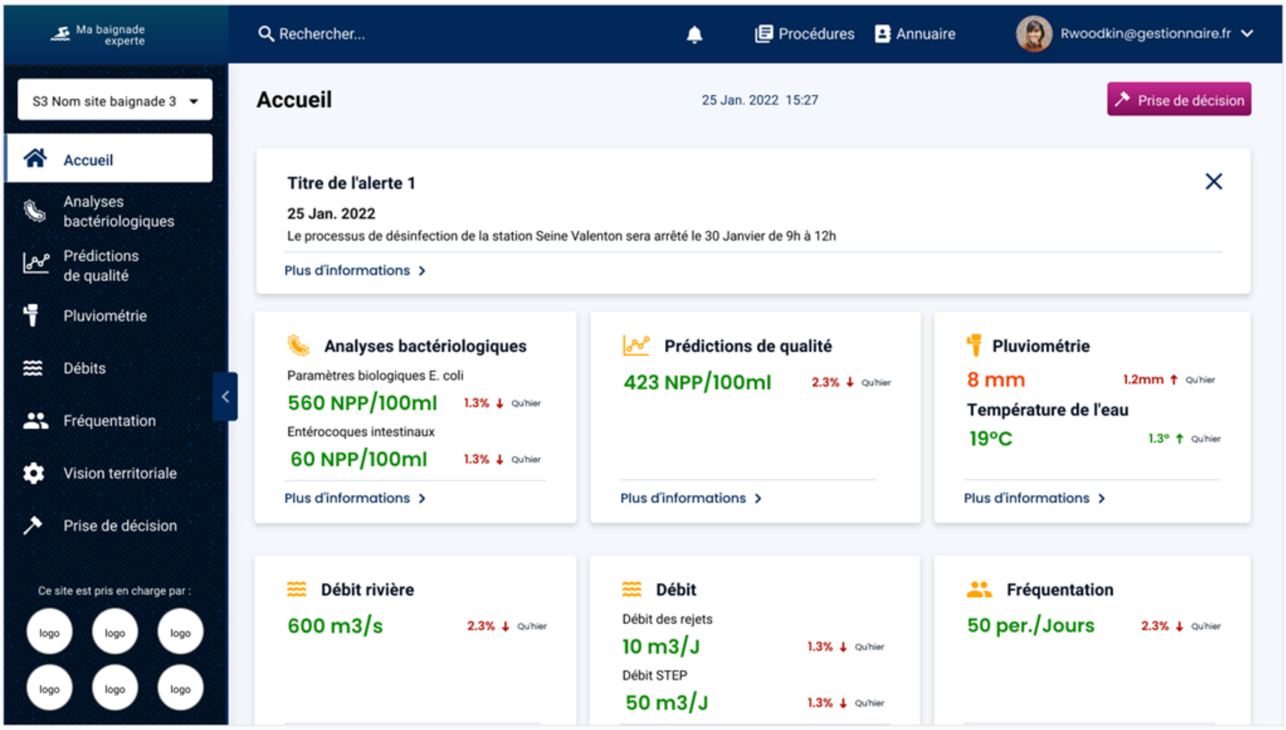


Figure1 Dashboard of the "expert" app

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

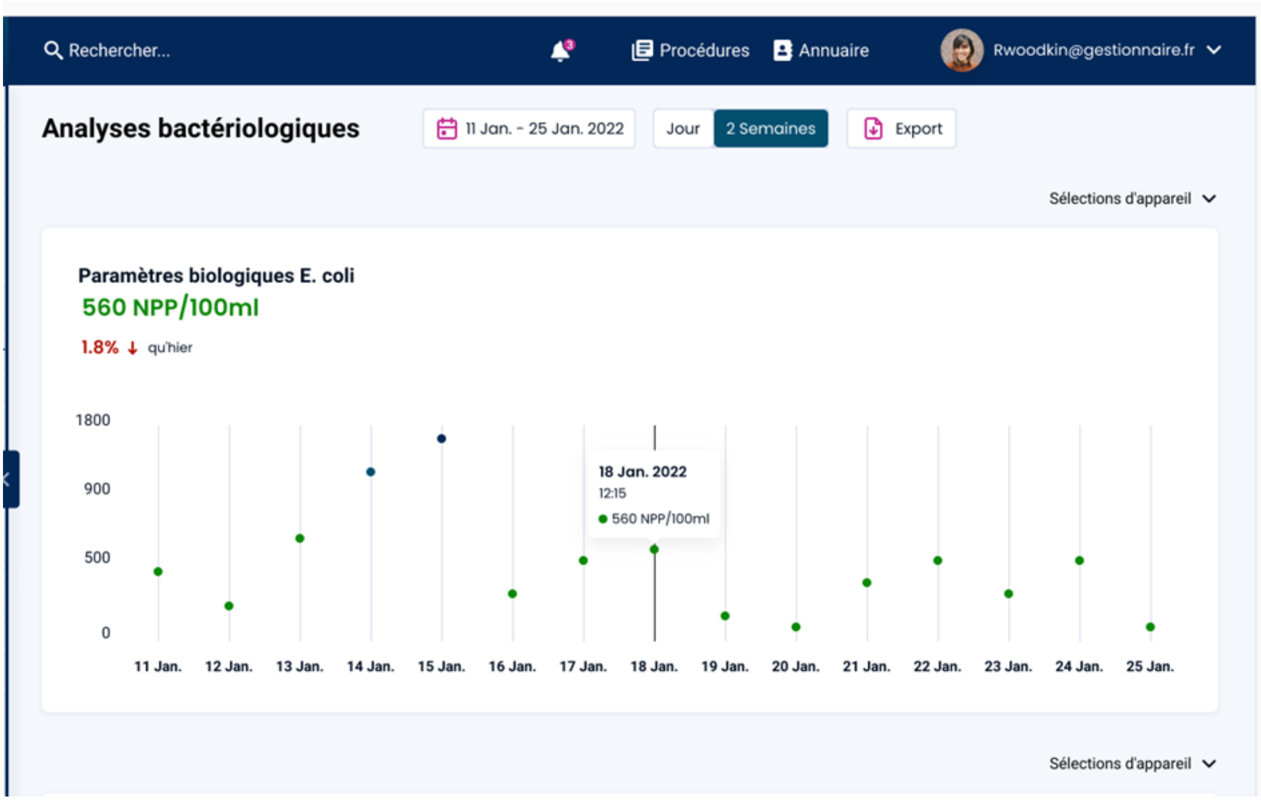


Figure2 Specific page of one of the parameters

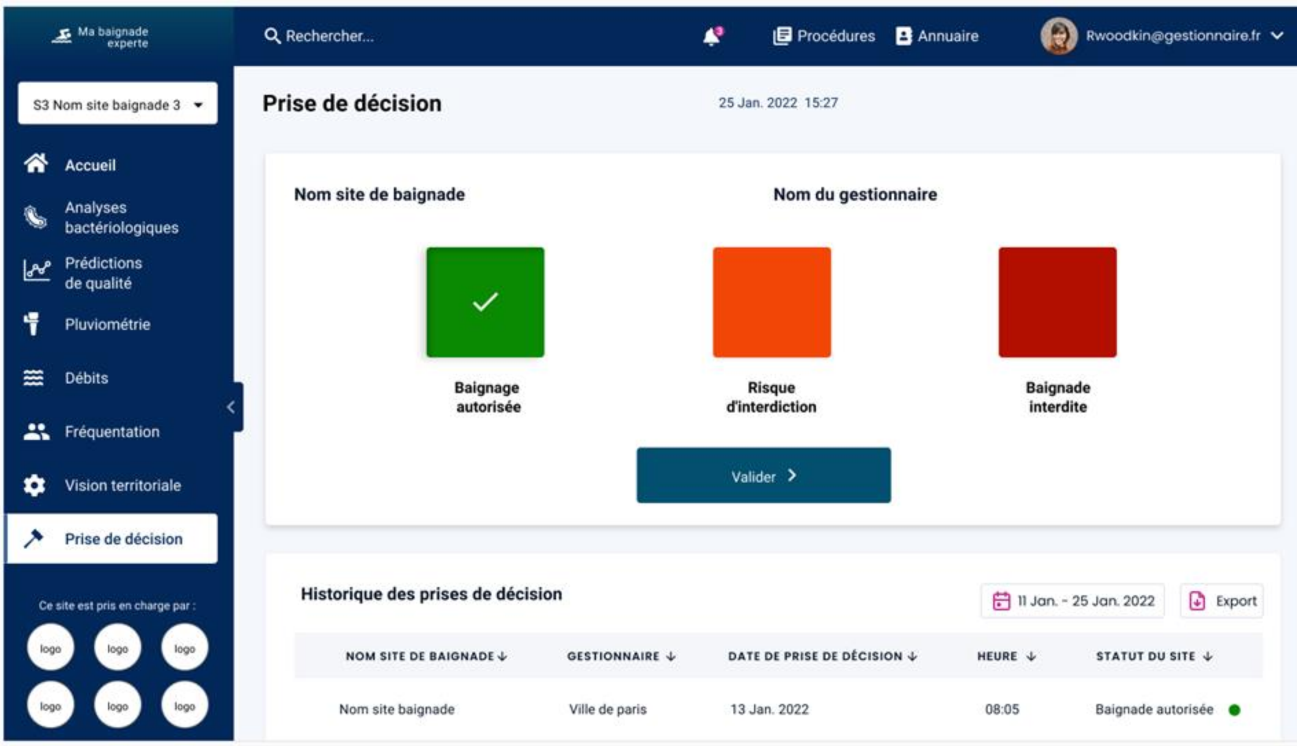


Figure3 making the decision on the status

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

“Public” app

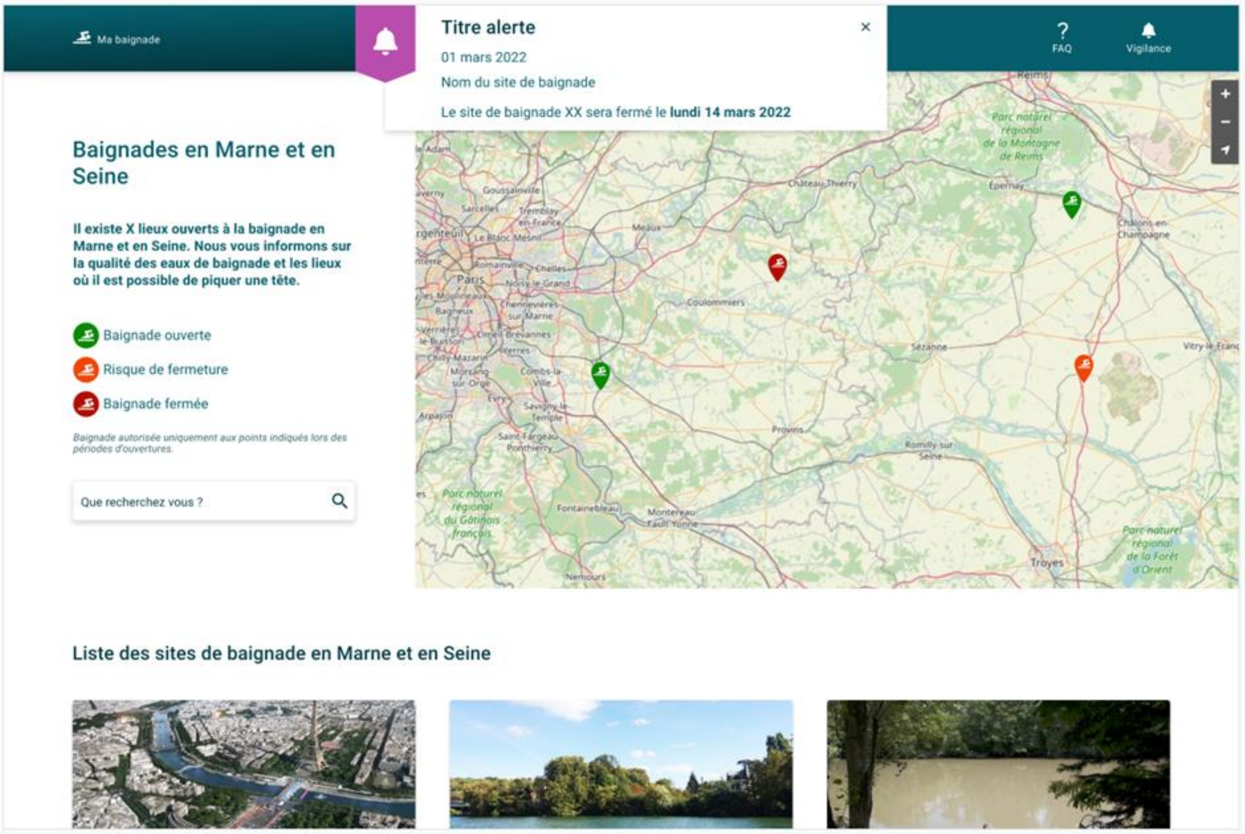
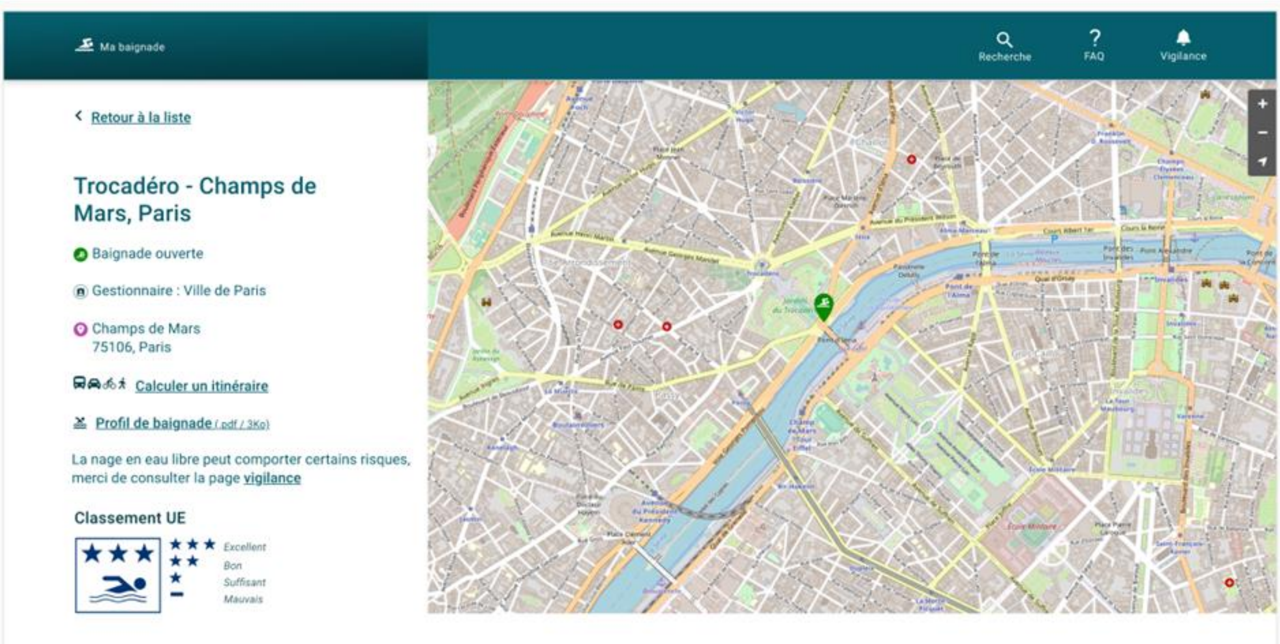


Figure4 Welcome page



digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Figure5 Bathing site page

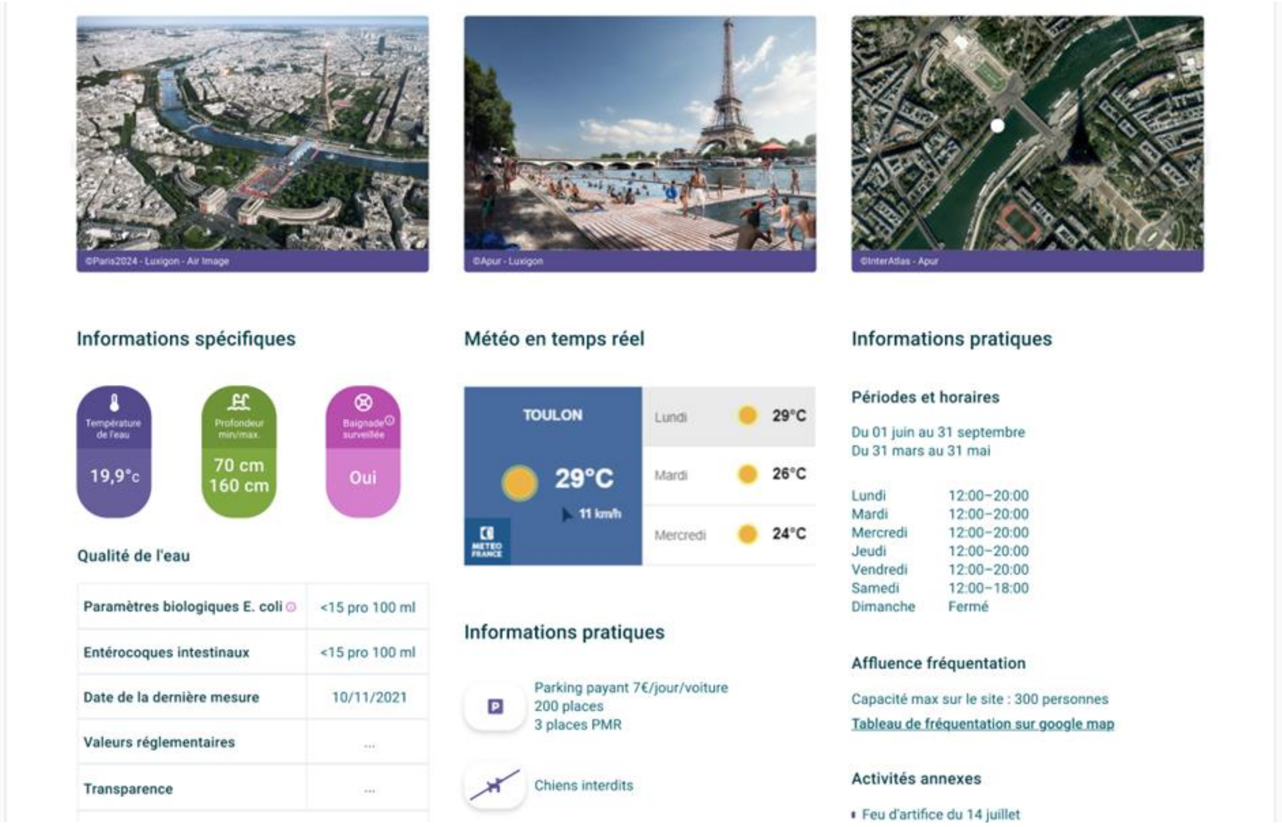


Figure6 Information shared on the bathing site page

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

On the "expert" app, giving that the information are technical, they come directly from specific databases.

On the "public" app, apart from the status that comes from the "expert" app one the bathing site manager make a decision, all the other information are filled in when the page of the bathing site is created.

In both cases, the user will interact with the interface thanks to the typical component of the progressive web app such as:

- Menu
- Pictures
- Lists
- …

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

What information/data is required?

For the "expert" app, the prediction of the prediction tool and in addition to that, it was decided to add local faecal contamination indicators, river flow, sewer flow discharges, WWTP flow discharges, rain data, weather forecast, frequentation, water temperature, etc.

For the "public" app, the main information is the decision taken by the site manager. In addition to that, general information on the site description were added such as: beach place description, restaurants, picnic places, pets allowance, access and public transport, opening schedules, Q&A section about water pollution, etc.

What are the results?

The result is that thanks to the "expert" app, the bathing site manager has all of the necessary data to make an informed decision on the status of his bathing site. He does not have to open up multiple tabs and pages on his computer or move on site.

As for the "public" app, the real gain is the ability to inform the citizens in near real-time about the status of the bathing site of their choice.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

6.3.2. Technical description of the tool

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

We currently have two interactive mock-up of the "expert" and "public" app. The development phase has just started and it will include the connection of both application to the whole Paris region case architecture as you can see on the following figure:

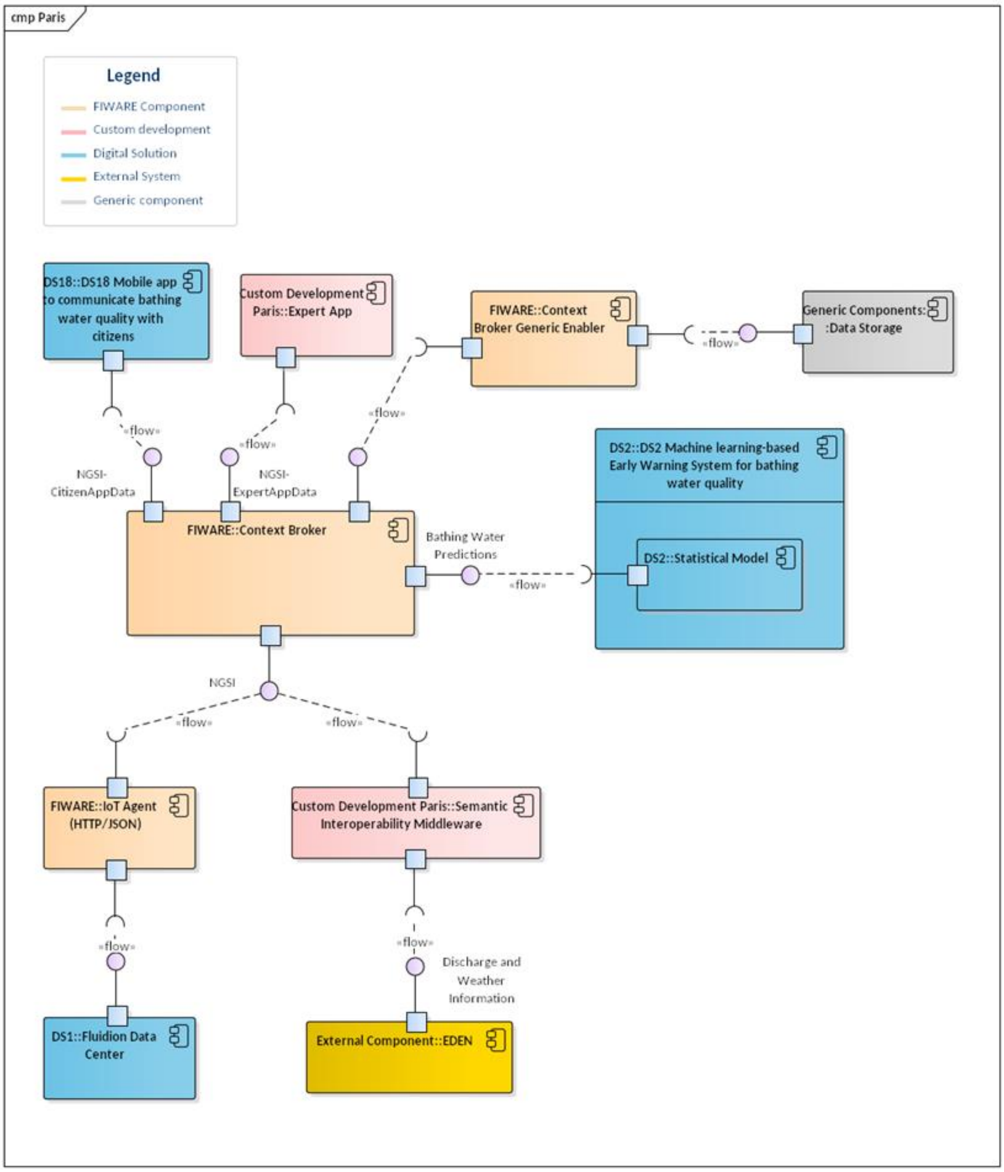


Figure7 Paris region case architecture

The main part of this architecture is the Context broker where all of the information will be gathered and access by the different component.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

The data available for the “expert” app will come from the context broker and one the bathing site manager makes his decision, the status will go through the context broker in order to be available for the “public” app.

The data that will be available on the “expert” app will come from the database at the bottom (yellow box).

What are the software components for the product?

Both applications are developed using the tool TYPO3. It is a CMS Open Source in PHP. The mobile part of both applications will be dealt with the PWA technology.

How are these components implemented?

The CMS is installed on the server and linked to a database. As much as possible we will rely on the native features and tools provided by TYPO3. For the missing elements, we will make specific developments, respecting the guidelines and best practices of TYPO3.

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

For the “expert” app, in addition to the data directly entered in the database from the administration interface of the site, we will connect to the API of the Context Broker used by FIWARE to retrieve information on:

Rainfall, bacteriological analysis, quality predictions, flows.

The data format will be JSON.

On the public app, only the weather will be used as a widget.

Which data sets (including formats) are produced?

The only data produce in this case is the status of the bathing site chosen by the bathing site manager on the “expert” app. This data will be transmitted through Context Broker used by FIWARE.

The format of the data will be JSON.

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

We will use Apache servers, installed on a Debian operating system. The database management system used is MySQL.

6.3.3. Quality attributes

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

What are the availability requirements?

The “public” app will be available by research on any browser.

The “expert” app will be available by research on any browser. It will however need an ID and code to access the data for each bathing site manager.

What are the performance requirements?

Both applications will be available through tablets, computers, phones with internet access

What are the security requirements?

The “expert” app is the only one that needs a security check to access it. Considering the fact that all of the data are raw data and very technical, each bathing site manager will need and ID and code to access its own page.

What are the usability requirements?

Any browser can be used to access both applications

What are the modifiability requirements?

Considering the fact that the entity that will be in charge of both applications has not been identified, there is still a lot of changes possible on both applications such as:

- The name of the apps;
- Some of the data require a specific subscription that will be decided by the entity;
- Pictures;
- Each bathing site manager will decided on the information that they want to make available to the public.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

7. References

Bjornlund, H., S. Girma et al. (2018). Smart Water Management. Case Study Report, Deajeon: K-Water & International Water Resources Association.

Börzel, T. A. and T. Risse (2010). "Governance without a state: Can it work?" Regulation & Governance **4** (2): 113-134.

Bouckaert, G., B. G. Peters, et al. (2016). Coordination of public sector organizations, Springer.

Bouleau, G., R. Barbier, et al. (2020). "Despite great expectations in the Seine River Basin, the WFD did not reduce diffuse pollution." Water alternatives **13**(3).

Bouwma, I., A. Gerritsen, et al. (2015). Policy instruments and modes of governance in environmental policies of the European Union: past, present and future, Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu).

Brown, T. (2008). Design thinking. Harvard Business Review June 2008.

EurEau (2018). Governance of water services in Europe. p. 34 https://www.eureau.org/resources/publications/150-report-on-the-governance-of-water-services-in-europe/file (Last accessed on 23 November 2020).

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.

Huppé, G. A., H. Creech, et al. (2012). The frontiers of networked governance, International Institute for Sustainable Development Winnipeg, Manitoba, Canada.

Illinois CITL (2020). Design Thinking. https://citl.illinois.edu/paradigms/design-thinking (Last accessed 26 November 2020).

Pahl-Wostl, C. (2015). "Water governance in the face of global change." Water Governance in the face of global change: From understanding to transformation: 1-287.

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.

Digital Water .City

Leading urban water management to its digital future

digital-water.city has received funding from the European Union's H2020 Research and Innovation Programme under Grant Agreement No. 820954.