



# IDEATION

## SWOT analysis (KER4) V1

Deliverable 5.2

WP5

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<b>ABSTRACT</b>	<p>This deliverable identifies areas to maximise the effectiveness of technological infrastructure and services using a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis on six water types: lakes, reservoirs, snow and ice, urban water, groundwater, and coastal water. Key strengths of Digital Twins include real-time monitoring, simulation, forecasting, support for regulatory compliance, and enhanced climate resilience. Digital Twins also encourage interdisciplinary collaboration and stakeholder engagement. Challenges include high implementation costs, reliance on accurate and timely data, and the complexity of integrating diverse datasets. Opportunities lie in early warning systems and interoperable DT platforms. Threats include rapid technological evolution, shifting regulations, and cybersecurity risks. Next steps will refine the SWOT findings in Deliverable D5.3 (due February 2026) and feed into the final IDEATION roadmap in Deliverable D5.5 (due May 2026).</p>		



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## ACRONYMS

Acronym	Full name / Description
AI	Artificial Intelligence
B	Biodiversity and ecosystem management
CD	Coastal Development
CSD	Coastal system dynamics
CSO	Combined Sewer Overflow
DA	Data Assimilation
DT	Digital Twin
DWTP	Drinking Water Treatment Plant
EU	European Union
FM	Fluvial model
ML	Machine Learning
MSF	Multi-Stakeholder Forum
NBS	Nature Based Solutions
NGO	Non-governmental organisation
NWP	Numerical Weather Prediction
RUC	Reference use case
SLR	Sea level rise
SME	Small to Medium-sized Enterprise
SWDN	Stormwater drainage network
SWOT	Strengths, Weaknesses, Opportunities, and Threats analysis
WWCS	Wastewater Collection System
WDS	Water Distribution System
WP	Work Package
WRP	Water Reclamation Plant
WQ	Water quality
WWTP	Wastewater Treatment Plant

## EXECUTIVE SUMMARY

A key enabler of the EU Mission “Restore our Ocean and Waters” (under the call HORIZON-MISS-2023-OCEAN-01-09) is the creation of a Digital Twin of inland waters, which is supported by cross-cutting actions that foster public engagement and mobilisation. To support the achievement of this goal, IDEATION considers eight types of inland waters: rivers and estuaries, lakes, reservoirs, wetlands, snow and ice, urban water, groundwater, and coastal water. For each type of water, as part of the T2.3 “Definition of reference use cases”, we co-created a Reference Use Case (RUC) as a tool to engage a diverse set of stakeholders to define a Digital Twin (DT) of that kind of water and understand the common or specific requirements and barriers. The RUC were defined for the countries selected as relevant for the corresponding type of water, as explained in the deliverable D2.1 “Stakeholder registers for all reference scenarios”, submitted at M3 (August 2025). The co-creation of the RUCs enables us to collect the relevant information to develop the final IDEATION roadmap for creating inland water DTs.

In conjunction with the co-creation of the RUCs, a Strengths, Weaknesses, Opportunities, and Threats analysis (SWOT) analysis have been performed for each of them. This deliverable presents the SWOT analysis performed on lakes, reservoirs, snow and ice, urban water, groundwater, and coastal water. The SWOTs for rivers and estuaries and wetlands are still work in progress and will be included in the updated deliverable (D5.3 to be submitted at M21, February 2026)<sup>1</sup>. Key findings from the SWOT analysis reveal several strengths of DTs, notably their ability to deliver real-time monitoring, simulation, and forecasting of water quality and quantity. They enhance data-driven decision-making, support regulatory compliance, and strengthen climate resilience. DTs also foster interdisciplinary collaboration and facilitate active stakeholder engagement. However, their adoption and effectiveness may be challenged by high setup and maintenance costs, dependence on accurate and regularly updated data, and the complex integration of diverse datasets. Key opportunities include leveraging DTs for early warning systems and developing shared, interoperable platforms. However, there are significant threats, including the fast pace of technological change, evolving regulatory requirements, and cybersecurity risks.

The next steps involve further developing the SWOT analysis and using its findings to create the roadmap, which will be documented in D5.3 (due in M21, February 2026). This deliverable will incorporate additional insights from the Multi-Stakeholder Forums (MSFs) and integrate new research outcomes from WP3 (OpenKIWAS: Open Knowledge Inventory for Inland Water Systems), WP4 (Reference Architecture for interoperable inland water Digital Twin), and Tasks 5.3 (Technical governance for managing inland waters), and 5.4 (IDEATION monitoring and assessment) to inform the development of the roadmap and recommendations in Task 5.5.

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<sup>1</sup> The co-creation of the RUCs, as part of T2.3, will end on M18, November 2025, and reported in the deliverable D2.5 “Co-created use cases description and visual representation”.

## 1.0 Introduction

### 1.1 Overview

Digital innovation plays a vital role in transforming the European Union (EU) into a modern, resource-efficient, and globally competitive economy. This is an essential step towards achieving climate neutrality by 2050. Within this framework, the EU Mission “Restore our Ocean and Waters” aims to develop a unified and effective strategy for managing Europe's aquatic environments. This EU mission leverages regional strengths and addresses local challenges to deliver wide-ranging environmental, social, and economic benefits. A key enabler of this mission is the creation of a Digital Twin (DT) of inland waters, a dynamic digital representation of inland water systems, which is supported by cross-cutting actions that foster public engagement and mobilisation.

To achieve the goal, IDEATION considers eight types of water (rivers and estuaries, lakes, reservoirs, wetlands, snow and ice, urban water, groundwater, and coastal water) and for each a Reference Use Case (RUC) was defined to understand the common or specific requirements and barriers in different DT applications in order to develop a roadmap for creating a DT for inland waters. Thus, through the close collaboration with Work Package 2 in Multi-Stakeholder Forums (MSFs), stakeholders have been engaged to perform a preliminary Strengths, Weaknesses, Opportunities, and Threats analysis (SWOT). This SWOT analysis is reported in this document.

Engaging a diverse set of stakeholders, including scientists, policymakers, industry leaders, local communities, local governments, and underrepresented groups, is essential to the successful development and use of the DTs. The diversity of stakeholders ensures that the system reflects multiple perspectives, incorporates localised knowledge, supports inclusive innovation, and builds trust and legitimacy across different regions and sectors. In IDEATION, we used the RUCs, which were co-created in 7 of the countries involved in IDEATION, to engage with the different stakeholders across Europe and use the SWOT analysis tool to evaluate the use of DTs.

The outcome will support the design of the reference architecture and the final IDEATION roadmap. An updated SWOT analysis will be reported as D5.3 in M21 (February 2026), based on the additional feedback from MSFs, and new research outcomes achieved in WP3, WP4, and WP5.

### 1.2 Literature Review

A SWOT analysis is a strategic planning tool used to identify and evaluate the Strengths, Weaknesses, Opportunities, and Threats related to the use of DT. It is a common tool that is used to understand internal and external factors that can affect decision-making. In IDEATION, we are using it to identify areas to maximise the effectiveness of technological infrastructure and services and optimise architecture design. Here are the four different categories used in the SWOT analysis:

- **Strengths (S)** – Internal attributes that give an advantage over current technology and ways of working today (e.g., real time monitoring, interdisciplinary integration)
- **Weaknesses (W)** – Internal limitations or areas where the entity lacks capability (e.g., high setup and maintenance costs, dependent on the quality and completeness of input data).
- **Opportunities (O)** – External chances to improve performance or gain advantage (e.g., enables early warning systems, helps protect coastal tourism assets).
- **Threats (T)** – External challenges that could cause trouble or risk (e.g., sensor/data failure risks, cybersecurity vulnerabilities).

The SWOT analysis is one of the oldest and widely used strategy tools in the world (Puyt et al., 2023). It originated in the early 1960s as the SOFT approach, which was developed by Robert Franklin Stewart at the Stanford Research Institute. SOFT stood for Satisfactory, Opportunity, Fault, and Threat, serving as a participative framework where managers identified key issues within their units and classified them accordingly. This process created a space for stakeholder engagement and collaborative dialogue to align with corporate strategies where there are diverse interests. By 1965, the terminology evolved to SWOT (Strengths, Weaknesses, Opportunities, and Threats), but it retained its foundational principles of inclusivity and strategic alignment (Puyt et al., 2023). Over time, SWOT analysis has gained widespread adoption, becoming integral to organisational decision-making and strategic planning.

Some research has raised concerns over the potential limitations of the strategic management tool (Chang and Huang, 2006; Teece, 2018). As there are no clear guidelines on what elements to include in a SWOT analysis and their relative importance, users can potentially overlook key factors or fail to identify cause-and-effect relationships (Teece, 2018). The results of a SWOT analysis can also be too superficial, imprecise, or incomplete (Chang and Huang, 2006). Therefore, to effectively support strategy development, the SWOT analysis should be integrated with other methods offering structured data collection approaches and strategic interpretation and application (Teece, 2018).

### *1.3 Aim and Objectives*

This deliverable aims to identify areas to maximise the effectiveness of technological infrastructure and services and optimise architecture design, through critical analysis using a SWOT analysis.

Objectives:

- Conduct a SWOT analysis of the DT co-defined together with selected stakeholders while defining the RUCs
- Develop and prioritise recommendations based on strategic impact.

This report is organised as follows:

- Chapter 2 presents the co-creation of the SWOT analysis;
- Chapter 3 presents the results of the SWOT analysis in the different sites;



- Chapter 4 presents the discussion where we formulate recommendations based on the analysis
- Chapter 5 is the Conclusion.

## 2.0 Co-creation of the SWOT analysis

The SWOT analysis was carried out in 6 sites where the RUCs have already been co-created: Italy - Lakes; Cyprus - Reservoirs; Switzerland - Snow and Ice; Spain - Urban water; The Netherlands - Groundwater; and The UK - Coastal water.

We worked closely with the activities in WP2, especially those related to the co-creation of the RUCs engaging selected stakeholders in all the sites.

### 2.1 *Type of Water: Lakes*

The definition of the SWOT analysis originates from the RUC on lakes, which was initiated by Engineering through collaboration with the Eurolakes project<sup>2</sup>. Eurolakes is a Mission Ocean initiative aiming to propose an innovative, holistic, and science-based approach to safeguarding and restoring European natural lakes and their ecosystems, with a particular emphasis on Nature-Based Solutions (NBS). Among the Eurolakes partners, IDEATION collaborated with the International Institute for Applied Systems Analysis (IIASA) and the University of Tuscia, who are respectively leading WP2 – Modelling and Digital Twin Demonstrations – and WP3 – Demonstrations.

During the first meeting, the Eurolakes partners presented the main challenges faced by Lake Vico, located in central Italy, and the discussion focused on how a DT could help address these issues. In the second meeting, attention shifted to the first draft of the SWOT analysis provided by Engineering, which was discussed alongside additional aspects related to the RUC. Thus, the final version of the SWOT analysis is the result of a collaborative effort between internal consortium partners and Eurolakes project partners.

### 2.2 *Type of Water: Reservoirs*

The SWOT analysis for the RUC on Water Reservoirs was conducted by the KIOS Centre of Excellence at the University of Cyprus (UCY), which also coordinates the Cyprus Multi-Stakeholder Forum (MSF). The RUC was defined based on discussions held during the Cyprus MSF meeting in October 2024. This structured engagement focused on the water cycle in Cyprus, existing infrastructure, and available technologies, ultimately identifying reservoirs as the primary use case for the Cyprus MSF and a key driver case for IDEATION. Both the RUC definition and the SWOT analysis were subsequently reviewed and validated by the Cyprus Water Development Department (WDD).

### 2.3 *Type of Water: Snow and Ice*

The SWOT analysis for the RUC on Snow and Ice was carried out by WSL Institute for Snow and Avalanche Research SLF (WSL/SLF) who also led the development of the RUC. The definition of the RUC and the SWOT analysis were closely intertwined, with several of the SWOT insights originating from discussions held during the MSF. These discussions informed and shaped the development of the RUC, with input from the same group of experts. A final review at WSL/SLF with people from the operational model

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<sup>2</sup> <https://eurolakes.eu/>

development team provided an additional view and consolidated the input. One of the people involved is part of the DestinE / Glori-A project consortium<sup>3</sup>, therefore they were able to provide expertise from the actual implementation of a DT related to snow and ice.

## *2.4 Type of Water: Urban Water*

The SWOT analysis for Urban Water was carried out by CETAQUA using the RUC developed in collaboration with Aigües de Barcelona, the water utility company from Barcelona, Spain. The RUC was defined through input from Aigües de Barcelona's innovation team and technical experts from CETAQUA representing a range of disciplines, including Hydroinformatics, Water Management, and Smart Networks (a total of 5 external stakeholders have been involved). The process involved two meetings and frequent follow-up sessions in order to shape the RUC based on a specific and realistic challenge that could be addressed using a DT. From the RUC, the analysis identified key system components, such as Water Treatment Plant, Sewer System, and Water Distribution System that could be used as separate DTs, while also examining their interrelations and interdependencies, data or information on which the Use Case relies.

## *2.5 Type of Water: Groundwater*

A SWOT analysis was carried out for the Netherlands RUC on groundwater. Following two meetings, an initial brainstorming meeting on 11 March between CETAQUA and 3 colleagues from KWR's Ecohydrology team, followed by an internal KWR meeting on 17 April with the ecohydrology experts, and a review, the RUC was validated and finalised. On the basis of this RUC, a SWOT analysis was carried out to assess the strengths, weaknesses, opportunities and threats of the proposed RUC. The SWOT was validated by the KWR ecohydrology experts.

## *2.6 Type of Water: Coastal Water*

The workshops were organised by the University of Exeter. They included an online meeting on 10 April where four stakeholders from the University of Exeter and KWR worked together on creating a SWOT analysis for Coastal Waters. This was then verified at an in-person meeting at the University of Exeter on 29 April with 28 people in total (see Figure 1). It included participants from four different sectors, including water company, consultancy, small-medium enterprises (SME), higher education and research institutes, regional and local authorities, and non-governmental organizations (NGO). The participants were split into 5 tables where they worked on developing a SWOT analysis for coastal waters. This was followed by a group discussion where themes and ideas were combined with the SWOT analysis that was created during the online meeting.

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<sup>3</sup> <https://www.meteoswiss.admin.ch/about-us/research-and-cooperation/projects/en/2023/glori-a-global-to-regional-icon-alpine-twin.html>



*Figure 1 - Workshop at the University of Exeter on 29 April.*

## 3.0 SWOT Analysis

This chapter presents findings from the SWOT analysis conducted in 6 sites including: Italy - Lakes; Cyprus - Reservoirs; Switzerland - Snow and Ice; Spain - Urban water; The Netherlands - Groundwater; and The UK - Coastal water.

### 3.1 Type of Water: Lakes

Table 1 shows the SWOT analysis for the Lake. Digital Twins are required to solve the problem:

- Water quality monitoring
- Sustainable management of the lake and its resources

Table 1 - SWOT analysis of using DT for Lakes

<i>Lakes</i>	
<b>Strengths</b>	<ul style="list-style-type: none"> <li>• To provide a digital tool that is easy to use, accessible, intuitive, up-to-date, visual, and provides simple indicators use</li> <li>• Download of data and reports at different levels of detail according to user needs</li> <li>• Capacity to assess, monitor, and forecast water quality and quantity</li> <li>• Supports local decision-making through clear, actionable KPIs</li> <li>• Real-time data integration and visualization</li> <li>• Enables simulation of agricultural impacts and environmental policy outcomes</li> <li>• Encourages collaboration across sectors and stakeholder groups</li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>• High maintenance costs (e.g., sensors, data transmission, hardware)</li> <li>• Need for frequent updates and ongoing model calibration</li> <li>• Potential complex integration of heterogeneous data types (e.g., geospatial, ecological, hydrological)</li> <li>• Potential issues with data quality (e.g., gaps, low resolution, sensor errors)</li> <li>• Cybersecurity vulnerabilities</li> <li>• Limited scalability due to reliance on lake-specific parameters and conditions</li> </ul>

	<ul style="list-style-type: none"> <li>• Dependency on availability of open data and institutional cooperation</li> </ul>
<b>Opportunities</b>	<ul style="list-style-type: none"> <li>• High potential for interoperability with other environmental and governmental systems</li> <li>• Availability of public funding and EU incentives for digital and environmental innovation</li> <li>• Public and institutional interest in protecting local natural resources</li> <li>• Engagement of local communities and academic researchers can enhance model relevance</li> <li>• Potential replication in other lake or water basin contexts with similar challenges</li> <li>• Advances in Artificial Intelligence/Machine Learning (AI/ML) and IoT technologies could improve model performance and usability</li> </ul>
<b>Threats</b>	<ul style="list-style-type: none"> <li>• Evolving regulatory frameworks may affect compliance and data standards</li> <li>• Risk of cyberattacks or data breaches, especially in public platforms</li> <li>• Rapid technological evolution</li> <li>• Resistance to adoption by traditional stakeholders due to complexity or perceived risks</li> </ul>

### 3.2 Type of Water: Reservoirs

Table 2 shows the SWOT analysis for the Reservoirs. The DTs required to solve the problem:

- water levels and quality in reservoirs

Table 2 - SWOT analysis of using DT for reservoirs

	<i>Reservoirs</i>
<b>Strengths</b>	<ul style="list-style-type: none"> <li>• Provides an integrated, real-time view of storage, flows, water quality and energy cost/production across reservoirs, as well as treatment plants</li> <li>• Offers short-term forecasts (hours to days) for inflows, spills, stratification and algae blooms, and multi-year scenario analysis for drought planning and policy testing</li> <li>• Includes simulation and risk-based decision support and optimisation tools that balance potable demand,</li> </ul>



	<p>environmental flows, desalination production, floating PV and hydropower (pumped storage) revenue and electricity tariffs, reducing operating cost and greenhouse-gas footprint</p> <ul style="list-style-type: none"> <li>• Delivers clear, actionable KPIs such as shortage risk, supporting executive and regulatory reporting</li> <li>• Uses modular, standards-based APIs that allow easy connection to meteorology, power-grid, desalination-plant and smart-irrigation digital twins</li> <li>• Encourages collaboration among water, energy and civil-protection agencies through a shared data space and common digital vocabulary</li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>• Relies on continuous sensor measurements</li> <li>• Requires regular model calibration and skilled staff</li> <li>• Incorporates heterogeneous data sources (including legacy sources) that may introduce latency or format-change issues</li> <li>• Computationally intensive Monte-Carlo and optimisation runs can have limited real-time use during emergencies</li> <li>• Operators are more accustomed to manual rules and may hesitate to follow Digital Twin recommendations</li> <li>• Some elements of the model are simplified</li> </ul>
<b>Opportunities</b>	<ul style="list-style-type: none"> <li>• Access to EU funding can subsidise deployment, sensor expansion and ongoing operation</li> <li>• Falling costs of IoT devices, drones and satellite imagery can densify data, improve forecasts and reduce manual sampling needs</li> <li>• Dynamic electricity-tariff and carbon-pricing schemes increase financial value of real-time cost and emissions optimisation</li> <li>• Emerging interoperability frameworks and data-space initiatives facilitate seamless exchange with energy, transport and emergency-management systems</li> <li>• Advances in physics-informed AI and surrogate modelling promise faster simulations, enabling broader scenario exploration and edge deployment</li> <li>• Potential exists to extend the digital twin to physical safety monitoring (e.g., during seismic activities)</li> </ul>
<b>Threats</b>	<ul style="list-style-type: none"> <li>• Cyber-security breaches targeting critical reservoirs infrastructure could corrupt models, falsify data or disrupt operations</li> <li>• Increasing climate extremes may push the system outside calibration ranges, diminishing model reliability under unprecedented conditions</li> </ul>

	<ul style="list-style-type: none"> <li>• Rapid technological evolution risks vendor lock-in or obsolescence if solutions depend on proprietary platforms that lose support</li> <li>• Budget constraints or delayed public tenders could limit maintenance, causing data gaps and gradual loss of confidence in the digital twin</li> <li>• Deployment of Digital Twin systems require employee education, training, and reskilling and up-skilling which is not always considered by organisations.</li> </ul>
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### 3.3 Type of Water: Snow and Ice

Table 3 shows the SWOT analysis for Snow and Ice. Only one digital Twin is required to solve the problem which is Mountain hydrology in extreme weather

Table 3 - SWOT analysis of using DT for Snow and Ice

	Snow and Ice
<b>Strengths</b>	<ul style="list-style-type: none"> <li>• DT will provide real-time assessment and forecast of snowmelt, surface water input, and runoff with a detailed system model and functionality that are usually unavailable in operational settings</li> <li>• DT will enable next-level reanalysis of past extreme weather events by involving reruns of the Numerical Weather Prediction (NWP) component</li> <li>• Can build on existing model components (NWP, snow model, runoff model), where the challenge lies “only” in the model interfacing.</li> <li>• Can benefit from developments in the context of DestinE / Glori-A<sup>4</sup></li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>• Any forecast is only useful if the initial states are reasonable. Therefore, model states such as snow amounts and extent will need to remain realistic at all times (which requires solutions beyond current Data Assimilation (DA) methods within NWP systems).</li> <li>• Unclear, if a two-way coupling is necessary (NWP &lt;-&gt; snow model), which would complicate the matter considerably</li> <li>• Will likely not allow solutions to account for horizontal transport of water within the snowpack (potentially relevant in steep terrain)</li> </ul>
<b>Opportunities</b>	<ul style="list-style-type: none"> <li>• DT will provide data for subsequent modelling/forecasting of other natural hazards such as shallow landslides</li> </ul>

<sup>4</sup><https://destination-earth.eu/national-initiative/glori/>

	<ul style="list-style-type: none"> <li>DT will serve as a normal weather and hydrological forecasting system particularly developed for mountain regions even if not needed in the context of extreme weather events, but with the added benefit of allowing users to prescribe weather (what-if scenarios)</li> </ul>
<b>Threats</b>	<ul style="list-style-type: none"> <li>Such a DT requires substantial resources for optimizing and tuning, whereas most of the funding is often associated with developing functionality</li> <li>Such a DT may require supervision if it is to be readily exploitable when needed (incoming extreme weather)</li> <li>Since simulations are computationally expensive, user-interaction must be limited / prioritized / coordinated, particularly in the case of an extreme weather event</li> </ul>

### 3.4 Type of Water: Urban Water

Table 4 shows the SWOT analysis for Urban Water. The following Digital Twins are required to solve the problem:

- Water Distribution System (WDS)
- Wastewater Treatment Plant (WWTP)
- Water Reclamation Plant (WRP)
- Drinking Water Treatment Plant (DWTP)
- Wastewater collection System (WWCS)
- Storm water drainage network (SWDN)

Table 4 - SWOT analysis of using DT of urban water

	Urban Water
<b>Strengths</b>	<ul style="list-style-type: none"> <li>To support operational management</li> <li>To cover short timescales and appropriate time resolutions of data</li> <li>To provide a digital tool easy to use, accessible, intuitive, updated, visual, and providing simple indicators.</li> <li>To be able to systematically solve multiple problems (e.g., water scarcity, decrease of water quality, water saline intrusion).</li> <li>To provide models of past events to enable analysis and to develop predictive models.</li> <li>To enable download of data and reports at different levels of detail according to user needs</li> <li>To enable the evaluation of the impact of extreme weather scenarios, such as water scarcity and water saline intrusion.</li> <li>To assess, monitor, and forecast water quality and quantity. [WWTP, WRP, DWTP, WWCS, SWDN]</li> </ul>



	<ul style="list-style-type: none"> <li>To replicate potential operational scenarios based on seasonality, new added demands, interruptions caused by leakages in main pipes, power interruptions, shortages in sources, possible cascading effects from events that happen within the system, and estimate their impacts on the served population. [WDS]</li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>To increase of cybersecurity risks</li> <li>Maintenance cost (sensor maintenance/operation, data transmission)</li> <li>Need for integration between different technologies regarding data measuring and transmission</li> <li>Possibility of poor quality of data (e.g., missing values, frequency, error measures) and low performance of current models (e.g., calibration, changes in operational conditions, assumptions)</li> <li>Need for maintenance and updating of the Digital Twin, linked with modifications of the water infrastructure or of the operation (e.g., changes of valves status, sources that feed the system, pump settings, pressure points)</li> <li>Current models are (or can be) simplifications of the real models [WDS, WWCS]</li> </ul>
<b>Opportunities</b>	<ul style="list-style-type: none"> <li>Be able to connect various existing digital systems (e.g., sensors), as well as be useful to local decision-making.</li> <li>To cover different spatial resolutions of the data.</li> <li>To share a common structure for collecting and processing data (e.g., data lake, data spaces).</li> <li>To integrate different models and tools, such as hydraulics models.</li> <li>To enable connection with ML/AI predictive systems. For instance, forecasting of water resources based on demand and availability.</li> <li>To enable early warning to the population or authorities due to interruption services.</li> <li>To explore, monitor and compare alternatives for feeding specific parts of the WDS in case of disruptions or serious operation problems, for choosing the best option [WDS, DWTP]</li> <li>To improve energy efficiency and water efficiency of the networks (water quality, leak detection, Non-revenue Water reduction) [WDS]</li> </ul>
<b>Threats</b>	<ul style="list-style-type: none"> <li>Lack of training for operators</li> <li>Risk of cyberattacks</li> </ul>

	<ul style="list-style-type: none"> <li>• Integration challenges of external systems and/or components</li> <li>• Future interoperability with other digital twins because of lack of standardisation</li> <li>• Dependence of private commercial software for modelling</li> <li>• Resistance to change of the operators</li> <li>• Possible need of continuous updates to keep up with evolving regulatory changes</li> <li>• Dependence on external providers and/or developers for retrieving data</li> </ul>
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### 3.5 Type of Water: Groundwater

Table 5 shows the SWOT analysis for the Groundwater. The DT required to solve the problem:

- Groundwater Status DT to improve water availability and to support decision making on water distribution across the different functions that depend on it – these include agriculture, nature, drinking water and industries.

Table 5 - SWOT analysis of using DT for groundwater

	Groundwater
<b>Strengths</b>	<ul style="list-style-type: none"> <li>• Provides a spatial view of groundwater conditions</li> <li>• Integrate data from surface water, meteorological data, vegetation and system knowledge</li> <li>• Allows exploration of what-if scenarios</li> <li>• Supports design and long-term planning of the water system</li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>• Variability in data formats and quality across organisations may hinder interoperability</li> <li>• Ensuring the DT is intuitive and accessible to a diverse user base with varying technical skills is challenging</li> <li>• Fragmented decision-making across provinces, boards, and agencies</li> </ul>
<b>Opportunities</b>	<ul style="list-style-type: none"> <li>• Improves the prediction of the effects of management decisions</li> <li>• Provides a new approach to designing and managing the water system to improve water availability and to support decision-making on water distribution.</li> <li>• Improve long-term design choices for the spatial development of rural areas</li> <li>• Improve compliance with EU water directives, the national KRW directive, and Natura2000</li> </ul>

	<ul style="list-style-type: none"> <li>• Opportunity for interoperability, standardized data formats, and adaptability to different geographical and temporal scales</li> </ul>
<b>Threats</b>	<ul style="list-style-type: none"> <li>• Unclear responsibilities for long-term maintenance and data management</li> <li>• Ongoing development and maintenance depend on consistent funding and political will</li> <li>• Misalignment between short-term political goals and long-term planning</li> <li>• Data availability (especially data on surface water levels which is currently not available at a national scale)</li> <li>• Constraints on data sharing (e.g., data security, privacy, and intellectual property concerns)</li> <li>• Cybersecurity risks</li> <li>• Potential lack of buy-in from key end-user groups or political actors</li> <li>• Dependence on emerging technology (e.g., AI) introduces unknown vulnerabilities</li> </ul>

### 3.6 Type of Water: Coastal Water

**Table 1** shows the SWOT analysis for Coastal Water. The following DTs are required to solve the problem:

- Combined Sewer Overflow (CSO)
- Sea level rise (SLR)
- Coastal system dynamics (CSD)
- Water quality (WQ)
- Water distribution System (WDS)
- Fluvial model (FM)
- Coastal Development (CD)
- Biodiversity and ecosystem management (B)

Table 6 - SWOT analysis of using DT of coastal water

Coastal Water	
<b>Strengths</b>	<ul style="list-style-type: none"> <li>• Real time monitoring and prediction</li> <li>• Data-driven, evidence-based decision-making</li> <li>• Scenario simulations aid in operational planning and stakeholder communication.</li> <li>• Supports policy development and regulatory compliance (SLR, CSD, WQ, WDS).</li> <li>• Enables climate change and sea level rise scenario modelling</li> <li>• Aids in infrastructure and ecosystem planning (FM).</li> <li>• Interdisciplinary integration (hydrology, chemistry, biology, engineering).</li> <li>• Enhances public health protection (WQ, WDS).</li> <li>• Integrated catchment-to-coast modelling with predictive flood management (FM).</li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>• High setup and maintenance costs.</li> <li>• Dependent on the quality and completeness of input data.</li> <li>• Requires continuous updates and maintenance to stay relevant.</li> <li>• Complex integration of diverse data types (geospatial, hydrodynamic, etc.).</li> <li>• Training needed for stakeholders.</li> <li>• Limited scalability due to region-specific modelling.</li> <li>• Interoperability issues between coastal and inland models (FM).</li> <li>• Standards - general interoperability issues</li> <li>• Accuracy impacted by unmonitored tributaries (FM)</li> <li>• Transition (updating outdated infrastructure)</li> <li>• Energy/economic cost</li> <li>• Public faith in outputs (e.g. false alarms)</li> </ul>



<b>Opportunities</b>	<ul style="list-style-type: none"><li>• Prepares cities for extreme weather and erosion events.</li><li>• Reduces health risks and pollution by minimising CSO events.</li><li>• Enables early warning systems for floods, erosion, and contamination.</li><li>• Supports the design of nature-based and engineered mitigation solutions.</li><li>• Enhances resilience to climate impacts like saltwater intrusion, flooding, and drought (WDS, FM).</li><li>• Promotes collaboration across agencies and urban planning integration.</li><li>• Helps protect coastal tourism assets</li></ul>
<b>Threats</b>	<ul style="list-style-type: none"><li>• Need for continuous updates due to evolving regulations and environmental change</li><li>• Risk of inaccurate predictions from malfunctions or misinterpretation (black box)</li><li>• Sensor/data failure risks.</li><li>• Rapid tech evolution may outdate existing models quickly.</li><li>• Accelerating environmental change (erosion, sea level rise, etc.) may outpace model capabilities (CSD, FM).</li><li>• Cybersecurity vulnerabilities</li><li>• Unintended consequences</li></ul>

## 4.0 Discussion

In total eight types of water bodies were included in the SWOT analysis including lakes, reservoirs, wetlands, snow and ice, urban water, groundwater, and coastal water. The co-creation activity for both the RUCs definition and the SWOT analysis were an excellent tool to engage a diverse set of stakeholders to understand the specific requirements and barriers in the different DT applications. This chapter firstly consolidates the main themes from the SWOTs and then provides some initial recommendations which will be explored further in the next stage of the project.

### 4.1 Consolidated SWOT Analysis for Digital Twins of Inland Waters

#### 4.1.1 Strengths

- Enables real-time monitoring, simulation, and forecasting of water quality and quantity.
- Facilitates data-driven decision-making and regulatory compliance.
- Improves public health protection and climate resilience (e.g., flood management, drought readiness).
- Allows scenario modelling for operational planning and extreme event preparedness.
- Fosters collaboration among stakeholders and promotes interdisciplinary integration
- Tools are increasingly accessible and user-friendly, with potential for local customisation

#### 4.1.2 Weaknesses

- High setup and maintenance costs (e.g., sensors, calibration, infrastructure).
- Dependent on data quality, availability, and frequent updates.
- Complex integration of heterogeneous data (hydrological, ecological, geospatial, etc.).
- Lack of standardisation
- Potential training gaps among users would reduce the use of the DTs and there might be resistance to change
- Models may simplify complex realities, limiting accuracy

#### 4.1.3 Opportunities

- EU funding and incentives can drive innovation and adoption.
- Potential for AI/ML integration, energy efficiency, and operational optimisation
- DTs can support early warning systems and nature-based solutions.
- Improve stakeholder engagement (eg easier to explain complex interactions and concepts and to gain feedback)
- Opportunities for replication across similar inland ecosystems.
- Build shared platforms and interconnected data spaces.

## 4.1.4 Threats

- Rapid technological evolution may outpace model capabilities.
- Environmental change and evolving regulations require continuous adaptation.
- Cyberattacks and data breaches could compromise trust.
- Dependence on commercial software or external vendors limits flexibility.
- Resistance from traditional stakeholders can hinder implementation.

## 4.2 Recommendations based on the SWOT analysis

At this stage of the project, the following themes have emerged as the key recommendations from the SWOT analysis. This includes the importance of stakeholder engagement, improving data quality and integration, and enhancing cybersecurity and data governance. These themes came up consistently across all SWOT exercises and will be explored in more detail in the next phase. It is predicted that other themes will also emerge as the project progresses.

### 4.2.1 Importance of stakeholder engagement

Stakeholder engagement is vitally important, this includes engagement with users (i.e., professionals within the water sector from different disciplines) and the general public to ensure there is trust and that the DTs are designed in a way that is helpful to the user. There may be resistance from some stakeholders, especially when systems are perceived as overly complex or if staff lack proper training. While, the public needs to trust the outputs of the system for it to have impact. Therefore, involving a diverse range of users in the co-design process helps ensure relevance, usability, and adoption. Training and outreach are also important to address resistance and skill gaps.

### 4.2.3 Improve Data Quality and Integration

The “DTs will only be as good as the data”, this was a statement that was repeatedly heard during the workshops and meetings. It is therefore essential to develop clear standards for data interoperability and establish robust sensor networks to ensure consistent, reliable data collection. Continuous investment in data validation and model calibration is crucial to maintain the accuracy and relevance of digital twin outputs.

### 4.2.3 Enhance Cybersecurity and Data Governance

Enhancing cybersecurity and data governance is a topic that came up at all RUCs especially with recent events across Europe (e.g., power outages at Heathrow airport and in Spain). It requires the implementation of strict data security protocols and reliable backup systems to protect against cyber threats and data loss. Equally important is ensuring transparency in model assumptions, which helps build user trust and allows stakeholders to understand how decisions and forecasts are generated by the digital twin systems.

## 5.0 Conclusion

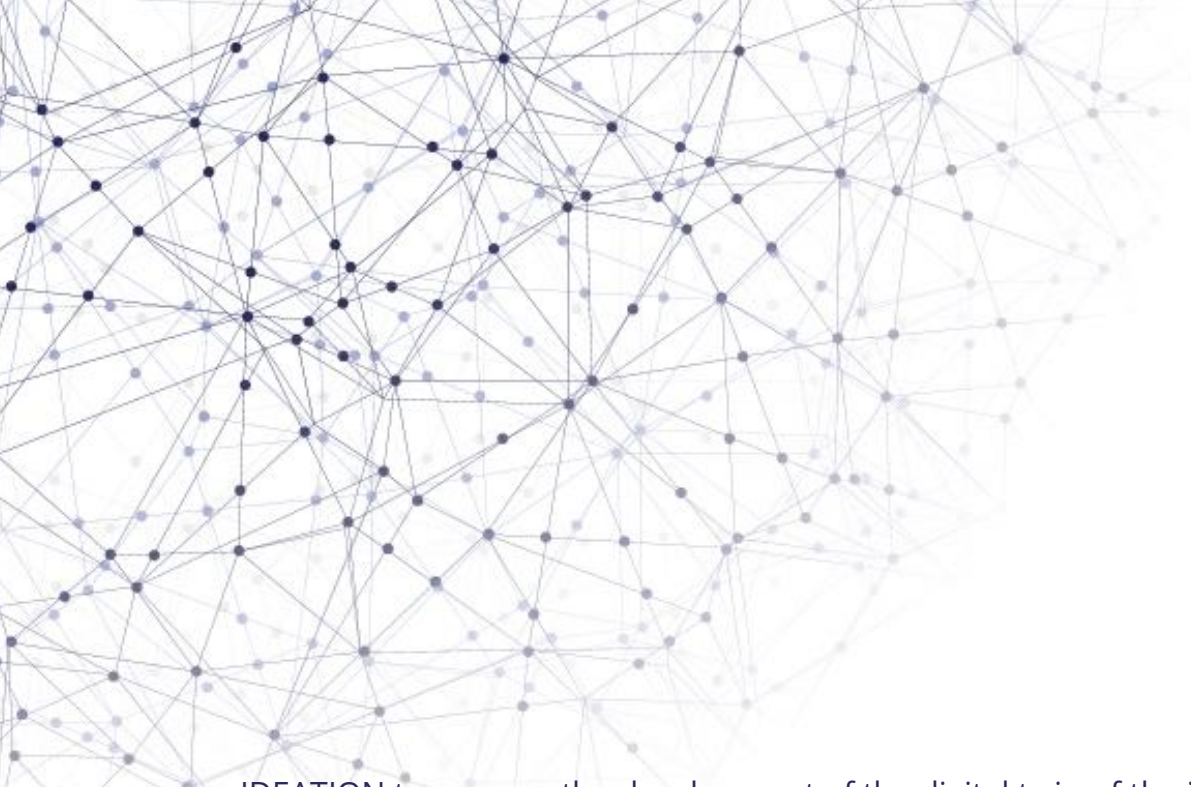
This deliverable has laid the foundation for identifying areas to maximise the effectiveness of technological infrastructure and services and optimise architecture design. It has done this by examining six types of inland water bodies through Reference Use Cases, engaging diverse stakeholders in a co-creation activity to identify shared and unique requirements and challenges. A deep analysis was performed as a strategic planning tool to identify and evaluate the Strengths, Weaknesses, Opportunities, and Threats (SWOT) related to the use of DTs.

Preliminary SWOT analyses highlighted common themes, including the critical importance of stakeholder trust and involvement, the need for improved data quality and integration, and the urgency of robust cybersecurity and transparent data governance. As work progresses, particularly for rivers and wetlands, these insights will be expanded and refined. The close collaboration with WP2 has been a real asset to the project as it has enabled IDEATION to use the relationships that have already been established to foster deeper engagement using the SWOT framework.

The next phase involves using the SWOT findings to provide further recommendations for DT development, which will be detailed in D5.3 “SWOT analysis (KER4) V2” to be submitted at M21 (February 2026). These recommendations will integrate ongoing research and feedback from multiple work packages and tasks, ultimately shaping recommendations to advance the inland water DTs.

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IDEATION to prepare the development of the digital twin of the inland waters (rivers, lakes, reservoirs, wetlands, snow, and ice) addressing activities to be developed and to make it integrated and interoperable with the DTO for a unified digital twin of ocean and waters.



# IDEATION



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