STARS 4 Water

Dashboard for supporting decision-making on water resources management at river basin level: prototype

Deliverable 1.4

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Summary

This report introduces Deliverable 1.4 of the STARS4Water project: a prototype dashboard to support decision-making on water resources management at river basin scale. STARS4Water is an EU-horizon project, which aims to improve the understanding of climate change impacts on water resources availability and the vulnerabilities for ecosystems, society, and economic sectors at river basin scale. The prototype dashboard is developed through co-creation with stakeholders from seven European river basins, namely the Drammen, East Anglia, Duero, Rhine, Seine, Messara and the Danube. The co-creation approach with the stakeholders in the river basins improves the understanding and use of existing and newly generated data and information in their river basin.

Two types of dashboards will be co-created in the 4-year timespan of the project based on the dashboard needs derived from the stakeholders in the 7 river basins:

1) a generic dashboard, primarily designed to see how global/less-specific indicators change depending on the various climate and socio-economic scenarios selected within STARS4Water; and
2) a tailor-made dashboard, made for selected river basins, which incorporates specific information relevant to the river basin's specific context, priorities, and spatial scale. Such a tailor-made dashboard empowers the river basin hubs to enrich their analyses with locally relevant information, fostering more informed decision-making and effective management of water resources.

So far, content needs and design needs of the stakeholders in each river basin were collected in workshops based on a mock-up dashboard to further progress the mock-up towards a generic dashboard prototype. The prototype dashboard is designed using PowerBI, which is a well-established software package for interactive data visualization. Currently, new feedback from the river basin hubs is collected on this prototype to further improve it and make a final version of the generic dashboard.

This final version will be used as a starting point to develop the tailor-made dashboard(s). Workshop(s) will be held within the selected river basin(s), to gather information on their more basin-specific needs. These needs will be implemented, herein developing the prototype(s) of the tailor-made dashboard. Another feedback round is hereafter held, to further improve the tailor-made prototype(s) and make the final tailor-made dashboard(s). Trainings on how to use and adjust the dashboards are given to ensure maintenance and uptake of the dashboards also after the duration of the STARS4Water project.

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1. The STARS4Water project

1.1. Introduction to the project: ambition and approach

STARS4Water (Supporting Stakeholders for Adaptive, Resilient and Sustainable Water Management) is a collaborative project funded under the Horizon Europe Framework Program, the project started in October 2022 and will finish in September 2026 (48 months). The aim of the project is to improve the understanding of climate change impacts on water resources availability and the vulnerabilities for ecosystems, society, and economic sectors at river basin scale. Herein, STARS4Water will co-create the next generation river basin tools and data services with stakeholders to better support decision-making in planning actions for adaptive, resilient, and sustainable management of freshwater resources. The next generation tools developed within this project may include developing or improving process based and data-driven models multi-level scale models integration and developing dashboards. Data services could entail unlocking existing datasets, developing datasets on indicators, improving future projections, and setting up a meta-data platform.

A co-creation approach in STARS4Water is taken to ensure that the stakeholders' modelling and data needs are met to promote uptake for use beyond the lifetime of the project, thus, building a strong Community of Practice. It specifically entails bringing together academic experts, developers, service providers, river basin managers, water use sectors, communities, environmental agencies, and NGOs to share their modelling and data needs and discuss the possibilities to fulfil these needs. The STARS4Water approach is schematically shown in Figure 1.

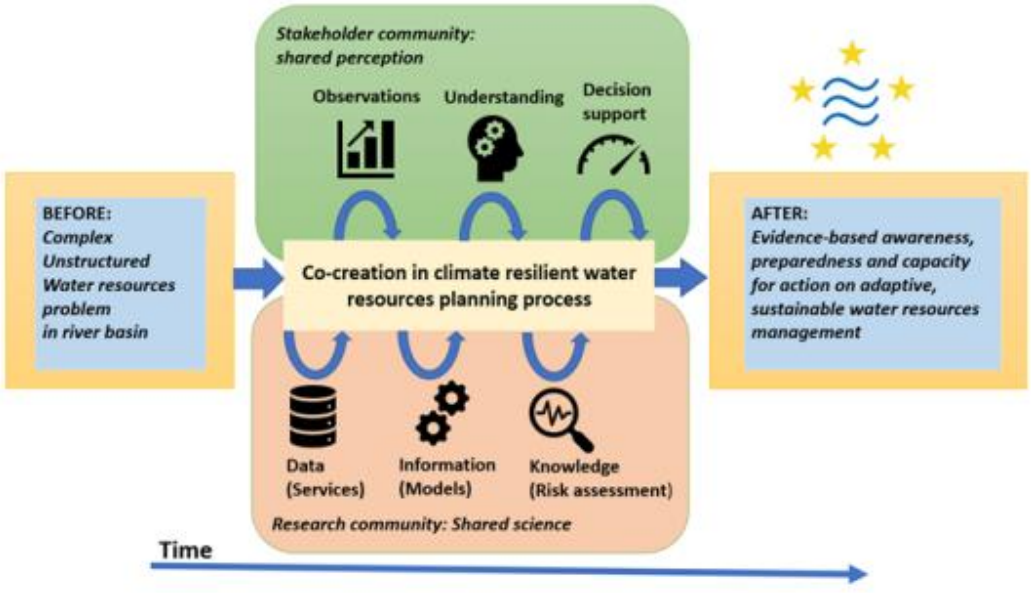


Figure 1: Co-creation approach taken within STARS4Water.

The specific objectives of the project are:

1. Provide stakeholders with new generation data services and data-driven models tailored to their needs and requirements.
2. Improve accuracy and resolution of regional-scale projections of water resources availability, from 10 to 1 km^2 grids.
3. Enhance the knowledge base and the scientific underpinning of climate risks and impacts, in various scenarios and time horizons.
4. Improve stakeholder's decision-making through the development of dashboards: co-designed & co-developed information systems.
5. Promote uptake and transferability of the data services & tools through guidance documents and capacity building activities.

To implement the project activities, the project is structured into 7 Work Packages (Figure 2):

1. WP1 focuses on working with stakeholders through a co-creation approach, herein addressing their needs in water resource information.
2. WP2 focuses on dataset and data services development to create a good knowledge base for water resources management, consistent with the stakeholder needs.
3. WP3 focuses on developing next generation models and tools for water resources management, consistent with the stakeholder needs.
4. WP4 focuses on validating and applying the new data services and modelling tools for an integrated risk assessment of the future Europe's freshwater resources.
5. WP5 focuses on synthesizing the results from the risk assessments at river basin and pan-European level, whilst promoting uptake and upscaling.
6. WP6 focuses on disseminating and communicating the project's results, products and knowledge base to maximize uptake.
7. WP7 focuses on facilitating, supporting, and monitoring the project's progress towards achieving the above-mentioned objectives of the project.

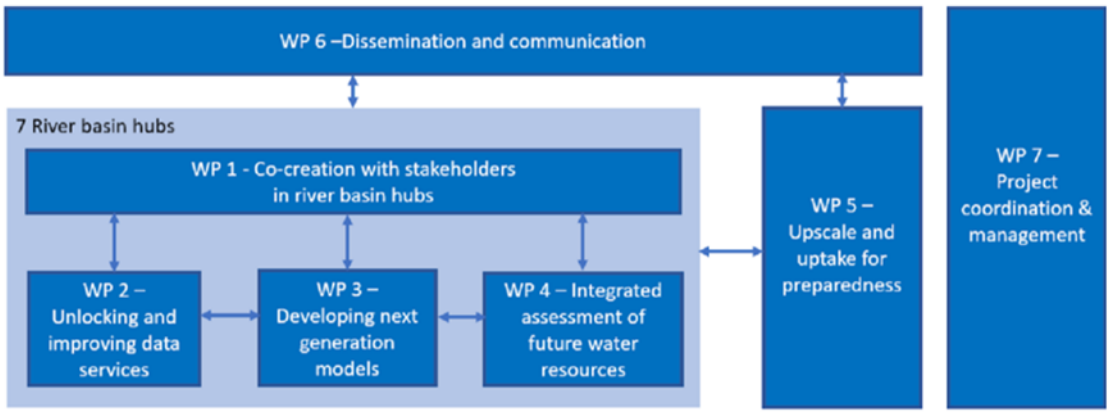


Figure 2: Workplan of STARS4Water in which the relations between the seven work packages and seven river basin hubs are displayed.

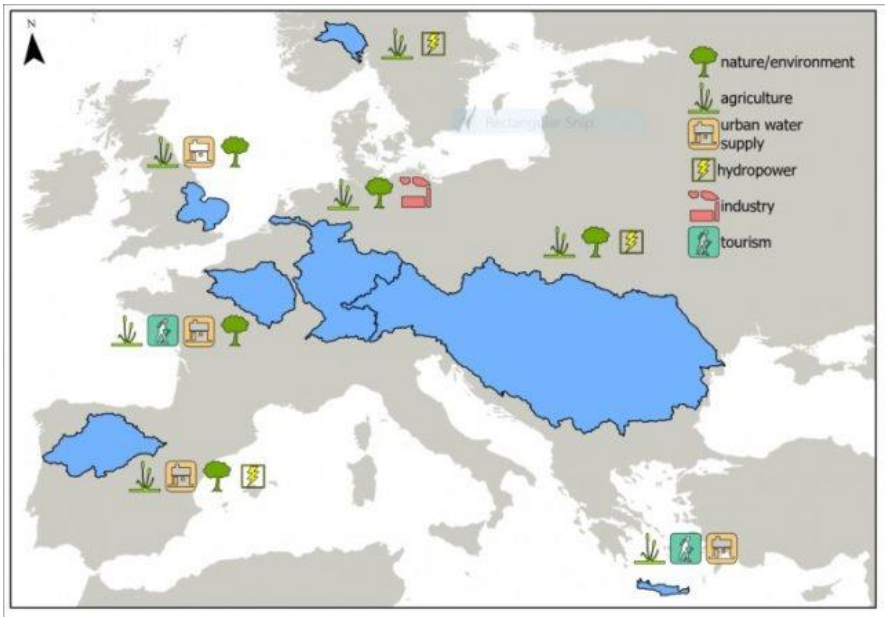
1.2. Seven River Basin hubs

STARS4Water develops the new generation water resources models and data services through the method of co-creation (Figure 1). Together with stakeholders in the river basin and the data community (data providers, monitoring services, etc.), the project will co-develop data services and applications of (data-driven) modelling approaches. To facilitate the co-creation of data-services, the project has introduced the concept of river basin hubs. A river basin hub serves as living lab for the co-creation of data services and tools with stakeholder communities and for the upscaling of these services and tools to other river basins worldwide.

The hubs serve several purposes related to the various activities within the project:

1. Co-design of new services, tools and scenarios to support climate resilient water resources planning, carried out in WP1.
2. Co-development of data services by unlocking data services from global to local levels, carried out in WP2.
3. Co-development of a new generation of models using data-science techniques, carried out in WP3.
4. Validating and testing of the data services and tools in risk assessments, carried out in WP4.
5. Building capacity for stakeholders to apply services and tools developed in the project and to scale these up to national and EU level, carried out in WP5.
6. Dissemination and communication of the results in each river basin hub, carried out in WP6.

The seven river basin hubs are (Figure 3):



1. Drammen (Norway)
2. East Anglia (UK)
3. Duero (Spain)
4. Rhine (International)
5. Seine (France)
6. Messara (Greece)
7. Danube (International)

Figure 3: The seven river basins hubs in the STARS4Water project.

1.3. Report and outline.

This deliverable reports on the functional design (prototype) of the generic dashboard, whilst also providing more details on the next steps foreseen. Chapter 2 presents a general background to the use of dashboards as a co-creation tool. Chapter 3 discusses the two dashboard developments within STARS4Water, a generic dashboard development and a tailor-made dashboard development, and how these developments link to the different indicators developed within STARS4Water. Chapter 4 discusses what steps in the dashboard development have already been taken in the project, and how the front-end design and back-end design of the set-up prototype dashboard is structured. Chapter 5 discusses the next steps for both the generic dashboard and tailor-made dashboard. Lastly, Chapter 6 presents the conclusions and recommendations for further progress.

2. Dashboards as a co-creation tool

Dashboards can best be described as a type of graphical user interface or interactive information visualization tool, which can provide a direct, coherent, and intelligible view of data, results, and key performance indicators (Deltares, 2022). Dashboards need to be co-created to ensure that the dashboard coincides well with the stakeholder requirements and needs (fit-for-purpose). Dashboards can act as an initial diagnostic tool for the status and trends of water related assessment. The ability to generate the dashboard output and evaluate the information provided increases the usefulness of the tool (Deoffinger et al., 2020). Furthermore, this increases usability also beyond the implementation phase in which the dashboard is developed. Thus, it is important clearly identify the users and owner(s) of the dashboard.

In general, there are five co-creation stages to a dashboard:

1. Scope: Identify through stakeholder gap analysis who will use the dashboard and for what purpose. The envisioned end-user(s) of the dashboard determine the intended use of the dashboard and provide input for the indicators that the dashboard should present.
2. Design: Together with the stakeholders, a preferred design/lay-out is chosen and set-up. The preferred content is also discussed. During the design phase, a dashboard mock-up is set-up, to illustrate the visual appearance and structure of the dashboard. This can help stakeholders to visualize the overall look and get an appreciation of the dashboard.
3. Development: Based on the mock-up and feedback on the mock-up, developers can make a prototype version, which is an actual interactive functional representation of the dashboard, simulating its behaviour and functionalities.
4. Application: Stakeholders can use the prototype version (and subsequence versions) for assessing the current and future situation in water resources availability under climate change.
5. Evaluation: Stakeholders and developers provide feedback on the functioning of the dashboard, identify additional information needs and give further feedback based on the use and determine how the dashboard can continue to support the assessments and/or if a subsequent version is necessary. If relevant, the process can be iterated and going through all steps again.

As abovementioned, co-creation specifically combines two concepts:

- (1) Co-design, focusing on set-up, lay-out, deciding functionalities, indicators, visualization etc. and
- (2) Co-develop, focusing on building the dashboard, collecting, and structuring datasets etc.

This co-design and co-development process is built around five key words:

1. Salient: The relevance of information to the decision-making process, the content, the selected indicators, and the spatial and temporal scales.
2. Legitimate: The process through which the information is developed together with the involvement of stakeholders and end-users.
3. Credibility: Goodness of fit, the accuracy of the input data and models.
4. Actionability: Which actions should be decided on based on the input data, models, and information.
5. Accessibility: How does the information need to be made available for it to be relevant and useful (e.g. what medium, what types of visualization etc.).

By setting these five key words at the core of the co-creation process and fitting the dashboards to the stakeholder needs, dashboards ultimately help stakeholders to (Van der Most et al., 2018):

- Structurally visualize and communicate on the system's understanding and risk information.
- Use the existing and newly generated data and information, also after the implementation phase.
- Support in identifying the most appropriate decisions.

The dashboard is also an excellent tool to accommodate situations in which there are heterogeneous stakeholders involved, meaning each stakeholder has different needs and activities (Orlando et al., 2017). Dashboards can namely accommodate different design needs and thus ways to present data (e.g. time series, graphs, tables etc.) and accommodate presenting data on different levels, corresponding to the different needs of the heterogeneous stakeholders. What is specifically meant by these different levels is discussed in the next chapter.

3. Scoping dashboards within STARS4Water

3.1. Diversity in stakeholders

Within STARS4Water 7 river basins are involved, each with a different water system, different social-economic and climate problems, and therefore also different data and modelling needs (e.g. low flow and water intakes, floods, reservoir management etc.). These needs do not solely vary between the 7 river basins (different hydrology, different water uses etc.) but can already vary largely within each river basin itself, due to the many different stakeholders within each basin. An overview of the stakeholders involved per river basin is reported by Hegdahl et al. (2023). The stakeholders vary from policy analysts, decision-makers, water users such as citizens and farmers to representatives from (hydro-)electricity production and drinking water companies. As was explained the dashboards are co-created with the stakeholders in the different river basins to improve their understanding and use of existing and newly generated data and information in their river basin.

3.2. Two types of dashboards developed within STARS4Water

In the STARS4Water project we will distinguish two types of dashboards: a **generic dashboard** and a **tailor-made dashboard**. The generic dashboard provides basic practical information about the 7 river basins hubs and expected water related changes in each of the river basins. This dashboard unlocks different sources of open global datasets to provide this information. The dashboard makes it possible to get a first impression of the status of the basin and compare it with other basins, based on the same information.

The tailor-made dashboard is a sequence version of the generic one. This version will be further designed and developed based on the determined stakeholder needs in the selected river basin in a co-creation process with stakeholders and research focal points of the consortium for the basin. Currently, conversations with river basin organizations is ongoing, to make a final decision on which basin to select to co-create a tailored version.

A first inventory about the preferred type of dashboard has been made in the past months. These needs are displayed in Table 1.

As indicated in Table 1, several river basins, (e.g. Rhine, Duero) expressed a need for more general indicators based on global and local data sets and did not specifically require indicators that are based on combining datasets or modelled data. Their needs would be met by being able to display more global data with a lower specificity, as often other information systems already exist in these river basins and the dashboard would just need to support these existing systems. This resonates with the generic dashboard development.

In addition, several river basins (e.g., East Anglia, Drammen, Messara) did express a need for more river basin specific indicators and datasets and these basins are candidates to provide access to tailor-made dashboards.

Table 1: Dashboard needs collected through stakeholder consultations (Hegdahl et al., 2023).

River Basin	Dashboard related need	Preferred type of dashboard
Duero	CHD has already an information system. STARS4Water dashboard can complement this information system. Expressed need for general indications such as water management scenarios in context of climate change jointly with hydrological information.	Generic
East Anglia	Dashboard would help to visualize outcomes of different scenarios. Expressed need for more specific dashboard.	Tailor-made
Rhine	CHR already develops its own information system. Dashboard could be communication tool on top of this information system.	Generic
Drammen	Need to combine SSPs with local information for development of future scenarios and need for information on shorter time horizons. This would require a dashboard that can be more specific and more frequently updated.	Tailor-made
Danube	Uncertain whether a tailor-made dashboard is of added value, as this depends on scope of information and timeliness of the data. Need for information on low flows.	Generic
Messara	Need for development of online information and visualization tool to allow visualization of more specific key indicators.	Tailor-made
Seine	No specific needs.	Generic

For both type of dashboards, it is important to integrate the needs of the river basins in data visualization tools, including charts, graphs, maps, tables, and custom visuals needs. The goal is to create visually compelling and informative dashboards and reports that effectively communicate key insights and trends in their data. This will be beneficial to customize the dashboards to each river basin's need. It leaves room for advancement and tailor-made adjustments.

It is likely that a wide range of different indicators is determined for each river basin and within each river basin, as different stakeholders have different needs and value different levels of complexity, as was explained above. For this reason, indicators at different levels of complexity are developed within STARS4Water based on the determined stakeholders' modelling and data needs. Table 2 presents the different types of indicators developed within WP2 of STARS4Water, which is based on a 3-Tier approach.

The main objective of the generic dashboard is to provide information on future changes in water resources availability based on available datasets taken into account existing climate scenarios and socio-economic scenarios. This information can be used to identify key challenges and hot spots that need more detailed analysis. The generic dashboards will, in general, not be as accurate as regional model results. The generic dashboards will provide information on the relative changes that can be expected in the next decades.

In addition, there is a need for indicators that are more linked to practical water management. The tailor-made dashboards will contain more detailed information on the impacts of climate change on water resources availability, water use and impacts on sectors. Therefore, more detailed data is needed from the data services developed and modelled data. Consequently, the tailor-made dashboards can be used to provide information for decision-making based on detailed data.

Table 2: Explanation of the tiers of indicators, their corresponding data sources, and the link to the dashboard types.

Tier	Data source	Further explanation of indicators in this Tier	Examples of indicators in this Tier	Type of dashboard
1	Fully based on global datasets	Set of general indicators directly derived from readily available global datasets with only limited postprocessing needed. Tier 1, thus, is global data with low specificity and indicating changes in the river basin.	✓ Air temperature ✓ Precipitation ✓ River discharge ✓ Population density	Generic
2	Combining global and local data	Indicators which are formed by combining the Tier 1 global datasets with auxiliary data from various sources to yield indicators more directly related to practical water resources management. Tier 2, thus, is global data but made more specific for water resources management.	✓ Precipitation deficit ✓ Agricultural water demand ✓ Water demand per sector ✓ Low flow occurrence and duration	Tailor-made
3	Combining global and local data, including river basin modelled data	Model-based indicators formed by combining global and local data, and numerical models and machine learning to predict how the hydrologic system will change over the next decades. Tier 3, thus, is highly specific to the river basin.	✓ Reservoir storage ✓ Agricultural water consumption and return flow ✓ Industrial water consumption and return flow ✓ Ecological flows and thresholds	

Therefore, the tailor-made dashboards will contain information on indicators are based on combining global datasets with local data datasets (Tier 2 indicators) or modelled data (Tier 3 indicators). For example, we can combine potential evaporation and precipitation to calculate evaporation deficit, which is a common indicator for agricultural drought. The Tier 2 indicators are currently under development. Although the Tier 2 indicators will be more specific and meet more user needs, they will still be (partly) based on global datasets and water resources management in general (often used in various basins). To address more specific user needs, we therefore have defined Tier 3 indicators, for which numerical models and machine learning techniques are employed to precisely capture the catchment hydrology. The indicators that follow from these activities are the most specific to the river basin hubs and will become available at a later stage in the project.

More information on this 3-Tier approach can be found in Deliverable 2.3 by Beckers et al. (2023). Table 2 explains on which types of data sources the Tier 1, Tier 2 and Tier 3 indicators are based, and gives examples of indicators in each Tier. The last column makes the link to the dashboard development within STARS4Water, which is subdivided into a generic dashboard development (only Tier 1, based on global datasets) and a tailor-made dashboard development (all three indicators, including regional models). Both types of dashboards are developed within WP1, whilst the development of data and modelling inputs for the dashboard are tackled in the other work packages (WP2, WP3, WP4).

3.3. Co-creating a prototype

The stakeholder needs in the 7 river basin hubs were identified in stakeholder consultation workshops in March/April 2023 (Hegdahl et al., 2023). In these workshops, a mock-up of what a STARS4Water dashboard can look like and can contain was displayed to the stakeholders and feedback was collected on the design and possible indicators and scenarios as well as thoughts on the priority or need for a certain dashboard for each river basin was collected. Table 1 summarizes these dashboard priority and needs expressed during these workshops for each river basin. Additionally, a list of indicators relevant to water resources was identified in each workshop. From both the widely varying preferred indicators coming from these workshops, as well the differences in priority and needs for a dashboard, it became evident that a more generic dashboard and tailor-made dashboard were required. The feedback on the mock-up from the workshops was used as input for the design and development of a prototype for the generic dashboard. The design (both front-end and back-end) of this prototype is further discussed and explained in chapter 4.

In March 2024, the prototype was sent to the river basin hub leaders together with an evaluation form containing questions about the presented indicators, timelines, climate scenarios and prototype design. So far, we have received feedback from the stakeholder of the Drammen Basin (Annex A) and the Messara Basin (Annex B). This feedback and the feedback from the other river basin stakeholders will be used to further improve the prototype of the generic dashboard in the coming months. At this moment, we are awaiting feedback from the stakeholders from the remaining river basin hubs to update the prototype of the generic dashboard and implement adjustments towards a final version.

4. Dashboard technical design and development

4.1. Selection of software for dashboard development

The choice of the dashboard creation tool for the STARS4Water project was made based on the identified needs of the stakeholders involved. Given that users of the dashboard are expected to come from different locations across Europe, with the project aiming to reach a broad audience within the European Union, it was crucial to select a tool that could effectively meet these diverse needs. As a result, several software options for dashboard development and presentation were considered and evaluated. Commonly used software options in the scientific community for creating dashboards include Tableau, Microsoft Power BI, Google Data Studio, as well as Python with libraries such as Plotly and Dash. Each of these tools offers unique features and capabilities, allowing for tailored solutions to meet the specific requirements of the STARS4Water project stakeholders.

A key requirement identified by stakeholders in the project is the diverse background of users, necessitating a beginner-friendly user interface. Given the wide range of expertise within the stakeholder-developer group, software options like Microsoft Power BI and Google Data Studio are preferred for their user-friendly interfaces. These tools offer a shorter learning curve compared to others, allowing users to swiftly create interactive dashboards and reports. This accessibility is particularly beneficial as not only dashboard experts will be involved in dashboard development, but also each river basin hub will need to learn how to utilize the software to embed and update their individual datasets for the generic dashboard, as previously outlined.

Due to the stepwise development of the generic and tailor-made dashboard an increased complexity in data processing will be required within the STARS4Water project. Power BI offers more advanced analytics features compared to Google Data Studio. It supports complex data modelling, calculations, and machine learning integration, making it suitable for analysing and visualizing complex datasets. Power BI supports connectivity to a wide range of data sources, including databases, cloud services, Excel spreadsheets, web APIs, and streaming data sources. For example, different stakeholder needs for example for public engagement. Therefore, the dashboard needs a simple visualization, as well as more detailed timeseries and options for data downloads for water managers.

Additional very important needs and requirements were the integration of the generic dashboards in the already existing project environment. Most of the project is conducted in the Microsoft Ecosystems and also the STARS4Water SharePoint was set up in this environment. Therefore, choosing a software within this environment has the advantage of incorporating in an already existing infrastructure. The users are to be already familiar with design, workflow and this will facilitate its usage, which increases productivity and facilitates collaboration. The files Power BI would use could be prepared in excel which most stakeholders are familiar with or already have datasets in this format.

The exploration of various scenarios is the core of the dashboard presentation. To support interactive and collaborative features such as filtering, slicing, drill-down, and cross-filtering, enabling users to explore data dynamically and gain deeper insights should be possible for different types of stakeholders needs and questions. The dashboard development in STARS4Water is a team effort on multiple levels and an app that allows easy interaction is crucial to keep people involved and motivated to contribute to this process.

4.2. Back-end design

For this initial prototype, the data currently displayed in the prototype dashboard serves as dummy data and acts solely as a placeholder. It is essential to note that this data does not represent actual or real-time information but rather serves as a temporary representation to demonstrate the functionality and layout of the dashboard. This dummy data will be replaced with actual, relevant data sources once they become available, ensuring the accuracy and reliability of information presented in the dashboard. Until then, stakeholders are encouraged to familiarize themselves with the generic dashboard's interface and features and ensure that the dashboard can provide meaningful insights and actionable information pertinent to their needs. Afterwards feedback will be collected from the stakeholders that will be used in the further development.

In the back-end design of the dashboard, a simple system has been developed to facilitate the selection and combination of socio-economic scenarios and climate scenarios into integrated cases (See Figure 4 and Table 3). All data is pre-processed, and no data is generated on the fly. Reason for this is to enhance fast data availability and avoid long processing while using the dashboard. Once selected, the back-end dynamically combines the chosen scenarios into comprehensive cases, enabling users to explore the potential impacts of different socio-economic and climate conditions on various indicators. This approach to scenario integration empowers users to generate insights into complex interactions between socio-economic trends and climate dynamics.

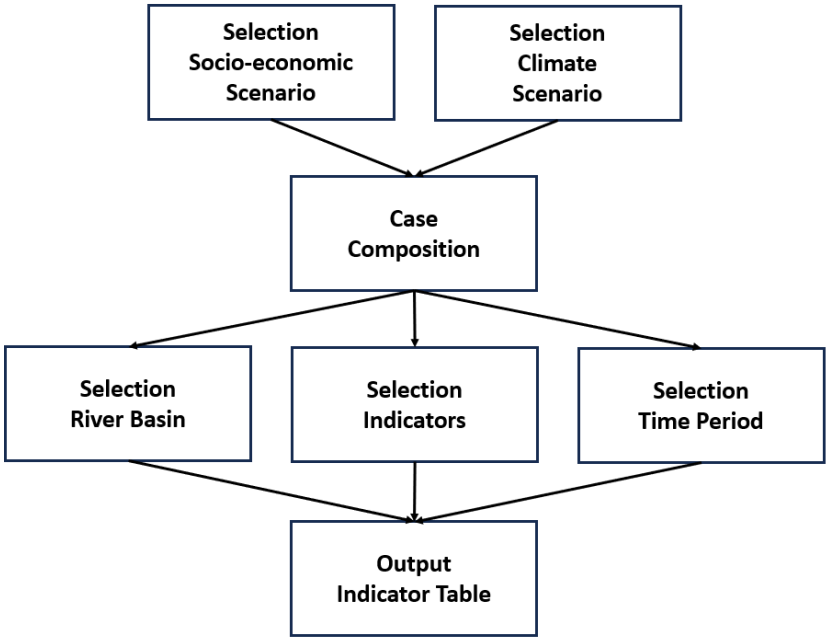


Figure 4: Back-end processing

The generic dashboard is primarily designed to provide information on changes in water resources availability based on Tier 1 indicators and to explore how these indicators change depending on the various climate and socio-economic scenarios selected within STARS4Water. The generic dashboard can be applicable everywhere in Europe and can be altered by the river basin hub and even interested parties outside of the STARS4Water project. It can best be seen as a template based on global and less-specific data. The generic dashboard does offer customization options for river basin

hubs, but these are limited, because its primary purpose is to provide information on changes in water resources availability based on mainly global datasets.

Table 3: Scenario combination into cases

Socio-economic scenario	*Climate scenario*	*Case*
Business as usual	*RCP 2.6*	*1*
More sustainable		*2*
Less sustainable		*3*
Business as usual	*RCP 8.5*	*4*
More sustainable		*5*
Less sustainable		*6*

The tailor-made dashboards differ from the generic dashboard as it will include additional river basin specific indicators and datasets (Tier 2 and Tier 3 indicators, see chapter 3) and thus incorporates specific information relevant to their basin's context and priorities. Hence, the tailor-made dashboards are primarily created to visualize the Tier 2 and Tier 3 indicators developed within the project, herein enabling visualization of the different issues, challenges, and spatial scales of the different basins. It, thus, builds upon the (basic structure of the generic dashboard by including additional river basin specific indicators and datasets. This approach ensures that while the generic dashboard provides essential standardized data, the tailor-made dashboards empower river basin hubs to enrich their analyses with locally relevant information, fostering more informed decision-making and effective management of water resources.

All data will be pre-processed in the back-end of the dashboard. The purpose of data pre-processing is to ensure consistency and comparability across the different scenarios used in STARS4Water. This process of making used data compatible allows for meaningful comparisons and analyses by standardizing the indicators to a common baseline or reference point. Figure 5 gives an overview of the data processing steps we anticipate:

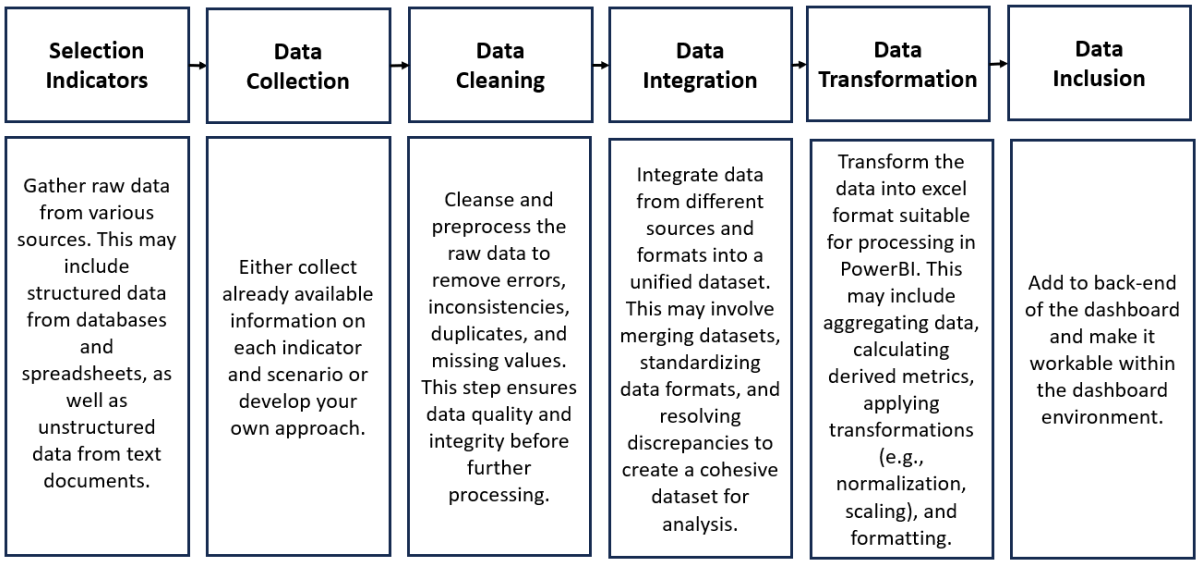


Figure 1: Dashboard data processing steps.

Part of the data processing is the data integration, which involves the consolidation of data from various sources for analysis and visualization. This process entails identifying and connecting to diverse data sources, extracting data in the required format, and transforming it to ensure consistency and compatibility. Once transformed, the data is loaded into the dashboard's storage or memory, where it is organized and structured using data models and relationships.

4.3. Front-end design

The dashboard prototype for the generic dashboard features a modern and intuitive layout, with a clean design that prioritizes ease of use and data accessibility (See Figure 6). Users can interact with the dashboard by selecting scenarios and indicators, applying spatial and temporal filters, and adjusting parameters to customize maps and graphs.

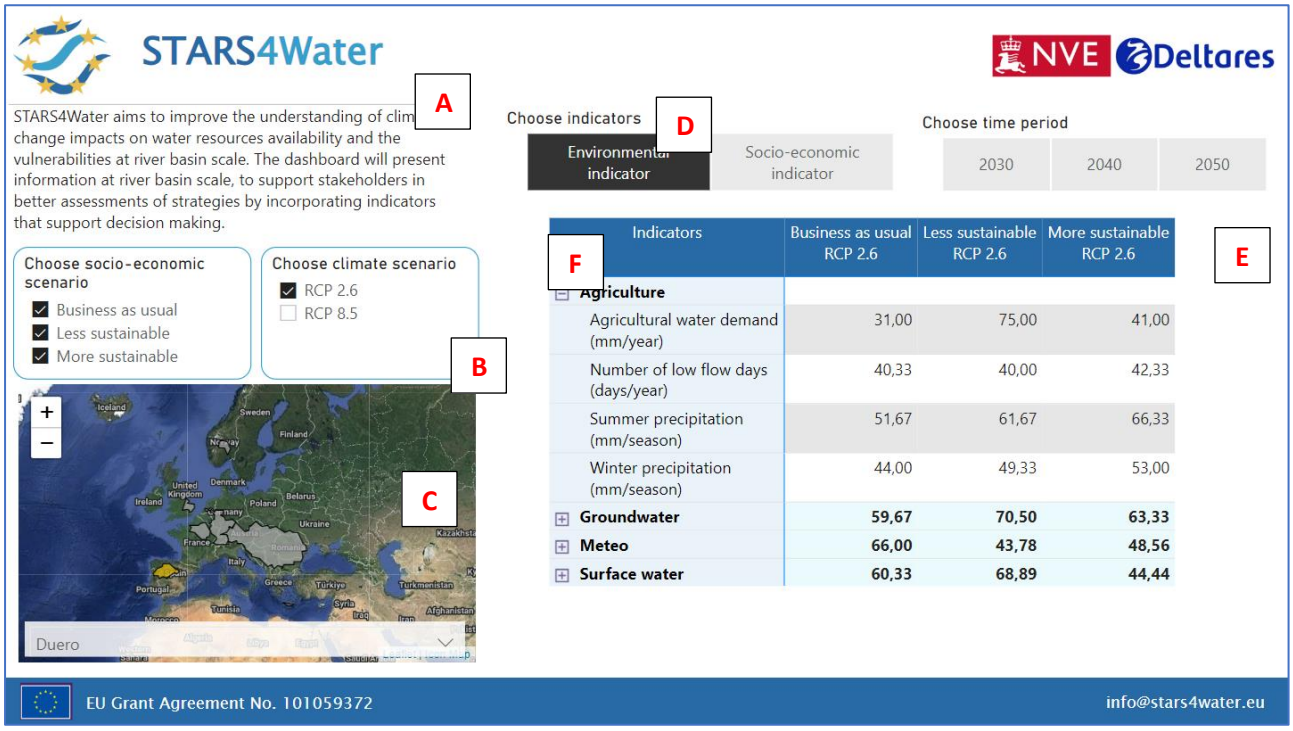


Figure 6: The different fields of the User Interface: introduction (A), scenario selection (B), river basin selection (C), indicator selection (D), time horizon selection (E) and display of information (F).

The dashboard is designed as follows.

A - Description: In the upper left corner, the logo and a brief description of the STARS4Water project is presented.

B - Scenario Selection: On this selection the user of the dashboard can select two types of scenarios: socio-economic scenarios and climate scenarios (compare Figure 4 in previous section).

C - Map: Below the scenario section, an interactive map panel is shown where one of the seven river basins can be selected. When hoovering over each river basin additional information is displayed on the key characteristics and risks each basin will face in the future.

D- Indicator selection: Data from the scenarios are presented based on different indicators. The indicators are categorized in two types of indicators. In this section of the dashboard one can select either environmental or socio-economic indicators.

E- Timeline selection: Three different time horizons will be presented: 2030, 2040 and 2050. The exact calculation and interpretation (e.g. each year representing an average of the time period prior to the year) will be determined in the next phase.

F- Central workspace table: Depending on the selections made in all sections, lines and columns are added to the central workspace table for viewing data visualizations and insights. Additional information is provided about each indicator when hoovering over the name of the indicator. This is important as not all users will be familiar with all indicators. Users can hover over data points to view detailed information and click on elements to filter data dynamically. This enables users to search for answers to their own specific questions and use the dashboard for their own purposes.

The colour scheme aligns with the projects website and logo design incorporating visual elements to reinforce project identity and recognition. Consistency in colour usage across the dashboard creates a cohesive and professional look. The primary colours of the dashboard are shades of blue and yellow. Blue relates to theme of water and is often associated with neutral and professional contexts. Yellow is contrasting blue and is associated with the “Stars” of the European Union (EU). The EU is the funding entity of the STARS4Water project. Contrasting colours might be used in a later stage to highlight and draw attention to certain data visuals. Neutral tones such as grey and white serve as complementary colours, providing balance and contrast to the primary and contrasting colours. Black and grey is used for text content, labels, and borders, ensuring readability, and reducing visual clutter, while white is applied for background areas and negative space, creating a clean and minimalist aesthetic. The colour choices for the dashboard are carefully selected, taking into consideration colour-blind impairment, to ensure inclusivity and accessibility for all users. By considering factors such as colour impairment, we strive to create an inclusive tool that prioritizes accessibility and usability for all stakeholders.

The central element of the dashboard is the central workspace table (F in Figure 5). It accommodates users' selections and preferences. The content of this interactive table adjusts based on the criteria and indictor types chosen by the user, dynamically resizing depending on space requirement of the relevant data. For example, users can select specific river basins and time periods so the table updates in real-time to reflect the selected parameters. This functionality enhances user flexibility and allows for detailed exploration of the dataset, empowering users to tailor their analysis to their specific needs and gain deeper insights into the underlying data trends. This allows for individual exploration for different stakeholders with varying interests. The dynamic table provides a customizable and intuitive interface for data exploration and decision-making within the dashboard.

As an additional design element, a map for river basin selection is provided. In the dashboard, users can interact with a map displaying the seven river basins represented by shapefiles. They can select different river basins by clicking on the corresponding shapefile, allowing for easy exploration of watershed boundaries and geographical location. The map is interactive, enabling users to zoom in/out for detailed viewing and access additional information about each basin through tooltips. This feature enhances user engagement and facilitates the visual analysis of characteristic information of each river basin within the dashboard.

The dashboard includes line charts that appear when hovering over the names and values in the central workspace table. The x-axis displays the time periods, while the y-axis represents the values of the indicators.

Additionally, the dashboard facilitates the downloading of data in timeseries format and as images, allowing users to access and analyse the generated data over time. This functionality enhances the flexibility and utility of the dashboard, empowering users to conduct in-depth analyses and derive meaningful insights from the data tailored to their own needs. Whether it's tracking trends, conducting historical comparisons, or conducting research, the ability to download timeseries for indicators for each river basin provides users with valuable resources for their work and decision-making processes.

Due to the generic set-up of the dashboard front-end and back-end it will be relatively easy (if they are familiar with Power-Bi and have some basic knowledge on database structures) for representatives from river basins to make adjustments and/or add more data to the database. This is not only valid for the STARS4Wate river basin hubs, but also other river basins.

5. Next steps in dashboard development

This section presents the next steps both for the generic dashboard development and tailor-made dashboard development. Ultimately, training sessions for the dashboard maintenance and dissemination/deployment are described (Section 5.3.).

5.1. Generic dashboard

To develop the prototype generic dashboard input and feedback have been collected during the stakeholder consultations and workshops. As a next step in de co-creation process the prototype was made available to the stakeholders to provide feedback to make the final step in development. Therefore, an evaluation form was designed to collect feedback on the current features, usability, and functionality. Together with the launch of the prototype of the dashboard, the evaluation form was circulated to the stakeholders. Based on the feedback received the final version of the generic dashboard will be developed. The release of the generic dashboard is scheduled at month 24, so that the generic dashboard will be available for use in the river basins.

In the prototype, no actual data processing has been performed yet. As a next step towards the launch of the generic dashboard, the data processing steps data transformation and data inclusion will be performed to have the pre-processed data included and workable within the dashboard environment.

The next steps also include testing and validation of the dashboard. This includes functional testing to verify that all interactive elements, such as filters, drill-downs, and navigation paths, work as intended. This process checks for any bugs, errors, or inconsistencies in the dashboard's functionality. Next, data validation is performed to ensure that the data displayed on the dashboard is accurate, complete, and up to date. This involves comparing the dashboard's output with the data source and conducting reconciliation tests to identify any discrepancies. Additionally, usability testing is conducted to evaluate the dashboard's user interface, layout, and navigation. The stakeholders could be asked to perform use the dashboard for their own questions and provide feedback on the dashboard's ease of use, clarity, and intuitiveness on the final version. By conducting thorough testing and validation, the project partners can ensure that the dashboard delivers reliable insights and supports informed decision-making.

5.2. Tailor-made dashboard

The stakeholders of the Drammen, Messara and East Anglia have expressed the interest in a tailor-made dashboard. An intake-meeting with the stakeholders will be organised to determine if a tailor-made dashboard is of most added value and highest priority for the stakeholders. To co-design the tailor-made river basin, a co-creation workshop with the stakeholders will take place to co-design the dashboard considering the specific needs of the stakeholders. Therefore, it will include a more in-depth discussion with the stakeholders on layout and content, including the choice of specific indicators to present. There are several steps taken in this co-designing workshop to gather the specific information on the stakeholder needs for the dashboard. An overview of the steps to accurately co-create the dashboard and determine all needs is presented in Table 4.

Table 4: Steps during the co-designing workshop of dashboard development.

Steps during the session	Dashboard development – Steps for co-creation with stakeholders
Step 1: Give information on STARS4Water and dashboards.	It is important to first familiarize the stakeholders with the STARS4Water project and dashboards, through presentations about what STARS4Water entails, what a dashboard is, what the aim of the session is, and how dashboards can be used for informed decision-making.
Step 2: Context description	Hereafter, a clearer picture on the water system, water users, and other major themes in the basin needs to be generated. Mapping the basin in this way already broadly clarifies what is important to include in the dashboards.
Step 3: Determine the user requirements, such as indicators and challenges.	The generated information gathered in step 2 needs to be made more concrete. This is done by giving statements, such as 'I want to be able to…' in which stakeholders can fill in the blanks. Their responses are the user requirements / content needs for the dashboards. Good statements to retrieve the desired information are given below: - 'I will need the dashboard for …'. This will show under what circumstances stakeholders use the dashboards, for example for communicative or more technical purposes. - 'Important needs within my basin are …'. This will reveal the most important themes and needs within the river basin. - 'I need knowledge and information about …'. This will determine the knowledge and information that needs to be in the dashboard for stakeholders to use it. - 'I have used this dashboard … in the past'. This can give an idea on whether stakeholders like figures or maps, and what other aspects of the lay-out they might like. - 'Which three indicators are the most important to you to include in the dashboard?'. This will result in a list of the most important key indicators to the stakeholders. - 'Using the dashboard, I want to be able to …'. This results in user requirements. - 'I am interested in these socio-economic developments and how these influence the basin: …'. This might give clarification of which socio-economic scenarios would be useful to include for the stakeholders.
Step 4: Discuss mock-up (=final version generic dashboard)	In the last step of the session, a mock-up of the dashboard is presented to the stakeholders, containing suggestions of what the dashboard can look like and what information it can contain and in what manner (graphs/tables/figures etc.). This can function as a starting point for stakeholders to give feedback on, such as what information or which functionality they would like to add or remove. This mock-up is also very important to gather information on the stakeholder preferences for the design of the dashboard.

After the co-designing workshop, which will clarify the content and design needs for the chosen river basin(s), a prototype for the tailor-made dashboard(s) can be set up. This, however, needs to align with the timeline of the Tier 2 and Tier 3 indicators, developed in 2025 and 2026. Therefore, the timeline for the tailor-made dashboard remains flexible and aligned with these indicator developments. After the new prototype(s) is/are set-up, tailormade to the wishes of the river basin(s) including the preferred Tier 2 and Tier 3 indicators, a new feedback process is initiated in which wishes for adjustments to the data visualization and input can be expressed. The feedback from the river basin(s) will be incorporated before October 2026, when the final tailor-made dashboard needs to be finalized.

5.3. Maintenance and deployment/dissemination

To ensure both the generic and tailor-made dashboards are maintained during and after the STARS4Water project and that the results are disseminated, a dashboard training will be provided to interested parties and an appointed end-users in the river basins. An exact format for the training still needs to be determined, but the training will encompass various components to ensure stakeholders and decision-makers are equipped with the necessary skills and knowledge to effectively utilize the dashboard. An introduction to the dashboard's purpose, objectives, and target audience, will be given followed by familiarization with the navigation and interface. The STARS4Water stakeholders will learn to interpret and analyse the data presented, apply filtering and customization options, and troubleshoot common issues. Best practices and tips will be shared to optimize dashboard usage, supported by real-world case studies and examples demonstrating practical application. Feedback mechanisms will be established to encourage user input and drive continuous improvement during the lifetime of the project. Through comprehensive training covering these aspects, users gain the confidence and proficiency needed to leverage the dashboard for informed decision-making and business success. The training could be accompanied by an online manual in form of a video or written instruction with images on how to use and update the dashboard. The dashboard training will be part of the STARS4Water Academy.

As part of the upscale and uptake activities, a manual will be developed on how to work with the dashboards.

An exploitation plan for the dashboards needs to be developed. The exploitation plan includes actions for future maintenance and updating of the dashboard, and an established mechanism for user feedback, leading to continuous updates and improvements based on stakeholder input

6. Conclusions

The stakeholder involvement and collaboration in designing the dashboards for the seven river basin hubs have been successful, and this process is still ongoing. Through active engagement and co-collaboration, the dashboards are being tailored to meet diverse needs. The iterative design process, coupled with continuous feedback, ensures user-friendly and informative dashboards. Overall, these efforts, while still ongoing, have laid a solid foundation for effective water resources management on a basin scale within the European Union.

To ensure the continued success of our collaborative efforts in designing the dashboards for the seven river basin hubs, we recommend focusing on concrete actions to collect and prepare the data that will be used in the dashboards. This entails establishing clear data collection protocols and methodologies to ensure the accuracy and reliability of the information gathered. By prioritizing these actions, we can enhance the design process on the back-end of the dashboards, whilst staying connected to the stakeholders needs.

The river basin hubs are encouraged to decide which basin will develop tailor-made dashboards as soon as possible. This will initiate the development of mockups for tailor-made dashboards to ensure timely progress in the STARS4Water project. By following the steps outlined in the development of the generic dashboards, the river basin hubs can effectively structure their mockup creation process. This includes defining the scope and objectives of the tailor-made dashboards, identifying key stakeholders and their needs per basin, collecting relevant data, and designing intuitive user interfaces accordingly.

The final dashboards, both generic and tailor-made, will be integrated in story maps developed in WP4. The dashboard can support the storytelling and visualization of the story for each river basin hub. WP4 also performs the water resources risk assessment, where the dashboard can be used as the information system that gives easy access to the modelling results and communicates them based on stakeholders' pre-defined indicators. We recommend keeping the final use of the dashboards in mind in the overall development of both the generic dashboard and the tailor-made dashboards.

7. References

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A. Annex I: Feedback on generic prototype from Drammen

Subject to receive feedback on	Question to answer	Answers from Trine Hegdahl – river basin hub leader in the Drammen River Basin
Dashboard generic	How do we balance consistency amongst the seven basins and individual river basin representation?	- Need some common input and modelling tools, could be used as a benchmark - One set that includes the same indicators based on the same data for all basins - The larger portions of the dashboard content should be basin specific, since this is most what is most interesting for the stakeholders and makes most sense since the focus and challenges in the basins are not similar
Dashboard process	Who do we envision as the end-user for the generic dashboard?	- State county authorities. - RBO - NVE - European interests
	Do you have any ideas about the interactive design process?	- We use a service design approach for development of products at NVE - Get some overview of needs - presents some possibilities -
Dashboard content: Information about River basin hubs	What sort of knowledge and information in the dashboard is meaningful to the stakeholders?	- Hydropower production information, HP plants and reservoirs - Ecological states - Vulnerable states or areas within the basin - Main usage and general description of landuse, population, urban areas etc
Dashboard content: Scenarios	Which scenarios are meaningful to present?	- Climate scenarios - Energy production potential - What if scenarios (story lines) perhaps create one storyline for all of Europe - Drought situation for all Europe could be one case
Dashboard content: Indicators	Which indicators are meaningful to present?	- In the cases where clear decision support indicators already exist, these could be presented in the dashboard - Eg. ecoflow, or licensing regulations, and whether there is a change in how often these are violated.
	What are meaningful statistics to present?	- Comparative information - Absolut and % change - High flows, low flows, seasonal flow, changes in discharge etc
	What do you prefer for the visualization of these indicators?	- Drought duration - Dry years versus wet year - Consecutive dry years - Seasonal values -dry – wet - changes - Seasonal changes -snow

B. Annex II: Feedback on generic prototype from Messara

Subject to receive feedback on	Question to answer	Answers from Maggie Kossida – river basin hub leader in the Messara River Basin
Dashboard generic	How do we balance consistency amongst the seven basins and individual river basin representation?	1. Establish Common Indicators: Start by identifying a set of core indicators that are relevant across all river basins. These might include: Precipitation/snow levels, Streamflow rates, groundwater levels, reservoir levels, water and demand metrics, drought and flood risk indicators. 2. Allow for Basin-Specific Indicators: Recognizing that each river basin has unique characteristics, challenges, and priorities., we should allow space on the dashboard for indicators that are specific to individual basins (we could also have a predefined list of additional/complementary indicators). 3. Adaptive Visualization Techniques: Dynamic scaling of graphs to accommodate varying ranges of data values across basins; Color-coded maps to represent data spatially, allowing for quick visual comparisons while also detailing specific regional issues; Interactive elements (e.g., hover details, zoom features) that allow users to delve into the specifics of each basin without cluttering the initial view. 4. Customizable Dashboard Views: Implement user-customizable views where stakeholders can select which sub-basins, use nodes, and indicators to display at any given time. This approach respects the diverse interests of different users, allowing them to tailor the information to their needs while maintaining an overarching consistency in how data is presented. 5. Standarisation, protocols: disseminate information about each basin's standardized protocols for data measurement and reporting, metadata, etc. Employ common methodologies for data analysis, such as for calculating averages, trends, and anomalies. 6. Incorporate Contextual Information to support common interpretations: Provide users with the ability to access contextual information about each river basin, such as geographic details, key water uses, and management challenges. This information can help users interpret the indicators more effectively, understanding the nuances that might influence water management strategies.
Dashboard process	Who do we envision as the end-user for the generic dashboard?	The end-users are envisioned to span a range of professionals and organizations involved in water resource management, environmental conservation, and risk analysis. The dashboard would serve multiple purposes, from operational management and policy development to research and public information. Here's a breakdown of specific end-user groups and their interests: - River Basin Organization: access to comprehensive data on water levels, flow rates, water demand, etc. to make informed decisions, ensure sustainable water use, assess policy options. - Water Resource Managers and Engineers, tasked with planning, developing, and managing water resources to meet current and future water demands. - Local and Regional Government Agencies responsible for water governance, environmental regulation, and land use planning within jurisdictions that fall within river basins. They can get insights into water resource status and trends for regulatory compliance, policy-making, disaster preparedness, and community development planning.

		- Agricultural Stakeholders (farmers, irrigation districts, and agricultural cooperatives that rely on river basin water for irrigation and livestock). They can access information on water availability and future forecasts. - Environmental and Conservation Organizations, focused on protecting and conserving natural resources, including water bodies, biodiversity, and ecosystems within river basins. They can access information to assess impacts, advocate for conservation measures, and engage in restoration projects. - Research and Academic Institutions, studying hydrology, environmental science, climate change, and related fields. They can have access to historical and current data sets for analysis, modelling, and the development of new water management strategies and technologies. - Water Users (e.g. industrial, tourist, etc.) that require significant water inputs. They can access information on water availability and future forecasts to manage operational risks and ensure compliance. - Community, CSOs, NGOs and Citizen Groups interested in the sustainable management and protection of their water resources. They can benefit from understandable and accessible information on water resources state, risks, and management plans to participate in decision-making processes and advocacy. - Investors and Financial Analysts, assessing risks and opportunities related to water resources for investment in sectors like agriculture, energy, and water infrastructure. They can access data for water related risk analysed and informed investment decisions.
	Do you have any ideas about the interactive design process?	1. Stakeholder Identification and Needs Assessment: identify all potential stakeholders who will interact with or be affected by the dashboard. Conduct a comprehensive needs assessment with them to gather input on: (a) the key indicators stakeholders are most interested in monitoring, (b) the functionality and features they would find useful in a dashboard, (c) any specific challenges or concerns they have with current monitoring systems (This step in mostly covered by the 2nd S4W Workshop) 2. Development of an initial prototype: based on the needs assessment, this should include: Core and customizable indicators for the different river basins; Basic interactive elements like filtering, search, and data selection options; Initial visualizations for the identified key metrics. 3. Stakeholder Feedback Sessions: organize feedback sessions with the stakeholders to present the prototype. These sessions can be conducted individually or in groups, depending on the number of stakeholders and the diversity of their interests. During these sessions we should: Demonstrate the dashboard's capabilities; Encourage stakeholders to interact with the dashboard and explore its features; Collect detailed feedback on what they like, what doesn't meet their needs, and any additional features they would like to see. 4. Iterative Refinement: use the above feedback to iteratively refine/ adjust the dashboard. This might involve: Adjusting the layout and design for better usability; Adding or modifying indicators and interactive features based on stakeholder needs; Enhancing the data visualization for clarity and impact. This phase may go through several cycles to ensure the dashboard meets the broad spectrum of user

		requirements effectively. Iteratively refining the dashboard based on user input ensures it remains relevant and useful over time. 5. User Testing and Training: once the dashboard has evolved based on stakeholder feedback, conduct formal user testing sessions to identify any usability issues (the stakeholders champions can support this). Additionally, provide training sessions or materials to help stakeholders understand how to use the dashboard effectively, including interpreting data visualizations and customizing views (e.g. through the S4W Academy) 6. Launch and Ongoing Support: after testing and training, launch the dashboard to the wider user community. Establish a support system for users to report issues, request features, or seek help (it is important to identify here who should address the users' requests in each basin). 7. Regular Updates and Reassessment: schedule regular updates and reassessments with stakeholders to ensure the dashboard continues to meet evolving needs. This could involve adding new data sources, updating indicators, or incorporating new technologies for data visualization and interaction (probably to be addressed in the S4W Exploitation Plan)
Dashboard content: Information about River basin hubs	What sort of knowledge and information in the dashboard is meaningful to the stakeholders?	Different levels are relevant, ranging from local (specific river segments or catchment areas) to regional (entire river basins) for comparative purposes. It is recommended to use: Basin level; Sub-basin level; Water use node level, or groups of water users per sector. Meaningful information: - Interactive maps with layers that users can toggle on/off for different indicators, such as precipitation patterns, drought severity areas, water use rates, etc. Features like zoom and pan allow users to explore data at the granularity they need. - Line graphs or bar charts that allow users to select time periods of interest (e.g., monthly, yearly) and compare current data against historical averages or extremes. - Heat maps: Color-coded representation of data where different colours indicate levels of intensity or deviation from the norm, allowing for quick identification of hotspots or areas of concern. - Sankey Diagrams to Illustrate water allocation and usage pathways among different sectors (agricultural, industrial, domestic, etc.) and how it flows through a river basin (the width of the bands is proportional to the flow volume, showing the transfer of water between sources and uses, highlighting inefficiencies or overuse) - Interactive Widgets to provide users the ability to customize views and drill down into specifics (filtering data based on time, location, and other parameters) - Statistical and Predictive Models Output: visual representations of the S4Wmodel predictions, such as probability density functions for flood risks or spatial projections of future water scarcity, unmet demand, etc. under the different future climate and socio-economic scenarios (including contextual information about the scenarios and/or links to the StoryMaps). The model outputs can be detailed for specific high-risk areas or aggregated for entire river basins or regions, depending on the model/ demonstration need. - Infographics and Summary Statistics, to summarize key findings, policy implications, and action items derived from data analysis

		(also linked to the StoryMaps). Visually engaging summaries that highlight crucial data points, trends, and recommendations, using a combination of charts, graphs, and brief text explanations, tailored to specific areas of interest within the basin or provided at the broader basin scale for general awareness.
Dashboard content: Scenarios	Which scenarios are meaningful to present?	- IPCC Climate scenarios (2030, 2040, 2050). (e.g. RCP4.5, RCP8.5, etc.), - River basin tailored climate scenario: these are users' defined stochastic scenarios/seasonal climate outlooks that provide insights into expected long-term changes in precipitation and temperature patterns (e.g. X months of consecutive drought) that are meaningful for assessing future risks relevant to the basin as a function of changes in water availability (quantity, variability and seasonal patterns) - Future socio-economic (2030, 2040, 2050) scenarios/projections that are linked to the future water needs/water demand (e.g. changes of land use and related future irrigation needs, expansion of tourism activities and related increased needs for domestic water, etc.) - Portfolio of plausible adaptation measures and an ex-ante evaluation of their impact on reducing the future vulnerabilities (resulting from the combination of the future climate and socio-economic changes). The ex-ante evaluation will be based on modelled results simulating different adaptation measures and interventions.
Dashboard content: Indicators	Which indicators are meaningful to present?	- Water state indicators: temperature, precipitation, ET, snow cover, discharge (river and/or springs), groundwater levels, reservoir/lake levels, drought indicators (e.g. SPI), water use (per user or user nodes), water abstraction (per source), water abstraction (per supplier – PWSS vs. private), water availability (per source, and per user or user nodes), water supply reliability - Decision support indicators, to be calculated for different future scenarios: changes in precipitation and ET (quantity + seasonal patterns), estimated water demands/needs (per user and supply source), estimated water availability (per user and supply source), unmet demand (per user or user nodes), % coverage ((per user or user nodes), water supply reliability, agricultural Impact: assessments of how precipitation patterns are affecting crop planting, growth, and harvesting cycles. - Decision support indicators on record extremes: Historical records of the highest and lowest monthly streamflows, groundwater levels, precipitation, temperature, ET, which are useful for understanding potential range of conditions
	What are meaningful statistics to present?	- Recent Precipitation: Total rainfall/snowfall over the last 24 hours, 7 days, and 30 days compared to normal (historical averages). - Seasonal Precipitation Trends: How current season's precipitation compares to historical seasonal averages. - Reservoir and Lake Levels: Absolute water levels and as a percentage of full capacity. - Groundwater Levels: Current levels compared to historical averages and extremes. - River Discharge Rates: Current flow rates in comparison to historical data to indicate the amount of water moving through river systems (both for high and low flows)

		- Water Use Rates: By sector (e.g., agricultural, industrial, residential) and how these rates are trending over time (interannually and seasonal statistics comparing also with past averages of the dry and wet seasons' rates) - Water Abstractions: Total volume of water withdrawn from different sources, monthly and seasonal averages comparing to historical seasonal averages
	What do you prefer for the visualization of these indicators?	- Monthly timeseries - Annual values - Seasonal values (dry and wet periods)
	Using the dashboard, I want to be able to…	Aggregate and visualize data from multiple sources, select and overlay different indicators about the current and future state of water resources in the basin, and conduct relevant assessments.
	What would success look like at the end of dashboard development?	At the end of the development process, success would manifest through several key indicators, both technical and user-centric: - Comprehensive Data Integration is achieved: the dashboard aggregates and visualizes (into a unique platform) data from multiple sources, including hydrological measurements, water abstraction data, meteorological information, and usage statistics, providing a holistic view of water resources across the river basin. - Operational Efficiency gains: the dashboard automates the integration, analysis, and presentation of data, reducing the time and resources needed to access/collect and interpret water management information. - Users' Engagement and Satisfaction is high: the ultimate goal of the dashboard is to serve its users—ranging from water resource managers to environmentalists and policymakers. Their active use and satisfaction are primary measures of success. High levels of engagement from the dashboard's target audience, including regular usage, positive feedback, and low levels of user-reported issues are indicators of success. - Decision-Making Capabilities are enhanced: stakeholders report improvements in their ability to make informed decisions based on the data and insights provided by the dashboard. - Stakeholders' Collaboration is improved: water management is inherently interdisciplinary and requires cooperation across sectors and disciplines. the dashboard facilitates better collaboration among stakeholders by providing a common platform for data sharing and discussion, leading to more integrated water management approaches. - Awareness about the basin issues and challenges is Increased: the dashboard successfully raises awareness about water management issues among a broader audience and enhances the understanding of complex water-related challenges. - A tool capable to support multiple purposes: the dashboard becomes a go-to source tool for data and insights that support multiple requirements/ fields: policy development, academic research, environmental advocacy, education and public awareness. - An adaptable and scalable tool is co-developed with stakeholders: water management challenges evolve, and so should the tools used to address them. A successful dashboard is one that can grow and adapt over time. The dashboard development has considered the stakeholders needs through an iterative process, while its architecture supports easy updates and scalability,

		allowing the addition of new data sources, functionalities, and user requirements without significant overhauls. - An exploitation plan for the dashboard is developed (including a mechanism for user feedback and refinement): there is an agreed action plan among the key stakeholders on the future maintenance and updating of the dashboard, and an established mechanism for user feedback, leading to continuous updates and improvements based on stakeholder input