RECONECT Services Platform

Preliminary version

D3.3

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Abstract (for dissemination, 100 words)	The RECONECT Services Platform is a web-based platform that enables various aspects of the RECONECT co-creation work including NBS monitoring, implementation and operation. It also provides services that enable the NBS evaluation process, gather evidence base, and promote upscaling of NBS. Additionally, the platform offers storage of raw data and analytics and interactive presentation of processed data. There are several existing and new web-based tools developed within RECONECT that makes up the services platform. Those tools include TeleControlNet, Measures Selector, HydroNET, Crowdsourcing app and ARGOS-NBS.
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Executive Summary

The purpose of this deliverable is to explain what the RECONECT Services Platform is, its components, and the description of the components. The TeleControlNet is the main component of the platform that will store, manage and analyze monitoring and evaluation data. The other products include Measures Selector, HydroNET, Crowdsourcing web application, ARGOS-NBS system and a decision support system for provincial flood analysis.

One of the ambitions of RECONECT is to upscale NBS innovation by mainstreaming best practices into land management plans and transfer the knowledge through knowledge co-creation processes that involve data collection, storage, management, analysis and visualization. These processes also require the evaluation of different scenarios and combinations of various NBS technologies. Through a set of tools that will support the co-creation process, users will visualize the effects of the NBS technologies at different spatial and temporal scales by running and visualizing several “what if” scenarios.

Demonstrators are the direct audience and beneficiaries of the RECONECT Services Platform. Other RECONECT partners also benefit from the platform as it will be the central data management system that catalogues available data and shows the level of monitoring and evaluation work to plan remaining work adequately. When the platform is ready for open access, it will also benefit other users to understand the importance of NBSs better and appreciate the resources needed to implement, monitor, and evaluate NBS.

This report is a preliminary version; hence, it explains the development up-to-date. The final version will include future developments

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1 Introduction

1.1 Background

RECONECT aims to rapidly enhance the European reference framework on Nature-Based Solutions (NBS) for hydro-meteorological risk reduction by demonstrating, referencing, upscaling and exploiting large-scale NBS in rural and natural areas. In an era of Europe's natural capital being under increased cumulative pressure, RECONECT will stimulate a new culture of co-creation of land use planning that links the reduction of hydro-meteorological risk with local and regional development objectives in a sustainable and financially viable way.

To do that, RECONECT draws upon a network of carefully selected Demonstrators and Collaborators that cover a broad and diverse range of local conditions, geographic characteristics, institutional/governance structures and social/cultural settings to upscale NBS successfully throughout Europe and internationally.

One of the ambitions of RECONECT is to upscale innovation by mainstreaming best practices into land management plans and transfer the knowledge through knowledge co-creation. The co-creation process involves four sub-processes:

1. Co-assessment: this sub-process addresses the assessment of hazards, vulnerabilities and risks of Demonstrators and Collaborators to hydro-meteorological events, their experiences, expectations, needs and capacities to implement NBS and other risk mitigation options as well as decision-making processes, practices and stakeholders.
2. Co-design: this sub-process involves analyzing different NBS design configurations and discussing their preferences and needs with local stakeholders.
3. Co-implementation: this sub-process addresses the development and implementation of selected and co-designed NBS in land use management through an in-depth understanding of the regulatory process, public opinion, stakeholder involvement and construction practices.
4. Co-evaluation and co-monitoring: this sub-process addresses the evaluation and monitoring of the performance of NBS are evaluated by using indicators developed during the co-design stage to measure progress on developers' expectations for benefits and co-benefits of NBS.

Figure 1 shows the operationalization of the RECONECT co-creation process, taking into account the above-mentioned sub-processes. These processes involve in-situ activities, modelling works and data collection, storage, management, analysis and visualization and requires evaluation of different scenarios and combinations of multiple NBS technologies. Through a set of tools that will support the co-creation process, users will visualize the effects of the NBS technologies at different spatial and temporal scales by running and visualizing various "what if" scenarios in 2D or 3D. Within Task 3.2, RECONECT envisaged to implement and enhance existing tools and ICT platforms to support the co-creation process using the RECONECT Services Platform.

The purpose of this deliverable is to explain what the RECONECT Services platform is, what it comprises, and a description of the components. The report is a preliminary version; hence, it explains the development up-to-date. The final version (due by 31 May 2023) will incorporate future developments.

The rest of the document is structured as follows: The remaining of Section 1 will describe the RECONECT Services Platform in relation to the co-creation workflow shown in Figure 1

and the information communication technology (ICT) behind the platform. Sections 2 to 8 describe the major tools that make up the Services Platform.

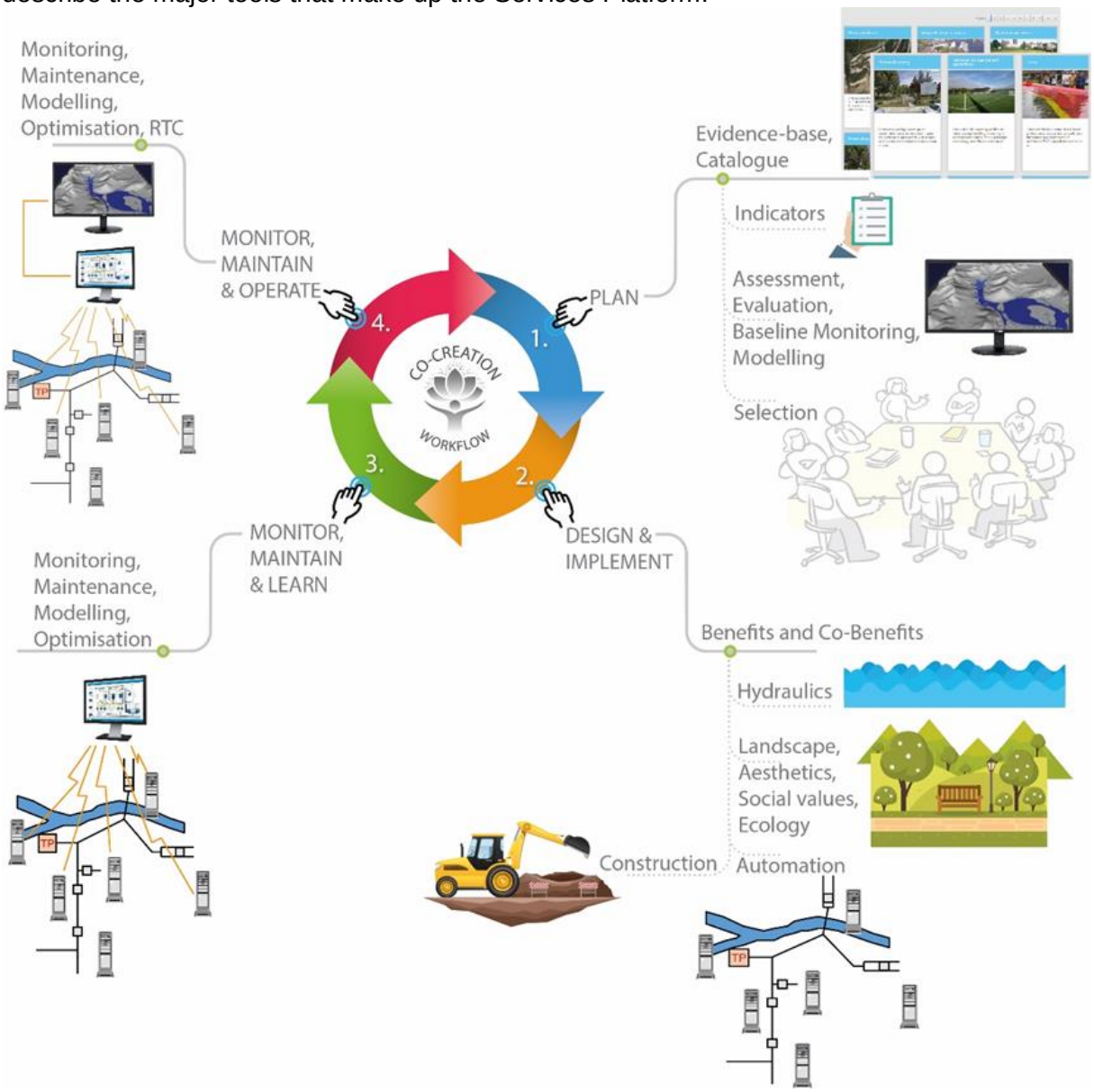

Figure 1. The RECONECT co-creation process workflow showing activities aggregated in four phases

1.2 RECONECT Services Platform

The RECONECT Services Platform is a platform that enables various aspects of the RECONECT co-creation work, including NBS monitoring, implementation and operation. It also provides services that allow the NBS evaluation process, gather evidence base, and promote upscaling of NBS. Additionally, the platform offers raw data storage and analytics and interactive presentation of processed data.

In a more technical description, the RECONECT Services Platform is an ICT platform that combines a network of distributed data, intelligent tools and standardized web services, accessible through a centralized catalogue of network services. Figure 2 illustrates the platform, which consists of three types of distributed services: (1) data access services, (2) generic NBS network services and (3) tools for analysis and feedback. The platform will have

a flexible topology for project partners, especially Demonstrators and Collaborators. Later on, other users connect to the available services with their data sources and tools. This approach has been beneficial in co-creation activities, and most technologies are already available from RECONECT project partners. The RECONECT Services Platform uses a blend of applications, technologies and solutions produced by consortium partners with new functionalities that will be configured/developed and added to support the RECONECT co-creation.

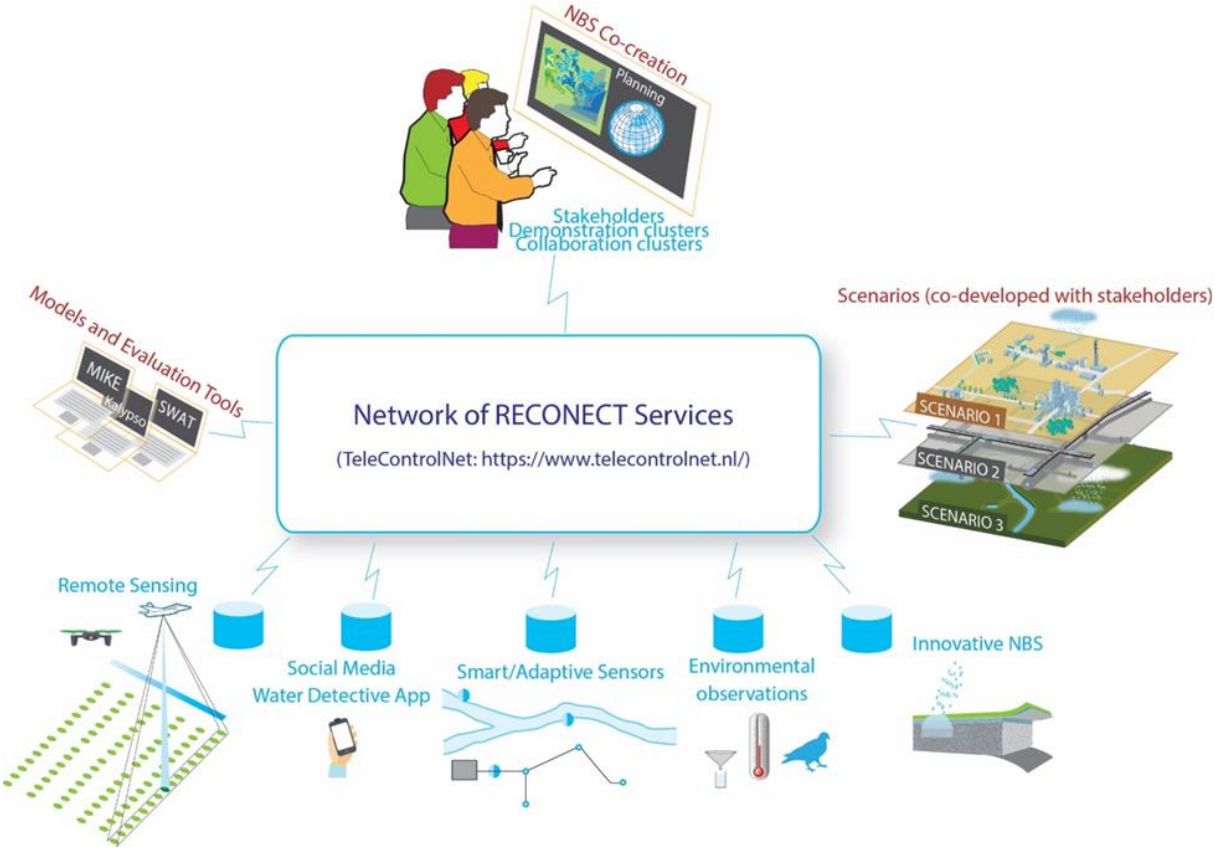

Figure 2. Overview of the RECONECT Services Platform

There are several existing and new tools developed within RECONECT. In this context, by tools, we refer to those that can be converted to a web-based application. These tools can be categorized as services that support the four phases of the co-creation process (see Figure 1):

1. Plan – the tools that provide services in the planning phase include the Measures Selector
2. Design and Implement – there are plans to develop tools that employ multicriteria analysis and landscape and hydraulic design to produce NBS layouts
3. Monitor, Maintain and Learn – tools that support co-creation in this phase include TeleControlNet, HydroNet, Crowdsourcing web application
4. Monitor, Maintain and Operate – tools that support NBS real-time operation in this phase include TeleControlNet

The RECONECT Services Platform has a decentralized architecture. It can use existing local servers (located in Europe) and private data centres to ensure the desired service levels and the required cyber security measures. The architecture shows layers of network isolation, creating segments of internal and edge (or public) components that will be established through logical and, in part, physical isolation. Modules in these layers have restricted access in

between and to other layers. This prohibits external direct access to internal components. Locations are required to be linked with a site-to-site encrypted strong virtual private network (VPN), enabling transport of several layers between sites. Edge protocols for transport should require strong cyphers in public key infrastructure (PKI) certificates for communication, although not always feasible between demo sites and TeleControlNet.

In developing the RECONECT ICT Platform, RECONECT partner Inter Act will explicitly deal with security issues from a technical perspective. Security and privacy issues are also addressed from the management perspective. For example, an essential aspect of data security and privacy is storing and managing personal data. The categories of data collected (e.g., by use of questionnaires) in RECONECT include socio-economic data. Such data will be stored in a project database managed by the project coordinator. Each project participant will have secured web access to data.

1.3 Implementation of the RECONECT Services Platform

The RECONECT project website (http://www.reconect.eu) is a key instrument for disseminating and promoting project outputs to project partners and external users. As one of the main project outputs, the RECONECT Services platform will become accessible through the project website, with the presentation of demonstration cases outlining the use of the platform. The goal is to centralize, integrate and showcase the different platform building blocks in a dedicated website section. It should be highlighted that the website, which is developed and maintained by project partner GISIG, will be used as a gateway to the Services Platform. However, the different tools are developed and hosted by other partners. Therefore, a collaboration between GISIG and ICT partners within RECONECT is fundamental.

To design and implement the platform page within the project website, GISIG will collect any material about the tools from the ICT partners, including text, links and graphical information. There is also an ongoing discussion to decide the level of interaction of users (partners and external users) with the different tools, for example, whether the tools are fully open or (semi) restricted to external users. Another aspect under consideration is the use of the RECONECT Services Platform and its various components. All partners from Demonstrator and Collaborator sites will be able to use the full functionality of the tools available on the platform. They will be able to set up and evaluate various scenarios and produce vital information for the co-creation of NBS-based land master plans. Hence, it is relevant to create documentation, guides and video tutorials to support users, including external ones.

1.4 Synergies with platforms developed in PHUSICOS and OPERANDUM projects

RECONECT gives great importance to establishing liaisons and synergies with other projects and initiatives that work on NBS. This action aims to exchange information about project activities and results, discuss and share different approaches, and collaborate to achieve joint impacts and upscale NBS. PHUSICOS (https://phusicos.eu/) and OPERANDUM (https://www.operandum-project.eu/) are two of the projects RECONECT has a closer collaboration. Regarding the synergies with platform development, there have been discussions at the project coordinators level regarding the desired level of synergy. The next step is regarding the possibilities if the desired synergy is technically feasible.

Some of the initiatives currently on discussion include:

- PHUSICOS stores all data generated in the project on their platform. However, PHUSICOS does not store real-time and monitoring data in the platform. The potential to use the TeleControlNet system by RECONECT to store and display such data is being investigated.

- PHUSICOS has developed a database of NBSs for hydro-meteorological events in mountains and rural areas. OPERANDUM has also developed a catalogue of existing NBS that are being collected within the project. There is a potential to connect those databases with the NBS Measures Selector developed within RECONECT.

2 TeleControlNet

2.1 Introducing TeleControlNet

TeleControlNet is a SaaS for remote management of technical installations and measuring locations, with standard functions such as web-based SCADA, web-based GIS presentation, smart (management) dashboards, smart reporting tools, big data analyses and asset management. Using Inter Act's high-end industrial IoT technology, existing technical installations, sensors and other sources of data wherever in the world can be connected to one central monitoring and control platform, as shown in Figure 3. Real-time and historical data and other relevant information such as documents and reports can be stored and managed in the TeleControlNet.

Recently, TeleControlNet successfully passed TÜV TRUST IT[1] tests for certification. Initially, only the TeleControlNet edge technology was certified in October 2020, but recently also the SaaS has passed all tests and will be certified. Part of the certification process was a GDPR/DPIA check that covers risks on data involving people, particularly bystanders, that could be filmed by surveillance cameras. When such data is stored, it needs appropriate attention to follow European legislation.

Figure 3. An example of a central control room that uses TeleControlNet

TeleControlNet offers its users secure web access to the cloud-based platform regardless of location or device. Installations and sensors are connected using a variety of TeleControllers (see Figure 4), while other systems and databases can be connected through secure internet connections. TeleControllers are edge devices that collect data in short time intervals and without interruption. Inline data validation can be performed to enhance data quality and accuracy. The collected datasets are validated and processed into operational information for engineers, analysts, experts and managers. Big data analysis tools provide the necessary means for experts and scientists to convert data into knowledge.

[1] https://it-tuv.com/en/

Figure 4. The TeleControlNet concept with edge controllers

TeleControlNet offers a variety of simulation, visualization and modelling tools. Thanks to open architecture, third-party applications can be integrated into the same platform. It is widely used by authorities responsible for environmental management of soil, water and air, and risk management and safety. By applying industrial IoT technology, existing infrastructural assets turn smart; as a result, cities and the environment gradually become smart.

TeleControlNet is mainly used to display time-series WATER indicators data in real-time and historical data. Moreover, data can be shown in different formats, such as graphs or bar charts. Photos and videos can also be saved and viewed. TeleControlNet has also been used to collect PEOPLE indicator data such as the number of visitors from Visitor Loggers (sensors). NATURE related data has not been uploaded yet. Figures 5-7 show some typical TeleControlNet screen displays.

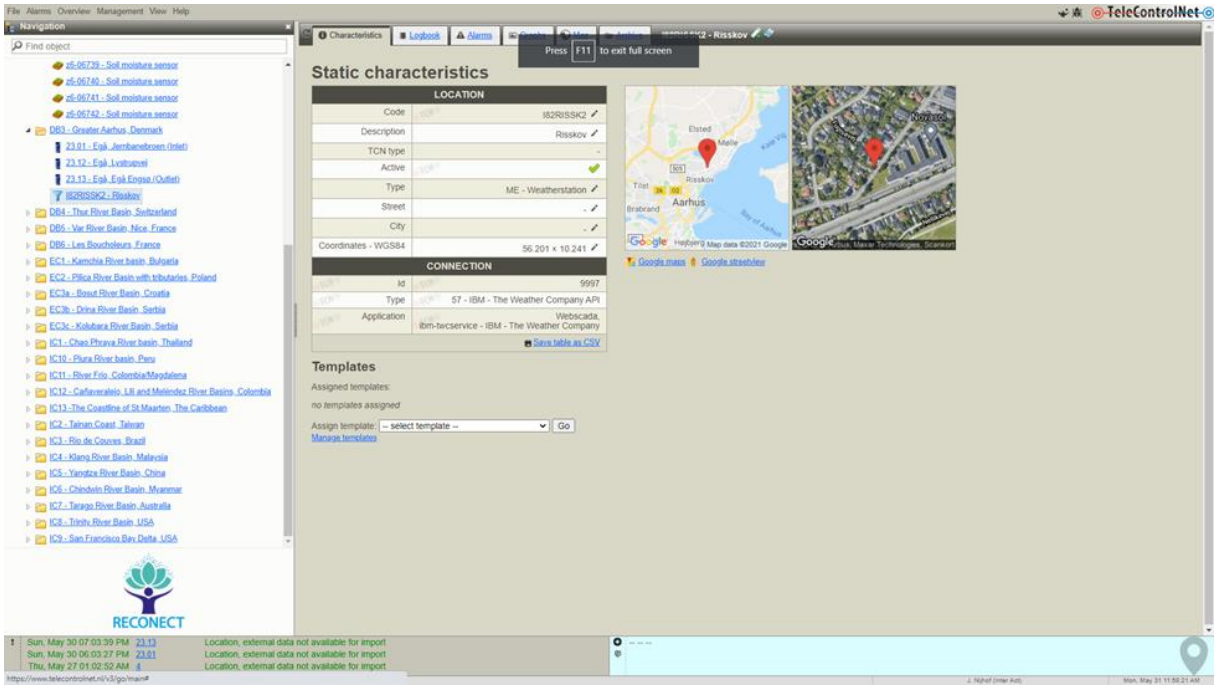

Figure 5. Navigation screen for the Demonstrator site Greater Aarhus Denmark

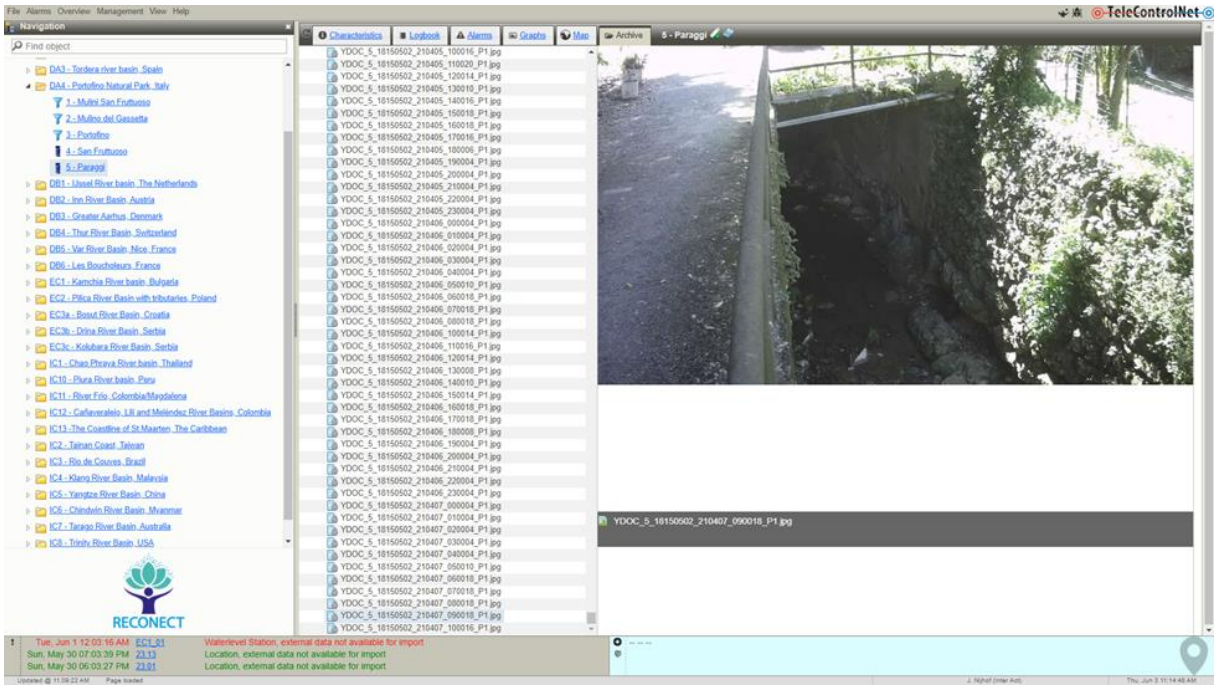

Figure 6. Storage of pictures for Demonstrator site Portofino Natural Park Italy

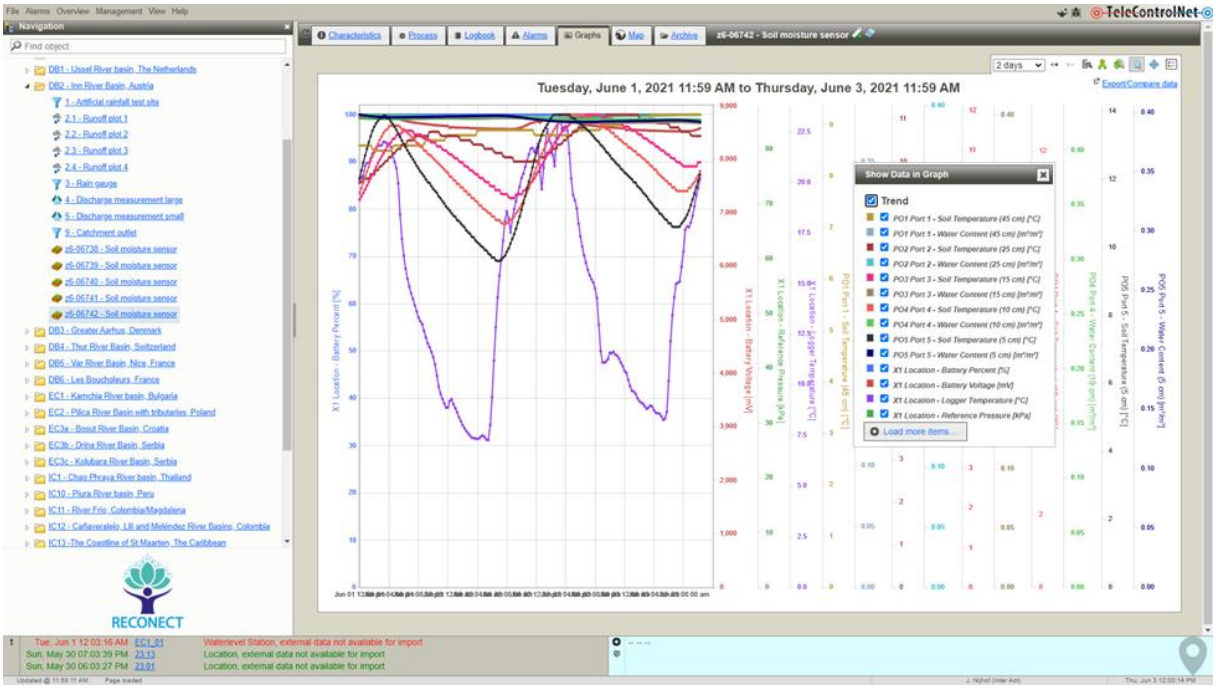

Figure 7. Soil moisture trend for Demonstrator site Inn River Basin Austria

2.2 Connected Demonstrator and Collaborator sites

Data will be collected from all demonstrator sites. As of August 2021, seven Demonstrator sites are connected to the TeleControlNet, and the other three will be connected soon. One European Collaborator and one international Collaborator are also connected. Table 1 shows the connected Demonstrators and Collaborators. An exhaustive list of sensors currently connected to the TeleControlNet is provided in Appendix A.

Table 1. Demonstrators and Collaborators connected to the TeleControlNet

Site	Sensor Data	Status of connection
DA-1 Dove/Gose Elbe Estuary, Germany	Gauging stations	Connection in progress
DA-2 Odense Coastal Area, Denmark	Webcams	Two sensors connected
DA-3 Tordera River Basin, Spain	Weather stations Water level stations	Four sensors connected
DA-4 Portofino Regional Natural Park, Italy	Weather stations Water level stations	Five sensors connected
DB-1 IJssel River Basin, the Netherlands	Water level stations	Seven sensors connected
DB-2 Inn River Basin, Austria	Weather stations Soil moisture stations	12 sensors connected
DB-3 Greater Aarhus, Denmark	Water level stations Weather stations	Four sensors connected
EC-1 Kamchia River basin, Bulgaria	Water level stations	Three sensors connected
IC-1 Chao Phraya River basin, Thailand	Water level stations Weather stations	Ten sensors connected

3 Measures Selector

3.1 Basic concept

In RECONECT, a database is developed to provide an extensive list of measures for hydro-meteorological risk reduction. Suitable options for a specific situation need to be singled out from this list. Since not all measures are suitable for all locations and hazard types, six filters are used in this process to narrow down the list of measures (See Figure 8). The first filter is the measure type, which can be NBS or grey infrastructure.

The second filter is hazard type, as the consequences of an event vary greatly depending on the hazard (e.g., floodplain restoration is suitable for fluvial floods but not pluvial floods). Considered hazard types include pluvial flooding, fluvial flooding, coastal flooding/storm surges, flash flooding, droughts, and landslides.

Thirdly, the affected area of such problems must be defined as either urban area, non-urban area or both. In the fourth filter, the users identify the potential location for implementing measures. There are two main sites for implementation; urban areas and non-urban areas. Non-urban areas include mountainous and coastal areas and river basins. If the case study is a river basin, the location within the basin also needs to be defined as upper course, middle course or lower course. It should be noted that no precise location (micro-location) has to be determined at this stage.

The fifth filter is the type of project that would be implemented, i.e., whether the completely new measures are to be implemented or existing measures are to be improved. The final filter is the prevalent land surface type in the area (e.g., artificial surfaces, agricultural areas, forest and semi-natural areas, wetlands, or water bodies). Within each filter, multiple selections can be made; for example, users can include both urban and non-urban measures in the filter.

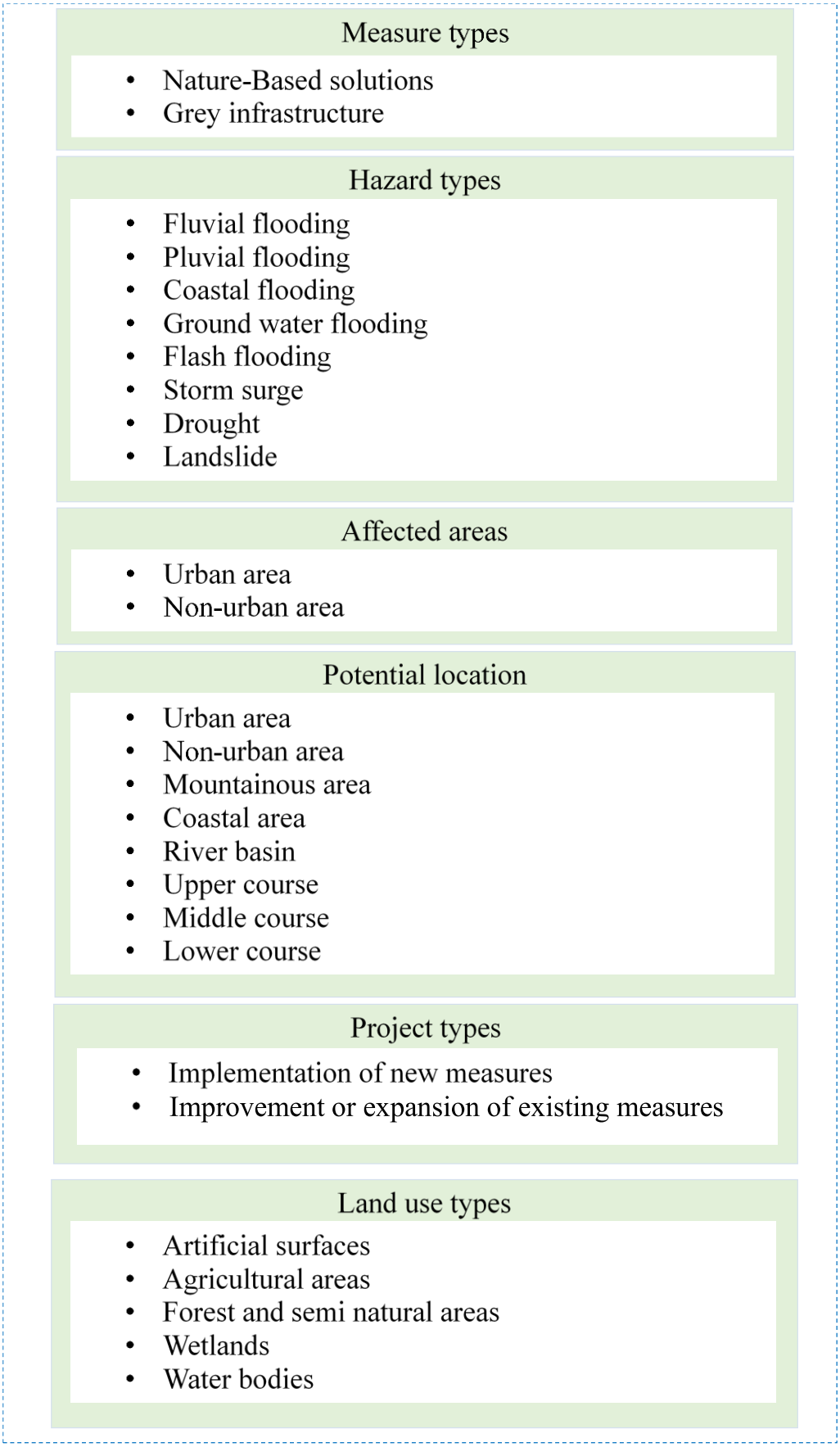

Figure 8. RECONECT Measure selector tool concept

3.2 How it works

The RECONECT Measure selector tool is accessible directly through a temporary web portal https://www.webscada.nl/reconect/measures-new/#!/filters. This NBS measures guide needs further development before it will be linked to http://www.reconect.eu/. The portal is available in English with open access.

The user interface of the tool is structured in three main sections (Figure 9):

- Section 1: Filters that are used in this process to narrow down the list of measures
- Section 2: Graphic interface of each filter
- Section 3: The results of applicable measures after filling in the filters.

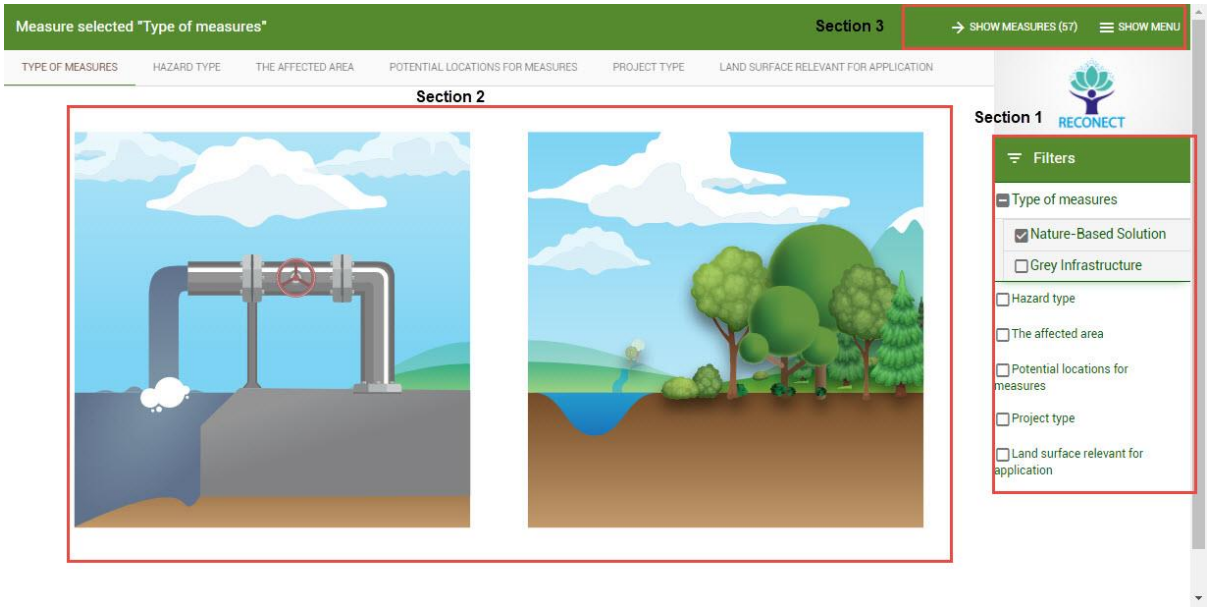

Figure 9. Measures selector tool main user interface. The three sections of the interface are shown in red boxes.

To narrow down the applicable measures, users need to select the criteria of each filter. An example of how to use the tool is explained below.

1. Select the type of measure that you wish to implement to reduce local risk (e.g., Nature-Based Solutions)
2. Select the hazard/hazards that most affect your area, and you would like to mitigate (e.g., Fluvial flooding)
3. Select the type of affected area of the hazards (e.g., urban and rural area)
4. Select the specific location within your catchment where you wish to implement your NBS measure (e.g., River basin -upper course (mountainous and source headwater zone) and middle course (middle of the river)
5. Select the type of project that you wish to implement (e.g., Implementation of new measures and Improvement or expansion of existing measures)
6. Select the primary type of land surface within your case study area (e.g., Agricultural areas, Forrest and semi-natural areas, Wetlands, and Water bodies)
7. You can see the number of applicable measures and see the list of measures at “SHOW MEASURES (number)” bottom
8. Click “MORE INFO” to see more information on applicable measures

4 HydroNET

The TeleControlNet is aimed at technically skilled users to work and interact with the data stored on the platform. The HydroNET platform developed by HydroLogic Research is a connected platform aimed at visualizing available data such that novice users can easily understand and interact with the data. The HydroNET platform follows the SaaS paradigm, runs from cloud infrastructure and is used in research and commercial environments. HydroNET is a web-based decision support system that provides live access to many meteorological, hydrological, climatic and related data sources. Data can be visualized and analyzed with sophisticated applications and dashboards through a web portal.

Data collected within RECONECT are connected to the TeleControlNet platform. A connection between this central platform and the HydroNET platform has been developed through a data service (API). Via this connection, RECONECT time-series data also become available in the HydroNET platform in real-time. The HydroNET platform can be used to create additional visualizations or interpretations of the data.

Within the HydroNET platform algorithms can be configured to add value to the connected data sources from TeleControlNet. Examples include rule-based calculations (such as testing against thresholds) with the 'HydroWatch' application. The HydroWatch application can be used to configure thresholds and smart algorithms to add value to all data sources which are connected to HydroNET. This allows for automatic monitoring of the status of these data sources via traffic light-coloured thematic maps and graphs. The HydroWatch graphs and maps can be exported to an image that can be automatically updated with the latest information. An example of such a HydroWatch graph is shown in Figure 10. The colour-coded threshold makes the interpretation of the actual, measured time-series easier, especially for non-expert users.

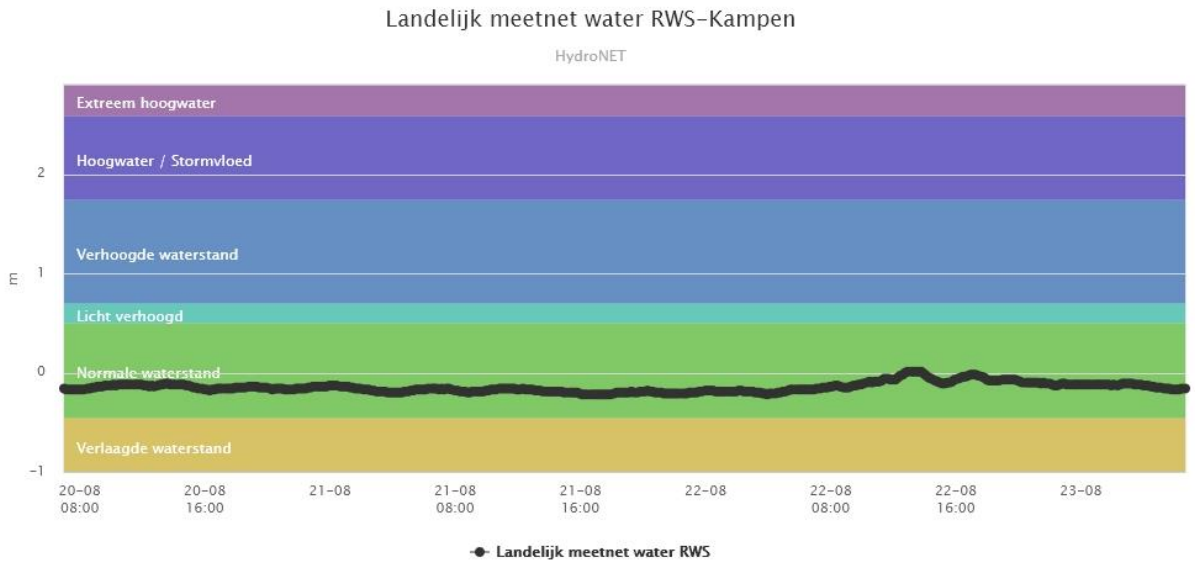

Figure 10. Example of a HydroNET dashboard where the measured time-series of water levels in the IJssel River is plotted against pre-defined threshold values

Within HydroNET, users can create personalized dashboards to add relevant maps and charts. A dashboard is a page upon which one or more small applications such as thematic maps or charts can be stored. Any dashboard can contain as many or few of these applets as a user wants, where the size of each applet can be changed by dragging and dropping the corners. This makes each dashboard a completely unique and personalized place for any type of analysis. For example, a user aimed at water quantity can create dashboards on observed water levels, whereas a soil scientist might have more interest in soil moisture observations. An example of a HydroNET dashboard is given in Figure 11.

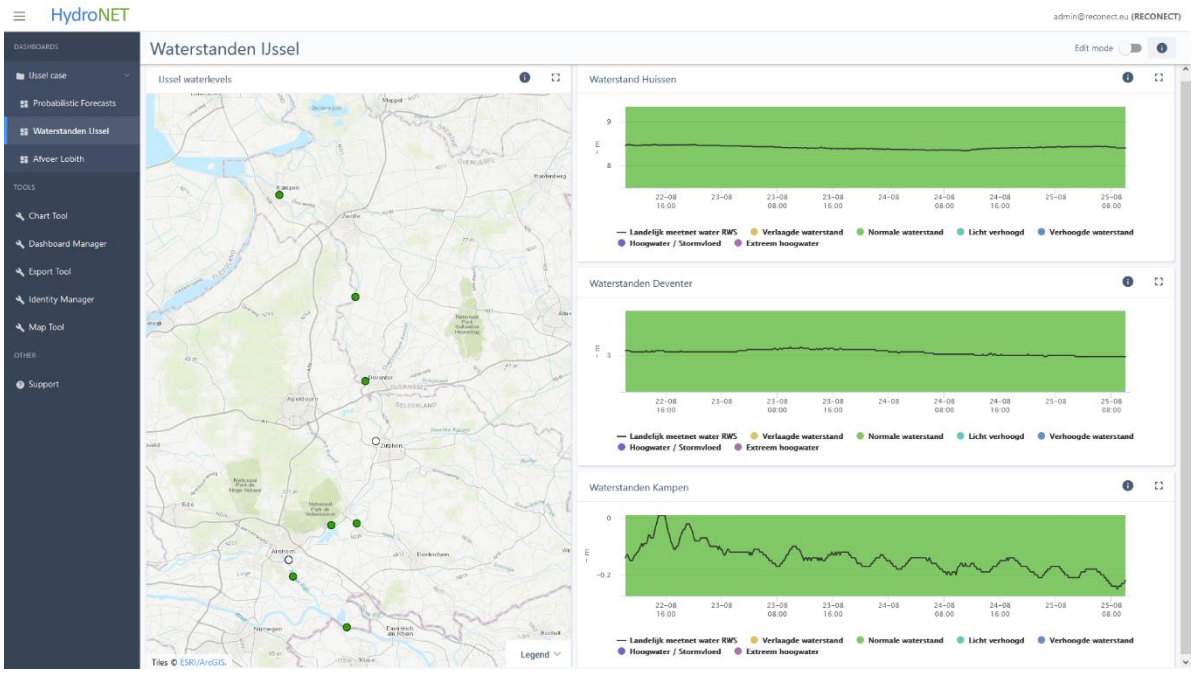

Figure 11. Example of a HydroNET dashboard. A map with colour-coded water level measurement locations and three graphs with time-series of water level measurements

The dashboards are accessible only for users with valid log-in credentials. However, it is relevant to share such an applet with external parties in some cases. For this purpose, each dashboard application can be exported to an image, where this image can continually update to show the most recent data. These images are available without a log-in, so they can easily be shared with other parties. It is also possible to add these images on the central TeleControlNet platform.

Apart from connecting with the TeleControlNet platform, the HydroNET platform also has several other data sources available. Examples are the probabilistic weather forecasts for Europe and in-situ measurements of Rijkswaterstaat in The Netherlands. The probabilistic weather forecasts data source can be used to view the weather forecast of precipitation and temperature for up to 10 days ahead for any place in Europe. A user (for example, Demonstrators) can view the original gridded data through configuration. The platform can also automatically calculate mean values per polygon, such as country mean values (see Figure 12).

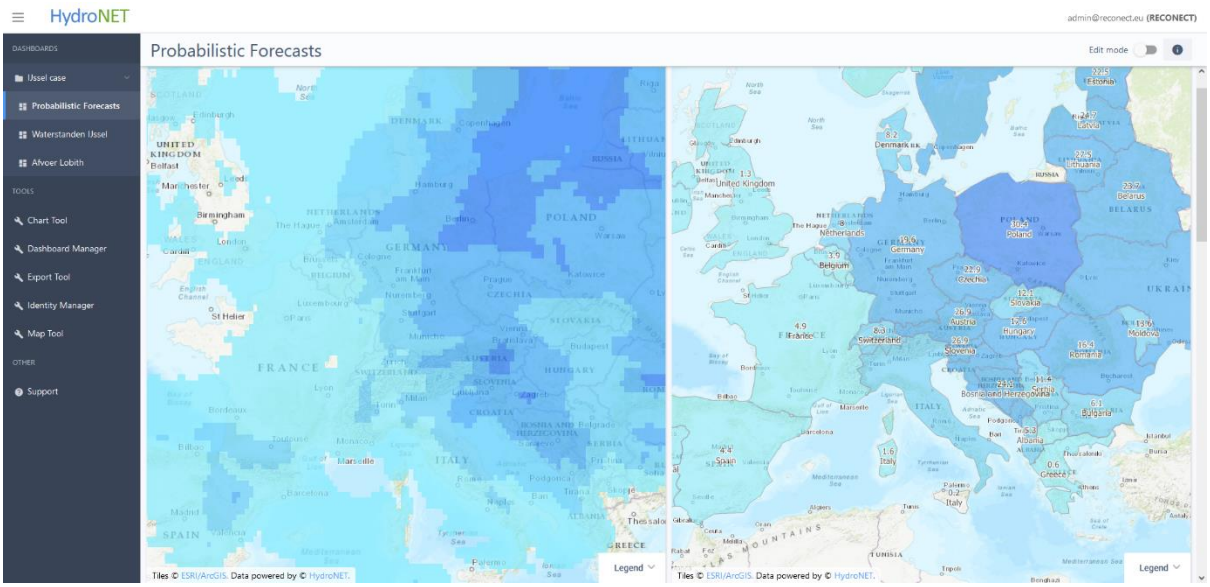

Figure 12. Example of a HydroNET Dashboard with maps of the probabilistic weather forecasts - left panel shows the original gridded data and right panel shows the averages per country in Europe

The time series of each grid cell or polygon can also be viewed. Probabilistic forecasts are weather forecasts with many dozens of perturbations. Instead of presenting all the perturbations, HydroNET can automatically analyze the data and return only the 30th, 50th and 90th percentile such that users can inspect the forecast uncertainty. An example is shown in Figure 13.

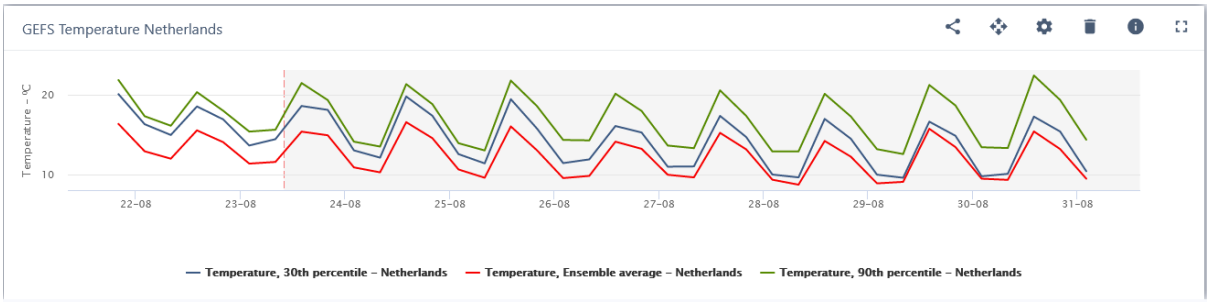

Figure 13. Example of the probabilistic weather forecast of the Temperature in The Netherlands, where the platform shows the 30th, 50th and 90th percentile

An API is being developed on top of the HydroNET platform, which is capable of disseminating data from various data sources available in the HydroNET platform. This API is secured using the OpenID (OAuth 2) standard. The HydroNET API is not only capable of disseminating the original data (such as all gridded ensembles of the probabilistic weather forecast), but it is also capable of on-the-fly calculations. For example, the API has support to download data aggregated over time, such as daily sums instead of hourly timesteps or in the case of the probabilistic data, the API can return the percentiles. Such functionality allows users of the API to directly query data in a ready-to-go format, such that it doesn't require any further post-processing by the user of the API.

The HydroNET platform API will be used to retrieve relevant data from HydroNET by the TeleControlNet platform. The TeleControlNet platform can then display this data natively in the

central IT platform. With both the TeleControlNet platform and the HydroNET platform connected via comprehensive API's, we're levering the strengths of each platform.

5 Crowdsourcing web application

HydroLogic Research has also created a crowdsourcing application for RECONECT. This application is an online web application, which can be used on both a mobile or desktop computer. This web application aims to collect information from the general public. Whenever a user visits this web application, a map is presented with all previously reported events (see Figure 14). The crowdsourcing application is available at: https://crowdsourcing.reconect.eu/home

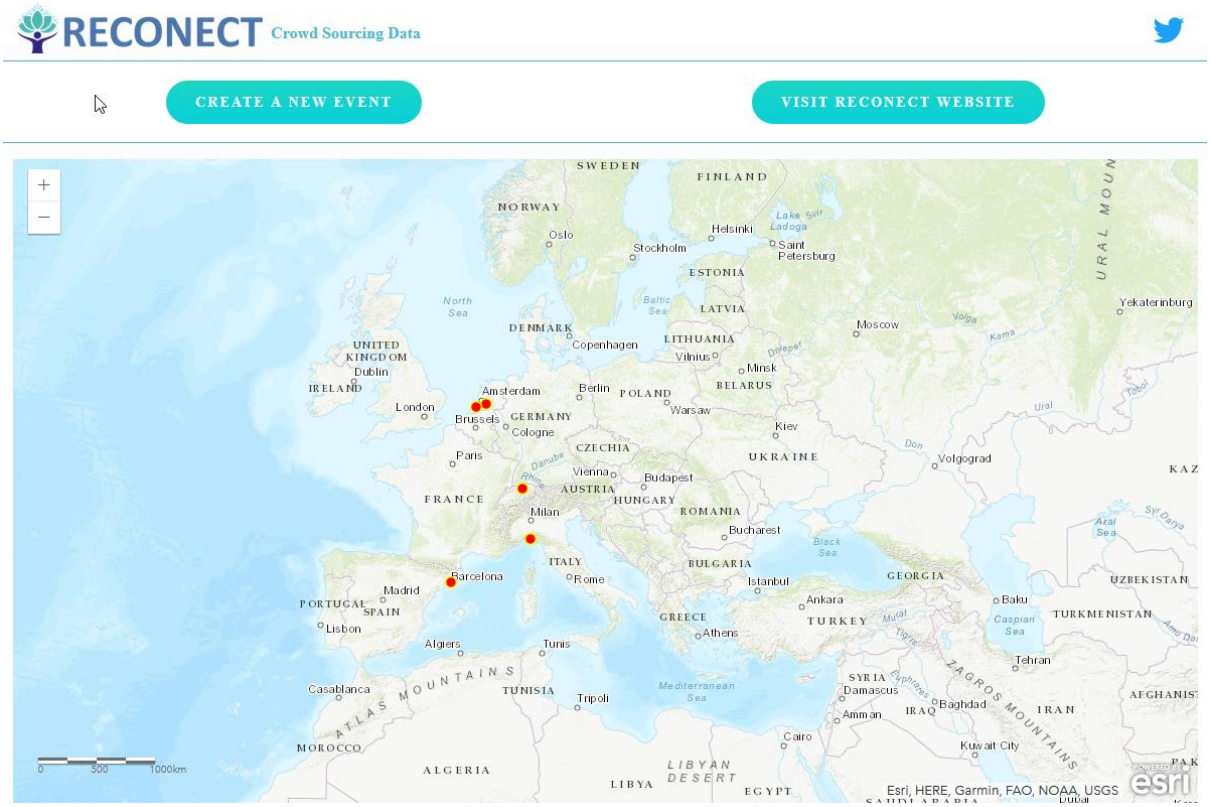

Figure 14. Crowdsourcing web application home page which shows a map with previously created reports (orange dots)

A user can create a new report by clicking the *Create a New Event* button, which opens up a new page (see Figure 15) where the user can fill in the following information:

- Location of the report
- Date and time of the report
- Details on the report, and
- One or more pictures

For example, if a tourist spots a landslide while visiting Portofino Park, they can use this web application to create a report. In this report, the tourist can describe that they noticed a landslide. They can use the GPS coordinates of a mobile phone and can add pictures of the event. Once submitted, the event will occur as a new orange dot on the map, as shown in Figure 14.

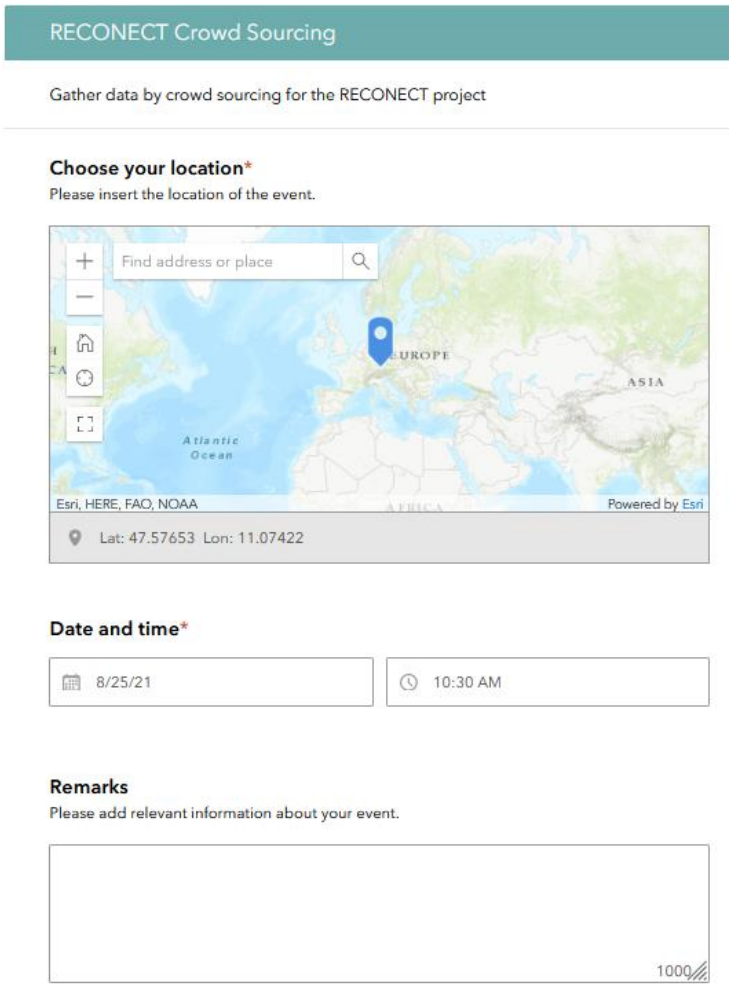

Figure 15. Form to report a new event to the crowdsourcing web application

All reported events are plotted as orange dots on the map. Each report can be inspected by selecting it on the map. This will open a dialogue window where details of the report, such as the time, remarks and attached pictures, can be inspected (see Figure 16). The crowdsourcing events are accessible via the Web Feature Service (WFS) protocol that connects the results of the crowdsourcing application to other platforms such as the TeleControlNet or ARGOS (see Section 6). The WFS standard can easily be filtered with a spatial extent. This filtering makes it possible only to retrieve events from a specific region (i.e., case study area).

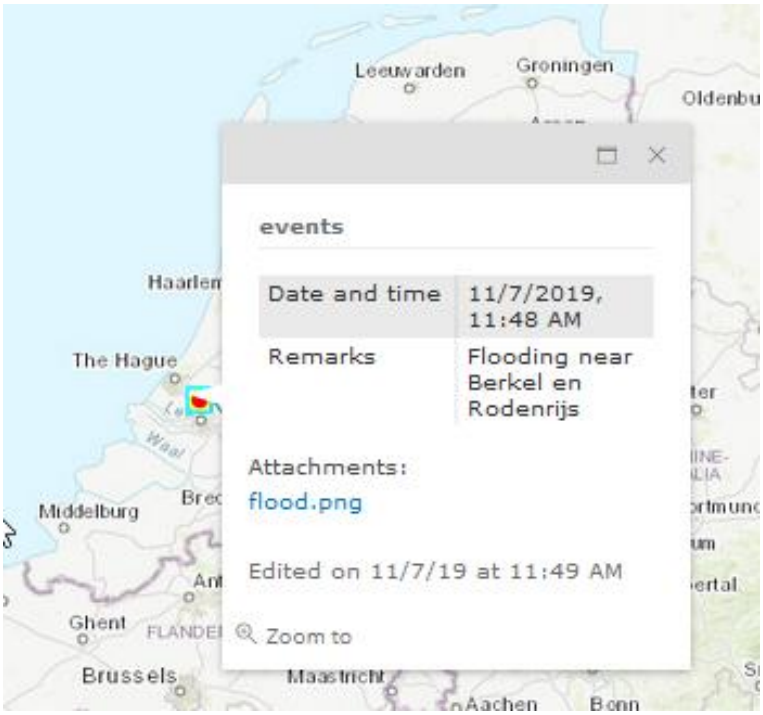

Figure 16. Event details can be viewed and inspected

6 ARGOS-NBS System

The ARGOS System (https://www.hyds.es/services/), which HYDS has developed, is a platform that can integrate a huge amount of historical and real-time data such as time series, raster maps, vector data and forecasts. It can display processed data in a responsive web-based viewer that automatically adapts to the device used – desktop, tablet and smartphone – and allow interaction with the data.

For RECONECT, a new version of the ARGOS system, called ARGOS-NBS, has been developed. ARGOS-NBS focuses on exploring Demonstrators' NBS concerning the WATER, PEOPLE and NATURE challenges, goals, sub-goals and indicators (see D2.6 for more information on challenges, goals, sub-goals and indicators). That helps users explore raw and processed data for the Demonstrator sites in a very structured manner.

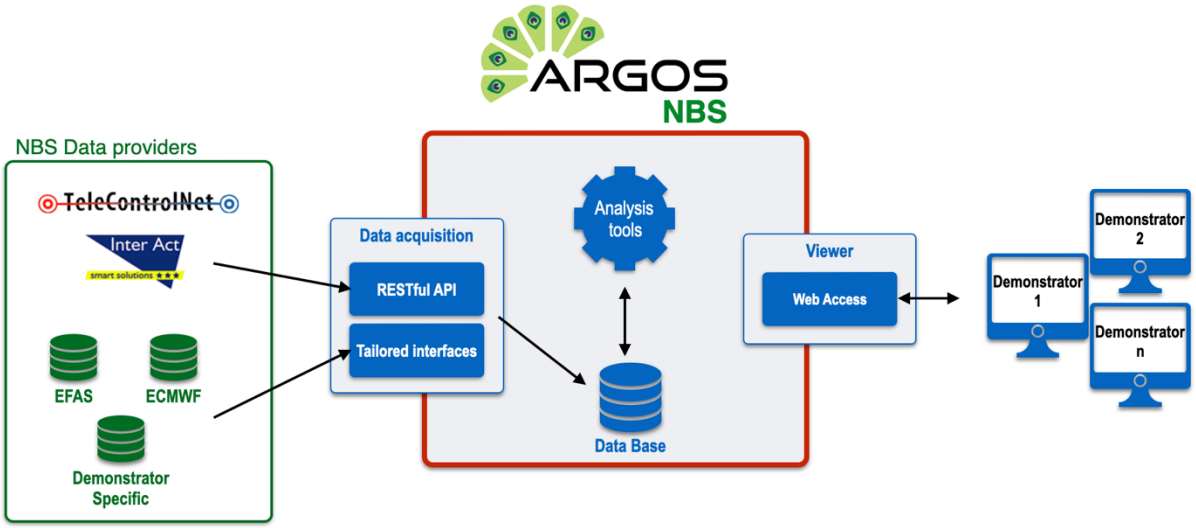

Figure 17. Schema of the ARGOS-NBS platform.

As shown in Figure 17, the ARGOS-NBS system has been connected to a set of data sources. ARGOS-NBS has been linked to the TeleControlNet to gather in real-time all the available data collected/generated at the Demonstrator sites and display it in ARGOS viewer together with other NBS-related data. TeleControlNet is the primary source of information for the ARGOS-NBS, especially for time series data. However, ARGOS also collects and displays different data types, such as GIS data.

The ARGOS-NBS also includes flood risk indicators generated by the European EFAS (European Flood Awareness System). The objective of EFAS is to provide complementary and value-added information to national and regional authorities to contribute to flood preparedness. EFAS has:

- Indicators of rapid floods: with horizons of hours or a few days for small basins, based directly on rainfall forecast over those basins.
- Medium-term flood forecasts: for large basins, using the LISFLOOD hydrological model fed by rain forecasts up to 10 days.

Some of those indicators have been selected and incorporated into the system (for example, see Figure 18).

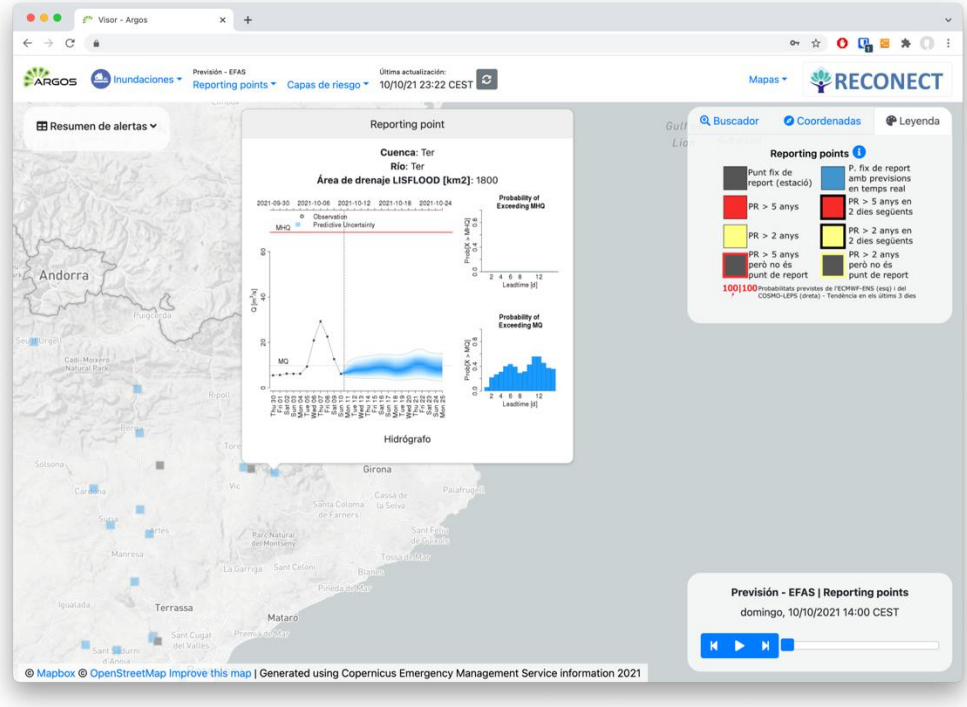

Figure 18. Example of the EFAS data integration in ARGOS-NBS showing LISFLOOD Reporting points

In addition, the ARGOS-NBS integrates products from the European Centre for Medium range Weather Forecast (ECMWF), such as the Integrated forecasting System (IFS) model and the Extreme Forecast Index (EFI) model. Due to ECMWF license limitations, the products are currently implemented only for the Tordera Demonstrator, as shown in Figure 19. However, the system is ready to incorporate the information from other demonstrators when license issues are resolved.

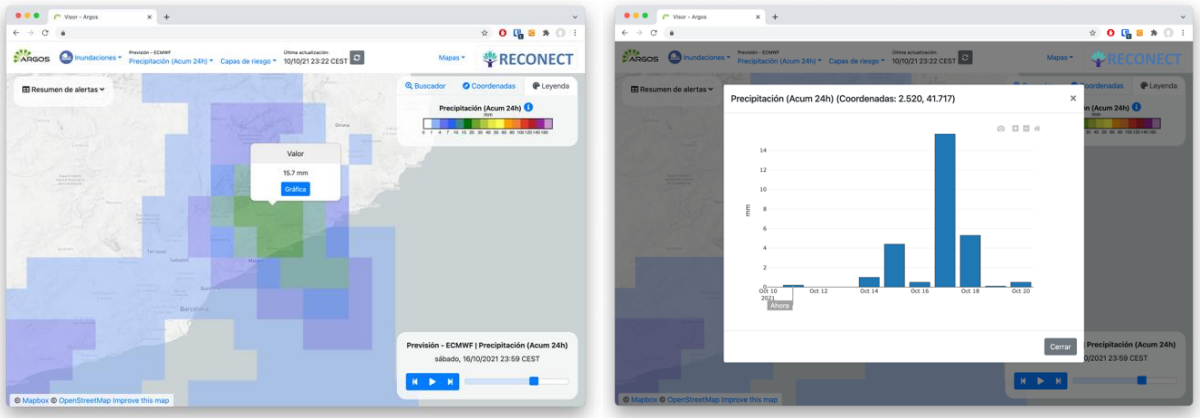

Figure 19. Example of ECMWF data integration in ARGOS-NBS. The left panel shows forecasted rainfall in 24h, and the right panel shows forecasted evolution of the 24h rainfall accumulation for a given place.

For the Tordera demonstrator, ARGOS-NBS has been connected to other sources of dynamic information in real-time. The data sources are:

- Rain-gauges from the Catalan Meteorological Service.
- Rain-gauges from the Spanish Meteorological Service.
- Radar information from the Catalan Meteorological Service (see Figure 20).

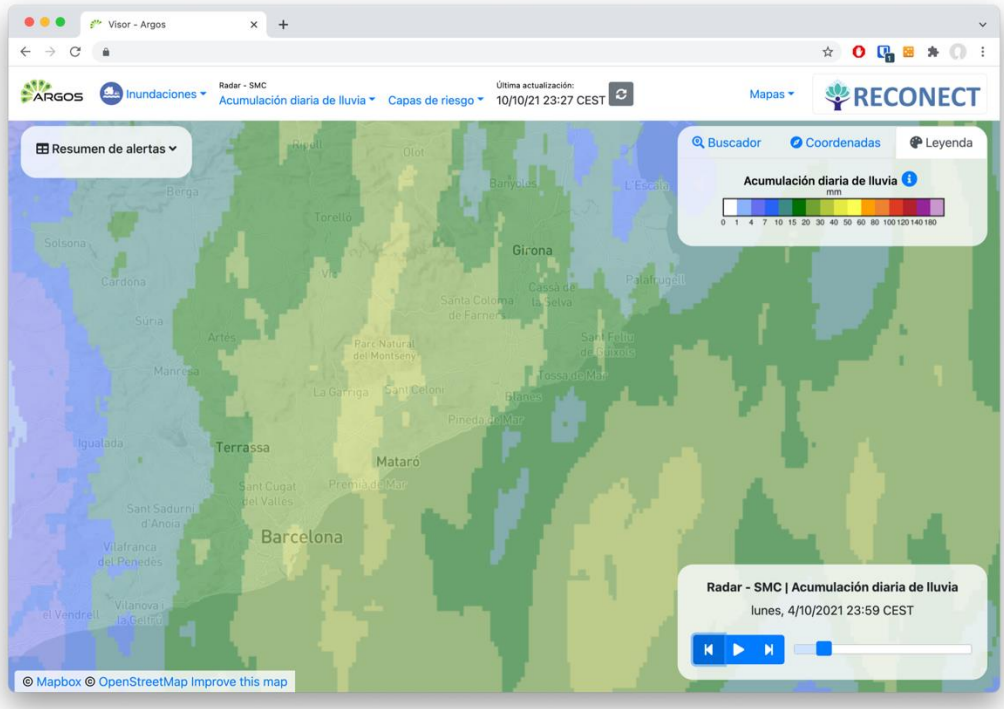

Figure 20. Example of Radar precipitation observations showing daily rainfall maps integrated into the ARGOS-NBS for the Tordera Demonstrator.

Finally, the ARGOS-NBS system can incorporate and show complementary layers together with the dynamic information. For example, this feature is used to show NBS boundaries and off-line model results such as flood extent and depth from hydraulic models and economic damage from damage models. Complementary layers also have a time stamp such that the platform allows seeing the evolution of those parameters with time (before and after NBS implementation or other changes, for example).

7 DSS system for provincial flood monitoring

Since 2012, HII has developed the national platform of NHC (National Hydroinformatics Data Center) to integrate water-related data and information from relevant government agencies in Thailand. The NHC provides services for national water monitoring and operations, for example, area-based data, rain forecasting, or real-time water level monitoring, as a decision support information for national management during normal or crisis of water-related disasters. For RECONECT, the ICT platform plays a crucial role in the entire NBS workflow, and HII wishes to demonstrate the importance of ICT service in some parts of the NBS workflow to reduce flood risks in our collaborator site.

The DSS system for provincial flood monitoring has been developed to efficiently visualize hydro-meteorological data for targeted audiences to monitor, operate, and evaluate the implemented measures. The visualization could be achieved using a co-designed DSS or dashboard with the targeted group and suitable with NBS workflow of monitoring and evaluation processes.

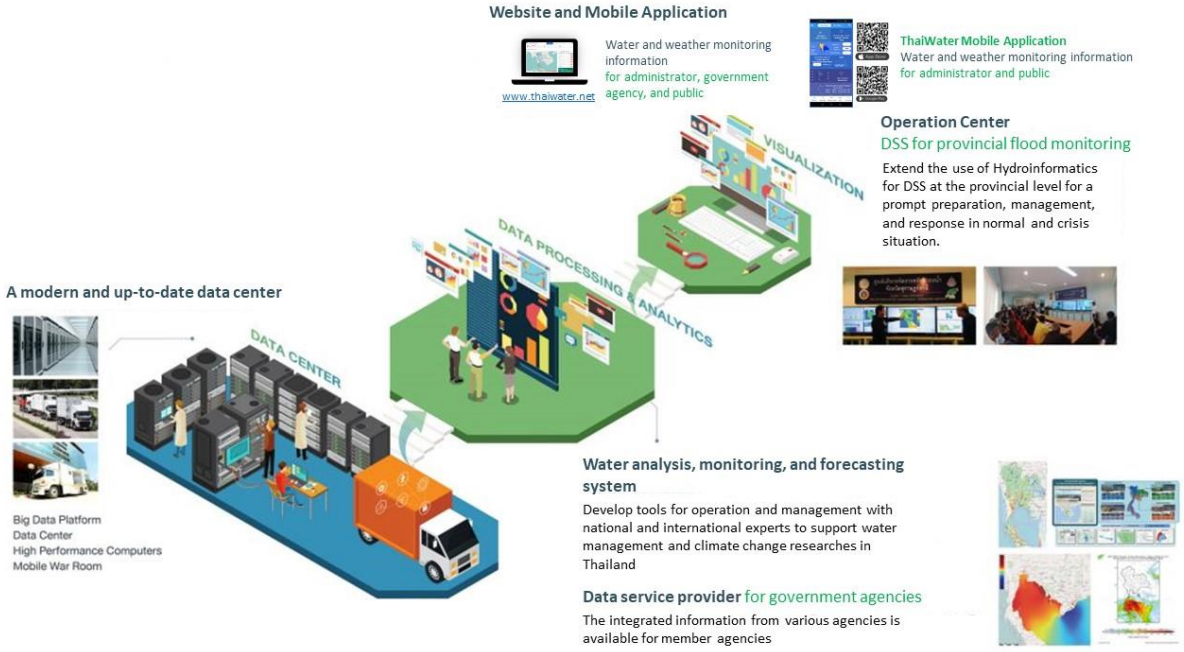

Figure 21. DSS cascading from national to provincial level for flood monitoring

As a linkage from the national to a local level, HII has developed the DSS system dedicated to provincial flood monitoring to support stakeholders at this collaborator site (Rangsit, Pathum Thani Province) of the Chao Phraya River basin, Thailand (Figure 22).

Local real-time weather information is vital for day-to-day, short-term, and long-term agronomic management of all crops and essential for timely disaster prevention. Local and timely data integrated into the decision support system and available for the NBS site could substantially support planning and reduce risk from the changing climate and local weather extremes.

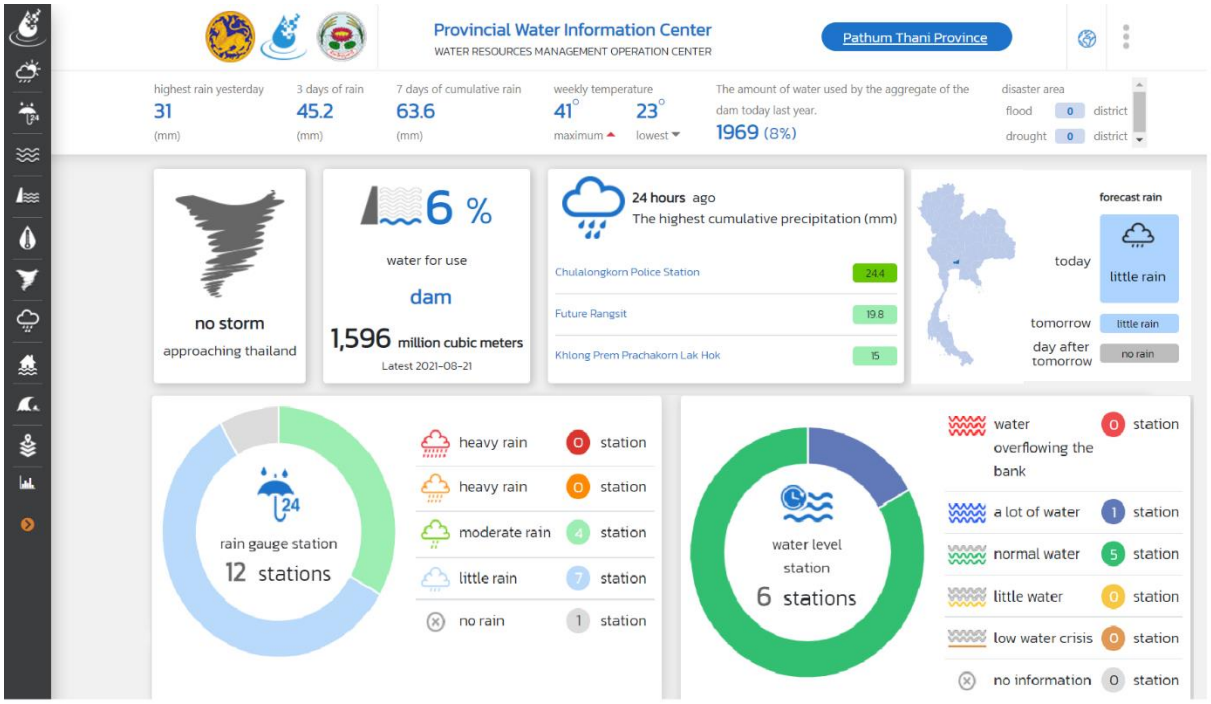

Figure 22. Dashboard of DSS system for provincial flood monitoring at Pathum Thani, Thailand

The DSS for provincial flood monitoring displays real-time hydro-meteorological data based on deployed sensors and other relevant datasets imported from the NHC, a national data platform (Figure 23 and Figure 24). This public website (http://pathumthani.thaiwater.net) is open for local operators and communities to access necessary information such as hydro-meteorological monitoring and forecasting, GIS layers and related statistics to minimize the hydrological risks. Equipped with tools for monitoring and operation (e.g., automated sensors, hydro-meteorological forecasting), this NBS site can effectively monitor and manage local water for every encountered situation.

Figure 23. The 2021 water level data from a deployed sensor in the collaborator site

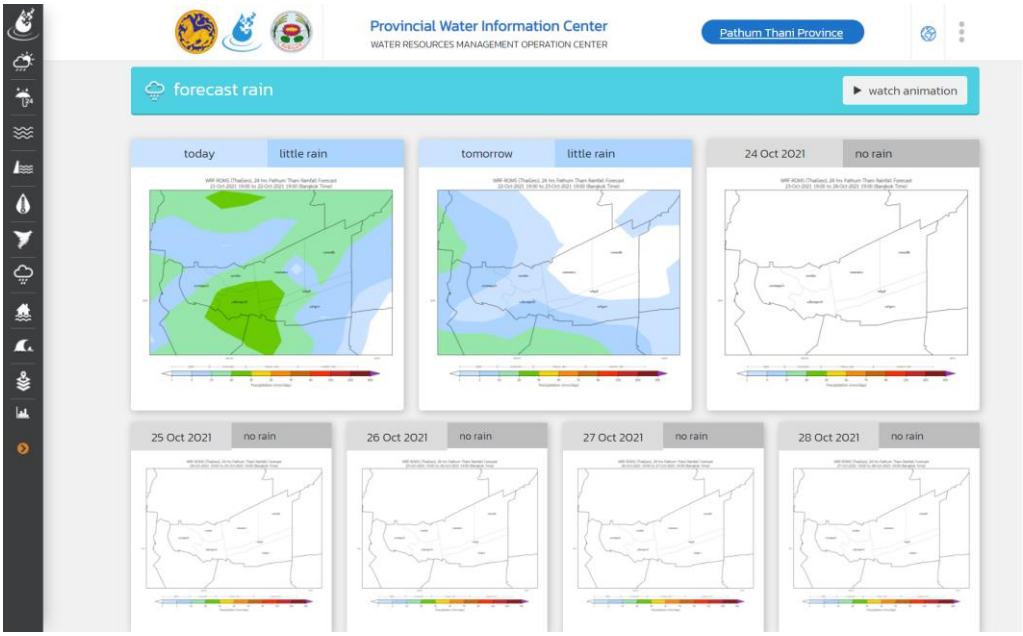

Figure 24. Dashboard of the 7-days rain forecasting

In future, HII plans to extend the ICT deployment of CCTV as part of the NBS workflow to monitor and evaluate our site during this wet season (for example, see Figure 25). This is part of data collection activities together with site visits and stakeholder consultation linked to the WP4. The tools for evaluation and maintenance developed by the WP4 will be used for this NBS site.

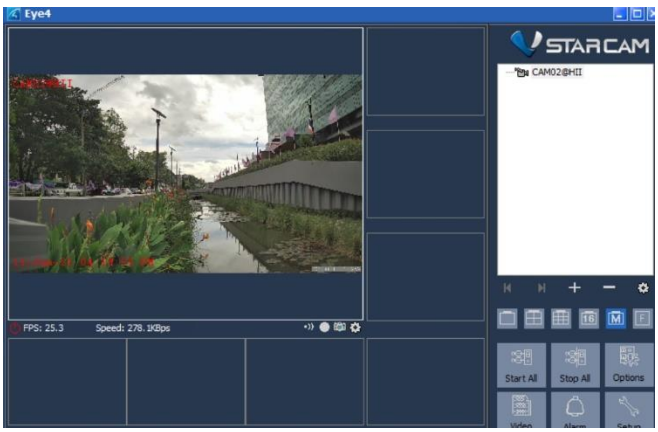

Figure 25. Example of CCTV image that will be implemented in the future for monitoring

Appendix A – Sensors connected to the TeleControlNet

Partner	Location code	Description	Sensor Type	Unit
DA3	080826-002	Fogars de la Selva (Can Simó)	Flow	m3/s
DA3	080826-002	Fogars de la Selva (Can Simó)	Precipitation	mm/h
DA3	080826-002	Fogars de la Selva (Can Simó)	Water level	cm
DA3	081379-001	Montseny (la Llavina)	Flow	m3/s
DA3	081379-001	Montseny (la Llavina)	Water level	cm
DA3	082021-001	Sant Celoni	Flow	m3/s
DA3	082021-001	Sant Celoni	Precipitation	mm/h
DA3	082021-001	Sant Celoni	Water level	cm
DA3	082845-001	Fogars de la Selva (Pont Eiffel)	Flow	m3/s
DA3	082845-001	Fogars de la Selva (Pont Eiffel)	Water level	cm
DA4	1	Mulini San Fruttuoso	precipitation	mm
DA4	1	Mulini San Fruttuoso	relative humidity	%
DA4	1	Mulini San Fruttuoso	temperature	c
DA4	1	Mulini San Fruttuoso	wind direction	deg
DA4	1	Mulini San Fruttuoso	wind speed	km/h
DA4	2	Mulino del Gassetta	precipitation	mm
DA4	2	Mulino del Gassetta	relative humidity	%
DA4	2	Mulino del Gassetta	temperature	c
DA4	2	Mulino del Gassetta	wind direction	deg
DA4	2	Mulino del Gassetta	wind speed	km/h
DA4	3	Portofino	precipitation	mm
DA4	3	Portofino	relative humidity	%
DA4	3	Portofino	temperature	c
DA4	3	Portofino	wind direction	deg
DA4	3	Portofino	wind speed	km/h
DA4	4	San Fruttuoso	waterlevel	cmmsl
DA4	5	Paraggi	waterlevel	cmmsl
DB1	DEVE	Deventer	Water level	cmnap
DB1	DOES	Doesburg brug	Water level	cmnap
DB1	IJSSEL	IJssel Marle	Depth	cm
DB1	IJSSEL	IJssel Marle	Electrical Conductivity	ms/cm
DB1	IJSSEL	IJssel Marle	Pressure	hpa
DB1	IJSSEL	IJssel Marle	Rugged Dissolved Oxygen	mg/l
DB1	IJSSEL	IJssel Marle	Rugged Dissolved Oxygen Saturation	%
DB1	IJSSEL	IJssel Marle	Temperature	c
DB1	IJSSEL	IJssel Marle	Turbidity	ntu
DB1	IJSSEL	IJssel Marle	Surfacewater Level (Wijhe)	cmnap
DB1	KAMP	Kampen	Water level	cmnap
DB1	KETD	Keteldiep	Water level	cmnap
DB1	OLST	Olst	Discharge	m3/s
DB1	OLST	Olst	Volume	m3
DB1	OLST	Olst	Water level	cmnap
DB1	WIJH	Wijhe	Water level	cmnap
DB1	ZUTP	Zutphen	Water level	cmnap
DB2	2.1	Runoff plot 1	ice cont. S1 TW	%
DB2	2.1	Runoff plot 1	water co. S1 TW	%
DB2	2.1	Runoff plot 1	density S1 TW	kg/m3
DB2	2.1	Runoff plot 1	SWE S1 TW	mmws
DB2	2.1	Runoff plot 1	C_LF S1 TW	pf
DB2	2.1	Runoff plot 1	C_HF S1 TW	pf
DB2	2.2	Runoff plot 2	ice cont. S2 TW	%
DB2	2.2	Runoff plot 2	water co. S2 TW	%
DB2	2.2	Runoff plot 2	density S2 TW	kg/m3
DB2	2.2	Runoff plot 2	SWE S2 TW	mmws
DB2	2.2	Runoff plot 2	C_LF S2 TW	pf
DB2	2.2	Runoff plot 2	C_HF S2 TW	pf
DB2	2.3	Runoff plot 3	ice cont. S3 TW	%
DB2	2.3	Runoff plot 3	water co. S3 TW	%
DB2	2.3	Runoff plot 3	density S3 TW	kg/m3
DB2	2.3	Runoff plot 3	SWE S3 TW	mmws
DB2	2.3	Runoff plot 3	C_LF S3 TW	pf

DB2	2.3	Runoff plot 3	C_HF S3 TW	pf
DB2	2.4	Runoff plot 4	ice cont. S4 TW	%
DB2	2.4	Runoff plot 4	water co. S4 TW	%
DB2	2.4	Runoff plot 4	density S4 TW	kg/m3
DB2	2.4	Runoff plot 4	SWE S4 TW	mmws
DB2	2.4	Runoff plot 4	C_LF S4 TW	pf
DB2	2.4	Runoff plot 4	C_HF S4 TW	pf
DB2	3	Rain gauge	Temp TW	c
DB2	3	Rain gauge	Feuchte TW	%rf
DB2	3	Rain gauge	Temp. ocm TW	c
DB2	3	Rain gauge	Temp. -10cm TW	c
DB2	3	Rain gauge	snow depth TW	cm
DB2	3	Rain gauge	Ubat TW	v
DB2	3	Rain gauge	Niederschlag TW	mm
DB2	3	Rain gauge	Niederschlagsintensität TW	mm/min
DB2	4	Discharge measurement large	Waage	ma
DB2	4	Discharge measurement large	Ultraschallpegel	mm
DB2	5	Discharge measurement small	Reserve TW	xx
DB2	5	Discharge measurement small	Reserve TW	xx
DB2	5	Discharge measurement small	Reserve TW	xx
DB2	5	Discharge measurement small	Reserve TW	xx
DB2	5	Discharge measurement small	Reserve TW	xx
DB2	z6-06738	Soil moisture sensor	Battery Percent	%
DB2	z6-06738	Soil moisture sensor	Battery Voltage	mv
DB2	z6-06738	Soil moisture sensor	Soil Temperature (40 cm)	c
DB2	z6-06738	Soil moisture sensor	Water Content (40 cm)	m3/m3
DB2	z6-06738	Soil moisture sensor	Soil Temperature (25 cm)	c
DB2	z6-06738	Soil moisture sensor	Water Content (25 cm)	m3/m3
DB2	z6-06738	Soil moisture sensor	Soil Temperature (15 cm)	c
DB2	z6-06738	Soil moisture sensor	Water Content (15 cm)	m3/m3
DB2	z6-06738	Soil moisture sensor	Soil Temperature (10 cm)	c
DB2	z6-06738	Soil moisture sensor	Water Content (10 cm)	m3/m3
DB2	z6-06738	Soil moisture sensor	Soil Temperature (5 cm)	c
DB2	z6-06738	Soil moisture sensor	Water Content (5 cm)	m3/m3
DB2	z6-06738	Soil moisture sensor	Reference Pressure	kpa
DB2	z6-06738	Soil moisture sensor	Logger Temperature	c
DB2	z6-06739	Soil moisture sensor	Battery Percent	%
DB2	z6-06739	Soil moisture sensor	Battery Voltage	mv
DB2	z6-06739	Soil moisture sensor	Soil Temperature (40 cm)	c
DB2	z6-06739	Soil moisture sensor	Water Content (40 cm)	m3/m3
DB2	z6-06739	Soil moisture sensor	Soil Temperature (25 cm)	c
DB2	z6-06739	Soil moisture sensor	Water Content (25 cm)	m3/m3
DB2	z6-06739	Soil moisture sensor	Soil Temperature (15 cm)	c
DB2	z6-06739	Soil moisture sensor	Water Content (15 cm)	m3/m3
DB2	z6-06739	Soil moisture sensor	Soil Temperature (10 cm)	c
DB2	z6-06739	Soil moisture sensor	Water Content (10 cm)	m3/m3
DB2	z6-06739	Soil moisture sensor	Soil Temperature (5 cm)	c
DB2	z6-06739	Soil moisture sensor	Water Content (5 cm)	m3/m3
DB2	z6-06739	Soil moisture sensor	Reference Pressure	kpa
DB2	z6-06739	Soil moisture sensor	Logger Temperature	c
DB2	z6-06740	Soil moisture sensor	Battery Percent	%
DB2	z6-06740	Soil moisture sensor	Battery Voltage	mv
DB2	z6-06740	Soil moisture sensor	Soil Temperature (25 cm)	c
DB2	z6-06740	Soil moisture sensor	Water Content (25 cm)	m3/m3
DB2	z6-06740	Soil moisture sensor	Soil Temperature (20 cm)	c
DB2	z6-06740	Soil moisture sensor	Water Content (20 cm)	m3/m3
DB2	z6-06740	Soil moisture sensor	Soil Temperature (15 cm)	c
DB2	z6-06740	Soil moisture sensor	Water Content (15 cm)	m3/m3
DB2	z6-06740	Soil moisture sensor	Soil Temperature (10 cm)	c
DB2	z6-06740	Soil moisture sensor	Water Content (10 cm)	m3/m3
DB2	z6-06740	Soil moisture sensor	Soil Temperature (5 cm)	c
DB2	z6-06740	Soil moisture sensor	Water Content (5 cm)	m3/m3
DB2	z6-06740	Soil moisture sensor	Reference Pressure	kpa
DB2	z6-06740	Soil moisture sensor	Logger Temperature	c
DB2	z6-06741	Soil moisture sensor	Battery Percent	%
DB2	z6-06741	Soil moisture sensor	Battery Voltage	mv
DB2	z6-06741	Soil moisture sensor	Soil Temperature (5 cm)	c
DB2	z6-06741	Soil moisture sensor	Water Content (5 cm)	m3/m3
DB2	z6-06741	Soil moisture sensor	Soil Temperature (10 cm)	c
DB2	z6-06741	Soil moisture sensor	Water Content (10 cm)	m3/m3

DB2	z6-06741	Soil moisture sensor	Soil Temperature (20 cm)	c
DB2	z6-06741	Soil moisture sensor	Water Content (20 cm)	m3/m3
DB2	z6-06741	Soil moisture sensor	Soil Temperature (40 cm)	c
DB2	z6-06741	Soil moisture sensor	Water Content (40 cm)	m3/m3
DB2	z6-06741	Soil moisture sensor	Soil Temperature (60 cm)	c
DB2	z6-06741	Soil moisture sensor	Water Content (60 cm)	m3/m3
DB2	z6-06741	Soil moisture sensor	Reference Pressure	kpa
DB2	z6-06741	Soil moisture sensor	Logger Temperature	c
DB2	z6-06742	Soil moisture sensor	Battery Percent	%
DB2	z6-06742	Soil moisture sensor	Battery Voltage	mv
DB2	z6-06742	Soil moisture sensor	Soil Temperature (45 cm)	c
DB2	z6-06742	Soil moisture sensor	Water Content (45 cm)	m3/m3
DB2	z6-06742	Soil moisture sensor	Soil Temperature (25 cm)	c
DB2	z6-06742	Soil moisture sensor	Water Content (25 cm)	m3/m3
DB2	z6-06742	Soil moisture sensor	Soil Temperature (15 cm)	c
DB2	z6-06742	Soil moisture sensor	Water Content (15 cm)	m3/m3
DB2	z6-06742	Soil moisture sensor	Soil Temperature (10 cm)	c
DB2	z6-06742	Soil moisture sensor	Water Content (10 cm)	m3/m3
DB2	z6-06742	Soil moisture sensor	Soil Temperature (5 cm)	c
DB2	z6-06742	Soil moisture sensor	Water Content (5 cm)	m3/m3
DB2	z6-06742	Soil moisture sensor	Reference Pressure	kpa
DB2	z6-06742	Soil moisture sensor	Logger Temperature	c
DB3	23.01	Egå, Jernbanebroen (Inlet)	Flow	l/s
DB3	23.01	Egå, Jernbanebroen (Inlet)	Volume	m3
DB3	23.01	Egå, Jernbanebroen (Inlet)	Water level	mdvr90
DB3	23.12	Egå, Lystrupvej	Water level	mdvr90
DB3	23.13	Egå, Egå Engsø (Outlet)	Flow	l/s
DB3	23.13	Egå, Egå Engsø (Outlet)	Volume	m3
DB3	23.13	Egå, Egå Engsø (Outlet)	Water level	mdvr90
DB3	I82RISSK2	Risskov	Precipitation (Forecast)	mm
DB3	I82RISSK2	Risskov	Air Pressure	hpa
DB3	I82RISSK2	Risskov	Air Pressure (Forecast)	hpa
DB3	I82RISSK2	Risskov	Air Temperature	c
DB3	I82RISSK2	Risskov	Air Temperature (Forecast)	c
EC1	EC1_01	Poda/Kamchia	Waterlevel	mmsl
EC1	EC1_02	Velichkovo/Kamchia	Waterlevel	mmsl
EC1	EC1_03	Dalgopol town	Waterlevel	mmsl
IC1	ATG081	Upper Dhammaraja Gate	Water level	mmsl
IC1	ATG082	Dhammaraja Gate	Water level	mmsl
IC1	ATG101	ATG101	Water level	mmsl
IC1	BKK002	Krung Thep 2	Water level	mmsl
IC1	BKK013	Rabibadhana Nong Suea	Water level	mmsl
IC1	BKK015	Lam Luk Ka Klong8	Water level	mmsl
IC1	CAN001	Rabibadhana West Section	Water level	mmsl
IC1	FROC01	Future Park Rangsit	Water level	mmsl
IC1	LK13	Liab Khlong 13	Humidity	%
IC1	LK13	Liab Khlong 13	Barometric Pressure	hpa
IC1	LK13	Liab Khlong 13	Precipitation 10 minutes	mm
IC1	LK13	Liab Khlong 13	Precipitation 1 hour	mm
IC1	LK13	Liab Khlong 13	Precipitation last 24 hour	mm
IC1	LK13	Liab Khlong 13	Precipitation day	mm
IC1	LK13	Liab Khlong 13	Solar Radiation	w/m2
IC1	LK13	Liab Khlong 13	Air Temperature	c
IC1	RSK7	Rangsit Khlong 7	Humidity	%
IC1	RSK7	Rangsit Khlong 7	Barometric Pressure	hpa
IC1	RSK7	Rangsit Khlong 7	Precipitation 10 minutes	mm
IC1	RSK7	Rangsit Khlong 7	Precipitation 1 hour	mm
IC1	RSK7	Rangsit Khlong 7	Precipitation last 24 hour	mm
IC1	RSK7	Rangsit Khlong 7	Precipitation day	mm
IC1	RSK7	Rangsit Khlong 7	Solar Radiation	w/m2
IC1	RSK7	Rangsit Khlong 7	Air Temperature	c