



STARS 4 Water

STARS4Water Metadata portal (final release)

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September 2026

STARS4Water Metadata Portal (Final Release)

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Summary

The project STARS4Water 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 and to develop services that will help water authorities cope with these changes and impacts. To this end, STARS4Water developed and unlocked data services for better supporting the decision making on planning on actions for adaptive, resilient and sustainable management of freshwater resources. Hydro-meteorological data, climate projections and socio-economic scenarios play an important role in the decision support. There is a vast amount of data available from online sources, but much of this is not used to its full potential.

Improving the findability and accessibility of existing and newly derived datasets has been an important project objective. This ‘unlocking of datasets’ is accomplished by the STARS4Water Metadata Portal, accessible through the STARS4Water website (<https://STARS4Water.openearth.eu/>). Following the three earlier releases of this portal in September 2023, 2024, and 2025, respectively, this report introduces the fourth and final release of the STARS4Water Metadata Portal. The changes and additions relative to the previous release are described, as well as the plans for continued development and maintenance after the funded period of the project.

An important change compared to the third release of the Metadata Portal (Beckers et al., 2025) is that the portal has migrated from the GeoNetwork foundation to a STAC (Spatio-Temporal Asset Catalog) implementation. STAC is a standard and a community of collaborators working to enable increased access to information about our planet. The focus of STAC is to make it as easy as possible for data providers to expose their data to the world. This migration was essential to integrate the Metadata Portal into the Deltares Data Platform infrastructure and enable future development and maintenance.

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1. Introduction

1.1. The STARS4Water project

The project STARS4Water (Horizon Europe No 101059372) 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 project has developed new data services and data-driven models for better supporting the decision making by water authorities for adaptive, resilient, and sustainable management of freshwater resources (Figure 1). Furthermore, STARS4Water has facilitated the access to and demonstrated the use of existing global datasets for climate studies.

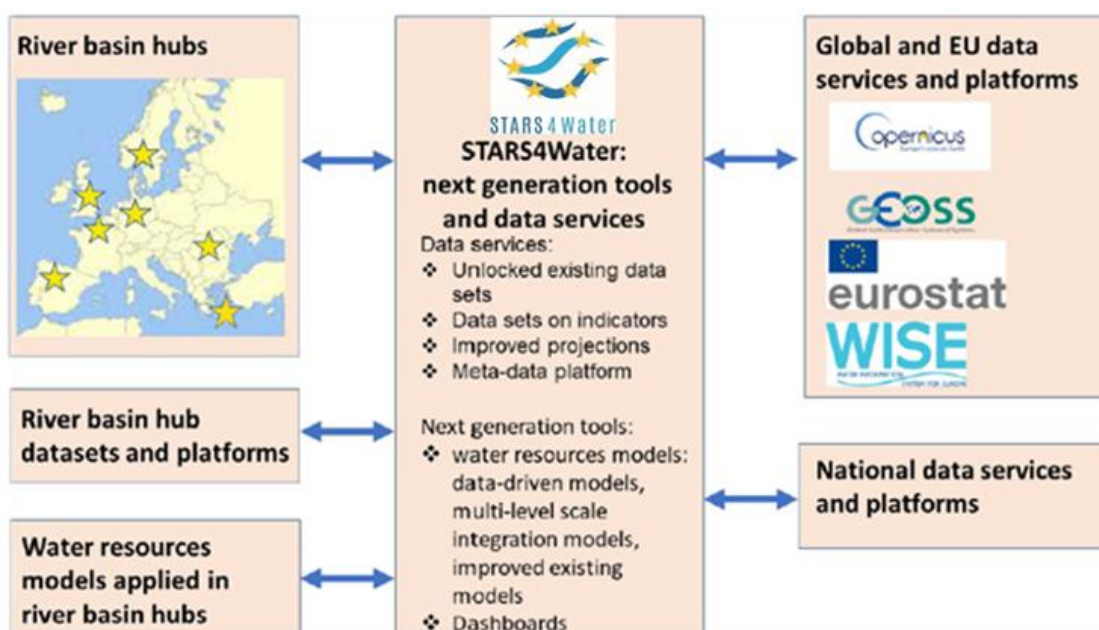


Figure 1. STARS4Water: developing next generation tools and data services.

Many global and local datasets are already used by river basin authorities to understand and manage their system. However, the STARS4Water project team believes that data utilisation can be improved. A vast amount of public geophysical, hydro-meteorological, and various other spatial data is produced each year, and river basin authorities often do not have the time to keep track of all new data sources and developments. Some available datasets therefore remain unknown to river basin authorities. Some datasets are difficult to access, or they do not come in a convenient format for application at the scale of the river basin. A Metadata Portal has therefore been developed to facilitate access to data sets and services from public sources, including earth observation, JRC activities and earlier EU research projects.

Moreover, data science techniques like machine learning have resulted in new modelling approaches and ways to combine data and generate new insights. STARS4Water builds upon these new technologies to develop data services and data-driven models, particularly with respect to water use by economic sectors and the impacts on water resources availability for ecosystems and water quality. STARS4Water is developing these data services and modelling tools in close consultation and collaboration with stakeholders from seven river basin hubs to meet their needs and to promote uptake of data services beyond the lifetime of the project. The river basin hubs serve as living labs for co-creation of data services and tools with stakeholder communities and as accelerators for further upscaling of these services and tools to other river basins worldwide.

1.2. WP2: Unlocking and improving data services

Work Package 2: “Unlocking and improving data services” is dedicated to collecting, managing, and providing access to existing and newly developed datasets. The work package has made an inventory of data services from earth observation (e.g. Copernicus, GEOSS), JRC activities, and other sources that are underexploited by public and private stakeholders in water resources planning. To facilitate access to these data sources and stimulate uptake by river basin authorities, Work Package 2 has also developed a Metadata Portal. This document reports on the final release of that Metadata Portal.

Work Package 2 has also demonstrated the use of global data sets for basin-scale climate change assessment, using climate indicators that quantify changes in climate risks and impacts for ecosystems, society, and water-dependent economic sectors.

As depicted in Figure 2, the new data services are input to the development of next generation models (Work Package 3) and assessment of future water resources availability (Work Package 4). After a review of existing observational systems and initiatives (Beckers et al., 2023), STARS4Water developed a Metadata Portal to facilitate data exchange (Schotmeijer et al., 2023).

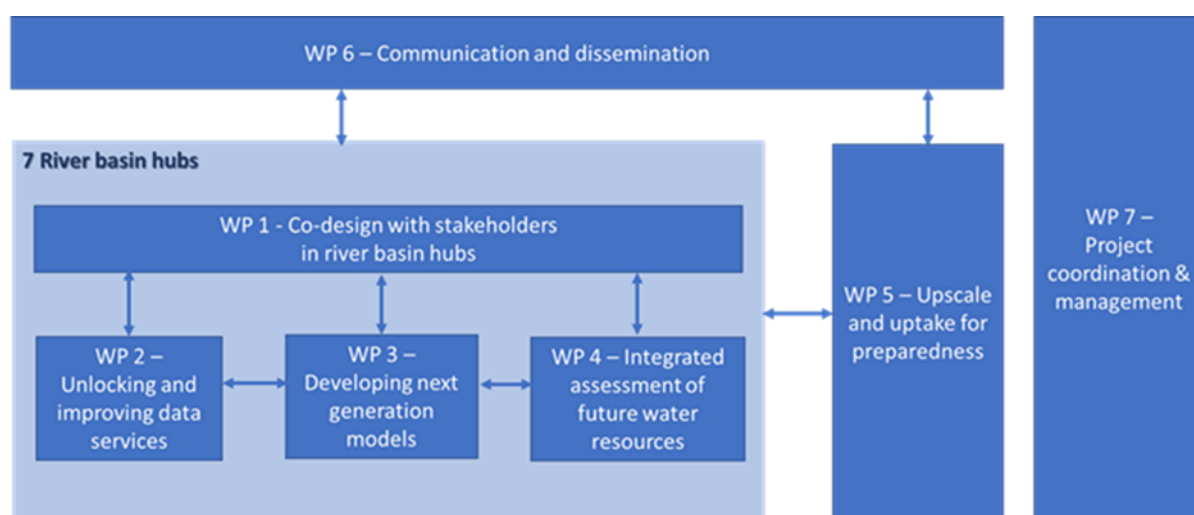


Figure 2. Work package structure of the STARS4Water project: unlocking and improving data services (WP2) as input for the development of the next generation models in WP3 and calibration and validation activities and integrated assessment of future water resources availability in WP4.

1.3. This report

This report describes the fourth and final release of this Metadata Portal. The purpose of the Metadata Portal is to unlock existing data services and information sources for water resources management, including new developments at EU and global level and lessons learnt from previous studies on data collection, data standards and unlocking data. Over the course of the STARS4Water project, more datasets have been added to the portal to add to its value as a central hub for finding relevant data for water resources management.

The Metadata Portal has been developed progressively throughout the STARS4Water project. Its first release, published in September 2023, provided access to metadata for approximately 200 global and local datasets (Schotmeijer et al., 2023). The second release, issued in September 2024, expanded the catalogue to over 430 datasets (Beckers et al., 2024). In the third release, the portal was further extended to include 460 datasets, including additional project-generated datasets and relevant external sources (Beckers et al., 2025). The following chapter presents the final release of the portal, describes the main changes compared with the third release, and outlines considerations for its continued development and sustainability.

2. The Metadata Portal principles

2.1. General approach

The development of the Metadata Portal is based on six principles that provide guidance during the development and configuration of the Metadata Portal:

- 1) Open-Source Environment.
Built on open standards and open-source technologies to promote transparency, sustainability, vendor independence, and broad community adoption.
- 2) Flexible by Design.
The portal can evolve with changing user needs, metadata requirements, and emerging technologies without requiring major redesign.
- 3) Modular Architecture.
Components and services are loosely coupled, enabling functionality to be added, replaced, or extended independently as requirements grow.
- 4) FAIR-Enabled Functionality.
The portal supports the FAIR principles by improving the Findability, Accessibility, Interoperability, and Reusability of data through rich metadata and standardised services.
- 5) Integrated Environment.
The portal connects seamlessly with existing data platforms, repositories, workflows, and tools, creating a coherent and efficient data ecosystem.
- 6) GeoDCAT-AP Compliant.
Standardised metadata enables interoperability, cross-platform discovery, and exchange of geospatial information across organisations, domains, and data portals.

The STARS4Water Metadata Portal is an *open* environment where everyone can access the metadata. In addition to its catalogue function, the Metadata Portal provides functionality to locate and access existing global and regional data sources; datasets derived from STARS4Water Task 1.3; river-basin-specific datasets; and project output datasets, such as data resulting from Task 2.3: Defining indicators for assessing climate risks and impacts on integrated water resources systems. Hence, metadata listed in the Metadata Portal meet the FAIR criteria: (meta)data must be Findable, Accessible, Interoperable, and Reusable (Wilkinson et al., 2016). It is important to mention that FAIR metadata does not imply FAIR data; the external datasets the Metadata Portal points to may not adhere to all FAIR principles.

2.2. General design of the framework

The Metadata Portal consists of technical and administrative components. Figure 3 provides a high-level architectural overview. The technical components are categorised as follows:

- 1) Metadata Portal: a catalogue solution combined with query functionality, allowing STARS4Water-relevant metadata to be stored, including, but not limited to, metadata for STARS4Water-generated data.
- 2) DOI environment: a solution to provide DOIs (persistent identifiers) for data generated by the STARS4Water project.

- 3) Storage environment: the environment where STARS4Water data are stored.
- 4) External data storage environments: locations where other data relevant to river basin management are hosted and made retrievable.

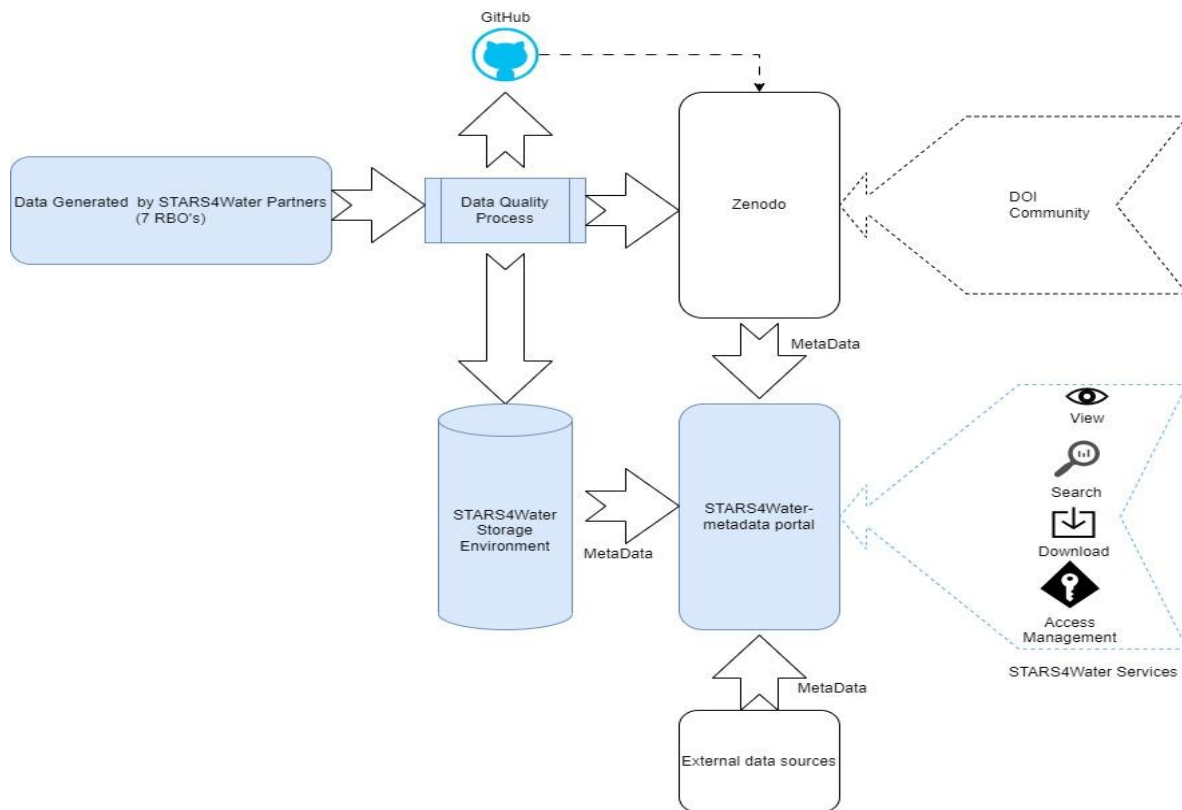


Figure 3. High-level architectural overview of the STARS4Water Metadata Portal.

The administrative (governance) component of the Metadata Portal is not explicitly represented in Figure 3. However, it is a critical element for ensuring the long-term sustainability and operation of the platform. Effective search, access, and reuse of datasets require a well-maintained metadata catalogue. The design and implementation of the STARS4Water metadata catalogue therefore follow the six design principles that underpin the project’s data management approach.

The first three releases of the Metadata Portal were implemented using the GeoNetwork catalogue platform (GeoNetwork Open Source, 2023). While GeoNetwork provided valuable functionality, particularly for harvesting and cataloguing existing public datasets, it did not fully meet the long-term sustainability requirements of the platform. As Deltares has committed to hosting, maintaining, and further developing the Metadata Portal beyond the project lifetime, alignment with its long-term digital infrastructure became an important consideration. Since GeoNetwork is not part of Deltares’ strategic digital infrastructure, the Metadata Portal was migrated to a STAC (Spatio-Temporal Asset Catalog) platform.

STAC is an open, widely adopted standard for describing and cataloguing geospatial assets through a common and interoperable framework. In addition to supporting human users, STAC enables machine-to-machine and AI-driven access to geospatial data, making datasets more discoverable and accessible through modern applications and intelligent agents. Further information on the STAC specifications, tools, and community is available at <https://stacspe.org/en/>. As a result, the STARS4Water Metadata

Portal is well positioned to remain operational beyond the project lifetime. Data providers can continue to contribute new datasets, while end users will retain the ability to efficiently search, discover, and access relevant data resources in the years ahead.

To ensure persistent storage and long-term accessibility of project-generated datasets, STARS4Water promotes the use of Zenodo (<https://zenodo.org/>) as both a data repository and DOI provider. Zenodo is a free, open-access research repository, operated by CERN Data Centre, that enables researchers to share, preserve, and cite digital research outputs from any scientific discipline. By assigning Digital Object Identifiers (DOIs), Zenodo ensures that datasets remain permanently accessible and citable. All data-related deliverables and datasets generated within the STARS4Water project are therefore hosted on Zenodo to support transparency, reproducibility, and long-term data stewardship.

2.3. Web interface

The web interface of the STARS4Water metadata portal is shown in Figure 4. Users can navigate the portal's interface through a multi-faceted search system that organizes datasets by spatial domains, standardized topics, and detailed keywords. When searching for specific data—such as river basin indicators, hydrological projections, or soil and climate assessments—users can enter free-text query terms into a central search bar or apply structured filters along the side panel. Filtering by thematic topics (such as hydrology, inland waters, or climatology) narrows down results to broad scientific fields, while selecting refined keywords or sub-domains isolates localized datasets and specific variables like soil parameters or regional catchment metrics. Each search entry presents a detailed metadata card outlining dataset coverage, methodology, source links, and download capabilities, allowing river basin organizations, researchers, and stakeholders to quickly evaluate and access relevant spatial data.

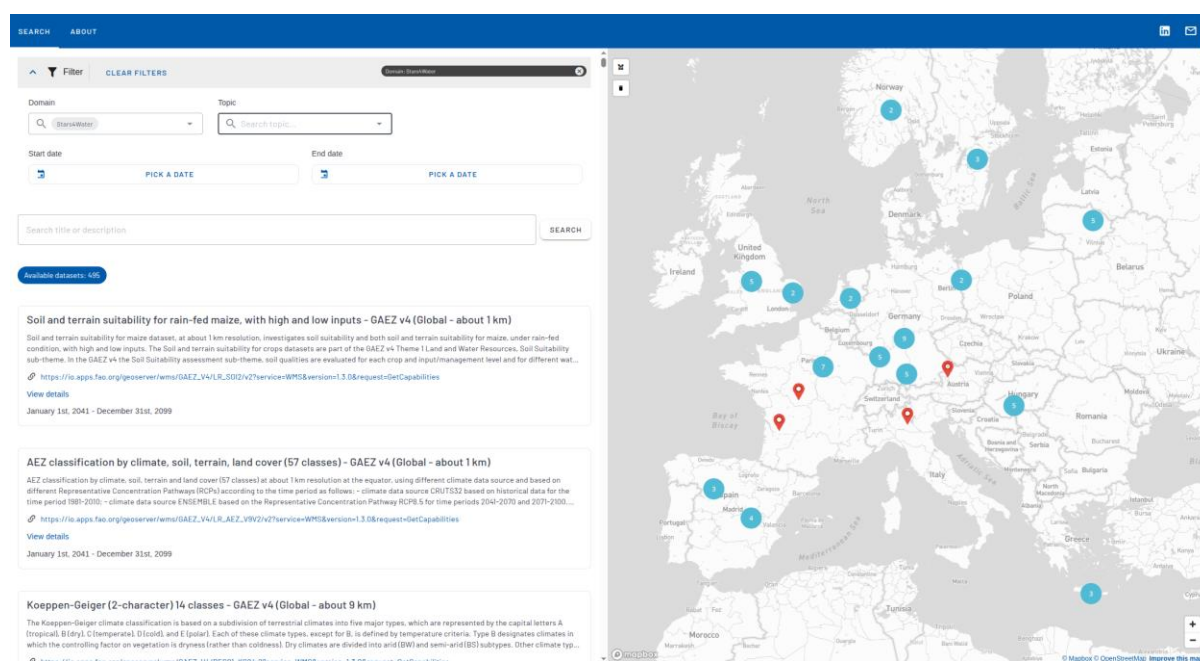


Figure 4. STARS4Water Metadata Portal web interface.

3. The Updated Metadata Catalogue

3.1. Current content of the Metadata Catalogue

The first release of the Metadata Portal, launched in 2023, contained metadata describing approximately 200 existing data sources identified and catalogued through WP2.1 (Beckers, 2023). Over the course of the project, the Metadata Portal was continuously expanded with metadata from additional sources, including datasets identified through targeted web searches, river basin datasets collected by project partners, and datasets generated within the STARS4Water project itself. By the final release in September 2026, the Metadata Portal contained metadata records for 495 datasets, including metadata records from STARS4Water output datasets (Annex 1).

A topic classification serves as a practical filtering mechanism, enabling users to quickly identify datasets relevant to their area of interest and improving the overall discoverability of data resources within the portal. The classification encompasses a broad range of thematic domains, including geography, climate, hydrology, land use, governance, population, agriculture, and related topics. By organizing datasets into clearly defined categories, users can more efficiently navigate the portal and access the information most relevant to their needs.

The steady growth demonstrates the portal's role as a central entry point for water-related data and highlights the project's efforts to improve data accessibility, interoperability, and reuse across different river basins and stakeholder communities.

The information about datasets in the Portal originate from several sources:

- Metadata collected in STARS4Water Task 1.3: River-basin-specific datasets, collected through a survey.
- Metadata collected in STARS4Water Task 2.1: Review of existing observational systems and initiatives (Beckers, 2023).
- Datasets that were generated by the STARS4Water project listed in the STARS4Water Zenodo Community (<https://zenodo.org/communities/stars4water/>).
- Metadata that were collected by the STARS4Water 'sister project' SOS-Water (<https://www.sos-water.eu/>). SOS-Water made a similar inventory of global data that are relevant to water resources management. The results of that inventory were shared with the STARS4Water project team and several datasets that were missing in the STARS4Water inventory were added to the portal.
- Metadata were also harvested directly from the United Nations Food and Agriculture Organization (FAO) and from World Soil Information (ISRIC) repositories, enriching the Metadata Portal with many national and international datasets, including datasets beyond Europe.

3.2. Enhanced Findability

To improve findability, datasets are assigned to thematic topics. The current catalogue includes 75 topics that can be used to classify datasets and support more targeted search and filtering.

In addition to topics, datasets can also be labelled by domain. In the September 2026 version, one domain is available: “STARS4Water”. This domain identifies datasets that are relevant to the objectives of the STARS4Water project. More domains can be added in the future to collect metadata for a specific context. Datasets can be shared between domains or kept to a single domain.

Besides text-based search using topics and domains, users can also apply map-based search to find datasets for a specific geographical area by drawing a polygon on the map. The map indicates how many datasets are available within a selected geographic area. When multiple datasets are found in the same location or in nearby locations, they are grouped in a blue circle that shows the number of datasets available in that area (see Figure 5). When the user selects one of the datasets, a metadata panel opens with detailed information about the dataset (see Figure 4). The metadata includes information about the spatial extent, format, terms of use and DOI.

3.3. Hosting and maintenance

Deltares will be hosting and maintaining the STARS4Water Metadata Portal at least until the end of 2031. Being a part of the Deltares digital infrastructure, additional functionality will be added to the portal as it becomes available to the overall infrastructure (see Chapter 4).

Metadata for new datasets can continue be added to the portal in the coming years. Data owners wishing to include metadata of their data sets in the Metadata Portal are invited to contact the hosting organisation (Deltares) through the contact form of the STARS4Water project <https://stars4water.eu/contact/> and provide preliminary details on the nature and number of datasets. Request will be reviewed periodically by the portal team. Once a request is approved, data owners will receive a metadata template together with instructions for completion. To illustrate the information currently required, the metadata fields included in the template are presented in Annex 2.

In the future, the intention is to automate the process of adding new metadata as much as possible. Metadata quality control will be partly automated, while still including review by data experts where needed.

Risk of ecological impacts due to flow alteration in the Seine river catchment, under future climate scenarios and reservoir management strategies

ID: 967f900c-4f15-5589-99ec-6df87064fb94

See supporting file

S4W_ERFA_Seine_ReadMe.txt, found at 10.5281/zenodo.21997573 (DOI)

Geometry



Assets

data

CSV

<https://zenodo.org/records/21997573>

[OPEN](#)

text/csv

Properties

Status existing

License CC BY-NC-SA 4.0

Language en

Deltares:doi 10.5281/zenodo.21997573

Deltares:topics

Deltares:cite_as Laize, C., Crapper, Z. (2026). Future ecological risk due to river flow alteration in the Seine river catchment, including the effect of future reservoir management scenarios (Version 1)[Data set]. Zenodo. <https://doi.org/10.5281/zenodo.21997573>

4. Conclusion

4.1. Release of the final version

The STARS4Water Metadata Portal currently lists metadata of 495 datasets. The Portal can be accessed at <https://stars4water.openearth.eu>. It contains a README section with basic information about the use of the portal. A tutorial about the portal is available in the STARS4Water Academy (<https://stars4water.eu/the-stars4water-academy/>).

The Metadata Portal has already proven to be a valuable source of information for water managers and other stakeholders. Since its first release, the portal has attracted more than 350 visitors, demonstrating a growing interest in accessible and well-organized water-related data resources. Feedback received from stakeholders further confirms the portal's value, highlighting its usefulness in identifying relevant datasets, supporting evidence-based decision-making, and improving access to information across different thematic domains.

4.2. Maintenance and future development

Deltares will be hosting and maintaining the STARS4Water Metadata Portal at least until the end of 2031. The STARS4Water Metadata Portal is integrated into the Deltares data infrastructure services. This supports its future sustainability and enables cross-fertilisation: feedback from STARS4Water users can be used to improve the Deltares data infrastructure, while improvements to the Deltares infrastructure can also benefit the STARS4Water portal.

Hosting the STARS4Water Metadata Portal provides several strategic benefits for Deltares. The portal strengthens its position as a trusted provider of water and climate information services and extends the institute's digital infrastructure with a sustainable, FAIR-compliant data discovery platform. By integrating the portal within its long-term digital ecosystem, Deltares can preserve the value of investments made through STARS4Water, support future research and innovation activities, and facilitate continued collaboration with European water management organisations and research institutions. Furthermore, the adoption of STAC enables machine-readable and AI-driven data discovery, ensuring that the platform remains aligned with emerging developments in data science and digital water management. As a result, the Metadata Portal serves not only as a legacy of the STARS4Water project but also as a strategic asset that supports Deltares' future data, research, and innovation ambitions.

New releases of the Metadata Portal are expected, although no timeline can be given yet. Deltares will design a maintenance and development plan when the Portal is handed over to Deltares after the closure of the project. Additional functionality regarding the front-end of the portal is specifically foreseen and will be prioritised based on user feedback. In particular, improving the ability to drill down into search results in an intuitive and effective way will be a key focus for the next release.

Improvements to the Metadata Portal will be developed within the same codebase, with a dedicated STARS4Water fork where project-specific adaptations are required. Further harmonisation with the Deltares data infrastructure and alignment with the Deltares release schedule is foreseen.

Hence, the integration of the STARS4Water Metadata Portal into the Deltares data infrastructure provides a sustainable basis for long-term maintenance and further development. Future improvements will build on the shared codebase, while allowing project-specific adaptations where needed and ensuring alignment with Deltares infrastructure requirements and release planning.

References

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Beckers, J., Schotmeijer, G.J., & G. Hendriksen (2025): Third release of the STARS4Water Metadata Portal. Horizon Europe project STARS4Water. Deliverable D2.7

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Wilkinson, M., Dumontier, M., Aalbersberg, I. et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data 3, 160018 (2016). <https://doi.org/10.1038/sdata.2016.18>

Annex 1: STARS4Water output datasets.

The STARS4Water output datasets are publicly available through the persistent identifiers/ links. All datasets are stored in data repository Zenodo. The metadata have been reviewed (QA).

Title/Description	PID
Discharge simulations for the Seine river catchment: the influence of the calibration strategy for projections with a semi-distributed model	10.5281/zenodo.18709621
Future ecological risk due to river flow alteration for the STARS4Water river basins	10.5281/zenodo.15190625
Ecological risk due to future flow alteration across the 7 European STARS4Water river basins for 56 climate and hydrological model ensemble combinations	10.5281/zenodo.21670346
Historical and future water demand for households and industry for the STARS4Water river basins	10.5281/zenodo.14252776
ConvLSTM-based Daily Snow Water Equivalent (SWE) Predictions in US (Rocky Mountains)	10.5281/zenodo.22238156
Discharge simulations for the Seine river catchment, scenarios to analyse the future of low-flows and reservoir management	10.5281/zenodo.17632107
ConvLSTM-based Daily Water Table Depth (WTD) Predictions over Europe	10.5281/zenodo.21406014
Future ecological risk due to river flow alteration in East Anglia, UK using CS-NOW projected river flow data as part of STARS4Water	10.5281/zenodo.21646744
ConvLSTM-based Daily Snow Water Equivalent (SWE) Predictions in the Norway	10.5281/zenodo.21291951
Groundwater vulnerability to agricultural contamination in the Duero River basin	10.5281/zenodo.21293759
Future ecological risk due to river flow alteration in East Anglia, UK using E-FLAG projected river flow data as part of STARS4Water	10.5281/zenodo.21649392
GWAI_duero	10.5281/zenodo.18299839
Gridded dataset for groundwater storage estimation in the Duero using a Deep Learning model	10.5281/zenodo.21642181
ConvLSTM-based Daily Water Table Depth (WTD) Predictions over Central Europe (Parflow DE06 domain)	10.5281/zenodo.20703031
ConvLSTM-based Daily Snow Water Equivalent (SWE) Predictions in the Drammen River Basin	10.5281/zenodo.20702459
Future ecological risk due to river flow alteration in the Drammen river catchment	10.5281/zenodo.22233710
ConvLSTM-based Daily Snow Water Equivalent (SWE) Predictions in the Alps	10.5281/zenodo.21257584
RIBASIM-Simulated Danube River Discharge under Reference and "What-If" Scenarios	10.5281/zenodo.21281935

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Historical and future irrigation water demand for the STARS4Water river basins	10.5281/zenodo.14246228
Historical and future land use and land cover data for the STARS4Water river basins	10.5281/zenodo.14246388
STARS4Water precipitation deficit for selected river basins in Europe	10.5281/zenodo.15240491
STARS4Water climate indicators - tier 1	10.5281/zenodo.15599187
LSTM and RF models to estimate monthly water table depth anomalies in the Seine river basin	10.5281/zenodo.20701987
Maps of irrigated area of the Rhine basin developed in the research "Identifying irrigated areas using land surface temperature and hydrological modelling: Application to Rhine basin"	10.4121/66647538-ed17-4dd2-9af8-962ed0c61177.v3
ConvLSTM model to predict daily snow water equivalent in the Drammen river basin	10.5281/zenodo.20702458
Data underlying the research of: Improving realism of high-resolution hydrological modelling with anthropogenic water use: a study on the Rhine basin	10.4121/1a382dde-616e-4894-a4b2-222ec45a8a5d.v1
Gauge-adjusted ERA5 Monthly Precipitation and Temperature data for Messara Basin, Crete, Greece	10.5281/zenodo.17130555
Risk of ecological impacts due to flow alteration in the Seine river catchment, under future climate scenarios and reservoir management strategies	10.5281/zenodo.21997573
ConvLSTM-based Daily Water Table Depth (WTD) Predictions in USA	10.5281/zenodo.22237372

Annex 2: STARS4Water Metadata Form

Category	Specified category	mandatory (V = yes, C = conditional)
Information about the source	Title of the source	V
	Date of the source	V
	Date type of the source	V
	Unique Identifier of the source.	C
	Summary	V
	Status	V
	Language of the source	V
	Subject	V
Responsible organization source	Organization	V
	E-mail	V
	Roll	V
Keywords	Keyword	V
Limitations	Legal access restrictions	V
	Usage restrictions	V
Spatial information source	Spatial schedule	C
	Resolution	C
	Spatial reference system	V
	Contiguous rectangle	V
	West	C
	East	C
	North	C
	South	C
Distribution format	Version	C
Distribution	URL	C
Quality information	Level quality description	V
	General description origin	V
Information about the metadata	Metadata unique identifier	V
	Metadata date	V
	Language of the metadata	V
	Hierarch level	V
Responsible organization metadata	Organization	V
	E-mail	V
	Roll	V
Metadata standard	Name metadata standard	V
	Version metadata standard	V

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Below not ISO but applicable to STARS4Water (IN PREVIOUS VERSION dmp)	Alternate Identifier (with type sub-property)	C
	Related Identifier (with type and relation type sub-properties)	C
	Related Identifier Type	C
	Format	C
	Cite as	C
	Data update frequency	C

