Good practices of digital solutions for information sharing to support water governance

GOVAQUA WP5 Good practice inventory

Deliverable 5.2

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Contents

Summary

To enable sustainable water management and governance across Europe and support implementation of water policies and strategies, continued improvement of digital solutions that provide trusted, relevant, accessible, and timely information is required. With growing pressures on Europe's water bodies due to climate change and rising cross-sectoral demands on water resources, such information is increasingly needed by a wide range of actors from local to EU level.

As part of the *Governance innovations for a transition to sustainable and equitable water use in Europe* (GOVAQUA) project, this report presents end user perspectives on five good practices that respond to different water issues and stakeholder needs in water governance. The identification of these good practices builds upon the "Review of digital solutions for information sharing" (Deliverable D5.1) which includes over 200 digital tools and solutions. The earlier deliverable provided an analysis of 20 selected cases using the GOVAQUA digital solution assessment framework. In this report, additional criteria were applied to further select practices to be highlighted and to ensure relevance to a range of European water governance contexts and issues. To gain further insights into the effectiveness, efficiency, inclusivity, and scalability of the good practices selected, a mixed-method approach was adopted to complement the initial findings based on the digital solution assessment framework: in-depth exploration of the content of the digital solution, and interviews with end users.

Good practices Riverfly Partnership (UK) and Guadalquivir SAIH (Spain) illustrate the increasing importance of citizen based and individual business (agronomic) based monitoring of water bodies to either supplement regulatory authorities statutory ecological monitoring and reporting for policies such as the Water Framework Directive (Riverfly Partnership), or as part of wider authority-based monitoring of water resources (SAIH).

Good practices Copernicus Emergency Management Service (EU and global) and Destination Earth (EU and global) provide insights into a long term (CEMS-EFAS) and more recent (Destination Earth) European Commission funded initiatives to provide trusted, relevant, accessible, and timely data that is increasingly demanded by a wider range of actors from the local to EU level on water related risks that society faces.

Good practice Water Risk Filter (EU and global) shows how a leading international NGO (WWF) is engaging private companies to meet their information needs in support of water governance.

Our focus is on understanding how the data and digital aspects of these practices are central to the collaborative processes of how individuals and organisations contribute to the collection, use, and continued improvement of these information flows to meet their needs. These practices have been designed and adapted to support a diverse range of water governance situations. Thus, the end users' needs and perspectives across them differ greatly. The documented practices illustrate and validate existing tools and provide innovative ideas for national and basin level water managers and other decision makers and actors in water governance.

Along this process, we have identified three key fundamentals that contribute to the success of digital tools in supporting water governance. First, continuous engagement to understand end user needs is essential. Second, transforming data into information is central to these practices, as they are designed to collect, process, store, and enable use of data. Third, to design, operate, and continually improve these digital solutions for information sharing requires significant financial investment to pay for the social and digital components.

1. Introduction

Improving the sustainable management and governance of water at local, basin and national levels is a core objective of major European and international policies, including the European Water Framework Directive (WFD)[1], the European Green Deal (EGD)[2], and the United Nations Sustainable Development Goals (SDGs)[3]. These policies call for transformative changes in how water is managed and governed to transition to a more sustainable and equitable future. Increased understanding of Europe's sustainable use of water and associated risks requires awareness of societies needs for information related to water resources and the improvements in data collection including environmental monitoring, near-real time data processing, and access to relevant actors (Quaranta *et al.,* 2023). Digital solutions for information sharing to support water governance are at the heart of the enabling action areas for a water resilient Europe through the European Water Resilience Strategy[4]. In particular, the strategy highlights 'Digitalisation and artificial intelligence to accelerate and simplify sound water management' and the flagship actions: Development and implementation of Destination Earth, development of an EU-wide action plan on digitalisation in the water sector and launch of a Copernicus Water Thematic Hub.

The primary objective of the GOVAQUA project is to identify, assess, develop, and validate innovative water governance approaches that promote a transition toward sustainable and equitable water use across Europe. By examining a broad range of governance innovations, the project aims to evaluate their adaptability and generate practical knowledge, tools, and guidelines that support sustainable and equitable water use across sectors. The overarching goal is to accelerate the shift toward more sustainable water management by identifying key innovations in governance approaches, models, and instruments. The project addresses the systemic changes needed for this transition through four key focus areas:

- Legislation and regulation
- Multi-stakeholder participation and collaboration
- Economics and finance
- Digital solutions for information sharing

Good practices in each of these areas are being systematically reviewed, analysed, and compared in work packages 2 to 5. They are co-developed, tested, and validated with key stakeholders in six Living Labs located in river basins, sub-basins, and catchments in France, Finland, Spain, UK, and Romania, as well as in a transnational context between Finland and Sweden.

The specific objectives of the work package on "Digital solutions for information sharing" (WP5) are:

- Identify the current digital solutions at a range of scales to enable the use/uptake/deployment of different types of information required to support sustainable water governance. Such information may include environmental observations, financial data and tools, and legislative requirements. (Task 5.1). The digital solutions identified will include tools from the legal and regulatory theme (WP2), participatory approaches such as citizen science (WP3) and tools related to economic and financial aspects of water governance (WP4). The results were reported in D5.1.

[1] Water Framework Directive 2000/60/EC (WFD) http://data.europa.eu/eli/dir/2000/60/oj
[2] European Green Deal https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
[3] UN Sustainable Development Goals https://sdgs.un.org/goals
[4] European Water Resilience Strategy COM/2025/280 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0280

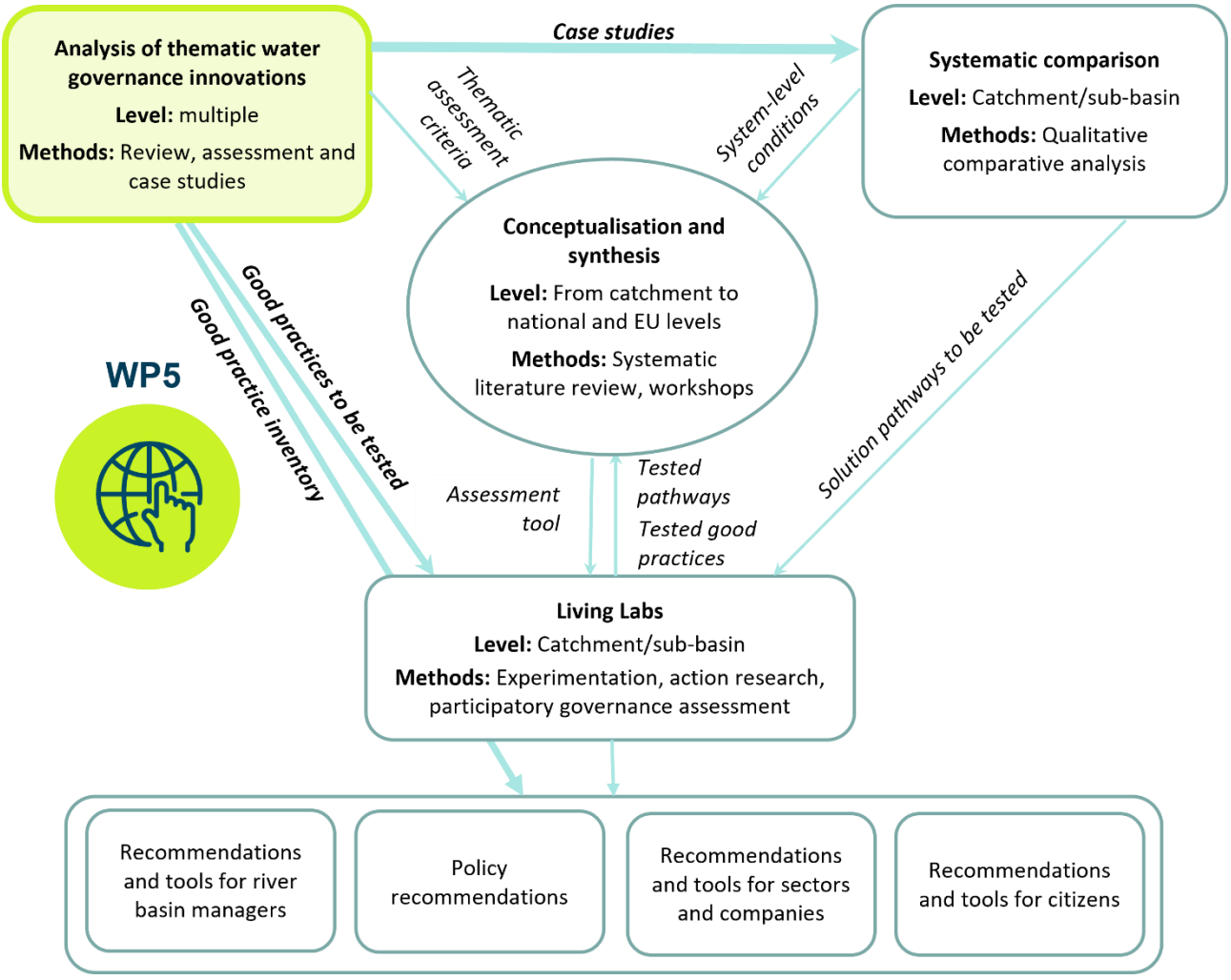

Figure 1. Positioning of WP5 and this report in the overall framework of the GOVAQUA project.

- Review and assess digital tools (Task 5.1) and data sharing (Task 5.2) between organisations and multiple stakeholders. The tools reviewed will cut across the thematic WPs 2-4. The digital solution assessment framework will be used to inform relevant parts of the assessment framework and the Qualitative Comparative Analysis developed in WP1.
- Develop two exemplar innovative tools (Task 5.3) for bringing multistakeholder data together to improve water governance. These two new tools will be applied and assessed within two Living Labs (WP6) to demonstrate the potential for data and digital solutions to underpin new governance models and will build on learning from the reviews of existing digital solutions.
- Provide recommendations on enhancing the use of digital for transition to sustainable and equitable water use in Europe (Task 5.4).

The approach adopted within WP5 and this deliverable feeds directly into the GOVAQUA methodological approach as illustrated in Figure 1.

The main aim of this report is to present a set of exemplar good practices related to Digital solutions for information sharing at multiple levels in water governance. The selection of good practices builds upon the review established in D5.1 "Review of digital solutions for information sharing" where over 200 digital tools and solutions were reviewed for their effectiveness to support water governance through information sharing (see 2.3 for further details). Through researching a broad range of operational digital solutions from an end user perspective our report provides new insights into the commonalities and challenges of establishing and maintaining digital solutions for ensuring a water resilient Europe.

Advancing social and digital innovations and scaling up proven good practices in water governance are essential to accelerating this transition (Garcia *et al*., 2024). Garcia *et al*. (2024) reported on the development of a digital evaluation tool for water governance integrated in the WATERMED platform to improve water use efficiency in agriculture. Their approach was based on the OECD Water Governance Indicator Framework[5]. In their discussion, they argued for a "new paradigm in the evaluation and governance of natural resources, such as water use in agriculture" due to the digital transformation of society. The EU-funded DSI4EU (Digital Social Innovation for Europe)[6] project ran between 2013 and 2019 to support the growth of digital social innovation. The project aims included "Harness digital technologies to improve lives and reorient technology towards more social ends" and "Empower citizens to take more control over their lives, and to use their collective knowledge and skills to positive effect".

This report is organised into four chapters. Chapter 1 provides a brief overview of the GOVAQUA project and introduces the content of this report. Chapter 2 details the method applied to compile and analyse the good practices. Chapter 3 provides a description of the good practices selected as part of "Digital solutions for information sharing". These are listed in Table 1. Finally, Chapter 4 provides our conclusions. For each good practice, an indication of the geographical applicability and level of water governance is provided to illustrate commonalities and differences in spatial extent the practice is applied at and the level of water related decision making (Table 1).

Table 1. Overview of all the good practice cases.

Name of the good practice	Type of innovative practice	Geographical applicability	Level of water governance
Riverfly Partnership (UK)	Citizen science network	National	Catchment
Copernicus Emergency Management Service	Disaster awareness	National, EU, Global	Catchment
Guadalquivir SAIH: Hydrological Information System (Spain)	Hydrological platform	Catchment, National	Catchment, River Basin District
WWF Water Risk Filter	Corporate tool	National, EU, Global	Catchment
Destination Earth: digital twins	Platform	National, EU, Global	Catchment, National

[5] OECD Water Governance Indicator Framework https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/water-governance/oecd_water-governance-indicator-framework_en.pdf
[6] Digital Social Innovation https://www.nesta.org.uk/project/digital-social-innovation/

2. Methodology

2.1 Good practice definition

A good water governance practice in the GOVAQUA project is defined as:

A good water governance practice exemplifies an innovative instrument, approach or arrangement that contributes to achieving water-related policy goals and targets in a sustainable and equitable manner. It has been tested in practice, assessed and validated by stakeholders and independent evaluators in a specific context against specific principles and criteria.

Water governance good practices originate from certain contexts and are tied to the water issues of that context. These contexts include political, geographical, socio-economic, cultural and hydrological aspects. Therefore, they entail certain prerequisites from their implementation environment. Thus, broadly applicable "best practices" for water governance cannot be discerned[7]. However, within implementation of good practices different performance levels can be achieved, typically requiring different levels of effort and resources, building on a continuous improvement.

The good practices documented in the GOVAQUA project under "digital solutions for information sharing" are examples of successful innovations that are transferrable and scalable in the EU context. The difference of this good practice documentation to the "macro level" water governance assessments, initiated e.g., by the OECD and the self-assessment tool developed in the GOVAQUA project, is that the focus of the good practice is at a "micro level", on an instrument, approach or arrangement, rather than the broader water governance context such as a nation or a basin.

The documented good practices are primarily intended to illustrate and validate existing practices and to provide innovative ideas for national and basin level water managers and other decision makers in water governance. The practices are also relevant to other water governance actors, such as NGOs, companies and research institutes that initiate or participate in water governance processes.

2.2 Good practice criteria

General criteria for good water governance practices applied here have been adapted from the 12 OECD water governance principles (OECD 2015)[8]. The full list of criteria developed for the purposes of the GOVAQUA project can be found in Annex I. Whilst the criteria aim to be comprehensive, they are not equally relevant for all innovative instruments, approaches and arrangements assessed but can be

[7] Note: For example, the recent OECD *Handbook of What Works Solutions for the Local Implementation of the OECD Principles on Water Governance* (OECD 2024) only makes reference to "evolving water governance practices" that "respond to the challenges underlying each of the 12 (OECD Water Governance) Principles", drawing lesson from "successful" and "challenging" implementation examples. Nevertheless, OECD generally advances identification of "good water governance" practices.

[8] Original principles: effectiveness (clear roles and responsibilities, appropriate scales within basin systems, policy coherence, capacity); efficiency (data and information, financing, regulatory frameworks, innovative governance); and trust and engagement (integrity and transparency, stakeholder engagement, managing trade-offs, monitoring and evaluation) (OECD 2015).

weighted. For each good practice, additional detailed criteria regarding the type of the innovation, i.e., legal and regulatory, participatory and collaborative, economic and financing or digital solutions, can be applied. Furthermore, we expect that most good practices do not fulfil all the criteria, or at least not all at the same time. For the practices documented by GOVAQUA factors concerning challenges in meeting the criteria are also reported.

In the case of digital solutions for information sharing the following criteria have been applied:

Effectiveness

1. Address a problem or a need related to sustainable and equitable water use
2. Connect and contribute to water-related policy goals and targets
3. Define and follow clear roles and responsibilities for different stakeholders
4. Are linked to appropriate scales within basin or other water governance systems
5. Match or advance the level of technical, financial and institutional capacity in the given water governance system

Efficiency

1. Utilize, share and enhance adequate water-related data and information
2. Are cost-effective and/or help mobilizing financing for associated water solutions
3. Connect to and advance sound regulatory frameworks

Inclusivity and reflexivity

1. Are built on or advance transparent and accountable processes and outcomes
2. Are built on or advance equal participation and collaboration between stakeholders and water justice, and are gender-sensitive
    a. Recognise the different types of stakeholders and their different needs
    b. Equally distribute the benefits, harms and costs that result from the practice among different stakeholders, and address and resolve trade-offs and potential conflicts between users
    c. Involve different stakeholders and integrate their different types of knowledge into the decision-making process
3. Include and advance regular monitoring and evaluation mechanisms

2.3 Data gathering, analysis and assessment

The identification of good practices builds upon the findings of Task 5.1 (Deliverable D5.1 'Review of digital solutions for information sharing'). This previous report was comprised of two main components:

- a non-exhaustive inventory of digital tools and solutions for information sharing to support water governance: this inventory covered a review of over 200 tools and encompassed the diversity of tools (legal, finance and participation), geographical scale (from catchment to global) and the multi-sectorial aspect of water governance (perspective and inputs from diverse sectors).
- a user-friendly and intuitive digital solution assessment framework: it was designed to systematically evaluate the digital tools effectiveness and comprised 4 main criteria: Transparency

and Accountability, Serving the purpose of water governance, Contextual Information, and Inclusivity.

A sub-set of these tools (around 20), selected in collaboration with project partners, were systematically assessed using the digital solution assessment framework to constitute a set of case studies. This approach provided an initial insight in terms of identifying a list of potential good practice to review as part of this deliverable. To further narrow down and finalise the list of selected good practices for this deliverable, a set of additional criteria for digital solutions for information sharing was applied to ensure the relevance of these to a range of water governance context:

- spatial scale of the solution: water governance applies at different geographic levels from catchment to European levels of governance.
- currently in operational use to support water governance with live data.
- the final set should include digital solutions covering a range of the main pressures on European freshwaters including both water quantity and water quality.

The selection of good practices was also discussed across the project team to ensure coherence across work packages and the Living Labs.

To gain further insights into the effectiveness, efficiency, inclusivity, and scalability of the good practices selected, a two-step approach was adopted to complement the initial findings based on the digital solution assessment framework:

- in-depth exploration of the content of the digital solution, and
- interviews with end users.

The interviews were based on a semi-structured approach to ensure coherence across practices, interviewees and interviewers. We designed a semi-structured interview guide based on the good practice criteria (Section 2.2). The interview guide was discussed and agreed upon within the wider consortium (Annex 2). Finally, to ensure we followed ethical data collection and processing best practices, the interview process and interview guide was established in line with the data management plan (Deliverable 8.4) prior to reaching out to potential interviewees. We supplied the interviewees with details of the project, the interview process including how the information was going to be used and provided them with the opportunity to withdraw at any point. A 30–60-minute online interview time was agreed with the interviewees, and these were carried out using Microsoft Teams, with the recording and transcript being stored securely with the permission of the interviewees.

To identify and contact potential interviewees, a range of approaches was used. The primary source was professional contacts amongst the GOVAQUA project team. Relevant end users were contacted via an introductory e-mail providing a brief outline of the GOVAQUA project with a focus on WP5 and its objectives. Where no existing professional contact was available within the consortium, potential contacts were gathered through attending end user events and contacting the creators/owners of the good practice for suggested end users.

For inclusivity purposes, the interviews were tailored to the interviewees in terms of time and language. Most interviews were kept to about 30 minutes based on the interviewees' availability and undertaken in English. Amongst the 12 interviews undertaken across the five good practices, seven were carried out in English. Interviews for three of the good practices were carried out by the lead author, the interviews for

two of the good practices were carried out by team members who were either native Spanish speakers (Guadalquivir SAIH) or were familiar with the practice (WWF Water Risk Filter).

A transcript of all the interviews was produced and the content analysed to evidence the good practice criteria alongside the results from the digital solution assessment framework. The interviews were thematically analysed using the good practice criteria (Section 2.2), thus allowing the identification of themes. These were carried out by a member of the team experienced in thematic analysis and checked by another member of the team.

A milestone report was prepared to document the progress of the case studies, and it was submitted by the end of September 2024 (Milestone 16). The progress of the good practice assessments was presented to the Living Lab representatives and project consortium partners at the GOVAQUA project's General Assembly meeting in Wallingford, UK, in May 2025, and at a project meeting in Microsoft Teams (online) on 1 October 2025. Feedback received at these events was incorporated in this final Deliverable report.

3. Good practices

3.1 Riverfly Partnership

General description

The Riverfly Partnership is a UK collaborative network of citizen scientists, called 'monitors', comprising anglers, scientists, water managers and others interested in the health of their local rivers, working collaboratively with relevant regulatory authorities e.g. Environment Agency in England. It stems from a UK Natural History Museum and Natural England Partnership project in 2002. Since then, the monitoring methods have been co-developed with UK freshwater regulatory authorities and launched nationally in 2007. The Riverfly Partnership is hosted by the Freshwater Biological Association, and focuses on protecting water quality, and enhancing people's understanding of river health through the presence and abundance of riverfly (including mayflies, caddisflies, and stoneflies) populations. A cornerstone of this partnership's efforts is the Riverfly Monitoring Initiative (RMI). It empowers trained volunteers to spend an hour per month to collect a sample in a river, to monitor eight key groups of aquatic invertebrates. The groups monitored are depicted in Figure 2, which are useful indicators of the local river conditions in terms of water quality.

The Riverfly Partnership data collection on indicators of water quality is related to the UK freshwater regulatory authorities' work on monitoring water bodies for good ecological status as part of the Water Framework Directive (WFD; 2000/60/EC). The Environment Agency's monitoring of freshwater ecology, that includes riverflies, is far more detailed in terms of macroinvertebrate family and species level identification, however fewer locations are monitored compared to the coverage provided by the Riverfly Partnership data.

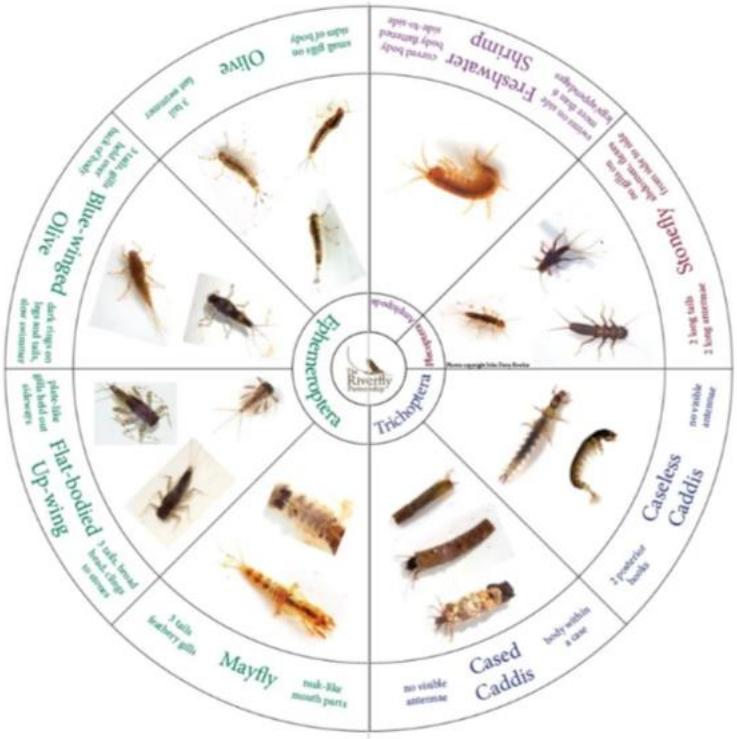

Figure 2. Pollution sensitive invertebrates monitored as part of Riverfly Monitoring Initiative.

From the species identified and their abundance, an RMI score is calculated and compared to the trigger level assigned for that site. The trigger level is set by ecology experts from the regulatory authorities and is the minimum RMI score that samples at the site should have. A score below the trigger level is reported as a "breach" to the local ecologist within the regulatory body for investigation. More recently, additional monitoring methods have been developed: Urban Riverfly and Extended Riverfly, designed to capture more detailed information to support understanding of additional habitats and water quality issues.

As a digital solution, the collection and use of Riverfly Partnership data is now based on the Cartographer platform and mobile app[1]. The later allows monitors to enter field information and calculate RMI scores. The Cartographer database and software systems collates the UK wide RMI data into a central data repository, these also support visualisation and basic analysis of the data, as well as data sharing with regulators and the wider public. The Riverfly Partnership also provides its own information-rich website with monthly and annual data reports, and extensive training resources. Importantly, all data is fully and freely accessible to the public[1,2].

National coordination of the Riverfly Partnership's data collection and sharing is funded through a variety of sources, including angling licence sales and government environmental improvement programmes. In 2023, the parent organisation of Riverfly Partnership secured a grant from a charitable foundation to supplement this funding. This grant enabled a move from an aging database to the Cartographer platform, and also funds ongoing open access to data. The Cartographer platform is a centralised data storage which supports quality assurance and quality control processes. Joining an RMI group or setting one up, is basically free. When setting up a new RMI group there is an option to pay for training and equipment. This support has led to widespread uptake of RMI. As an indication of the geographic breadth of monitoring, in 2024 over 7,000 RMI samples were collected from 624 rivers.

Methodology

An initial review of this case was compiled through an in-depth exploration of the content of the Riverfly Partnership platform[2] including videos, newsletters, data portal, and resources. The review was supplemented with further web and literature searches, and with knowledge of the lead author's involvement in citizen science projects that included RMI. Three interviews were carried out and analysed to provide end user perspectives (Table 22).

Table 22. Overview of interviews conducted to the Riverly Monitoring Initiative.

Interview code	Stakeholder	Time of the interview
A	National scale regulator responsible for water quality and resources	June 16th 2025
B	National scale regulator responsible for water quality and resources	June 16th 2025
C	Citizen involved in local water quality monitoring	July 7th 2025

Initiator

- Natural History Museum and Natural England Partnership

Category

- Citizen science network

Water issue

- Water quality
- Ecosystems

Geographical applicability

- Local
- National

Level of water governance

- Catchment

Stakeholders

- Primary sectors
    - Public authorities
        - catchment governance agencies
        - municipalities
- Other sectors
    - Civil society
        - NGOs
        - local communities
    - Research
        - research institutes
        - universities
    - Industry
        - consultants

Effectiveness of the practice

The effectiveness of the Riverfly Partnership practice is based on **their communication of how the data is used, the open sharing of monthly and annual data reports,** the large spatial and temporal coverage, and its co-design and operation with Environment Agency staff.

The Riverfly Partnership web pages[2] and related communication materials (e.g. a regular monthly newsletter) set out a range of situations where, the collection and use, of RMI data has demonstrated **significant success in enhancing river health monitoring and conservation efforts**. For instance, in July 2013, volunteers from Action for the River Kennet were the first to detect a catastrophic pesticide pollution event in the River Kennet near Marlborough, UK[3]. Their timely intervention led to immediate actions to mitigate the damage. Similarly, volunteers have been conducting Riverfly surveys in the New Forest, area of Southern England, for nine years, providing valuable data to monitor the impact of river restoration projects[4]. In an interview with a long-term Riverfly monitor, they stressed the trustworthy nature of the

national RMI data and its usefulness for communicating with local authority officials regarding local river health (Interview C). Though RMI was originally designed to detect pollution events, RMI data has been found to be **effective for detecting drought impacts on river ecology and analysing the rivers recovery capacity after low flow periods**. However, the Extended Riverfly groups are better suited to drought and recovery triggers.

The Riverfly Partnership publishes monthly and annual data reports, available in PDF format, covering the number of samples taken and key points about the month's data including comparisons with previous months and years[5]. It also **provides an account of the numbers of 'unconfirmed' or 'confirmed' breaches** (based on an additional second sample within 48 hours) per month and/or year. These breaches are reported manually to the regulatory authorities. The information is reported at the national and catchment level, through a range of formats including textual information, tables, maps, histograms and line charts. The information is clearly presented for a non-technical audience. The annual reports also include case studies of when the monitoring methods, including RMI, provided evidence of pollution for regulatory authorities. The monthly and annuals reports produced by the Riverfly Partnership are only available from 2023 onwards. However, some reports produced by regional hubs are also available on the platform. Historical data, prior to 2023, can be accessed via the Cartographer platform which contains much more detailed data than the dashboard or the monthly and annual reports.

Interviews with the regulatory sector (Interviews A and B) highlighted several aspects related to the effectiveness of RMI. Both interviewees commented on the importance of the large spatial (national) and temporal (monthly since 2007) coverage. Since its inception, the monitoring scheme was **co-designed and co-implemented in partnership with the Environment Agency**. Interviewees A and B noted how this co-creation approach has fostered trust in the data collated. One interviewee involved in dealing with trigger breaches, discussed the importance of personally knowing the groups collecting and reporting the data, as this could result in greater confidence in the data (Interview B). This point highlights that understanding who is providing the data is key to decision makers, in addition to standardised methods and their training requirements. Within Cartographer, the registered user can access a high level of information including the name of the teams, and occasionally individuals, who collated the data.

All three interviewees mentioned that the Riverfly data was **most effective when combined with other data** e.g. river flow (Interview A), and water quality data (Interviews B and C). The benefits of collating related data in one online location were also referred to (Interview A). Currently, this is achieved through access to a draft citizen science data catalogue that is being tested by the community, and through APIs that require advanced technical skills.

Interviewee C expressed a view that despite the large number of individuals collecting data across the UK, they were aware of **limited use of the data for actual investigations or prosecutions of polluters and would like the Environment Agency to talk more about their use of RMI data** (Interview C). The Riverfly Partnership data report for 2024, publishes that 7,832 samples resulted in 49 confirmed trigger level breaches[5]. Another interviewee claimed relatively few trigger breaches due to pollution incidents in their region (Interview B). They highlighted the relevancy of the approach but also mentioned that due to its simplicity it does not always detect minor changes in water quality. Its benefit for water governance lies in the greater spatial and temporal coverage, for example in 2024 only 465 Extended samples were taken across 69 rivers compared to the 7,179 RMI samples from across 624 rivers[5].

Efficiency of the practice

The efficiency of the Riverfly Partnership is achieved through a **combination of social and digital aspects that enable the centralised collection, processing, sharing, and use of the partnership data.** Key aspects include the input of volunteers to supplement the Environment Agency ecological monitoring, the

resources needed to enable this, and the data and digital components that enable the coordinators and regulatory authority ecological experts to quality control the data. This is standard practice in a wide range of ecological monitoring schemes carried out by citizen scientists.

The **Riverfly Partnership's leverage of the enthusiasm, time, and local knowledge of volunteers** makes it a cost-effective approach to river monitoring to supplement regulatory monitoring by statutory/regulatory agencies such as the Environment Agency. By training monitors/citizen scientists, the initiative extends the reach of environmental monitoring beyond the capacities of regulatory agencies alone. The standardized monitoring techniques developed by the Riverfly Partnership, particularly RMI, enables volunteers to act as guardians of their local rivers, effectively becoming an early warning system for detecting changes in water quality[2]. The benefits to water governance of the co-produced RMI data, and the efforts of local groups to care for their local rivers was clear in all three interviewees. Both representatives from the Environment Agency, emphasized the value of RMI data to supplement their regulatory river monitoring (Interviews A and B). The RMI data was used by Environment Agency colleagues in their decision making such as drought planning (Interview B). It was mentioned that more could be done to integrate the Riverfly Partnership's data into the Environment Agency data systems to aid their decision making (Interview A).

Enabling the training of volunteers, collection of data, sharing of this data, and use by the regulatory agencies is funded by the Riverfly Partnership and the regulatory agencies. The Riverfly Partnership receives income from a range of sources including fishing licenses, grants from charitable foundations and online shop, and creates a range of ways for people to donate financially. The reliance on volunteers necessitates continuous investment in training of citizen scientists and resources to maintain high quality data and community engagement (Interviews A and B). The resource intense nature of RMI includes time for the citizen scientists involved in the data collection and the regional Environment Agency ecological experts who set the trigger levels, train the citizen scientists (Interview B).

The Riverfly Partnership's efficiency is **enabled by data and digital components. These include common recording forms for the citizen scientists, a process of local coordinators checking the data, the rapid sharing of data via the Riverfly Partnerships website (and monthly and annual data reports), and the Cartographer app[1]**. All the interviewees discussed the web portal and app that was used for accessing the data. In general, all interviewees agreed that this platform meets most of their needs. Two talked about the difficulties that others faced including, not being able to quickly view a map of their river and its data points (Interview C), and difficulty to automate access to the RMI data, for some citizen science groups, in part due to the design of the Application Programming Interface (API) (Interview B). Data and visualisation platforms like Cartographer need to be paid.

Inclusivity and reflexivity of the practice

The Riverfly Partnership exemplifies inclusivity by **bringing together a diverse array of stakeholders including local communities, environmental groups, environmental regulators, and other ecological experts to better understand and improve river health.** The Riverfly Partnership website highlights the simplicity of the data reporting including monthly and annual data reports, and online dashboard. These have been designed for a broad audience of users and from our perspective scores high in terms of accessibility. Apart from the use of Cartographer, it is unclear what additional digital technology is used. The Cartographer app provides a commercial service, with limited details on the digital technologies and data processing used. This app is used to provide in-depth details about the monitoring data and as such, although accessible, is less understandable to a non-technical audience. It is worth noting that access to Cartographer although free in this instance, requires registration.

This collaborative approach ensures that **multiple parties are involved in river conservation efforts, using a common and transparent methodology**. The partnership's commitment to reflexivity is evident in its responsiveness to feedback and its efforts to adapt and improve monitoring methodologies (Interview C). Following the introduction of the Cartographer, new training material was produced and available on the platform to support end users. As a response to users' feedback, the materials were further improved to meet their needs (Interview B). Another example is the development of the Extended Riverfly scheme and Urban Riverfly: supported by new identification charts and training workshops, it provides volunteers with opportunities to further their knowledge and contribute more comprehensively to monitoring efforts[2]. The Riverfly Partnership web page has clearly signposted and informative 'Frequently Asked Question', a section available from the main horizontal navigation.

The Riverfly Partnership invest a lot of effort into communication about RMI and related methods. They also invest effort in building the community of monitors and enhancing the relationships between them (Interview B). The Riverfly Partnership provides training courses and training material, with extensive clear information available online[2]. One interviewee stated their collaboration with local schools to help provide outdoor education about the local rivers and their ecosystems (Interview C). The platform also provides educational materials to support such interactions[6].

Replicability and generalizability of the practice

The replicability and generalizability of the Riverfly Partnerships practice is very strong at the national level of England due to the funding from and close working with the Environment Agency. It is strong at the UK level due to the standardized data collection protocols, training, and online sharing of data. The Riverfly Partnership is a UK based initiative with samples collected across all four countries by many individual river trusts. The scale of the initiative demonstrates the replicability of the approach since all countries have different local authorities. This is evidenced by RMI data being collected across 624 rivers in 2024[5].

A key strength of the Riverfly Partnership in England is its unique partnership with the Environment Agency (England). There are multiple ways Environment Agency staff contribute to the collection of RMI data to meet their needs and support individual monitors and groups (Interview A). Within the UK, there is a regulatory authority for each country (i.e. England, Scotland, Wales and Northern Ireland). The other UK regulatory authorities have not yet set up such partnership, however the Riverfly Partnership is in discussion with the Scottish Environment Protection Agency to officially set up a partnership (Interview A).

The successful adoption of the Riverfly Partnership's monitoring initiatives is due to social and digital aspects. The standardised protocols and training programs, and digital platform Cartographer facilitate the replication of the practice in diverse river systems. The extra funding in 2023 enabled the Riverfly Partnership to improve their digital system including how users could utilise it. Case studies, such as those from the Kennet and Pang Catchments, and the New Forest, demonstrate the adaptability of the RMI to different environmental contexts and conservation objectives[3,4]. For successful replication, essential conditions include strong community engagement, co-design by key stakeholders including identification of end users, access to training and resources, and timely and informative sharing of the data and related material about the individuals and organisations involved. Information about the Riverfly Partnership's monitoring methods and data is presented concisely and in accessible ways to enable a broad audience, and uptake by new groups and decision makers. Establishing clear communication channels between citizen scientists and regulatory authorities is crucial to ensure that data collected leads to timely and effective actions. The shortage of trainers and lack of time for ecology experts to train new monitors limits uptake in certain geographical areas (Interview B). The limited number of people willing to go and collect RMI each month was mentioned (Interview C).

To extend the Riverfly Partnership approach beyond the UK and Ireland, would require the same collaborative approach involving regulatory agencies and citizen scientists, and appropriate levels of financial funding and in-kind donations of time.

Technical details

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Related websites:

Cartographer platform and mobile app. https://cartographer.io/

The Riverfly Partnership. https://www.riverflies.org/

Riverfly Monitoring - Citizen Science in action. https://www.kennetandpang.org/get-involved/riverfly-monitoring

New Forest Riverfly Case Study. The Riverfly Partnership https://www.riverflies.org/newsblog/new-forest-riverfly-case-study

Riverfly Partnership Data Reports https://www.riverflies.org/riverflyreports

6. Children's Activities — The Riverfly Partnership. https://www.riverflies.org/childrensactivities

3.2 Copernicus Emergency Management Service

General description

The Copernicus Emergency Management Service (CEMS) was set up to provide early warning and monitoring of natural disasters, such as droughts and floods, at a national and international level[1]. CEMS supports a range of water resource management situations in Europe through the European Flood Awareness System (EFAS) and On-Demand Mapping Service. It is part of the EU Copernicus programme that is aimed at European information services based on satellite remote sensing and *in-situ* (non-space) data. Although the service is mostly used across Europe, it is a global service for use by any authority involved in disaster management. CEMS has been operational since 2012 and is implemented by the European Commission DG Joint Research Centre (JRC) in collaboration with the European Centre for Medium-Range Weather Forecasts (ECMWF). The service encompasses a range of early warning and monitoring initiatives, all of which are important to support European water governance. These include the EFAS and its global counterpart Global Flood Awareness System (GloFAS), the European Drought Observatory (EDO), the European Forest Fire, and Information System (EFFIS). Alongside these services, CEMS also provides satellite remote sensing mapping, supporting all phases of the emergency management cycle: mapping for preparedness, rapid mapping support during the emergency response phase, and mapping for recovery.

Since 2012, EFAS is an operational system which aims to support preparatory measures before major flood events occur in Europe[2]. It is used by a wide range of member states to provide operational awareness of potential flood events. The system provides four main product categories[3]:

- EFAS medium range flood forecast: provides overviews of upcoming events and possible flood impacts up to 10 days in advance. Warnings of predicated high-risk of flooding are sent to EFAS partners.
- EFAS flash flood indicators: these are based on high resolution weather data 5-day forecast and radar based precipitation monitoring.
- EFAS sub-seasonal (5-6 weeks) and seasonal (7 months) hydrological outlooks: the sub-seasonal outlook is issued daily and the seasonal monthly, and can be used to support a range of water resources management issues (e.g. reservoir levels and flood preparation).
- Global flood monitoring: this is a near-real time automated monitoring of floods.

As a digital system, EFAS comprises several key elements, including:

- The EFAS map viewer, a web-based map interface which allows users to interact with and interrogate detailed forecasts, including flood extents and probabilities for the modelled area (Figure 3).
- The Early Warning Data Store (EWDS), an online repository of current and historical forecasts and reforecasts, enabling partners to undertake their own analysis and data integration, enabled by the Copernicus Climate Data Store API.
- The EFAS Dissemination Centre notification systems, which issues formal notification emails to partners in potentially affected river basins.
- The EFAS website, providing access to content such as detailed bulletins, technical assessment reports, as well as background information.

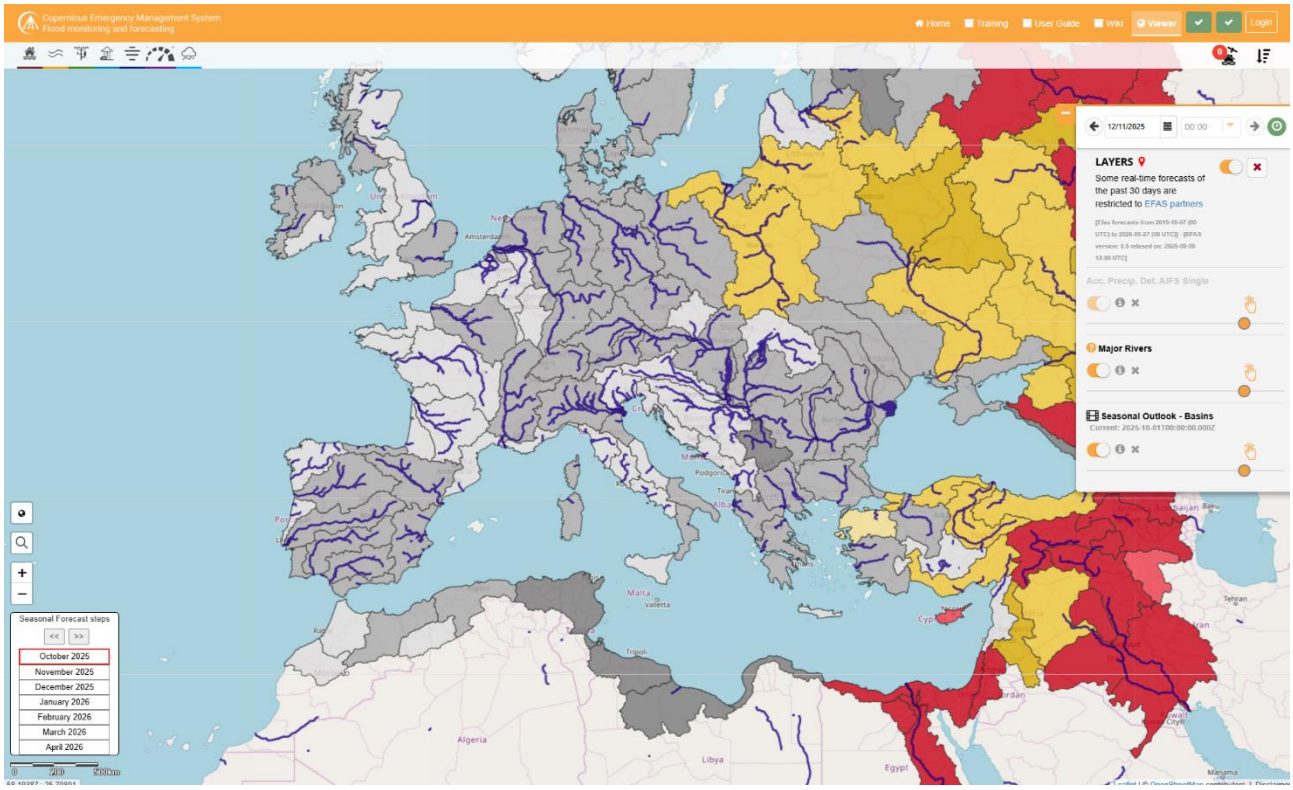

Figure 3.European Flood Awareness Situation map viewer.

Methodology

An initial review of this case was compiled through an in-depth exploration of the EFAS digital platform by the lead author. The review was supplemented with further web and literature searches. Two interviews were carried out and analysed to provide end user perspectives (Table 3).

Table 3. Overview table of interviews undertaken related to the European Flood Awareness Systems (EFAS) digital tool.

Interview code	Stakeholder	Time of the interview
A	National operational flood risk centre representative	July 22nd 2025
B	National waterways organisation, scientist working on extreme hydrological events	August 20th 2025

Initiator

- European Commission

Category

- Disaster awareness

Water issue

- Water quantity

Geographical applicability

- Global
- EU

Level of water governance

- Catchment

Stakeholders

- Primary sector
    - Public authorities
        - catchment governance agencies
        - municipalities
- Other sectors
    - Civil society
        - NGOs
        - local communities
    - Industry

Effectiveness of the practice

CEMS-EFAS directly **supports European Commission and member state policy goals related to the Floods Directive (2007/60/EC) and the EU Strategy on Adaptation to Climate Change (2021),** which are fundamental European policies related to sustainable and equitable water use. The latter EU strategy aims to build a climate resilient society by improving knowledge of climate impacts and adaptation solutions. It also acts as an enabler for the EU Mission Adaptation to Climate Change: supporting European regions and communities to become climate resilient by 2030[4]. This and the other four missions were designed to help deliver the European Green Deal. The 2025 EU Water Resilience Strategy includes a vision for a water resilient society that will be dependent on digital solutions for sharing information like CEMS-EFAS, and has a flagship action to launch a Copernicus Water Thematic Hub in 2026. Member state actors want to understand the nature of flood events and when they might occur. In addition to the existing flood modelling and warnings, a JRC study in 2020 demonstrated the feasibility of an automated, global satellite-based flood monitoring product for CEMS, which has now been operationalized (Matgen et al. 2020).

The effectiveness of EFAS to support water governance is dependent on the **modelled hydrological data and satellite data on flood events that it provides to users**, and the digital infrastructure that enables this including the web-based interface that has been designed and tested by users. The platform focusses on providing warning of potential flooding up to 10 days in advance. The data can be used alongside national data sources and in some instances it might bridge data gaps. An example of the later was provided by Interviewee A. All interviewees explained that EFAS data was used alongside their national models and data collection to provide a useful overview of potential flooding events. The combination of different flood model estimates, national estimates and European level modelled data, strengthens the accuracy of the flood forecasts.

A key aspect of the effectiveness of the EFAS digital system is the **quick release of information including the overview of flood risks over large geographic areas up to 10 days in advance** (Interview B) and the

mapping of actual flooding events (Interview B). This information is highly valuable and contributes to the decision making (Interview B).

The severe flooding in Germany and Belgium in 2021, which tragically claimed 200 lives, lead to a review of how well EFAS had functioned during the event (Grimaldi et al. 2021). This review concluded that forecasts had identified a risk of flooding and that alerts were issued. It recommended improvements of some aspects of the alerts system. However, it is the lack of uptake of the warnings that has been most criticised[5], suggesting a limited practical integration of forecasting approaches across agencies at different levels.

A further technical review of the effectiveness and limitations of EFAS in relation to the significant floods in Northern Germany in 2023/2024[6] identified potential for improved forecast accuracy and lead times in some areas. It also highlighted a need for more streamlined protocols for notifications and pre-tasking to support the issue of timely alerts. The availability of historic forecasts enables reassessment of the system following severe events and support ongoing improvements to its effectiveness.

EFAS is designed as a **European level near real-time and early warning information for ongoing and forecasted flood events**. As a result, the data available in this system is most suitable for large catchments (Interviews A and B), and is less accurate on smaller flashier catchments (Interview A). The early warning feature of CEMS-EFAS enables national and local/state representatives to collect additional data e.g. field work or drone/aircraft flights to better understand the risks faced (Interview B).

Part of the CEMS service (on demand mapping) is the provision of satellite data on actual flooding events, this data is useful and its resolution improving, however it would still benefit from further refinement (Interview B). It is worth noting that an increasing number of commercial satellites are providing higher resolution data (SAR- Synthetic Aperture Radar and optical data) compared to the Copernicus Sentinel-1 mission.

There are many organisations involved in local to national flood forecasting and responding to flood events. The interviewees talked about how they worked with local or state government colleagues who managed emergency responses to flood events, and emphasized that communication was key (Interviews A and B). Communication with a large network of users (over 300) of flood information was vital, to understand and interpret the data (Interview A). Communication also includes providing and facilitating training from EFAS experts (Interview A).

Efficiency of the practice

The efficiency of CEMS-EFAS has been **enhanced as the underpinning data and digital technologies have evolved.** For example, recent updates to the CEMS mapping service have improved the quality of the mapping results and of the web interface[7]**.** The interviewees found the CEMS-EFAS graphical interface to be straightforward to use. Adding the ability to create a web viewer/dashboard with local/national data relevant to a particular jurisdiction would help their work (Interview B). **Provision of forecast data via APIs from the Early Warning Data Store has potential to enable full integration within partner systems**, however this may require significant effort on behalf of the partner.

Compared to 2012 when CEMS and EFAS became operational, there is now greater access to satellite imagery that can help assess floods and their impacts. A study examined the automatic rapid mapping ability of the CEMS mapping services, based on Sentinel-1 data (Wagner et al., 2026). **The service has been in operation since 2021, to map floods reliably under diverse environmental conditions**. The authors discussed remaining challenges including reduction in false positives especially in agricultural and arid regions. Another advance in CEMS mapping service was the recent operationalization of the INterpolated FLOod Surface (INFLOS) tool that delivers accurate real-time flood depth estimates based on satellite data (Poterek et al., 2025). This reduced computational times by 15-fold compared to similar techniques of flood

depth estimation. The accuracy depends on the quality of the available terrain model and height of the water level (Interview B).

For end users to efficiently use CEMS-EFAS, **significant effort is required to aid communication and use of the information**. One interviewee discussed how CEMS-EFAS was important for bringing together the European flood forecasting community together from across all the different jurisdictions (Interview A). Information based on model outputs (e.g. flood forecasting) is fairly complicated, one interviewee highlighted the effort needed to help users understand and interpret the EFAS outputs and related notifications (Interview A). They noted the extensive training that they ran with EFAS for the users in their country. The EFAS community runs regular, annual, end user online conferences and makes the material available through news items and YouTube videos.

Inclusivity and reflexivity of the practice

Since its launch, CEMS **has evolved to better meet end user needs** and utilise advances in data availability. For example, in 2017 work was carried out to explore linking early warning systems with rapid mapping[7]. CEMS-EFAS have a range of end user events, training courses, and opportunities for feedback (Interviews A and B). One interviewee (Interview A) mentioned how they had helped inform the development of EFAS, due to their use of EFAS since it was started. They stated the key role for national representatives to translate between the needs of local and national agencies responding to flood events, and the EFAS developers. As flood forecast information is complicated and a lot of explanation and training is required to enable its use (Interview A). Another interviewee (Interview B) found that when working with their technical colleagues, EFAS was relatively easy to use, whereas the flood mapping was less so.

In terms of inclusivity, CEMS mapping service and the **EFAS flood warnings have always been freely available as an operational pan-European flood forecasting and monitoring system**, with some real-time information limited to project partners (any organisation involved in providing flood forecasting services)[8]. The warning alerts are only issued to the EFAS partners and the EU Emergency Coordination Centre. EFAS partners include national and regional hydrological services, national meteorological services and civil protection services in member countries.

Replicability and generalizability of the practice

The replicability and generalisability of EFAS, is enabled through a common approach to sharing of modelled hydrological and satellite data and digital infrastructure that enables this to be repeated across Europe's and the world's river basins. However, it should be noted that the issuing of flood warnings and satellite tasking requires manual processes by EFAS officers, which may represent a potential point of failure. CEMS mapping and EFAS flood warnings are Europe-wide practice supported by the European Commission, providing information that is applicable across large geographical areas in a consistent way2.

This results in greater levels of replicability and generalizability compared to individual local place-based flood modelling and warning practices. This characteristic has also led to its widespread use across Europe. Both interviewees (Interviews A and B) noted that EFAS worked well at the European level in terms of providing early warning especially in large river catchments. One interviewee talked about their use of CEMS-EFAS has changed over time; they used it more extensively when they did not have their national level models/approaches, they then developed their own approach, as they needed models that better suited the nature of the flood risks they face (Interview A). Another (Interview B) described how they used EFAS for long term forecasts (4-10 days), and was useful to aid discussions and preparations, and for shorter periods of time they used their national models. When designing a practice, like EFAS, that is

intended to span large geographic areas, then decisions in its design and implementation will influence performance in catchments with different flood risk characteristics.

Technical details

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Related websites

European Flood Awareness System. https://www.copernicus.eu/en/european-flood-awareness-system

European Flood Awareness System. https://european-flood.emergency.copernicus.eu/en

Copernicus Emergency Management Service-CEMS. EFAS products overview. https://confluence.ecmwf.int/display/CEMS/2+EFAS+products+overview

EU Strategy on Adaptation to Climate Change. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

POLITICO. Europe's floods: How a modern warning system was overwhelmed. https://www.politico.eu/article/unnatural-disaster-the-german-belgian-floods-climate-change/

European flood awareness system – A technical assessment of CEMS EFAS performance during the floods in Northern Germany in December 2023/January 2024, Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2760/1959574

Home | Copernicus EMS On Demand Mapping. https://mapping.emergency.copernicus.eu/.

European Flood Awareness System. Become EFAS Partner. https://european-flood.emergency.copernicus.eu/en/become-efas-partner

Related resources

Matgen, P., Martinis, S., Wagner, W., Freeman, V., Zeil, P., McCormick, N. (2020). Feasibility assessment of an automated, global, satellite-based flood monitoring product for the Copernicus Emergency Management Service. JRC Publications Repository https://publications.jrc.ec.europa.eu/repository/handle/JRC119812 (2020) doi:10.2760/653891.

Grimaldi, S., Thiemig, V., Pechlivanidis, I., Sprokkereef, E., Harrigan, S., Mazzetti, C., Prudhomme, C., Ziese, M.,Schirmeister, Z., Carpintero Salvo, I., Márquez Arroyo, M., F., Salamon, P. (2021). The European Flood Awareness System - A technical assessment of the EFAS performance during the Meuse and Rhine floods in July 2021, European Commission, JRC135679.

Wagner, W., Bauer-Marschallinger, B., Roth, F., Raiger-Stachl, T., Reimer, C., McCormick, N., Matgen, P., Chini, M., Li, Y., Martinis, S., Wieland, M., Kraft, F., Festa, D., Hassaan, M., Tupas, M. E., Zhao, J., Seewald, M., Riffler, M., Molini, L., Kidd, R., Briese, C., Salamon, P. (2026). The fully-automatic Sentinel-1 Global Flood Monitoring service: Scientific challenges and future directions, Remote Sensing of Environment, https://doi.org/10.1016/j.rse.2025.115108.

Poterek, Q., Caretto, A., Braun, R., Clandillon, S., Huber, C., Ceccato, P. (2025). INterpolated FLOod Surface (INFLOS), a Rapid and Operational Tool to Estimate Flood Depths from Earth Observation Data for Emergency Management. Remote Sensing 17, 329.

3.3 Guadalquivir SAIH: Hydrological Information System

General description

The Automatic Hydrological Information System (SAIH) is an online hydrological platform developed by the Spanish government's Ministry for the Ecologic Transition and Demographic Network, under the Hydrographic Confederation for the Guadalquivir catchment (Ministerio para la transición acológica y el reto demográfico - Hidrográfica del Guadalquivir O.A.) [1].

The online tool was released in 2014 and currently includes 439 gauge stations owned by SAIH, water levels at 59 reservoirs and 55 hydropower plants, and 3,400 sensors across the Guadalquivir catchment[2]. SAIH now provides automated real-time information on water-related data - such as temperature, precipitation, flow rate, and evaporation - in both graphical and table formats. It provides free of charge access to detailed, real-time water resource data (Figure 4).

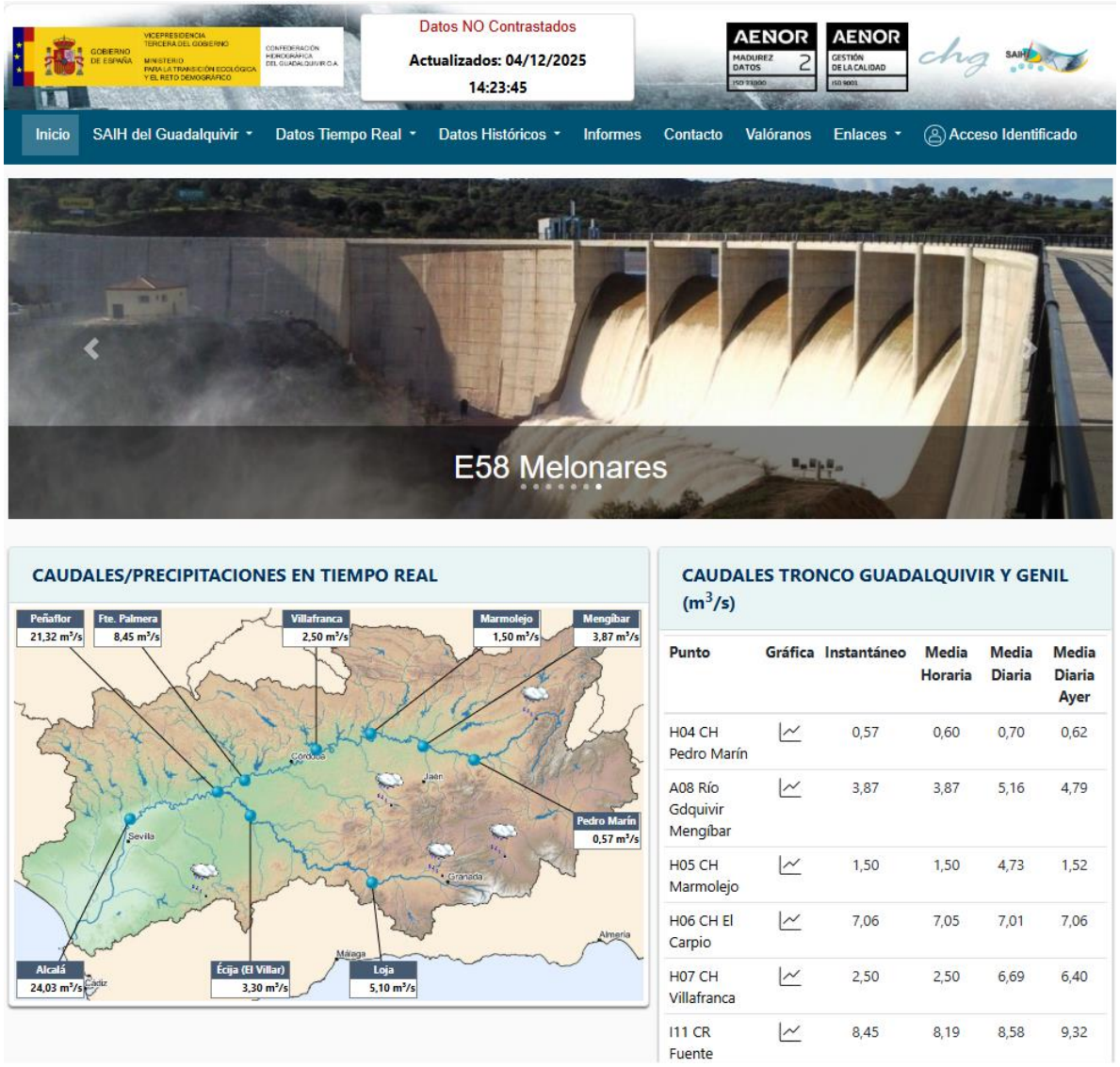

Figure 4. Introductory page of the Guadalquivir SAIH website.

The SAIH was designed for public access to hydrological data. Spain has a history of river basin management dating back to the 1920s, with the first hydrographic confederations (or Confederaciones Hidrográficas) created in 1926[3]. The online platform is based on one launched in 1998 designed to provide data to stakeholders in the Guadalquivir catchment. However, it is not the only one, there are similar tools for other catchments across Spain[4]. The data provided by SAIH are crucial for multiple stakeholders, ranging from industry and agriculture to urban planners[3].

In 2020, a clear need to strengthen coordination in river basin governance and improve data sharing amongst stakeholders was identified. The European Union's Water Framework directive (WFD) has set an upper bound of 2027 for its member states to achieve good ecological status[5]. Spain has a clear need to achieve this goal, because its water resources are at risk of becoming scarcer with current climate predictions[6].

Initiator

Confederación Hidrográfica Del Guadalquivir (Hydrographic Confederation for the Guadalquivir)

Category

- Hydrological platform

Water issue

- Water quantity
- Ecosystems

Geographical applicability

- National
- Regional
- Local

Level of water governance

- Catchment
- River Basin District

Stakeholders

- Primary sector
    - Industry
    - Primary production
        - Agriculture
- Other sectors
    - Public authorities
        - catchment governance agencies
        - municipalities
    - Civil society
        - NGOs
        - local communities
    - Industry
        - Consultants

Methodology

An in-depth review of the SAIH platform was conducted through an exploration of its content including basic climate look-up, basin-level irrigation availability data, and corporate-level flood risk investigation. This hands-on approach enabled evaluation of how effectively the tool integrates these assessments to provide a comprehensive view of water-related data and risks for companies and stakeholders. Three interviews were carried out and analysed to supplement our initial findings (Table 4). The interviewees represented different stakeholders using the SAIH Guadalquivir platform.

Table 4. Overview table of interviews undertaken related to the Guadalquivir SAIH digital system.

Interview code	Represented organisation types	Time of the interview
A	Irrigation community, one community and one site representative.	November 10th 2025
B	Association of Irrigation communities, multiple companies and one site representative	November 12th 2025
C	Municipal water enterprise, one company and one site representative	November 12th 2025

Effectiveness of the practice

The platform is especially significant for a region like Guadalquivir, which has historically been primarily an agricultural production area, and now has an increasing population of over four million people adding greater pressure on water resources. Additionally, the risk and impacts of flooding are greater due to the growing population. There is therefore **serious concern within the Guadalquivir basin with regards to water resources availability**. The primary sector using SAIH is agriculture, which accounts for 88% of the water demand in the basin. Thus, accountability in water use is essential to ensure sufficient water for other sectors, such as public water consumption, tourism and environmental water demand to sustain the ecological riverine system of the basin. Such competing demands are a challenge to achieve good ecological status as required by the WFD.

Stakeholder feedback suggests that the SAIH team defines and follows **clear roles and responsibilities for different stakeholders** (Interviews A and C). SAIH is widely adopted across several companies with water resources interests in the catchment area (Interviews A, B, and C). The interviewees considered the tool valuable and quoted that it is often used to check reservoir volume (Interviews B and C), manage irrigation timelines (Interviews A and B), calculate ecological flows (Interview B), and support cost forecasting (Interview C).

However, despite being part of a wider network of SAIH hydrographic areas, the platform is **not easily linked to other water governance systems nearby**. This was raised by Interviewee C, who noted that integration with other hydrographic areas would be especially useful for those stakeholders whose land lay across the Guadalquivir and other basins.

Nevertheless, the SAIH tool was considered very advanced in terms of the technical capacity for the water governance systems available. Interviewees praised the tool's web-based data accessibility compared to previous versions where this was done by phone. They also mentioned the usefulness of the mobile application, since discontinued, and noted the lack of integration of new technologies such as satellite information (Interviews B and C). As described in the Inclusivity and Reflexivity section, the team at SAIH are very prompt to reply and implement new features. The SAIH tool also acts as a point of communication for stakeholders. Indeed, it contains easily accessible reports regarding water availability,

irrigation and ecological flows. A strength of the platform is the end user capacity to adapt the data provided to fit their own needs (Interview C).

Efficiency of the practice

The platform provides real-time data for a range of hydrological variables across an extensive geographic area to a large number of users in a range of digital formats, thus providing an efficient digital solutions. The data, both historical and real time, is summarised and presented in tabular, graphic and map-based formats.

To be considered efficient under the GOVAQUA guidelines, a practice needs to be able to **utilise, share and enhance adequate water-related data and information**. An indication of this is whether the digital solution data abides by the FAIR (**F**indability, **A**ccessibility, **I**nteroperability, and **R**euse) data principles. There is a noticeable lack of metadata within the system, as an example the downloaded data in spreadsheet format does not always contain metadata. Furthermore, the website displays a disclaimer noting that the data is automatically uploaded and not quality controlled. Monthly and termly reports containing analyses of past gauge information are produced. The data can be downloaded through a series of steps in common formats such as a .csv file. In addition, the SAIH support team can also be contacted for data requests including additional data and amendment of data.

All those interviewed praised the tool for its features, indicating that **the Guadalquivir SAIH is cost-efficient** (Interviews A, B and C). The tool can be used free of charge and without a user account, however users can choose to apply for a login. An interviewee mentioned that users can be granted access to more advanced data and support for a fee (Interview B). The free historical data tool was found to be comprehensive, and is used by companies such as FERAGUA (the association of communities for irrigation in Andalucia) and EMASA (the municipal company for water in Malaga) to address water resource problems in the basin (Interviews B and C). It can enable users to model ecological flows in the Guadalquivir region, optimise their irrigation strategies and prepare for drought (Interviews A, B, and C).

Whilst the online platform is accessible for long-term users to drive water governance, it is difficult to use in the first instance (Interviews A, B, and C). All interviewed users noted the need for training in case of intensive use of the tool, and highlighted the lack of up-to-date online training material such as video tutorials or user guide. Part of these issues and inconsistencies with the assessment framework may be related to funding. Between 1994 and 2001, the EU invested heavily into real-time monitoring networks including the ones utilised by SAIH, meaning that this practice was at the time funded by both the Spanish government and the EU. However, this funding was designed for the setup of the monitoring network and platform, and not its maintenance[7, 8]. Despite its drawbacks including lack of metadata and training materials, feedback on the efficiency of SAIH by the interviewees was very positive. Indeed, SAIH is widely used to support decision making in that region. For example, in March 2024 the Nelson Storm caused widespread destruction across the whole of Spain, and its effects extended to increase the volume of water stored in the reservoirs above their storage capacity. The real-time data provided by SAIH allowed their system to communicate hydrological alerts in different parts within the basin, allowing for localised flood prevention measures[9].

Inclusivity and reflexivity of the practice

The Guadalquivir SAIH tool is designed to meet user needs and as such is in Spanish only. The feedback section in the website is helpful and reported problems are solved quickly. In our investigation, a query regarding the location of their gauges was responded to within two hours of contacting them. The lack of

training material detracts from how inclusive the tool is; however, this is counterbalanced by the timely and efficient responsivity of the digital tool support team (Interviews A and B). Thus, this is less of an issue for stakeholders. The collaborative nature of SAIH has led to improvements of the tool. Interviewees noted how user-requested data, such as reports on drought and scarcity, was added to the tool over time (Interviews A and C). Furthermore, as the **data added to SAIH varies from stakeholder to stakeholder**, the team integrates different types of information and knowledge into the decision-making process.

The tool has consistently improved over time, based partly on the feedback form on the website and user surveys conducted every few years (Interview B). It is important to note that there are still new features that users have requested but have not been implemented yet. Interviewee A wished for better graphical representation of the data, specifying that currently data can only be explored on a site by site basis and thus can be time-consuming. Interviewee C pointed out that the integration of new technologies such as satellite information is still lacking. The SAIH team said satellite imagery has been used on occasion to delimitate floodplains to calibrate hydrological models[10]. There is also no available specific statement regarding gender sensitivity and equal participation. However, the data is displayed simply and with a large variety of modes: maps, hydrographs, tables and overall simple language rendering the data accessible to most. The lack of metadata may hinder the usability of the data. Overall, the website is inclusive. Most of the information is free of charge, though collaborative projects between SAIH and stakeholder companies may require the user to pay a cost for specific data that is not available to the public for confidentiality reasons. Users can access the free data without a login. A login is only required by the members of the SAIH maintenance teams and the technicians of the Basin Hydrographic Confederation to incorporate or publish data relating to hydraulic infrastructures [10].

Replicability and generalizability of the practice

The SAIH Guadalquivir tool has received positive feedback from those interviewed and is now part of multiple companies' workflows related to water resources. For example, it has been incorporated in the Copernicus Emergency Management Serice's Meteorological Data Collection Centre (CEMS MDCC) in 2024[11] – the CEMS is another of the tools assessed for good practice, listed in section 3.2. SAIH Guadalquivir is therefore a key resource for water resource data, with an eye towards flood monitoring and drought prevention in a region heavily affected by climate change.

This catchment-wide automatic gauge network is not unique to Guadalquivir, with many others present in Spain. The key aspect to setting up a platform similar to the Guadalquivir SAIH involves establishing good links with the community of users and between platform developers and data providers. Similar to the other good practices selected, its success depends on sufficient funding to support the setup and maintenance of SAIH including its digital platform and user support. It is important to note that lack of fundings and/or resources can hinder, at time, the uptake and integration of new innovative technologies such as Artificial Intelligence and satellite imagery. It is important to note that this later observation is not specific to the Guadalquivir SAIH hydrologic platform.

Technical details

Author/Contact Person: Giovanni Bernardi, UKCEH

Related websites:

SAIH Guadalquivir – Main Portal. https://www.chguadalquivir.es/saih/Inicio.aspx

SAIH Guadalquivir 2024 Visits Report. https://www.chguadalquivir.es/en/-/el-portal-web-del-sistema-automatico-de-informacion-hidrologica-saih-del-guadalquivir-recibe-3-400-000-visitas-en-2024-un-47-mas-que-el-ano-anterior

Operational Snowmelt Runoff Simulation – Guadalquivir Basin. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2003WR002726

Hydrographic Confederations in Spain. https://hispagua.cedex.es/en/instituciones/confederaciones

Water Framework Directive (WFD). https://environment.ec.europa.eu/topics/water/water-framework-directive_en

River Basin Governance in Southern Spain – Ecologic Institute. https://www.ecologic.eu/sites/default/files/publication/2020/2290-coordination-in-river-basin-governance-in-southern-spain.pdf

European Parliament Written Question E-009060/2012. https://www.europarl.europa.eu/doceo/document/E-7-2012-009060_EN.html

European Commission Response to E-009060/2012. https://www.europarl.europa.eu/doceo/document/E-7-2012-009060-ASW_EN.html

Guadalquivir Basin Report – Ministry for the Ecological Transition. https://www.miteco.gob.es/content/dam/miteco/es/agua/temas/seguridad-de-presas-y-embalses/presas-y-seguridad-h%C3%ADdrica/Informe%20Guadalquivir%20Nelson_V07.pdf

SAIH Guadalquivir – Contact. https://www.chguadalquivir.es/saih/Contactarnos.aspx

CEMS MDCC – Guadalquivir Meteorological Station Data. https://european-flood.emergency.copernicus.eu/en/news/cems-mdcc-integrated-meteorological-station-data-saih-del-guadalquivir-spain

3.4 WWF Water Risk Filter

General description

The WWF Risk Filter Suite is a platform containing two freely available risk assessment tools – the WWF Water Risk Filter (WWF-WRF) and the WWF Biodiversity Risk Filter (WWF-BRF). This Suite was developed by the World Wide Fund for Nature (WWF), and was launched in 2023. However, the Water Risk Filter tool was first launched in 2012, in response to growing awareness of water risks faced by businesses and financial institutions. As global water scarcity, pollution, and climate change intensify, organizations need a way to assess water-related risks that could impact their operations, supply chains, and investments.

The WWF-WRF is designed to be used by companies and financial institutions as a screening and prioritisation tool for water-related risks (Figure 6). It allows users to assess water-related risks based on a combination of global datasets and location-specific information. The aim of the WWF-WRF is to help businesses identify risks and prioritize actions that would strengthen their resilience against water-related challenges.

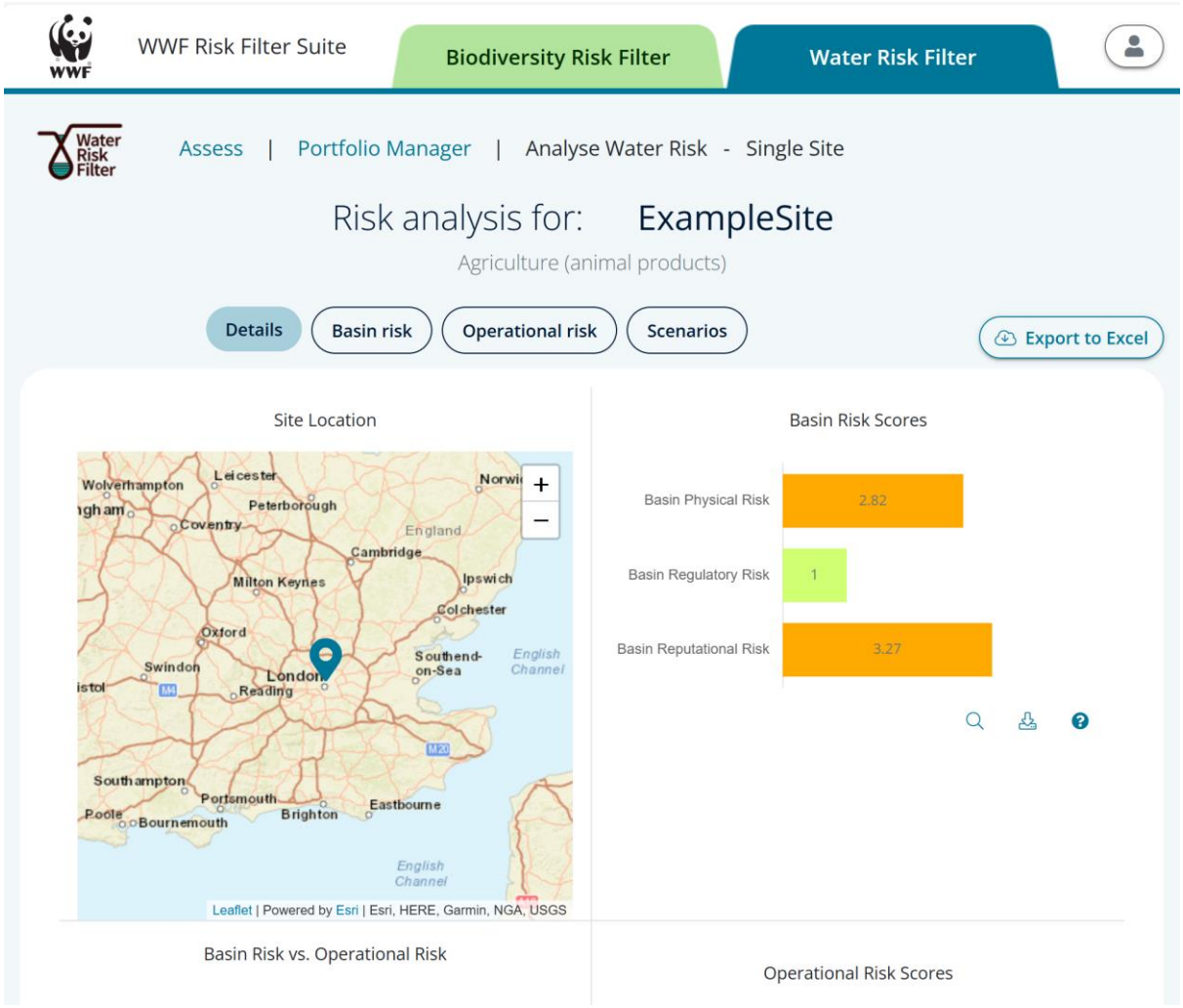

Figure 5. *Risk Analysis on the Water Risk Filter Website* [1].

The WWF-WRF provides a comprehensive assessment of water risks by accounting for two aspects:

1. The state of water resources surrounding a site's geographic location (e.g., drought, flooding, water quality, governance, etc.) – referred to as basin risks. Based on a site's geographic location, the WWF-WRF uses best available global datasets to assess basin risk.
2. How a site uses or needs water – referred to as operational risk. For operational risk assessments, the WWF-WRF tool requires users to input site-level operational via a questionnaire.

Furthermore, the WWF-WRF assesses three types of corporate water risks: physical, regulatory, and reputational[2]. These are scored on a scale of 1 – 5, from very low risk to very high risk.

The WRF website is organised into two Modules: Explore and Assess.

- The Explore Module allows one to view different water risks on global maps. It also allows one to download risk profiles as .xlsx files for whole countries, allowing for coarse intercomparison of country water resources.
- The Assess Module links to the Portfolio Manager, where a registered user can more precisely hone where to assess risk for their chosen company or location (example shown in Figure 6). The website, displays the results using maps and charts. The results can also be downloaded as either .xlsx or .csv formats, and contain a 'Help' section explaining their terminology. The downloaded file contains results for Basin Risk and Operational Risk.

WWF is currently developing a third Module which will be launched in 2027: Act. The Act Module aims to provide users with recommended actions to address their identified water risks.

Initiator

- World Wide Fund for Nature (WWF)

Category

- Corporate tool

Water issue

- Water quantity
- Water quality
- Ecosystems
- Safe access to water supply and sanitation

Geographical applicability

- Global
- National

Level of water governance

- Catchment
- National
- European

Stakeholders

- Primary sector
    - Industry
    - Financial institutions

- Other sectors
    - Industry
        - Consultants

Methodology

The WRF tool was tested through basin-level, operational-level, and combined basin-operational risk assessments using demo cases. This approach made it possible to assess how well the tool brings together these evaluations to deliver a comprehensive picture of water-related risks for companies and investors. Additionally, we explored the tool's future water risk projections for 2030 and 2050, gaining insights into potential long-term impacts. Three interviews were carried out and analysed to supplement the initial findings (Table 5).

Table 5. Overview table of interviews undertaken related to the World Wild Fund Water Risk Filter.

Interview code	Represented organisation types	Time of the interview
A	Water Risk Filter Team, one team representative	June 16th 2025
B	Forestry, pulp and paper company, one group level representative	October 27th 2025
C	Retail and Service company, one group level representative	November 7th 2025

Effectiveness of the practice

Climate change and other water pressures pose a threat to businesses' operations and targets related to sustainable and equitable water use. The **ability to assess water-related risks is a key need for businesses and financial institutions** looking to identify water related impacts at particular locations and manage and mitigate these impacts. The **WRF tool is designed to support companies in meeting their internal water targets and the regulatory obligations from the EU Corporate Sustainability Reporting Directive, following the European Sustainability Reporting Standards (ESRS)**[3].

The WRF benefits from substantial **credibility** from WWF's independent development of the platform. WWF is **widely trusted by diverse stakeholders**, including local communities and multinational corporations alike. The platform acknowledges the importance of engaging with local communities and stakeholders, recognizing that water governance is a shared responsibility. This credibility allows the WRF to act as a reliable tool producing outputs and can act as a **link between companies, governments and local communities** (Interview A).

The WRF team and the interviewed users both noted that with the tool only containing an assessment, it is only **delivering a part of a solution** (Interview A, B and C). However, the **assessment is a critical first step on businesses' water governance engagement journey**. Companies are looking to use different approaches such as the Science Based Targets for Nature (SBTN)[4] or instruments like Alliance for Water Stewardship International Water Stewardship Standard[5] to take the next steps in aligning their target setting and water action with broader water governance goals (Interviews B and C). The WRF team is also planning to implement an 'Act' feature, taking the user to the next step by recommending what to do in future for reaching their water related targets and goals. This could potentially further improve the effectiveness of the tool.

Other limitation to the tools' effectiveness in the broader water governance context relate to the data it is built on. The tool does not assess real-time water risk conditions at specific site locations. As a result, WRF advises users to verify and enhance the assessment findings with local expertise and on-the-ground information before making any decisions based on the basin risk assessment results. Interview feedback similarly suggests that the tool offers only a partial answer and should be used in combination with national datasets and site-specific information to create a plan of action. On a more technical level, Interviewee B noted the tool's strong focus on blue water (seas and rivers), and lack of inclusion for green water (held within terrestrial ecosystems) (Hoekstra, 2019). The EU's water resilience strategy outlines how it is necessary to invest in both blue water and green water conservation[6]. According to the WRF team, green water will be incorporated in the sector focused risk assessments in the future.

Efficiency of the practice

The WRF platform is user-friendly, free, and offering rapid assessments. It is designed to enable companies to prioritize water risk mitigation strategies efficiently, integrating environmental data with business needs.

Expanding capabilities and implementing novel technologies is an important aspect of a digital tool efficiency. The WRF team have stated that they would like to improve on their data resolution (Interview A), and data resolution was flagged as a current drawback of the tool (Interviews B & C). However, the limited availability of localised high-resolution data at a global scale is a challenge. **The priority of the WWF-WRF tool is to provide a screening and prioritisation tool at global scale based mostly on openly available global data sets** (Interview A). As a result, the risk assessment data is coarse, thus leading to criticism regarding the appropriateness of the resolution. Further, whilst country-wide values are relatively easy to comprehend and communicate, interviewees felt that they may simplify the overall assessment too much (Interview C). The WRF team was not confident that a future high-resolution dataset could be rolled out soon due to the size of the undertaking and the small size of their workforce (Interview A). The WWF-WRF team are hopeful that AI can improve data processing for less covered regions (Interview A). Despite this, the **speed at which new data is collected and processed is commended, and the bulk download tool is praised for its ease of us**e (Interview B). Datasets are updated and quality-controlled every two years.

According to the WWF-WRF team, **funding for the tool is an issue** (Interview A). This statement is corroborated by Interview B, who also mentioned the resource intensive aspect of this digital system. The tool was originally developed under WWF and the DEG (Deutsche Investitions- und Entwicklungsgesellschaft), the German development finance institution. Since, the tool and team have been **self-funded via paid partnership services**. Such services include advice on the use of the tool, and tailored expert support with water risk assessment, stewardship strategy and on-the-ground implementation. Nevertheless, according to the WWF-WRF team the benefits of the tool's use outweigh the potential financial losses associated with its continued support (Interview A). Indeed, the **platform is in line with the WWF's goal of supporting an advanced regulatory framework**[3]. Furthermore, the WRF tool scored well in the alignment with water governance goals section of the assessment framework, with clear GDPR and FAIR data policies (GOVAQUA Deliverable 5.1).

Inclusivity and reflexivity of the practice

The Water Risk Filter is **designed to be accessible to businesses of all sizes and sectors**, promoting inclusivity in water stewardship. The WWF-WRF team foster a culture of inclusivity and gender equality (Interview A). They believe in **transparency between stakeholders and water policy** and aim to recognise stakeholder needs. WWF is **fully transparent in its Methodology documentation** on what data it uses and how it processed into providing risk scores – unlike many existing paid-for risk assessment tools. However,

users of WRF interviewed noted that the platform does not explicitly display the raw data used for risk calculation, making it appear less transparent (Interview C). As WWF uses third party global datasets that it processes into risk scores, WWF is often not permitted to share directly the raw data but only its processed risk data. As a result, WWF is fully transparent on the source of the original raw data used so that users can then get access directly themselves to the original raw data if desired.

End users are for the main part corporate bodies. The WWF-WRF team source data for the tool from a range of institutions. They also work in collaboration with academia to source some of their data and consider future developments. The use of data from academia can be problematic due to the intrinsic nature of academia work which is high-paced and constantly seeking innovation. Thus, it is more difficult to incorporate data from academia as the methods are not always consistent through time. However, the WRF team do envision a way to better communicate with those institutions in the future (Interview A).

The interviewed business users were hoping for more reflexivity of the WRF (Interviews B and C). Users interviewed mentioned month-long response times for help requests (Interview B). However, it is worth mentioning that WWF-WRF is a free tool with over 27,000 registered users. When interviewed, the team said they were planning on implementing a feedback system, and the website now features a contact form to reach out on every page (Interview A). However, WWF cannot address every single user feedback request for changes in the tool and needs to prioritise most strategic changes for achieving WWF's mission.

Replicability and generalizability of the practice

The WWF-WRF is designed to be used as a screening and prioritization tool for water risks worldwide. Thus, it is not designed to be used for local-level assessment due to the coarse resolution of its data, which can impact effectiveness and efficiency, as mentioned above. However, it is useful when used in combination with national and local knowledge and products. Furthermore, if one was to develop a more locally relevant platform – potentially only spanning one country or continent – that would allow for more time to collate higher resolution data, improving both its effectiveness and usability. Ultimately, the success of a practice such as the WRF depends on the availability of relevant and accurate data and the capacity of businesses to implement water stewardship measures based on the tool's recommendations. A robust business model to ensure sufficient funding for providing effective user-support and ensuring technical maintenance and upgrade is also essential. The WRF tool has set an example governments could also follow, making their national water data publicly available and easily accessible for stakeholders such as businesses wanting to identify and understand their water risks and impacts, and target water stewardship action.

Technical details

Contact Persons: Suvi Sojamo, Finnish Environment Institute Syke & Giovanni Bernardi, UKCEH

Related Websites:

Water Risk Filter. WWF. https://waterriskfilter.org.

Physical, Regulatory and Reputational Water Risks as Predictors of Water Stewardship Among Global Corporations. CEO Water Mandate (2016). https://ceowatermandate.org/resources/physical-regulatory-and-reputational-water-risks-as-predictors-of-water-stewardship-among-global-corporations-2016/

WWF Risk Filter Suite – Technical Guidance for ESRS. wwf-risk-filter-suite---technical-guidance-for-ESRS. https://wwfint.awsassets.panda.org/downloads/wwf-risk-filter-suite---technical-guidance-for-esrs.pdf

Science Based Targets Network. Resources. https://sciencebasedtargetsnetwork.org/resources/.

Alliance for Water Stewardship International Water Stewardship Standard https://a4ws.org/aws-standard/.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. European Commission (2025). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52025DC0280.

Related Resources:

Hoekstra, A. Y. (2019). *Green-blue Water Accounting in a Soil Water Balance.* Advances in Water Resources, 129, 112–117. https://doi.org/10.1016/j.advwatres.2019.05.012.

3.5 Destination Earth: Digital Twins

General description

Destination Earth (also called DestinE) is a flagship initiative of the European Commission to support Europe's green transformation[1]and the European Water Resilience Strategy (mentioned in a flagship action). Its purpose is to develop a highly accurate digital model of the Earth by 2030. This will provide information needed by a range of actors through 'digital twins'[2]. A digital twin of Earth is an "information system that exposes users to a digital replication of the state and temporal evolution of the Earth system" and "delivers an interface and development toolkit that makes it easy to configure and efficient to use, and that can execute all of its tasks in a highly efficient virtual environment" (Bauer et al., 2021).

Destination Earth was launched in 2022, and the main components were implemented in 2024, working towards a full earth replica by 2030. The Destination Earth objective is to facilitate greater understanding of our changing climate - as well as dangerous, extreme weather events and impacts -informing effective European adaptation strategies in support of the green transition[3]. The development of Destination Earth was funded to help support the European Commission's Green Deal, Data Strategy, Digital Strategy, and European Water Resilience Strategy complementing existing national and European efforts. The first two high-priority digital twins are the Weather-Induced Extremes Digital Twin[4] and the Climate Change Adaptation Digital Twin[5]. The Destination Earth's Digital Twin for Climate Change Adaptation (Climate DT) supports adaptation activities by providing innovative climate information on multi-decadal timescales, globally, at local to national scales at which many impacts of climate change are observed. As well as ECMWF delivering these digital twins and the digital twin engine, the European Space Agency is leading on the Destination Earth platform (user access point for the Destination Earth ecosystem), and EUMETSAT is leading on the Destination Earth Data Lake, which provides data access and processing capabilities services.

This practice is at an early stage: it is currently still being developed and is currently undergoing testing, assessment and validation by stakeholders and independent evaluators. Destination Earth is included due to the large funding by the European Commission and relevance to European water governance and European Commission's Digital Europe Programme (with over 100 million euros in the 2025-2027 work programme[6]).

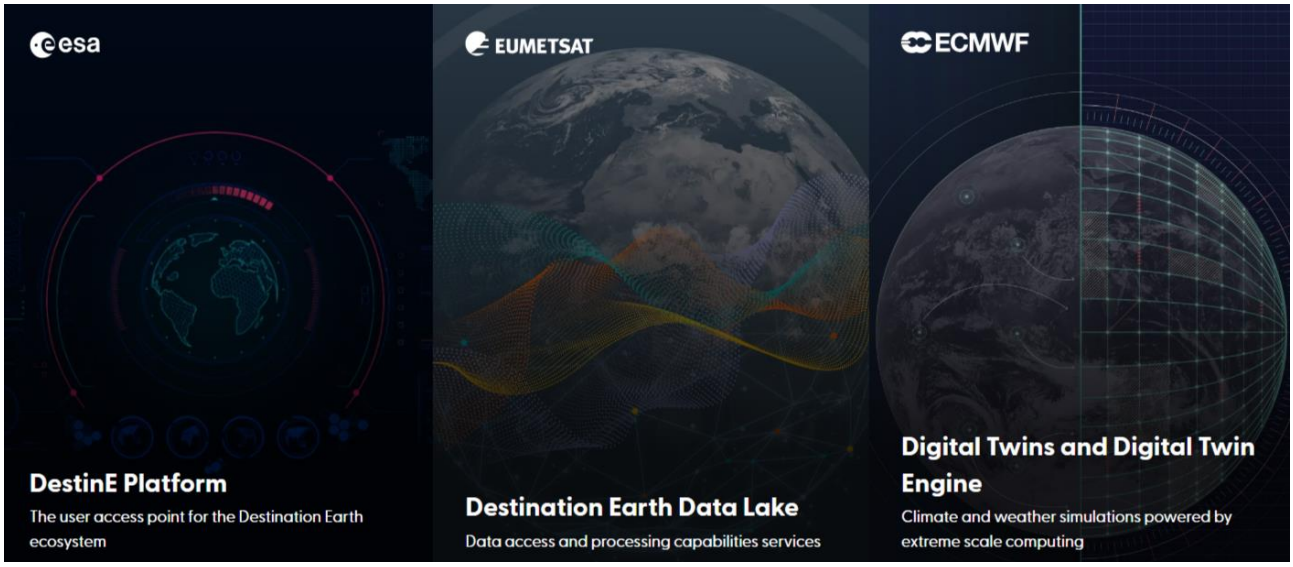

Figure 6. The three main components of Destination Earth.

Methodology

Information about this good practice was compiled through web and literature searches. The lead author attended user events to identify potential interviewees. To assess the good practice from an end user's perspective data from one interview was analysed (Table 6).

Table 6. Overview table of interviews undertaken related to the Destination Earth digital system.

Interview code	Stakeholder	Time of the interview
A	Europe based nonprofit organisation that applies science to create innovative solutions for real-world challenges including climate adaptation and water resources	August 20th 2025

Initiator

- European Commission

Category

- Platform

Water issue

- Water quantity
- Water quality
- Ecosystems

Geographical applicability

- Global
- EU

Level of water governance

- Local
- Catchment
- National

Stakeholders

- Primary sector
    - Industry
- Other sectors
    - Public authorities
        - catchment governance agencies
        - municipalities
    - Civil society
        - NGOs
        - local communities
    - Research

    - Research institutes
    - Universities
- Industry
    - Consultants

Effectiveness of the practice

Though Destination Earth as a practice is at an early stage of operation, becoming operational in June 2024[7], it is already being used to support a wide range of European policy areas related to water governance including the Floods Directive (2007/60/EC) and the EU Strategy on Adaptation to Climate Change (2021). There is a growing body of use cases demonstrating its effectiveness to potentially support policy and operational activities from the local to European level[8]. Many of these are related to water governance in Europe, for example Danube Delta Water reservoir monitoring[9] and HydroRiver application providing global freshwater data[10]. The benefits of Destination Earth for building data-driven high spatial and temporal resolution solutions with near-real time data were noted during our interview (Interview A). An example of the increase in spatial resolution of data was presented for a Southern European city. They discussed how Destination Earth's high resolution climate data was more effective for building digital solutions to support local decision makers in a consistent way compared to the existing patchwork of data providers across the member states they worked in. One topic the interviewee stressed was the importance of Destination Earth to provide data at a far shorter lag time compared to the current services offered by their national weather service (Interview A).

Efficiency of the practice

Assessing the efficiency of Destination Earth will be challenging for anyone involved due to the size of the project and the broad range of ways that it is being used to support water governance in Europe, across 28 services (and increasing in number)[11]. As noted, many use cases of Destination Earth are at an early stage compared to other European climate services like CEMS-EFAS, which has been in operation for over 10 years (see 3.2 CEMS-EFAS). An early paper making the case for why developing Destination Earth was needed, highlighted the challenges of providing an approach to support European and global policy needs e.g. SDGs (Nativi et al., 2021).

Drawing on our end user interview (Interview A), they discussed several areas related to efficiency, some positive and some less so. The ability of Destination Earth's digital twins to **provide high resolution data across Europe (and the rest of the world) is important for companies like theirs providing digital solutions to multiple local/city level stakeholders, enabling scalable solutions for clients**. They liked that there were multiple ways to access the Destination Earth data including programmatically through an Application Programming Interfaces (APIs) - to meet different user needs. During the interview, they described how Destination Earth enabled at least **50% gains in efficiency for accessing and using climate data compared to what previously existed**. And that Destination Earth were using or exploring recent advances in cloud native formats like Zarr, to enable faster operations/services for end users (Interview A).

Two topics from the interview that were potentially reducing the efficiency of Destination Earth were the large number of services (or channels) to get access to Destination Earth data and services; as it took time to be aware and understand what they offered, and what they should use in terms of viewing, accessing, and processing of data. They suggested there should be more of a focus on the major services for data visualisation, data downloading and processing as part of a basic toolkit. A bottle neck to the spread/uptake of Destination Earth data (and hence its efficiency) was the need for even greater resources to enable local

and member state level organisations to be aware of its potential. From their personal experience, they thought the downloading of Destination Earth data could still be improved to enable them to use their own analysis tools (Interview A).

Inclusivity and reflexivity of the practice

Active stakeholder engagement is vital for the success of Destination Earth. It is only through stakeholders guiding its development that Destination Earth can live up to its vision, deliver on Europe's investment, and **build a solution meeting the diverse user community needs related to water governance**. To this end, there has been **an increase in efforts to co-design their approach**, bringing in stakeholder communities through a range of activities including a series of hybrid User Exchange events[12,13]. A report from an early user engagement workshop in 2021[14], highlighted the need for engagement processes to empower users of Destination Earth and deliver to their needs. Our understanding is that feedback like this led to the establishment of a series of User Exchange events, which have run every 6-9 months, since the first one in February 2023[12]. The first event was attended by 100 people in person and over 300 online, and initiated the 'open stakeholder dialogue' pillar of the Destination Earth user engagement strategy. Since then, they have held a further four User Exchange events, with the next one planned for June 2026[15]. With the launch of the Destination Earth platform[11] in 2024, an increasing number and range of support materials have been added, including a Learning Hub[15] with video tutorials. During an interview with an end user, they said they found attending the 2025 User Exchange event to be useful and that Destination Earth staff were listening to the feedback they provided (Interview A).

Through discussions with an end user (Interview A) they said, they thought **Destination Earth was trying really hard to be inclusive of non-expert users, but there was still a gap to be filled at the national level - to have some kind of national ambassadors.** They made reference to the Copernicus services were this model was used (see 3.2 CEMS-EFAS). They went on to say that local to national stakeholders/end users were busy with their day-to-day jobs, and often do not have time to learn about innovations like Destination Earth. And that they may need a central national resource/point of contact to guide them. Additionally, they talked about how Destination Earth's services/channels need to be easily integrated into end users existing tools and procedures. They talked about the need for some kind of translation for local and national users once the services have matured, and this should be as close as possible to the end users. Due to the range of services/channels provided by the Destination Earth platform and digital twins, there probably needs to be greater sign posting to help different kinds of users with a road map/guide to help them navigate what is available (Interview A).

Replicability and generalizability of the practice

Destination Earth's breadth of potential use cases related to water governance and ambition, means that it is generalizable to all situations that are supported by appropriate data and understanding. All models and digital information solutions for aiding water governance may suffer from a lack of relevant data and understanding e.g. process representation. With Destination Earth, the European Commission are aiming to centrally and consistently solve many of Europe's information needs for water governance and related aspects of sustainable development. In terms of replicability, the idea behind the digital twin engine is that digital twins related to specific water governance issues or place-based needs could be more efficiently and effectively created and used in a consistent way. An end user noted the significance of a common platform, like Destination Earth, in terms of scalability across Europe and the rest of the world (Interview A). This combined with greater trust that a non-profit European platform (designed for European use cases) had over commercial North American offerings (Interview A), meant there was greater potential for replicability and generalizability across Europe.

Technical details

Author/contact person: Kit Macleod, UKCEH

Related websites

Destination Earth (DestinE) – digital model of the earth. https://digital-strategy.ec.europa.eu/en/policies/destination-earth

ECMWF Understanding DestinE's Digital Twins. https://destine.ecmwf.int/explainer/

Destination Earth, About Destination Earth. https://destination-earth.eu/destination-earth/

Destination Earth, Weather-Induced Extremes Digital Twin https://destine.ecmwf.int/weather-induced-extremes-digital-twin/

Destination Earth, Climate Change Adaptation Digital Twin https://destine.ecmwf.int/climate-change-adaptation-digital-twin-climate-dt/

The DIGITAL Europe Programme – Work Programmes. https://digital-strategy.ec.europa.eu/en/activities/work-programmes-digital

Destination Earth News, Launch of Destination Earth system. https://destination-earth.eu/news/destination-earth-system-launch/

Destination Earth Use Cases Catalogue. https://destination-earth.eu/use-cases/

Destination Earth Use Cases Catalogue, Danube Delta Water Reservoir Monitoring. https://destination-earth.eu/use-cases/danube-delta-water-reservoir-monitoring/

Destination Earth Use Cases Catalogue, Changes in the Water Cycle https://destination-earth.eu/use-cases/understanding-changes-in-the-water-cycle/

DestinE Platform https://platform.destine.eu/

Destination Earth Events, 1st Destination Earth User eXchange. https://destination-earth.eu/event/welcome-to-the-first-destination-earth-user-exchange/

Destination Earth Events, 5th Destination Earth User eXchange https://destine.ecmwf.int/5th-destination-earth-user-exchange/

Destination Earth initiative 3rd User Engagement Workshop - Summary Report. https://digital-strategy.ec.europa.eu/en/library/destination-earth-initiative-3rd-user-engagement-workshop-summary-report

DestinE Platform Learning Hub https://learninghub.destine.eu/

Related resources

Bauer, P., Stevens, B., Hazeleger, W. (2021). A digital twin of Earth for the green transition. Nature Climate Change. 11, 80-82. https://www.nature.com/articles/s41558-021-00986-y

Nativi, S., Mazzetti, P., Craglia, M. (2021). Digital Ecosystems for Developing Digital Twins of the Earth: The Destination Earth Case. Remote Sensing. 13, 2119.

4.Conclusions

Supporting sustainable and equitable water use across Europe—in line with key policies and strategies such as the WFD and European Water Resilience Strategy—requires continued improvement of digital solutions for information sharing to support water governance. This is particularly clear in the 'Five enabling areas to pave the way for a Water Resilient Europe' in the European Water Resilience Strategy. Climate change is intensifying pressures on Europe's water bodies, while sectoral demands on water resources continue to grow. Thus, these solutions must provide trusted, relevant information to a range of end users (from local to EU level) in formats and timeframes that support their planning and decision-making.

In this report, we have reviewed and presented end user perspectives on four long established good practices that support water governance, and the more recent Destination Earth that has a central role in the European Water Resilience Strategy. Through writing this report and the earlier broader review of Digital solutions for information sharing (D5.1), we have been able to draw on a wealth of practices that support sustainable water management from the farm level to EU and Global levels. We focus on understanding how data and digital elements enable collaborative processes where individuals and organizations collect, use, and improve information flows to meet their needs.

Throughout the in-depth study of these practices, we have established the fundamentals that contribute to their respective successes. Within these fundamentals there are differences driven by their purpose and their target audience, their geographic applicability, and their level of water governance:

- **Continuous engagement to understand end user needs**
  All our good practices were designed and operated to meet one or more decision makers' needs from the headwater catchment level water quality (Riverfly Partnership), river basin level flood risk (CEMS-EFAS), farm level water resources (SAIH), company asset level water risks (WRF), and European policy level (Destination Earth). The length of time through which these practices have been operational varied from the recent operational status of Destination Earth to the longer term established CEMS-EFAS and SAIH. Nonetheless, continuous engagement with end users through a range of activities is paramount to establish their need and ensure a continual improvement of the digital solution to address these. This aspect is an important contributor to the effectiveness and efficiency of a digital solution for information sharing amongst multiple stakeholders. Understanding the needs and expectations of the targeted audience is also quintessential to the inclusivity of the practice. The design requirement for continuous engagement with end users is based on industry best practice of user-centred design[9].

  Exemplary features of these practices to support water governance in terms of continuous engagement to understand end user needs include: Riverfly Partnership's close working with the Environment Agency (England). Another example is the large amount of training of end users of CEMS by core staff and national representatives.

  Across the good practices presented there is variation in the level of engagement with users, with some of our interviewees reporting a need for greater effort and investment to support user feedback and improvements e.g. SAIH and WRF.
- **Data into information: the core of these practices**
  All the practices presented demonstrate the need to present user relevant information in a range of formats including maps, tables and graphs. The variety of formats is key to address the needs of a wide audience with varying level of technical awareness. The data also needs to be

[9] User Centered Design https://www.interaction-design.org/literature/topics/user-centered-design

supported by clear and up-to-date metadata and training material. These aspects are key to the reflexivity and inclusivity of the practices. To meet users' needs for replicability and generalizability across geographic regions, the key data/digital and social enablers include standardised approaches to collecting and processing data, and the provision of information that is trusted, relevant, accessible, and timely.

Exemplary features of these practices to support water governance in terms of going from data to information include: the wide range of data collected by Guadalquivir SAIH and how this is transformed into useful and actionable information provided to water users and managers.

Regarding data into information, the greatest difference between the practices is the origin of the data including data type (*in-situ* and remote sensing observations, and modelled data), data collection, data purpose and data subject (e.g. water quantity, water quality, and ecological data). This spans from citizen scientists (Riverfly Partnership) to satellite collected data related to the state of water bodies (CEMS and Destination Earth). There are also differences in terms of the scale of the practices, the size and diversity of the end users and the number of water-related sectors supported.

- **Funding: Need for substantial and sustainable financial investment**

  The investigation of these practices, including the content of the interviews, emphasised that these solutions need significant financial investment to support operational needs. The practices had a variety of funding sources including grants and broader fisheries licensing (Riverfly Partnership), corporate licensing (WRF), and European Commission funding (CEMS and Destination Earth).

  Exemplary features of these practices to support water governance in terms of funding include: the European Commission's support for open European solutions to European geographic extent to support water management and governance from local to European level (CEMS and Destination Earth). This funding enables the development and maintenance teams to design and operate the intertwined social and digital aspects of these solutions and their continual improvement to meet end user needs.

In the next phase of GOVAQUA, the good practice descriptions will be moved to an online repository, with the intention to make them available for various water decision makers, managers and users across Europe. Further, the lessons learned from the digital solution good practices will be used in the next steps, which focuses on formulating recommendations on transition to sustainable and equitable water use in Europe (D5.4).

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Annexes

Annex I: GOVAQUA Good practice template

Good practice definition

A good water governance practice in the GOVAQUA project is defined as follows:

A good water governance practice exemplifies an innovative instrument, approach or arrangement that contributes to achieving water-related policy goals and targets in a sustainable and equitable manner. It has been tested in practice, assessed and validated by stakeholders and independent evaluators in a specific context against specific principles and criteria.

Water governance good practices originate from certain contexts and are tied to the water issues of that context. Therefore, they entail certain prerequisites from their implementation environment. Thus, broadly applicable "best practices" for water governance cannot be discern[10]. However, within good practices implementation different performance levels can be achieved, typically requiring different levels of effort and resources, building on a continuous improvement.

The good practices documented with this template are all examples of emerging water governance innovations that are not yet broadly applied but hold promise for replicability and up-scaling in the EU context. The difference of this good practice documentation to water governance assessments, initiated e.g., by the OECD and the self-assessment tool developed in the GOVAQUA project, is that the focus of the good practice is on an instrument, approach or arrangement, rather than the broader water governance context such as a nation or a basin.

Purpose and target audience

The documented good practices are primarily intended to validate existing niche practices and to provide innovative ideas for national and basin level water managers and other decision makers in water governance. The practices are also relevant to other water governance actors, such as NGOs, companies and research institutes that initiate or participate in water governance processes.

Good practice criteria

Water governance instruments, approaches and arrangements advance sustainable and equitable water use when they:

[10] Note: For example, the recent OECD *Handbook of What Works Solutions for the Local Implementation of the OECD Principles on Water Governance* (OECD 2024) only refers to "evolving water governance practices" that "respond to the challenges underlying each of the 12 (OECD Water Governance) Principles", drawing lesson from "successful" and "challenging" implementation examples. Nevertheless, OECD generally advances identification of "good water governance" practices.

Are effective, i.e., they

1. Address a problem or a need related to sustainable and equitable water use
2. Connect and contribute to water-related policy goals and targets
3. Define and follow clear roles and responsibilities for different stakeholders
4. Are linked to appropriate scales within basin or other water governance systems
5. Match or advance the level of technical, financial and institutional capacity in the given water governance system

Are efficient, i.e., they

1. Utilize, share and enhance adequate water-related data and information
2. Are cost-effective and/or help mobilizing financing for associated water solutions
3. Connect to and advance sound regulatory frameworks

Are built on or advance inclusivity and are reflexive, i.e., they

1. Are built on or advance transparent and accountable processes and outcomes
2. Are built on or advance equal participation and collaboration between stakeholders and water justice, and are gender-sensitive
    a. Recognise the different types of stakeholders and their different needs
    b. Equally distribute the benefits, harms and costs that result from the practice among different stakeholders, and address and resolve trade-offs and potential conflicts between users
    c. Involve different stakeholders and integrate their different types of knowledge into the decision-making process,
3. Include and advance regular monitoring and evaluation mechanisms
4. Promote social learning, innovative ways to cooperate and science-policy interface

Template

General information

Title

The name of the practice

General description

Initiator

Category

Water issue

Geographical applicability

Level of water governance

Stakeholders

Good practice description/assessment and validation

Methodology for the assessment and validation

Effectiveness of the practice

Reporting by criteria as listed in the previous section, including documented successes and challenges.

Efficiency of the practice

Reporting by criteria as listed in the previous section, including documented successes and challenges.

Inclusivity and reflexivity of the practice

Reporting by criteria as listed in the previous section, including documented successes and challenges.

Replicability and generalizability of the practice

Reflection on the necessary conditions.

Technical details

- Author/contact person
- Publication date
- Related websites
- Related resources

Annex 2: Interview guide

Table 7. The interview questions based on the OECD/GOVAQUA water governance themes.

ID	Topic and questions	Rationale
	Warm up	
1	Please summarise your role and use of digital solutions for information sharing to improve water governance, where? Prompt: explore their response Prompt: what sort of water related decision making are you and your organisation involved with?	To gain an understanding of the individual's role and use of digital solutions related to the water related decision making they are involved with. Also serves as an icebreaker and to better understand the context of the user in relation to the digital solution and how used to aid water governance.
	Effectiveness of digital solutions for information sharing to improve water governance.	Are digital solutions helping people access and use information to support better water governance decisions? This heading (and the others) is based on the OECD Principles of Water Governance headings, which have been adopted by the GOVAQUA project, and form the basis of the 'good practice' template this material will enrich.
2	How does X help you and your organisation achieve its water-related objectives? Prompt: please provide examples. Prompt: can you give an example of a recent decision or action where data helped?	Wanting to understand their perspective on how X helps them and their organisation achieve its water-related objectives. In line with OECD principles and GOVAQUA, need to understand the effectiveness of digital solutions to improve water governance (from the perspective/objectives of the individuals we interview).
3	Do you feel that the information available from X is trustworthy, relevant, and timely? Prompt: how do you judge the trustworthiness and reliability of the data? Prompt: how is the information relevant to you and your organisation? Prompt: how timely is the information to you and your organisation?	A range of previous studies have found that for end users to have confidence in data and associated digital solutions, they needs to be trustworthy, relevant, and timely.
4	Has your ability to take action or influence water-related outcomes improved thanks to X? Prompt: have you been able to use data from X reports, meetings, or campaigns?	Need to understand how end users have been able to use data from X. There is a lot of psychology including models on how people and organisations go from awareness to taking actions. There are a spectrum of impacts of research and tools. Often we are interested (sometimes overly optimistically) that X will lead to an action (more often than not, X is just one factor/components of a decision/action situation).
5	How is X effective for enabling you to access and use information? Prompt: please share any blockers or challenges to either access or using the information you required.	Often a key role of a digital solution is enabling access to and use of data/information.

	Efficiency of digital solutions for information sharing to improve water governance.	In this section we are wanting to learn: are digital tools saving users time, money, or resources in accessing and using water-related data? The concepts of efficiency and effectiveness are closely related (and often overlapping and at least connected); people do not always see them as different concepts.
6	How easy or time-consuming is it for you to find the data you need on X? Prompt: compare this to before the current tools existed, if possible.	Many studies report that lots of time is spent on finding the required data. One role of digital solutions is to aid this.
7	How has X helped you reduce duplication of effort or streamlined any workflows? Prompt: are you using APIs, dashboards etc?	Often an individual (let alone their team or organisation) is working on several related analysis tasks using the same digital tool; ideally it would make this repetitive work easier.
8	What bottlenecks or friction in using X do you face for your work? Prompt: what is most valuable functionality of this tool in terms of data accessibility and data interoperability? Prompt: is downloading, transforming, or interpreting data a pain point?	There are always multiple causes of friction when carrying out analysis based studies (some of technical and some are social). Need to understand this pain points, to improve the efficiency (and effectiveness) of the digital solutions.
9	What would X help make your use of water data more efficient? Prompt: think about interface design, formats, frequency of updates, or compatibility with other tools.	It is always good to ask the end user what would improve their experience of using X.
	Inclusivity and reflexivity of digital solutions for information sharing to improve water governance.	In this section we are looking to learn are platforms designed and managed in ways that include diverse users and are responsive to their needs and feedback?
10	Do you feel that X is designed with your needs in mind? Prompt: were you ever asked for feedback? And was anything changed as a result?	From WP3 interview template. This is about their direct involvement in the co-design and feedback. Fundamentally digital solutions need to be designed and operated based on end user needs. It is essential to ask end users if this is being achieved.
11	Is it easy for different types of users (technical/non-technical, local/national) to access and understand the data from X? Prompt: have you ever helped someone else use the tools? What challenges did they have?	Ideally a digital solution would be used by a range of end users (of varying technical expertise), this is not always possible or present in the current version of digital solutions as it is difficult to design for a range of technical abilities.
12	Have you seen any changes X in response to feedback or evolving user needs? Prompt: Do you know how to request features or report issues?	From WP3 interview template. This is about their wider awareness of co-design and feedback to improve X.
13	Any other challenges, and improvements? Or anything else you would like to say about X?	Inline with WP3 questions. Useful to ask a general question to surface other challenges or suggested improvements.