Untapping the Potential of Earth Observation and Digital Technologies for Improved EU Water Policies

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Delivering Advanced Predictive Tools from Medium to Seasonal Range for Water Dependent Industries Exploiting the Cross-Cutting Potential of EO and Hydro-Ecological Modelling

To access the full list of the partners of the project, visit: *https://www.primewater.eu/partners/*

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PrimeWater

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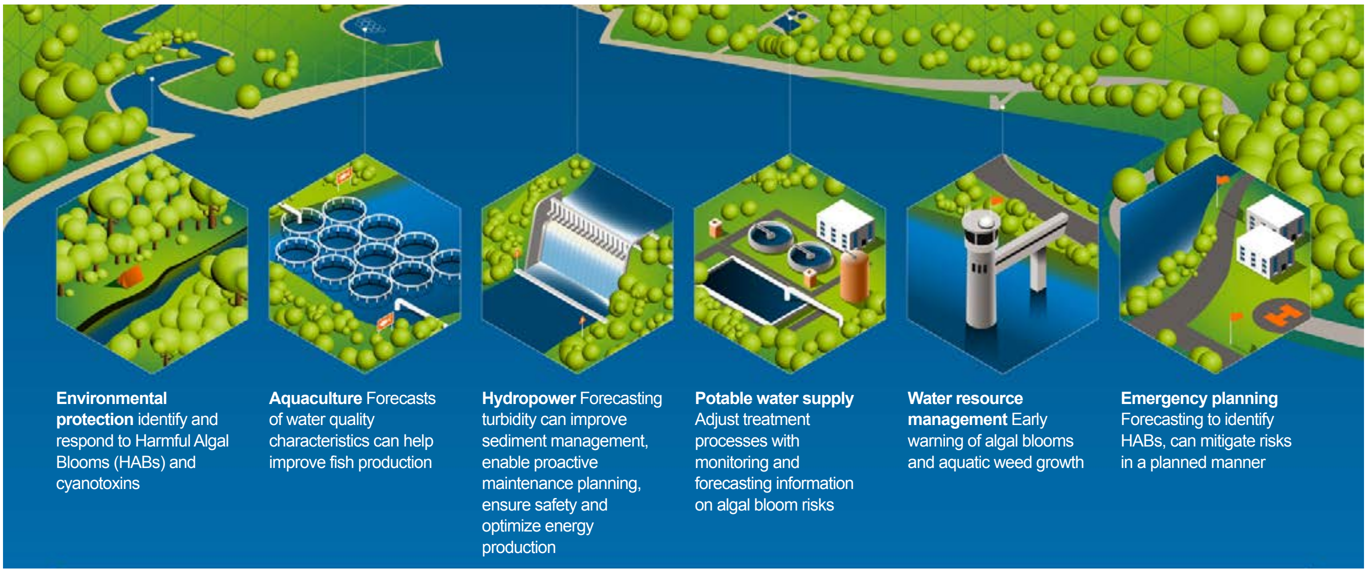

Figure 1 – Earth Observation technologies can be used to better monitor and manage different water services for maximum efficiency

Executive Summary

This policy brief highlights the potential of Earth Observation technologies for improved water management and presents areas of improvement for uptake by EU decision-makers. PrimeWater is a Horizon-2020 project funded by the European Union aimed at improving water management through the integration of Earth Observation technologies. The project has been successful in developing a robust platform for monitoring water quality, quantity, and distribution using satellite imagery and ground-based sensors. This policy brief provides an overview of current gaps in the EU policy, especially in relation to the Water Framework Directive and relevant programmes and strategies, such as the Digital Strategy, the Green Deal and Space Policy and Copernicus.

Based on the PrimeWater experience, the policy brief recommends research & development of digital water solutions, skills and collaboration in the water sector and recommends a holistic approach taking into account the need for further integration and harmonisation of technologies and digital applications for improved water management. Digital and technological innovations are crucial for water resources management and can effectively monitor and address issues such as climate change, extreme weather events, water scarcity, and other negative environmental impacts such as harmful algae blooms or deterioration in the ecological or physico-chemical quality. The challenges of digitalisation and water management can be addressed holistically through a dedicated initiative by the EU on Digital Water, as a way to ensure coherent integration with relevant priorities and support integrated water resources management in a digital era.

Key Messages

- Earth Observation technologies are crucial for improved water management.
- Digital water solutions, skills and collaboration need to be enhanced in the EU water sector. Investments in R&D and capacity building in the fields of Earth Observation and digital water solutions should be prioritised to build a water-smart society.
- A holistic approach is necessary for integrated water resources management, which should include harmonisation and guidance on technologies and digital applications.
- A dedicated initiative on Digital Water in the EU can improve water management in an era of digitalisation and ensure coherent integration with relevant programmes, policies and strategies of the European Union.
- As part of the twin green & digital transition, policymakers should drive innovation and sustainability in the European water sector through targeted investments and initiatives

1. Introduction

Water management is a critical challenge for the European Union, as well as for the rest of the globe. Water is a finite resource, and its availability and quality are essential for human life, economic development, and for human health and a prosperous environment. The European Union has made significant efforts to improve water management through various policies and initiatives, such as the Water Framework Directive and resultant policies on national or federal levels, the European Green Deal, and the Blue Growth Strategy, among others. While it is widely accepted that most EU policies in the field of water management are still fit for purpose, it is recommended that policies are adapted and updated, especially for what concerns digitalisation. The project highlighted how important international partnerships with dedicated groups like Geo AquaWatch, AquaWatch Australia, and the IWA EO for water management Community of Practice, can improve the development of EO and its uptake. The PrimeWater experience suggests that EU, and global, policymakers can do more to address numerous challenges that we have observed in the implementation of the project, such as lack of knowledge and institutional factors limiting the uptake of EO technologies in the water sector, data misinterpretation and inadequate EO skills, insufficient knowledge management and collaboration among stakeholders, especially between scientists and policymakers. The PrimeWater project aims to improve EO technologies to monitor water quality, quantity, and distribution. Working in concert with project partners from the EU, Australia and the US, the project has successfully developed a robust platform for water management, integrating satellite imagery and ground-based sensors with advanced data analytics tools. This policy brief consolidates the project results and highlights the relevance and application of Earth Observation technologies for improved water management. The brief also provides recommendations for the integration of water management initiatives with other relevant programmes, policies and strategies of the European Union, such as the Digital Strategy, the EU Green Deal, the European Space Programme and the Copernicus component. Furthermore, increased collaboration amongst EU, Australia, and the US can enhance the quality of EO and in situ modelling for the SDGs and the System for Economic and Environmental Accounting (SEEA).

1.1 PrimeWater and IWA's Digital Water Programme

PrimeWater is a Horizon2020 research project that focuses on understanding the impact of upstream changes on future water quality and quantity. The project aims to deliver critical information on inland waters, derived from Earth Observation (EO) or satellite technologies, more accessible and usable across the water sector. Earth Observation technologies use algorithms to integrate various types of imagery into the modeling chain from satellite, airborne and ground-based sensors. By using advanced data assimilation and machine learning algorithms, PrimeWater aims to enhance the accuracy of hydro-ecological forecasts at different space and time scales, which can then be utilised in decision-making. By providing increased predictive capabilities, PrimeWater allowed water managers to efficiently optimise downstream water services and better prepare against forthcoming critical changes in water quantity and quality. PrimeWater has provided better and more actionable information for water resources management for public and private sector decision-makers. PrimeWater has a unique strength as it connects the scientific community with stakeholders who can benefit from more accurate water quality forecasts for **potable water supply, recreation, hydropower, aquaculture, aquatic ecological health/environmental protection, catchment water resources management and emergency planning**.

The project's implementation is supported by the *IWA Earth Observation for Water Management Community of Practice (CoP)*. The CoP aims to bridge the gap between the scientific community and policymakers by facilitating collaboration among experts from different sectors and end-users. The CoP encompasses work beyond PrimeWater and focuses more broadly on the use of EO across the water cycle. The positive experience from the CoP on knowledge sharing and collaboration among different stakeholders suggests that more collaborative efforts such as these should be supported. **EU policymakers are welcome to engage in the CoP to bridge the gap between policy and practice and as a way to bring European institutions closer to citizens and stakeholders**.

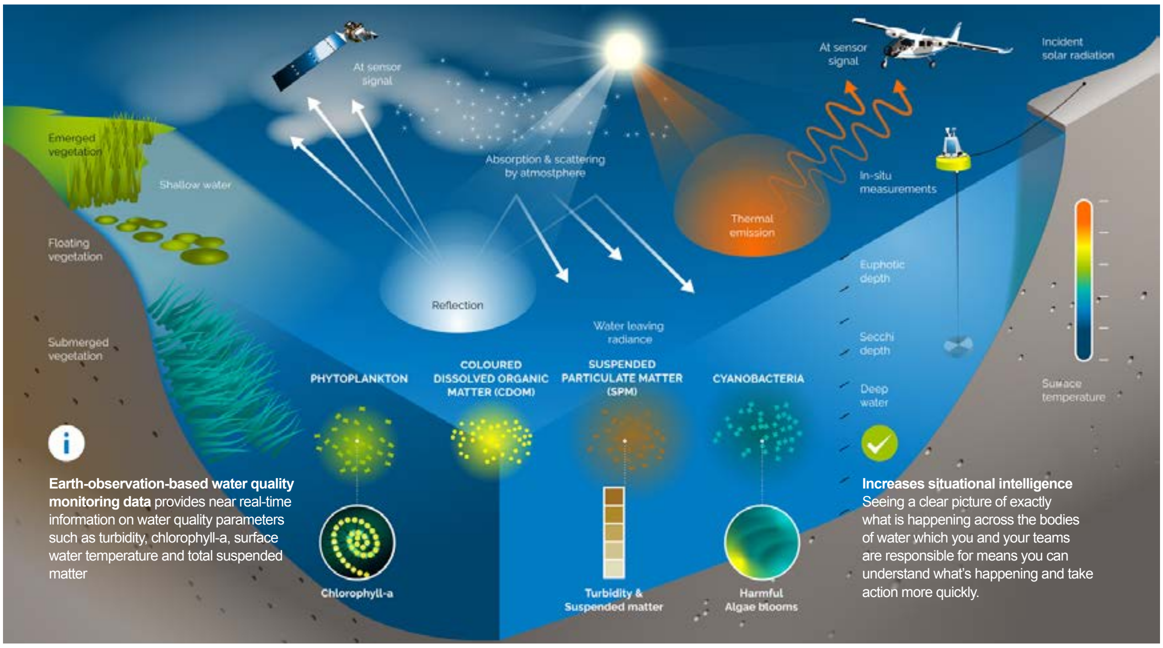

Figure 2 – Monitoring and gathering of water quality parameters

1.2 Project Applications and Limitations

The project applications touched different areas in the water sector, such as environmental protection and emergency response, water resources management, potable water supply, hydropower, and aquaculture. PrimeWater's application was tested in four full-scale international case studies across Europe, the USA, and Australia. These case studies assessed the transferability of PrimeWater applications in diverse water catchment systems and sectors and addressed various perspectives of water management. The case studies demonstrated the value of data for hydrological modelling and forecasting, which can be utilised by decision-makers. PrimeWater provided continuous environmental data that policymakers and water managers can use in a reliable format, incorporating in-situ data, and water quality modelling. The data was presented in a seamless and informative interpretation, ready to be used by water managers and decision-makers.

The PrimeWater project has achieved several significant results in improving water management through technologies. The project has developed a platform for monitoring water using satellite imagery and in-situ data. Achievements include:

1. Water quality monitoring: The platform integrates data on water temperature, turbidity, total suspended matter, chlorophyll-a and other parameters to assess water quality accurately. This information is critical for detecting pollution, identifying pollution sources, and mitigating the impact of pollution and other environmental risks such as algal blooms on human health and the environment.

2. Water quantity monitoring: The platform integrates data on evapotranspiration, seasonal hydrological forecasts and other parameters to assess water availability accurately. This information is critical for managing water resources, identifying water scarcity, and optimising water allocation among various users.

3. Flood and drought monitoring: The platform integrates data on precipitation, soil moisture, and other parameters to identify potential flood and drought risks. This information is critical for early warning and rapid response to mitigate the impact of floods and droughts.

4. Data-driven modelling and decision-making: The project has developed advanced data analytics tools for processing and analysing water-related data. These tools include machine learning algorithms, statistical models, and visualisation tools. These tools offer better and more actionable information to public and private sector decision-makers for water resource management, enabling stakeholders to make data-driven decisions for improved water management practices and adaptive management of water resources.

In terms of limitations of current technology and of the four regional applications, it is necessary to highlight that further research is required to improve satellite EO performance, especially over small water bodies, such as reservoirs, and incorporate observation uncertainties into the models. These limitations and further research opportunities are evidenced more extensively in the project results.

2. Overview of Relevant EU Policies & Strategies and Opportunities for Integration

The European Union recognises that Earth Observation data can be useful throughout the policy cycle to support the twin digital and green transitions (*JRC Portfolio 18*). The European Union also agrees that this is a critical period for defining and refining the next generation of the EU's EO capacity looking out to 2035 and beyond. The bloc's ambition is to ensure a more fit-for-purpose EO capacity to support the transitions. Despite this ambition, untapped opportunities remain in the application and integration of EO and digital tools for better water management. This policy brief has identified several relevant EU policies, programmes and priorities that can benefit from further integration of EO technologies and digital tools for improving water management. The most relevant areas for integration are the Water Framework Directive, the Digital Strategy (A Europe fit for the digital age), the European Green Deal, and the European Space Programme and the Copernicus component. The successful integration of EO technologies and data within relevant EU programmes and water policies is critical for improving water management.

2.1 Gaps in the EU Water Framework Directive

The EU Water Framework Directive (WFD) is a cornerstone of EU water policy, setting out a framework for the protection and management of water across the entire cycle, also through technical monitoring practices. While the WFD includes provisions on monitoring and reporting, there are still gaps in the directive related to digital water and Earth Observation technologies. One of the gaps in the WFD is the **lack of explicit recognition of the potential of digital water and Earth Observation**. Under the WFD, EU member states have the obligation to assess the status of water bodies, such as lakes larger than 0.5 km^2, by examining a range of biological, chemical, and hydro-morphological quality parameters, and subsequently report the status to the European Commission. While the directive requires Member States to monitor and report on the status of their water bodies, it does not specify the use of digital water and Earth Observation technologies to support monitoring and reporting. As a result, there may be a missed opportunity to improve the efficiency and effectiveness of water management practices by leveraging these technologies. At this point, EO methods are now developed to a degree of technical maturity that they can help bridge surveillance gaps - both in a temporal and spatial manner. In this spirit, it tremendously extends measurement and monitoring campaigns, allowing for accurate follow-ups on watershed management measures, depicting and highlighting climate change effects. Overall it contributes to obtaining a very detailed picture of environmental conditions by refining in situ data with an outstandingly high information content. Furthermore, the frequent availability of EO data allows for alert system designs, capable of forecasting harmful algae blooms in order to protect human health , especially in view of the EU Bathing Water Directive. Despite existing technical and legal limitations, satellite-based services can thus become effective and reliable tools to assist reporting authorities in meeting their obligations under the WFD. This can be a case for further improving EO services for water monitoring and reporting, in order to overcome current limitations.

With regards to the uptake of satellite EO services to assess biological elements in water bodies, it is opportune to reference the ongoing work being conducted by the EU Joint Research Centre in support of the Working Group (WG) on Ecological Status (ECOSTAT) towards the Common Implementation Strategy (CIS) for the WFD. The WG ECOSTAT serves a forum to support the implementation of the WFD by providing information, research, feedback and linkages with relevant activities at EU level. A recent proposal put forward by the WG ECOSTAT to investigate the potential of the EO services for biological assessment in water was accepted in 2022, based on the results of the activities of other downstream EO applications from other Horizon2020 projects.

In October 2022, the Commission proposed *new rules for cleaner water*. Among the proposals, there is a requirement to establish integrated water management plans in larger cities to manage heavy rains, made more frequent by climate change. This is an area which could benefit from the integration of EO services. EO systems can also help protect surface water from pollutants and nutrients, such as nitrogen and phosphorus. Nutrients are not directly measurable with satellite observations, but chlorophyll concentration, which can be measured by satellites, can be used to estimate nutrient and pollutant concentration in water bodies.

Another gap in the WFD is the lack of guidance on the use of digital water and EO technologies for water management practices. While the directive sets out general requirements for the protection and management of water resources, it does not provide specific guidance on the use of these technologies for water management practices. This can result in inconsistency in the application of these technologies and a lack of knowledge management/sharing across Member States. Additionally, there is a gap in the WFD related to the integration of digital water and EO technologies with other relevant policy areas, such as the EU's Digital Strategy and the Green Deal. Currently, this is limiting opportunities for cross-sectoral and multidisciplinary cooperation and innovation.

Relevant recommendations were also clearly presented in a 2019 White Paper on *Satellite-assisted monitoring of water quality to support the implementation of the Water Framework Directive* which asked to recognise satellite observation as an assessment method, harmonise metrics and agree on best practises and reporting standards for satellite based water quality metrics, and reference the use of satellite-based Earth observation metrics in the WFD Reporting Guidance.

Overall, gaps in the WFD suggest that there is a need for greater recognition and guidance on the use of digital water and EO technologies for water management practices. **Policymakers should consider updating the WFD to explicitly recognise the potential of digital water and EO technologies, provide guidance on their use, and promote their integration with other relevant policy areas. By doing so, the EU can improve water management practices and contribute to the achievement of sustainable development goals**.

2.2 European Water Fit for the Digital Age

Digital Skills

There is a broad consensus on the priorities for the European Union towards the green and digital transitions, and the need to equip European citizens (see *Digital Education Action Plan*) with the necessary digital skills to enhance economic, environmental and social resilience. The EU Council has adopted recommendations on the key enabling factors for successful digital education and training, recommending that member states agree on national strategies for *digital education and skills and competences*, which includes targeting 'priority groups and adults' among others.

We recognise the necessity to focus on the upskilling of the ageing water sector workforce with targeted training initiatives, in line with these recommendations, the European Growth Model and the digital skills policy. **Having the right capacity and skills in the water sector workforce is crucial to benefit from advanced EO technologies and digital tools for improved water management and to enhance the preparedness to future water shocks that are more likely to happen due to climate change**.

Digital Water

Additionally, the 2023-2024 *Digital Europe Programme* offers numerous opportunities for implementing digital water in action. For example, the *Destination Earth* initiative (part of the Green Deal Data Space) and the EU 'Citiverse' are highly relevant opportunities that could harness EO technology in the water sector. Currently, there are *9 Common European Data Spaces* covering multiple areas such as energy and agriculture, however, there is no dedicated data space for water. Currently, this critical component is embedded within the Green Deal Data Space together with other topics such as deforestation and biodiversity. This is a crucial missed opportunity. A dedicated **European Water Data Space could untap the full potential of EO data on water quality and quantity**. The PrimeWater project has shown that aggregating and sharing data on inland water can deliver many benefits and provide accurate information to address water challenges, including drought and floods and other environmental risks such as algal blooms. While the Citiverse initiative can be relevant for the integration of digital twins that are specific to water sector applications. The PrimeWater project has successfully created a watershed digital twin for operational hydro-ecological forecasting services. Digital twins for water using EO data could be further integrated with existing projects such as the Horizon's Europe *Restore our Ocean and Waters* mission which is delivering a *Digital Twin Ocean*. We recommend further integration of EO data in the development of the *Inland Waters Digital Twin* that is underway.

Space

The EU space policy and services are rapidly evolving and adapting to a changing environment in order to address current challenges and future needs. The **European Space Policy** is increasingly aware of the opportunities and benefits of EO technologies and the valuable insights that they provide on climate change and water resources. In particular, the EU Space Programme and Copernicus provide reliable information to society, climate researchers, and policymakers regarding the past, present, and future of water and climate in Europe and globally. Water products from Copernicus are relatively new (European Commission, 2019, Working Paper on the *Expression of User Needs for the Copernicus Programme*). Access to consistently produced, high-quality data is critical for making informed decisions for our water future. The Copernicus ecosystem can be extremely helpful in the implementation of the EU's ambitious climate and water plans. For these reasons, the EU should keep investing in the development and deployment of Earth Observation technologies for water management practices. Based on the challenges encountered in the PrimeWater project, it is suggested to channel investments towards the development of advanced data analytics tools, such as machine learning algorithms and statistical models. Primewater has a specific tool called "*virtual lab*" where some of this validated algorithm are implemented.

Copernicus, as the EO component of the European Union's Space Programme, currently provides a wide suite of services and environmental insights for better water management. The Copernicus services are structured according to 6 main services (Atmosphere, Marine, Land, Climate Change, Security, Emergency).

For these reasons, it is deemed opportune to simplify access to Copernicus water services. This service on water resources can account for downstream and cross-cutting applications of the existing services, particularly focusing on water stress, water-related hazards and water quality.

The *Water Scenarios for Copernicus Exploitation* consortium is currently developing a Roadmap for Copernicus water services. The Roadmap will provide a user and stakeholder driven concept for water services.

Overall, based on an overview of relevant projects in the field of space technologies, earth observation and digitalisation and an analysis of current water policies, it is possible to say that projects and initiatives are delivering advancements and ground-breaking results, while policy is still lagging behind and moving at a slower pace. Improved coordination by the EU between policy and practice could help reduce the lag.

3. Recommendations

Innovations such as EO for water management and other digital solutions are necessary for efficient and sustainable water management that can address challenges such as population growth, climate change, flood and droughts, water scarcity, environmental risks and pollution. However, EU water policies lack a coherent terminology and clear definitions of digitalisation in the water sector, which leads to a lack of understanding among users and providers of digital services, as also previously indicated by other stakeholders (see Stein et al. 2022, *Digitalisation in the Water Sector. Recommendations for Policy Developments at EU Level*).

Moreover, the absence of technical guidance and standards for monitoring hinders the full potential of innovation in EO applications for the water sector. For this reason, EU policymakers need to make informed decisions in support of EU policies that enable the twin digital and green transition in the European water sector. To do this, EU policies should take advantage of digital solutions and address shortcomings, such as integration, standardisation, knowledge-sharing, capacity building and engagement with relevant initiatives. The PrimeWater policy brief provides specific recommendations to bridge the gaps in the EU policy framework in order to achieve the full potential of digitalisation in the water sector. Drawing on the project results and the analysis of relevant policies, programmes and priorities in the EU, this policy brief recommends the following:

1. Adoption of a holistic approach to water management in a digital era: The EU should adopt a holistic approach to water management in an era of digitalisation. In particular, the WFD should include harmonisation and guidance on technologies and digital applications. A dedicated initiative or policy on Digital Water in the EU can improve water management and ensure coherent integration with relevant programmes, policies and strategies (Digital Strategy, EU Green Deal, Space Policy & Copernicus).

2. Drive innovation and sustainability in the European water sector: The EU policymakers must make informed decisions in support of the 'twin green & digital transition' for water. Therefore, the EU should invest in the research and development (R&D) of EO technologies and digital water solutions to build a water-smart society. The investments should prioritise the development of advanced data analytics tools, such as machine learning algorithms and statistical models, among others. These investments can deliver crucial insights and high-quality data for decision-makers.

3. Capacity building, coordination and collaboration: The EU should enhance the digital skills of the water sector's ageing workforce, and improve coordination between relevant projects and initiatives that are already underway as a way to bridge policy and practice. Additionally, EU policymakers can improve collaboration by engaging with relevant scientific groups, such as IWA's Community of Practice on Earth Observation for Water Management.

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