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EUROPEAN AND INTERNATIONAL POLICY DRIVERS IN WATER SCENARIOS FOR COPERNICUS EXPLOITATION

Abstract

Hydrology-related activities are provided by all six Copernicus Services. However, the European Commission discovered that this method makes it difficult to gain a full picture of the global water cycle. As a result, the consortium 'Water Scenarios for Copernicus Exploitation' (Water-ForCE) proposed creating a Roadmap for Copernicus water services. The Roadmap will provide a user- and stakeholder-driven concept for water services by examining the growing demands, as well as the possibilities given by existing and anticipated capabilities. To understand this, the project assesses whether existing services can satisfy current policy objectives. As a result, the paper identifies the indicators contained in policy and law for monitoring, reporting, and assessing the adoption of Earth Observation (EO) services, as well as the barriers to their implementation. The paper examines policies from two perspectives: first, from the perspective of space policy and how it drives Copernicus implementation in public domains such as water; and second, from the perspective of specific documentation from the water, agriculture, and environmental sectors to see how they can drive Copernicus uptake for monitoring efficient water use, its quality and quantity. The research looks into European Union (EU) laws as well as international treaties, United Nations instruments, and World Bank strategies. The paper concludes that water concerns are well represented in EU policy in general, although EO data as a tool of monitoring is included in just a few water-related policy instruments. Simultaneously, in other sectors that are inextricably intertwined with water consumption, new EU rules are being designed to take into account the availability of satellite imagery, which considerably adds to monitoring efforts. Notably, present water instruments supporting the use of space technology are mainly non-binding and do not necessitate government compliance. As a result, a new approach is required, as it is currently difficult for diverse user communities to identify relevant Copernicus services to effectively use them for socio-economic benefits. Therefore, it is advised to specify in further regulations the outcomes that must be accomplished while leaving states free to decide how to incorporate these objectives into national laws. This will not stifle innovation by prescribing stringent monitoring systems, but will instead outline the intended results.

Keywords: inland water, regulation, earth observation, Copernicus

1. Introduction

The Horizon 2020 project Water-ForCE (Water scenarios for Copernicus Exploitation) is developing a Roadmap to better integrate the entire water cycle within the Copernicus services, thereby addressing needs and requirements from the user community regarding the current disconnect between Earth Observation (EO) and in-situ observations for the upgrade of the modelling algorithms. The Roadmap will advise on a strategy to ensure effective uptake of water-related services by end-users and further support the implementation of relevant directives and policies.

The Water-ForCE consortium is led by the University of Tartu (Estonia) and consists of 20 organisations from all over Europe. It brings together experts on water quality and quantity, policy, research, engineering, and service sectors.

Thus, the aim of this research is to identify which links exist between the Copernicus programme and the policy/legislative cycle: the extent to which international treaties and global agreements benefit from the information provided by Copernicus water-related services; and, in turn, which of them influence the development of the Copernicus mission.

2. Policy and legislation

For the objectives of this research, the relevant policies and legislation are viewed from two perspectives: *i.* from the perspective of space policy and how Copernicus development drives the policy cycle and improves legislation in public sector domains such as water management, water pollution, etc. (2.1) and *ii.* from the perspective of domain-specific public sector policies and legislation and how these drive Copernicus evolution, such as increased emission requirements, the need for more efficient use of water in agriculture, etc. (2.2.).

2.1 Space policy and legislation: EU Space Programme and Copernicus

The Copernicus Programme was established under Regulation (EU) No 377/2014 of the European Parliament and of the Council of 3 April 2014. Copernicus is the successor to Global Monitoring for Environment and Security (GMES), an Earth monitoring initiative dating back to 1998. The mission is clear from the name: the aim is to set up an operational, continuous system of monitoring in support of the environment and security. Although water is a priority issue in both environmental (pollution, drinking water) and security (flooding, infrastructure) domains, it is not a given that this has been made explicit or addressed coherently and comprehensively in the EU's space policy and programme. Consequently, the main goal of the call setting up this Water-ForCE project was to analyse current and planned EO space capacities together with innovative processing, modelling, and computing techniques to reinforce the existing portfolio offered under Copernicus [1].

Regulation 377/2014 was superseded by Regulation (EU) 2021/696 of 28 April 2021 establishing the Union Space Programme and the European Union Agency for the Space Programme (EUSPA) for 2021-2027. This is the core space policy document for the EU. The analysis finds that the Space Programme Regulation in large part focuses on Copernicus. It specifies that one of the targets of Copernicus is to respond to the requirements of public policies and support their formulation and implementation. It is noted that this is a feature of autonomous access to environmental knowledge (free, full, open data policy) that allows independent decision-making. Though inland water is not explicitly mentioned, this provision shows the importance of Copernicus for, inter alia, the environment, agriculture, and land monitoring, which generally includes management of inland waters. The Regulation further states that activities under Copernicus should expand their global monitoring coverage to support applications in water management. Hence, it is found that the facilitation of open-source platforms available and understandable for end-users is key for ensuring successful policy implementation. The Regulation supports this application: per Articles 50-51, eligible actions for Copernicus and its services shall cover innovative applications for water management and inland water quality and quantity monitoring. Being permitted by Regulation, a separate service related to inland water currently does not exist, which is considered as a significant gap in Copernicus policy.

Furthermore, the Regulation provides for several levels of cooperation to facilitate Copernicus's uptake. For the Commission, it is advised to work together with the Member States and the European Environment Agency (EEA). Member States and the Commission should establish links between Copernicus and national policies to drive commercial Copernicus applications in enterprises and start-ups. Thus, this specifically concerns suitable policies for the industry and for small and medium-sized enterprises. This can be seen as another example of policies that can be impacted by the Copernicus exploitation.

Last but not least, the Regulation considers Copernicus as a contributor to international instruments related to the environment, such as the 1992 United Nations Framework Convention on Climate Change, the UN Sustainable Development

Goals, and the Sendai Framework for Disaster Risk Reduction. These and other international regulations will be analysed further in this chapter.

2.2 Thematic policies and legislation

As outlined above, a major goal of Copernicus is to develop or contribute to operational applications in support of EU and global policies. Indeed, the Regulation defines Copernicus core users as European, national, regional, or local authorities entrusted with the definition, implementation, enforcement, or monitoring of a public service or policy in the areas of atmospheric monitoring, marine environmental monitoring, land monitoring, climate change, emergency management, and security. This section provides an analysis of the priority documents for inland water bodies.

2.2.1 EU Water Policies

This analysis will start with the key water documents that, according to the Commission, include the Water Framework Directive, the Environmental Quality Standards Directive (EQSD), the Groundwater Directive (GWD), and the Floods Directive (FD) [2]. Other policies, including sectoral, will follow below.

a) Water Framework Directive (WFD)

The core instrument which commits European Union Member States to achieving the good qualitative and quantitative status of all water bodies is the WFD 2000/60/EC, with the text consolidated in 2014. The WFD comprises multiple elements of the aquatic cycle as defined by the Water-forCE team. Namely, the scope of WFD related to inland waters covers inland waters themselves in general, separately defining surface water, groundwater, rivers, lakes, transitional waters, coastal water, and artificial water bodies. Even though it was decided by the EC in 2020 not to revise WFD, it is still in force and its norms continue to be of huge importance for adequate governance of water management [3].

Through the analysis of the WFD, it was found that there is no specific or explicit mention of monitoring using EO data (perhaps unsurprising considering that both the WFD and the establishment of Copernicus were in 2014). Indeed, there are certain barriers to the uptake of Copernicus due to techniques explicitly mentioned in WFD, for instance, microscopy, samples, hydroacoustics, and multimesh gillnets as some of the methods related to water quality monitoring.

At the same time, certain opportunities for Copernicus uptake are identified, which are not explicitly mentioned but can be inferred from the text:

- Regarding water quality monitoring, there is no indication of measures for the investigation of marine phytoplankton, surveying of macrophytes in lakes, biological surveys, assessing the hydromorphological features of rivers and lakes. These examinations can be based on EO data.
- To determine the chlorophyll-a concentration in the absence or replacement of in-situ data, monitoring can be done with remote sensing if sufficient accuracy is attained.
- A general remark on water quality monitoring methods is that these should not exclusively comply with the standards listed in WFD but also with other standards ensuring the provision of data of equivalent scientific quality and comparability. From this, the conclusion follows that methods involving Copernicus EO can also be used.
- Unlike the description of water quality measures and standards, there is no elaboration of water quantity monitoring mechanisms. However, the WFD states that control of quantity is an ancillary element in securing good water quality, and measures on quantity should be established. Further, for groundwater quantity status monitoring, the WFD requires maps of groundwater monitoring networks in the river basin management plan. Such actions can be implemented through the use of Copernicus.
- In general, there are no mentions of in situ monitoring or measurement; there are therefore no barriers to the use of EO, which potentially opens ways for Copernicus uptake.
- Among implementation actions, it is required to provide cartographic data for technical adaptations to the Directive.

As a result, even though some barriers to using Copernicus for WFD implementation exist, these are outweighed by the opportunities. According to the report from the European Environment Agency, the Directive now reports on 111,062 surface water bodies, 46% of which are regularly monitored for their ecological state. In the most recent evaluation, 4% (4,442) of water bodies still had an unclear ecological state, and 23% of monitoring did not involve in situ water samples to enable ecological status assessment. Individual (mostly biological) evaluation criteria have a substantially higher proportion of water bodies with no observation data; hence, the full extent of monitoring under the WFD is still far from being fulfilled [4].

Further opportunities for using EO data for WFD implementation were examined in the Earth Observation-based Services for Monitoring and Reporting of Ecological Status (EOMORES) White Paper [5]. They conclude that water quality indicators obtained from EO data significantly complement the standard sampling, while significantly increasing the spatial and temporal coverage, especially in larger water bodies. Thus, it can improve the classification, the representativeness of the state of water bodies, and the standardisation of the assessment, which ultimately leads to a simplification of water management. Therefore, it is recommended to recognise satellite observation data as the assessment method for the purposes of WFD, create an expert group to harmonise metrics, refer to EO data in the Reporting Guidance of WFD, and discuss common practices on using such data at the Member States conference.

b) Environmental Quality Standards Directive (EQSD)

Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy establishes environmental quality standards for the presence of specific substances or combinations of substances in surface water that have been recognized as priority pollutants due to the severe harm they pose to or via the aquatic ecosystem. The consolidated text of 2013 modified EQSD for 7 of the initial 33 priority substances to reflect the most recent scientific and technological understanding of the characteristics of those substances.

The Directive does not include any requirements on EO data, which can be explained by the Directive's predating the operational Copernicus programme. Even though EQSD refers to *sampling* regarding specific substances such as cadmium, lead, mercury, and nickel, the text is open to the uptake of Copernicus. This is possible as EQSD frequently asks for monitoring measures. The identified opportunities for Copernicus in EQSD include the following:

- Sediment and biota monitoring should be done at an adequate frequency and provide sufficient data for reliable long-term analysis.
- Member States are required to establish and submit to the Commission a supplementary monitoring program.
- Member States need to establish maps of emissions, discharges and losses of all priority substances and pollutants, and may provide additional maps that present the chemical status information for one or more substances listed.
- It is noted that monitoring should take place every three years unless technical knowledge and expert judgement justify another interval.
- At the same time, Member States are allowed to be flexible in their monitoring measures, but they should ensure that they are carried out using the best available techniques. In this case, (Copernicus) EO providers need to establish themselves as providing the best available technique.
- The Commission itself shall develop guidelines, including technical specifications, with a view to facilitating the monitoring and is invited to promote coordination of such monitoring.

Thus, the EQSD provides an opportunity for using EO data, giving flexibility in choosing monitoring methods and emphasising that the best of them should be used. As a result, there is a possibility of Copernicus implementation for providing data on specific substances in surface waters.

c) Groundwater Directive (GWD)

Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration establishes a framework that sets groundwater quality standards and implements steps to avoid or restrict pollution inputs into groundwater. GWD defines quality requirements that take into consideration local peculiarities and allow for future enhancements based on monitoring data and new scientific understanding. Thus, it complements WFD so its objectives regarding groundwater can be achieved more effectively.

Similar to the directives discussed above, the GWD does not mention any of the space applications. Again, this can be explained by the fact that the GWD was developed before Copernicus became operational. A potential barrier to EO data uptake was identified, which is that the GWD states that when determining background levels, the principles of a simplified approach using a subset of samples should be taken into account. However, certain requirements providing opportunities for Copernicus are definitely present:

- GWD first of all states that reliable and comparable methods for groundwater monitoring are an important tool for assessment of groundwater quality and also for choosing the most appropriate measures.
- There is no mention of the necessity for in situ observations.
- GWD refers to methods provided in WFD (Annex V) to provide a coherent and comprehensive overview of groundwater chemical status and to provide representative monitoring data. As observed above in this section, for groundwater quantity WFD requires mapping of the monitoring network.

Thus, GWD generally does not pose obstacles to the uptake of Copernicus for groundwater monitoring. This conclusion is also supported by the fact that GWD is largely based on WFD concerning monitoring requirements.

d) Floods Directive (FD)

Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks requires the Member States to determine whether all water courses and coast lines are in danger of flooding, to map the flood extent and assets and people at risk in these regions, and to implement effective and coordinated flood risk reduction measures. This Directive also underlines the public's right to obtain this information and have a say in the planning process. It mainly focuses on mapping and flood risk management plans and does not elaborate on specific monitoring measures. This is seen as a significant gap, but at the same time, it is implied from the FD text that Copernicus can be utilised to its full capacity without any barriers. Especially relevant is the public’s right to transparent and objective information, which Copernicus can provide. The particular opportunities for Copernicus uptake following from FD are:

- Maps within the preliminary flood risk assessment (chapter II FD).
- Flood hazard maps and flood risk maps (chapter III FD).
- Flood risk management plans (chapter IV FD).

e) Other related EU policies

The EU addressed the issue of pollution in the aquatic environment even before the WFD. Such thematic directives include Urban Waste Water Treatment 91/271/EEC (UWWTD, consolidated in 2014), Nitrates 91/676/EEC (ND, consolidated in 2008), and Industrial Emissions Directive 2010/75/EU (IPPC-IED, consolidated in 2011). As seen from the time of these documents’ adoption and later modifications, all except UWWTD, cannot mention Copernicus simply because it was not operational at the time of their development. Still, the UWWTD consolidated text does not mention it either. The examination of these directives shows that no mention of space technology is present. Still, the requirement for monitoring is present.

In UWWTD, the named methods of monitoring include only sample collections with laboratory examination, which can be considered a barrier to Copernicus uptake. However, the Directive states that alternative methods may be used if the obtained results are equivalent. Hence, there is an opportunity to use Copernicus as an alternative if it is possible to obtain the necessary results, or at least it can be an addition to sampling since UWWTD does not provide any limitations on additional measures (in fact, there is no provision mentioning them).

In the ND, the Commission notes that there is a necessity for monitoring waters and applying methods of measurement of nitrogen compounds. Regarding the barriers, the ND includes surface and groundwater sampling as one of the methods for such monitoring. However, in general, the ND requires the Member States to implement suitable monitoring programmes to assess the effectiveness of action programmes provided in the Directive. Action programmes at the same time shall take into account available scientific and technical data and environmental conditions in the relevant regions of the Member State concerned. Therefore, it is concluded that there is no regulatory barrier; the ND does not limit the uptake of Copernicus as it recommends the Commission to draw up guidelines for the monitoring, and for the Member States to take additional measures if the methods from the ND are insufficient, also considering their effectiveness and cost in comparison to other possible preventive measures. Hence, there are opportunities for the use of Copernicus in water nitrate monitoring.

IPPC-IED provides for an environmental inspection which includes emissions monitoring. The Directive lists certain methods, such as site visits and sampling. Such specific requirements can be seen as Copernicus barriers, but further provisions ensure that opportunities are not limited. Thus, it is permitted to introduce supplementary technical measures to ensure an equivalent level of environmental protection. It also requests to provide measures on the minimisation of long-distance or transboundary pollution, which is also an option for Copernicus uptake. IPPC-IED preamble notes that, in accordance with Article 193 of the Treaty on the Functioning of the European Union, this Directive does not prevent the Member States from maintaining or introducing more stringent protective measures.

Attention to water pollution is also paid in the new ‘Inland Navigation Action Plan 2021-2027’ (NAIADES III), to support a gradual modal shift towards zero emission inland waterways transport (COM/2021/324). It does not contain EO data requirements, but at the same time, no barriers for Copernicus are created there. In several ways, this Action Plan can open new applications for Copernicus. It states that there is a need for monitoring and reporting the carbon intensity of inland waterway vessels. Furthermore, innovative sector-wide solutions, including monitoring tools, should be implemented in ports. It is also required to use innovative solutions to reduce waterway pollution emissions, which can potentially include monitoring such pollution with EO.

Next is the Bathing Water Directive (BWD, Directive 2006/7/EC concerning the management of bathing water quality and repealing Directive 76/160/EEC, consolidated in 2014). It establishes management measures that include monitoring of bathing water. The BWD is pretty restrictive in formulating the measures for monitoring, mostly focusing on the sampling method. However, further reading provides the measures for which Copernicus can potentially be involved. Such an opportunity arises due to the provision of BWD stating that the Member States may permit the use of other methods provided the results obtained are equivalent to those provided in BWD (such as sampling). Analysing the BWD, the following opportunities for Copernicus uptake were identified:

- BWD requires observation and quality assessment over an extended period, which can be achieved through the Copernicus temporal capabilities.
- All bathing waters shall be identified annually, and they shall be inspected visually for pollution. That can be done through Copernicus's spatial capabilities, especially for large water bodies.
- BWD requires appropriate monitoring of waters with a potential for cyanobacterial proliferation. This is also possible with satellite data.
- Generally, the management measures of bathing waters as described by the Directive include, inter alia, assessing water quality, classifying, identifying and assessing causes of pollution, giving information to the public, taking action to prevent bathers' exposure to pollution, and taking action to reduce the risk of pollution. To all these measures we can contribute by increasing Copernicus uptake.

Finally, the most recent of the presented water policies related to the current analysis is Regulation (EU) 2020/741 on minimum requirements for water reuse. It lays down minimum requirements for water quality and monitoring and makes provisions for risk management. It requires performing routine monitoring to ensure compliance with the reclaimed water with the minimum water quality requirements. As it is natural for water monitoring, this Regulation also requires sampling methods for certain elements. However, opportunities for Copernicus can be implied too, from the provisions allowing monitoring measures that are additional or stricter than those listed in the Regulation, particularly (but not excluding) for heavy metals, pesticides, disinfection by-products, pharmaceuticals, and other substances of emerging concern, including micropollutants, microplastics, and antimicrobial resistance. Further, the Regulation provides for turbidity continuous monitoring, which can be performed with EO data. There is also an obligation to develop risk management plans, which should comprise identifying and managing risks in a proactive way. One of their elements shall be the identification of the environments and populations at risk, and the exposure routes to the identified potential hazards, taking into account local hydrogeology, topology, soil type and ecology, and factors related to the type of crops and farming and irrigation practices. The described tasks can be accomplished through the Copernicus uptake.

The responsibility for water policy and legislation at the EU level rests with the European Commission DG Environment, notably the 2012 'Water Blueprint' (the blueprint to Safeguard Europe's Water Resources - Communication from the Commission (COM(2012)673). Unlike previous policies, the Blueprint does provide that reliance on satellite imagery and derived information could help the Member States to identify irrigated areas. Therefore, it considerably adds to the understanding that space data use is recognized in water management. The Blueprint confirms that monitoring of the chemical status and pollution of EU waters is not sufficient - not only that not all substances are monitored, but also that the number of monitored water bodies is very limited. It is concluded that this leads to inappropriate decisions, the cost of which is higher than implementing suitable monitoring techniques. This justifies the observations presented above.

2.2.2 EU Sectoral Policies

Agricultural and environmental policies are closely linked to inland water management.

a) Agriculture

Agricultural policies are directly related to inland water management. Agriculture accounts for the largest use of water: around 40 % of the total water used per year in Europe [6]. The 2017 EC Communication ‘Future of Food and Farming’ states that climate-smart farming supported by innovation should be implemented for monitoring in the agriculture domain through developing policy with a strong commitment to delivering public goods and ecosystem services, including for water. Farmers have a dual challenge: producing food while also protecting nature and preserving biodiversity. It is critical for our food production to use natural resources wisely. Thus, water management in agriculture is developing as a critical problem in the context of climate change, and this is something that the new Common Agriculture Policy (CAP) takes into account. The proposal for the new CAP was already presented in 2018 (COM/2018/392), with the specific objective of fostering sustainable development and efficient management of water. Particularly for the fruit and vegetable sector, it required actions to improve the use and management of water, including water-saving and drainage. However, space-related elements are not present, and water management mechanisms in the agricultural sector are not described in this proposal.

The new CAP was formally adopted on 2 December 2021. The new CAP is due to be implemented on 1 January 2023. The new CAP covers three regulations, which will generally apply from 1 January 2023: EU Regulation 2021/2116, repealing EU Regulation 1306/2013 on the financing, management and monitoring of the CAP; EU Regulation 2021/2115, establishing rules on support for national CAP strategic plans and repealing EU Regulations 1305/2013 on support for rural development and 1307/2013 on rules for direct payments to farmers; EU Regulation 2021/2117, amending EU Regulations 1308/2013 on the common organisation of the agricultural markets, 1151/2012 on quality schemes for agricultural products, 251/2014 on geographical indications for aromatised wine products, and 228/2013 laying down measures for agriculture in the outermost regions of the EU. For the years 2021-22, a transitional regulation (EU Regulation 2020/2220) is in force.

For this research, EU Regulation 2021/2116 should be considered in the first place. It significantly amended the provisions of the previous version of 2013, explicitly requiring the use of Copernicus, thus giving space solutions in the legislation and providing more opportunities for the Copernicus uptake:

- The Regulation encourages the Member States to use data or information products provided by Copernicus to ensure that comprehensive and comparable data is available for the purposes of monitoring agri-environment-climate policy, including the CAPs.
- As a means for the CAP's implementation, the Member States shall develop integrated administration and control systems which shall comprise, inter alia, a geospatial application system and an area monitoring system. An ‘area monitoring system’ means a procedure of regular and systematic observation, tracking, and assessment of agricultural activities and practices in agricultural areas by Copernicus Sentinels satellite data or other data with at least equivalent value.
- The Member States are encouraged to use remote sensing, the area monitoring system or other relevant technologies to assist them in carrying out the on-the-spot checks.
- It is further required to supply the satellite data free of charge to those exercising area monitoring. At the same time, the Commission should remain the owner of the satellite data.
- The Commission shall finance the actions concerning the collection or purchase of data needed to implement and monitor the CAP, including satellite data and remote sensing used to assist in the monitoring of agricultural land use.

Hence, this horizontal Regulation prescribes legally binding EO methods for monitoring in the agricultural sector, which inherently involves water use, thus covering inland water monitoring by listed methods as well.

The next relevant document is EU Regulation 2021/2115. It establishes guidelines for the forms of interventions that can be used, as well as standard requirements for Member States to follow in order to achieve CAP goals. It establishes regulations for CAP Strategic Plans as well as provides coordination, governance, monitoring, reporting, and evaluation measures for the period 2023-2027. It also covers maintenance measures for rural areas and landscapes (as from the previous CAP regulations), which is one of the CAP's core aims directly related to water management. Analysis of this Regulation shows that no space-related elements are mentioned, including Copernicus Services. This is a major gap in this policy, also providing that even though the Regulation sets an objective for the efficient management of water and further lists the necessary measures, they are not precise and do not mention any water monitoring/observation techniques, unlike EU Regulation 2021/2116. Still, reference is made to this Regulation. Furthermore, open formulations in EU Regulation 2021/2115 itself can provide an opportunity for Copernicus. Thus, water management with EO data can be integrated for the implementation of the following requirements:

- The Member States are obliged to establish the legal framework for the CAP Strategic Plans in accordance with the principles and requirements set out in this Regulation and in EU Regulation 2021/2116. The latter, as described above, highly relies on the use of satellite data for monitoring. Furthermore, the CAP Strategic Plans will be assessed on the level of implementation of the acts pursuant to EU Regulation 2021/2116.
- Modernisation of agriculture and rural areas by fostering and sharing of knowledge, innovation and digitalisation in agriculture and rural areas and by encouraging their uptake by farmers through improved access to research and innovation. Moreover, a result indicator

for this objective is the protection of water quality and sustainable water use. For this objective, the Regulation calls for the establishment of the European Innovation Partnership for agricultural productivity and sustainability to stimulate innovation in this realm and encourage its wide use. As the text leaves it unspecified what type of innovation it should be, we imply that space technology is included.

- Protection of water in the fruit and vegetable sector, the hops sector, the olive oil and table olives sector, where water management, water saving, water conservation and drainage are included among intervention measures. They can be enhanced via Copernicus monitoring.
- The development of innovative products, processes, and technologies in the wine sector at any stage of the supply chain.

b) Environment

The most significant in this sector is the European Green Deal (COM/2019/640). It aims to transform the EU into a modern, resource-efficient and competitive economy. There are no space technology requirements in this act, but it does not create barriers to the uptake of EO data. Opportunities for Copernicus follow from the objectives of the Green Deal, as well as a general description of desired methods for achieving them. Thus, the Green Deal promotes digital technologies used for maximising the impact of policies on climate change and the environment, including distance monitoring of water pollution. The given examples are artificial intelligence, 5G, cloud and edge computing, and the internet of things. This reads as a non-exclusive list, so EO data can be added. The Green Deal also mentions the issue of food production, which results in water pollution, which shall be addressed by new technologies and scientific discoveries. This refers to the agricultural sector addressed earlier in this section.

The European Commission published the new Circular Economy Action Plan on March 11, 2020 (COM/2020/98), with the goal of preparing the economy for a green future and increasing competitiveness while conserving the environment. The Plan encourages the Commission to facilitate water reuse and efficiency, including in industrial processes. The core implementation instrument is the Monitoring Framework for the Circular Economy. This will rely on European statistics and new indicators for the interconnection of circularity, climate neutrality, and zero pollution ambition. Space applications are not mentioned in the Plan, but this is where Copernicus data can be utilised to enhance circularity measures at multiple levels that are not yet represented in official statistics [7].

A more specific document in this domain is Directive 92/43/EEC (consolidated in 2013) on the conservation of natural habitats and of wild fauna and flora (Habitats Directive). Water is a natural habitat for many species. The Directive aims to contribute towards ensuring bio-diversity through the conservation of natural habitats and of wild fauna and flora in the European territory. Space technology is not listed in this Directive. At the same time, it asks for the monitoring of the incidental capture and killing of the animal species listed in Annex IV (a). Other monitoring requirements are not mentioned. However, for the objectives of this Directive, it would be essential to monitor the habitat (water) itself to investigate factors influencing species there. This creates an opportunity for Copernicus.

In the Biodiversity Strategy for 2030 'Bringing nature back into our lives' (COM/2020/380) no space technology is mentioned. However, it does not pose any barriers for Copernicus. Regarding inland waters and EO, the opportunities are created by requirements for forest monitoring (as they are hugely important for biodiversity, climate and water regulation); restoring free-flow of rivers; monitoring of protected areas; mapping and monitoring of ecosystem services, health or restoration efforts; and the creation of an EU-wide methodology to map and assess ecosystems.

In 2021, a new Zero Pollution Action Plan for Air, Water, and Soil (COM/2021/400) was adopted. It sets the zero pollution vision for 2050 - 'Healthy Planet for All', stating that water pollution shall be reduced to levels no longer considered harmful to health and natural ecosystems. It also encourages taking action under WFD to realise the zero pollution ambition for all aquatic ecosystems. For this aim, the Action Plan asks the Commission to support better monitoring and reduce pollution from key substances in surface and ground waters. This policy document is one of those that explicitly mentions space methods, directly providing opportunities for Copernicus. It acknowledges the potential of innovation and digital solutions in reducing pollution and therefore declares Copernicus as a major building block for providing monitoring data.

Regarding water pollution, the Strategic Approach to Pharmaceuticals (COM/2019/128) states that implementing innovation in this sector could support green design, for example, by facilitating the recycling of wastewater. Pharmaceuticals that are spread through water may pose a risk because of their toxicity or similar properties. The opportunity is created by the Strategic Approach in the way that it acknowledges a limited scale of monitoring in this domain and only selected substances are monitored in surface and ground waters under WFD. Space applications mentioning is not present. However, because the gathering and management of environmental data are mostly dependent on Union legislation and/or backed by Union finance, this might indicate a possible application of Copernicus to discover more about pharmaceutical concentrations in the environment, enabling better environmental risk assessments.

2.2.3 International Policies

Water is also an important topic for action at the international level, with a number of intergovernmental treaties in place, as well as soft law instruments and guidelines setting targets for water management. International law takes precedence over EU law [8].

a) International treaties

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) of 1992 is a one-of-a-kind international legal instrument and intergovernmental platform that strives to facilitate collaboration in order to guarantee sustainable use of transboundary water resources. It promotes joint management and conservation of freshwater ecosystems in Europe and neighbouring countries. Even though no 'space' indicators are found in the convention as it was written prior to Copernicus, it creates opportunities for the use of EO data by setting an obligation to establish programmes for monitoring the conditions of transboundary waters. Moreover, for monitoring the conditions of transboundary waters, including floods and ice drifts, as well as transboundary impact, joint monitoring programmes shall be implemented within the scope of cooperation. This approach is also in line with the EU Copernicus programme.

The Convention on wetlands of international importance especially as waterfowl habitat (Ramsar Convention) of 1971, provides that wetlands are a valuable resource in terms of economic, cultural, scientific, and recreational importance, and their destruction would be irreversible. It does not mention any space or monitoring-related elements. However, indirect opportunities for the Copernicus uptake in wetlands can still be implied. Thus, the Ramsar Convention obliges to precisely describe and delimit on a map the wetland boundaries. Furthermore, parties are internationally responsible for the management and wise use of migratory stocks of waterfowl, which potentially involves monitoring efforts. Management obligations are also set regarding measures to increase waterfowl populations on appropriate wetlands. On top of this, parties should encourage research on wetlands and their flora and fauna. All those obligations can be fulfilled with the use of Copernicus.

Under the Convention on Biological Diversity of 1992, 'biological diversity' means the variability among living organisms from all sources, including, inter alia, aquatic ecosystems and the ecological complexes of which they are part, such as diversity within species, between species and ecosystems. The Convention provides monitoring requirements and does not limit them to sampling methods - along with samples, parties are also encouraged to use other techniques. Hence, there is an opportunity to implement Copernicus as a technique for monitoring aquatic ecosystems requiring urgent conservation measures and those that offer the greatest potential for sustainable use. Furthermore, it can be used for monitoring the effects of activities that have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity.

Next, under the Paris Agreement of 2015, all parties committed to a worldwide stocktake every five years, beginning in 2023. The goal is to review collective progress toward attaining the purpose of the Agreement and to advise the parties of additional individual activities to be undertaken. The EU Member States, like all other nations that have accepted the Paris Agreement, have committed to making Nationally Determined Contributions to reduce greenhouse gas emissions. These contributions will be evaluated as part of the five-year global stocktake. Copernicus' planned service would provide observation-based data to make global evaluations more complete and uniform. Water monitoring concerns are also covered in the Climate Change Service inside the Copernicus framework. The Paris Agreement provides for monitoring measures. However, there is no mention of water in the treaty, despite the fact that there are many inland water bodies that are exposed to strong anthropogenic influences, particularly climate change, hence this might be considered as a gap.

b) United Nations (UN) Instruments

Unlike international treaties, UN resolutions and guidelines are non-binding. Still, they play a significant role in international order by expressing UN members' views, thus impacting not legally, but politically. Some resolutions also reaffirm norms of international treaties and promote treaty parties' commitment to compliance with their international obligations. Others may be the first steps in a process that leads to the signing of a multilateral treaty. The same applies to policies developed by other international organizations. Below we present an overview of major documents regarding inland water management from the UN, WHO, UNESCO, and the World Bank.

Adopted by the UN General Assembly, the Sendai Framework for Disaster Risk Reduction 2015-2030 sets a goal to prevent new and reduce existing water disaster risks through the implementation of a variety of measures, from legal to technological. It balances the use of both in situ and remote sensing information. The Framework references geospatial information technology, space data, space-based technologies, and related services for water monitoring. Information from these sources should be disseminated to decision-makers and the general public. According to the framework, these measures should be promoted at both national and global levels. Moreover, through international cooperation, technology transfer should be promoted and space data should be shared.

UN Environmental Programme (UNEP) Resolution 3/10 'Addressing water pollution to protect and restore water-related ecosystems' of 2018 stresses that monitoring water quality and quantity and sharing data are important for the effective management of water pollution. There is also a concern from the UNEP regarding the limited technological capacities available to monitor water pollution. Thus, it encourages setting up water quality monitoring of significant water bodies and associated ecosystems at national levels. Governments and relevant stakeholders are invited to address this issue with tailored technologies. As a result, even if no space-related measures are present in the resolution, opportunities for Copernicus can follow from these statements.

The 2030 Agenda for Sustainable Development was adopted by the UN in 2015, setting up 17 global goals to serve as a blueprint to achieve a better and more sustainable future for all. It contains a specific goal dedicated to water, namely Goal 6, Clean Water and Sanitation. It provides that protecting and restoring water-related ecosystems is essential, but due to its framework, the text leaves it up to states to decide how to achieve this goal. The research in this regard shows that satellite data plays a significant role in relation to most of the agenda's goals [9]. Copernicus gives an unprecedented amount of data to support policy-makers striving to implement the SDGs. Copernicus data is available on a full, free and open basis, thus simplifying monitoring efforts and reducing their costs [10]. Therefore, Copernicus can serve as an instrument to take action in accordance with Agenda 2030. Although the goals are not legally binding, they have a huge impact on EU strategic development policy, serving as guiding principles.

Next, the World Health Organisation (WHO), a specialised UN agency, has developed several water management guiding documents. The Guidelines for safe recreational water environments 2003 note that recreational uses of inland waters are increasing in many countries worldwide. It specifically provides for the use of satellite imagery for the proactive monitoring of the areas affected by blooms of toxic algae or cyanobacteria. However, this reference is made specifically to marine environments, and there is no such indication for inland waters. This is seen as a disadvantage since the same problem is observed for inland water recreational areas. Enabling this method for monitoring would create an opportunity for Copernicus. Furthermore, WHO Guidelines for the safe use of wastewater, excreta and greywater of 2006 have the goal of protecting public health and facilitating rational use of wastewater and identifying chemicals and pathogens for risk assessment. Space-related elements are not present, however, the guidelines describe a variety of measures, including monitoring techniques. Hence, potential opportunities for Copernicus uptake can be discovered. Another consideration is the WHO Guidelines for sanitation and health of 2018, which focus on water use and its pollution, encouraging innovation and experimentation accompanied by rigorous monitoring. No reference to space technologies was made there. However, an important remark is made regarding the development of standards and regulations: according to WHO, they should avoid prescribing specific technologies or systems for particular situations since it can impede innovation. Instead, it is recommended to set an expected level of performance.

Another UN specialised agency, the United Nations Educational, Scientific and Cultural Organisation (UNESCO), established the Intergovernmental Hydrological Programme, which is currently in the ninth phase (IHP-IX) for the period 2022-2029. This new issue, unlike the previous one for 2014-2021 specifically addresses the use of space technologies for water resources management. It is stated that new technologies will benefit many related issues, such as timely disaster forecasting, the use of cubesats, groundwater governance, evidence-based planning, conflict resolution and trust building, real-time monitoring, and effective decision support systems. However, UNESCO affirms that there is difficulty in gathering and comprehending raw data before applying it to a hydrological system in a decision-making context. Thus, the gap between data and knowledge should be bridged so it can be applicable to policymakers. As a result, it is recommended to develop techniques that are able to merge different sources of data, including those from remote sensing. This provides an opportunity for Copernicus downstream applications.

c) World Bank

Water management concerns were also addressed by other international organisations impacting policymakers. The World Bank released in 2019 a strategic action plan on water 'Working together for a water-secure world'. The World Bank has water investments of over $29 billion and a staff of 300 water experts in locations worldwide. Its strategy, therefore, promotes water stewardship. Actions under this target should include, inter alia, measuring, planning, and monitoring water use. Furthermore, it encourages taking action to cope with droughts through drought monitoring and forecasting. Although there is no reference to space, such targets can be achieved in practice with satellite data, including from Copernicus.

3. Concluding remarks

Inland water management is very well represented in EU policy in general. However, EO data as a measure of monitoring is present in only a few, even in instruments that came after the Copernicus launch. EU policies are interconnected with one contributing and referring to another, with the Water Framework Directive as a central part. In other sectors, tightly linked with water use, such as agriculture, new EU policies are developed taking into account the availability of satellite imagery, which significantly contributes to monitoring efforts. Thus, the presented research can further be used as an interim step to determine which policy domains could benefit from the use of Copernicus for water monitoring purposes. In this realm, it is recommended to lay down certain results that must be achieved but leave each Member State free to decide how to transpose directives into national laws. This also falls in line with the recommendations from WHO not to impede innovations by giving strict prescriptions on monitoring techniques but to set out the desired outcomes. As seen from the analysis, such an approach allows deriving the potential applicability of Copernicus to a particular problem even if no space references are made directly.

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