Introduction to Section 3: Strategy, actions planning and implementation in basins

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Climate change adaptation in river basins

Studies to assess the impact of climate change on water resources at global and regional scales (IPCC, 2023; Hassan et al, 2024, in this issue) agree that the consequences of climate change will differ markedly between regions and that climate change will have a very negative impact on the availability of water resources in some regions. Climate change scenarios point to an aggravation of existing problems, making it necessary and urgent to address them decisively. Climate change adaptation is a main concern in countries and regions where water management has traditionally faced water scarcity (Garrote, 2017).

The IPCC (2023) indicates that climate change has affected water security, making it difficult to meet the SDGs. Approximately half of the world's population experiences severe water scarcity problems. Climate and extreme weather events are leading to increasing displacement of people in Africa, Asia and North America. Changes in extreme hydrological events are increasing and global warming will intensify the variability of the hydrological cycle (IPCC, 2023). The status of species that inhabit aquatic ecosystems relates strongly to changes in their physical environment. Water temperatures have risen in rivers (up to 1°C per decade) and lakes (up to 0.45°C per decade). Changes in flow regimes have led to a reduction in connectivity in rivers and have indirectly led to alterations in river morphology, substrate composition, oxygen concentrations or thermal regime in lakes (Parmesan et al, 2022)

The *construction of infrastructure*, such as dams and large water distribution pipelines, has been one of the main responses to the growing demand for water in the world over the last few decades. However, advancing sustainable water management in the coming decades, within a framework of adaptation to climate change, requires approaches that consider the interrelationships between all components of the basin. Lester (2024, in this issue) uses an integrated, multi-stakeholder approach (providers, policymakers, water managers and water users) to identify vulnerability indicators in the Kingston

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Basin in Jamaica. Stakeholders can use these results to guide their management strategy and choose the best adaptation option.

Improving efficiency in the use of water is essential to reduce water consumption, especially in territories with more fragile balances between the availability of water resources and water demands, which may be aggravated by the effects of climate change. Irrigation is the main use of water in the world, accounting for 72% of total water demand (UN, 2023). Irrigation modernization projects are therefore a vital element in improving water efficiency and improving the quality of water returns. However, it is not enough to modernize irrigation, since in many cities around the world, water consumption losses are very high and it is necessary to improve efficiency.

Climate change adaptation plans have developed in the water sector at national and river basin scales, such as the adaptation plans implemented by river basin organizations in France. A good example of this is the Adaptation Plan in the Corsica basin (Comité de Bassin de Corse, 2018).

Water-related risks

In many parts of the world, climate change will lead to an increased frequency of extreme hydrological events, such as droughts and floods. Traditionally, these extreme events were managed as crises that had to deal with by mobilizing extraordinary resources. However, this crisis management-based approach is a reactive approach with measures put in place after the event has begun. It often results in inefficient technical and economic solutions, as measures are taken with little time to assess the best alternatives and stakeholder participation is very limited (Estrela & Sancho, 2016). In recent years, policies are evolving around the world towards approaches based on risk management. UNDDR (2019) discusses the relationships between disaster risk management, climate change and sustainable development.

Nowadays, drought management requires programming measures according to the phase of drought. Monitoring, forecasting and warning systems (cf. Section 2) are essential when it comes to managing droughts as they use to control ecological flows, improve water availability or make forecasts of reservoir releases and water consumptions. These systems require small investments relative to potential damage.

Samaniego et al (2019) have developed a seasonal hydrological forecasting system to improve decision-making in the water sector within the framework of the EDge project funded by the EU Climate Change Service. A combined index for drought monitoring, the U.S. Drought Monitor, is used In the U.S., where drought intensity categories are based on five key indicators, numerous complementary indicators, including drought impact indicators, and local reports from more than 350 experts across the country (https://droughtmonitor.unl.edu). In Europe, the European Commission has developed the European Drought Observatory (https://edo.jrc.ec.europa.eu/), which contains relevant information on droughts in Europe, such as indicator maps derived from different data sources (e.g. precipitation measurements, satellite measurements, soil moisture content modelling data).

In drought periods, it is common that impacts on the associated aquatic and terrestrial ecosystems take place. Integrated management of all available water resources to meet water demands and environmental needs is imperative. However, the use of water resources greater than renewable resources, as it often happens with groundwater resources, can affect aquifer discharge in rivers and wetlands. For this reason, it is necessary to control the status of surface and groundwater bodies and compliance with the environmental flows set in rivers and wetlands.

In the case of floods, significant progress has made in risk management-based approaches in recent years. Measures to deal with flood risks should be prioritized and implemented once the risk is known and therefore hazard and risk mapping is essential. There are a large number of measures, which can classify into structural protection measures and management or non-structural measures. The OECD (2019) indicates that hybrid solutions are often required, combining structural and management measures in the most effective way for flood protection and contributing to the good status of water bodies.

Many experts are convinced that unsustainable development contributes to an increase in flood damage. Designing mitigation strategies provides an appropriate way to avoid or minimize increasing losses from flooding. Limiting land use in flood-prone areas is a good example of such strategies. It is widely accepted that flood risk cannot be eliminated and that there is therefore a need to integrate flood risk into the territorial and urban planning process. In many cases, the most efficient measure to reduce the impact of flooding is to avoid locating the most vulnerable uses in the most hazardous areas.

Flood risk management plans have been developed in EU Member States, in compliance with the European Directive on Assessment and Management of Flood Risk (European Union, 2007) adopted in 2007. These plans include measures that consider all phases of risk management: prevention, protection, preparedness and recovery and are committed to the application of nature-based solutions. Natural Water Retention Measures (NWRMs) are a highly innovative approach, which not only protect against flooding, but also produce other benefits, such as increased biodiversity, energy savings or opportunities for rural development (European Commission, 2015).

One of the major risks facing many regions of the world is water scarcity, which is expected to be exacerbated by climate change. To address these situations, water security should increase by promoting projects that contribute to saving and reducing water consumption through the efficient and rational use of water resources, the reduction of water demand and the protection of water bodies and associated ecosystems. It is foreseeable that the water authorities will promote the construction of new desalination plants, which include renewable energy installations that contribute to energy optimization and cost reduction.

Likewise, water authorities will most likely promote a *circular water economy*, considering treated wastewater as a safe resource and not as a waste, especially for use

in agriculture (Radini et al, 2023). On the other hand, the deterioration of groundwater, due to the intense exploitation that has taken place in many regions of the world, will make it essential to apply measures for the recovery of aquifers through the reduction in groundwater abstraction through substitution by alternative resources, especially those coming from water reuse and desalination. In addition to all this, the authorities, both national and regional, will have to promote the safety of existing infrastructures, such as large dams and water distribution channels, so that they continue to provide service in the proper safety conditions.

Another major risk facing the water sector is *water quality*. In the EU, the European Green Deal aims to achieve "zero pollution for an environment free of toxic substances", both to prevent pollution from being generated and to eliminate it in cases where it is already present in the water environment. To respond to these challenges, the European Commission adopted a "zero pollution" action plan for air, water and soil in 2021.

The European Waste Water Directive is under review, addressing important issues that are still outstanding, such as the presence of remaining pollution, the pollution generated in small agglomerations of less than 2,000 equivalent-inhabitants, the individual treatment systems, the urban runoff or storm water overflows, the need for higher requirements for nitrogen and phosphorus, the obligation to treat micro pollutants and the improvement of the energy balance of urban wastewater plants. To achieve these ambitious goals, the latest innovations and technological advances will incorporate into the water treatment plants, which will allow them to adapt to the new requirements of the European Waste Water Directive.

On the other hand, the increase in nitrate content in groundwater bodies has increased very significantly in recent decades through many areas of the world, coinciding with an intensive use of groundwater for irrigation (UN, 2023). The presence of pesticides in water is an increasingly important challenge. Practices for the sustainable use of pesticides should be implemented, promoting integrated pest management and using alternative techniques to current products.

The high level of deterioration that has occurred in a great number of rivers around the world in recent decades requires the implementation of ambitious *restoration policies*. One of the EU's Biodiversity Strategy 2030 targets is to restore river continuity over a length of 25,000 km in the European Union. In Spain, the National River Restoration Strategy aims to recover 3,000 km by 2030. This strategy proposes numerous actions aimed at conserving and recovering the good condition of its rivers, minimizing the risks of flooding through proper management of the river space, the recovery of banks and meanders, and the expansion of river spaces through the implementation of nature-based solutions.

River Basin Management Plans

River basin management plans (RBMP) are increasingly focusing on the environmental protection of water bodies and water security, seeking the greatest possible equity in the allocation of water resources to different water uses. Competition for access to

water resources is increasing around the world due to population growth, economic development and the effects of climate change. Documented examples of best practice show that well-designed water allocation regimes help allocate water where it creates the greatest value, economically, ecologically or socio-culturally, for society (OECD, 2015).

In the EU, river basin management plans have as their main purpose the achievement of environmental objectives in surface and groundwater bodies integrating continental, transitional and coastal waters. RBMPs for the third planning cycle have been approved in most EU Member States in recent years. In addition to this, specific drought management plans have developed in the EU following the recommendations of the European Commission's Report on Drought Management Plans (European Commission, 2007)

In Spain, RBMPs have two main objectives, the water allocation and the environmental protection of water bodies. Water allocation is an essential mechanism for allocating available resources and achieving sustainable water use. It also provides a regulatory basis for establishing water rights. The system operates on three levels: 1) the assessment of water resources and demands, which is carried out in the RBMPs, 2) the water balance through the simulation of the water resource system to allocate resources to the demand units, a task that is also developed in the RBMPs, and 3) water rights or licenses, carried out by the river basin organizations, in accordance with the water allocations and the priority criteria for water use also set out in the RBMPs.

In Australia (Freak et al, in this issue), the Murray-Darling Basin Management Plan has been a major step forward in quantitative water resources management. Henceforth, it is very likely that plans will also address issues such as river degradation, in addition to the quantitative management approaches considered in the current plans.

Poncin et al (2024, in this issue) discuss hydrological planning in transboundary basins and indicate that an Integrated Master Plan in a transboundary basin is more than just a planning tool. When done jointly with all basin stakeholders, it becomes a very powerful tool for increasing cooperation, capacity building, holistic understanding of the basin and the principles of integrated water resources management, as well as improving access to finance. They give the example of the OMVG Master Plan in West Africa, which strengthened the role of the basin agency in the management of transboundary waters.

Investment programs and funding

Climate change is reinforcing the need for increased investment in the water sector. Water policies and plans do not always highlight the positive externalities of water investments. Indicator 6.a.1 of the Sustainable Development Goals (SDGs) tracks the official development assistance (ODA) related to water and sanitation. According to estimates by the Organization for Economic Co-operation and Development (OECD), ODA disbursed and committed to water in 2020 was estimated at $8.7 billion globally, up from $2.7 billion in 2002 (OECD stat, n.d.), which it means a significant increase on a

global scale. The main investments made in water supply and sanitation, water resources for agricultural use, and hydropower plants (UN, 2023). Despite this increase, the current global financial flows for adaptation in the water sector, both from public sources of finance, which have been the norm in recent years, and from private sources, are insufficient, especially in developing countries (IPCC, 2023).

Regardless of this insufficiency in economic and financial resources, all stakeholders at the national level and international partners now seem ready to support governments in addressing the challenge of water, climate and finance. For example, in Egypt, Jordan, Lebanon and Tunisia, Team Europe Initiatives (TEI) for water have launched across the region, involving different financing tools and European actors (EU budget, EU Member States and European funding institutions) to address investment-financing needs. Others TEI have been launched on Transboundary Water Management in Africa, and on Water, Energy and Climate Change in Central Asia.

Governance and stakeholders' participation.

Water governance can make a major contribution to better design and implementation of water policies, with shared responsibility between national, regional and local governments, civil society, businesses and other stakeholders (cf. Chapter I). The OECD Principles on Water Governance (OECD, 2015) are based on three dimensions: a) *effectiveness*, which refers to the contribution of governance to defining clear objectives and targets for sustainable water policies, b) *efficiency*, which refers to the contribution of governance to maximizing the benefits of sustainable water management, and well-being at the lowest cost to society and c) *trust and commitment*, which relate to the contribution of governance to building public trust and ensuring the inclusion of all stakeholders (Akhmouch et al, 2018) https://www.tandfonline.com/toc/rwin20/43/1. The OECD (2018) establishes a set of indicators to help countries implement the principles of water governance and applies them in a series of pilot cases, which illustrate the situation of water governance in different countries and regions in the world.

Sebastian et al (2024, in this issue) compare governance in relation to water quality in the Mendoza and Santiago river basins, analyzing the impact of different water policies and institutional structures in Argentina and Mexico, respectively. Despite the different climates, both basins present common challenges, such as agricultural runoff, sedimentation or industrial discharges. The research carried out highlights the need to seek integrated solutions to address challenges such as the need for legislative reforms, the participation of all stakeholders or the use of innovative technologies and procedures in river basin monitoring.

Rugel (2024, in this issue) discusses the history, successes and challenges of protecting and sharing water resources in the Canterbury region of the South Island of Aotearoa-New Zealand. Specifically, she describes efforts to reduce nutrients, which have grown due to an unsustainable increase in milk production that threatened water bodies, including the sacred waters of the indigenous Ngāi Tahu. The implementation of the Canterbury Water Management Strategy, with the presence of the Ngāi Tahu, helped to

promote trust and cooperation to reduce nutrients and improve water management in this region.

Meeting the growing demand for water while achieving the environmental goals of water bodies presents a major challenge for water management. National, regional and international stakeholders need examples of good practice to help them manage scarce and often shared water resources in transboundary basins.

Transboundary cooperation

Two UN Conventions show the importance of transboundary cooperation among countries. The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) was adopted in Helsinki in 1992 and it is aimed to protect and use transboundary watercourses and international lakes, encouraging cooperation and information exchange among countries. The 1997 Convention on the Law of the Non-navigational Uses of International Watercourses (Watercourses Convention) complements the 1992 UNECE Water Convention.

Regional stakeholder dialogues provide an opportunity for the region's most relevant actors to meet in neutral spaces, get to know each other, and build trust and mutual understanding before addressing water cooperation. Yasuda el al (2024, in this issue) identifies four key enablers to stimulate such dialogues: (a) seeking an appropriate balance between different stakeholders and the role they will play, (b) using existing regional political and economic processes, (c) using thematic anchoring and strategic design, and (d) leveraging sustainable finance.

As the impacts of climate change and competition for water use increase, sharing water resources is becoming an increasingly difficult task. This accentuates in transboundary environments where a watershed with scarcity problems shares by different countries. This happens, for example, in a region such as the Horn of Africa which is 60% arid and semi-arid and where tensions due to water scarcity are very high. Stakeholders often represent diverse interests, coming from different sectors and levels. Owino (2024, in this issue) raises the need for dialogues on benefit sharing in such cases.

Groundwater is an important source of water supply and is the base flow for aquatic and associated terrestrial ecosystems in many regions of the world, such as sub-Saharan Africa. In line with the principles of integrated water resources management, the institutionalization of groundwater management and cooperation on transboundary aquifers (UNESCO, 2022) has long been on the agenda.

Although progress has made at the institutional and operational levels over the past decade, the capacity of these organizations has not increased according to Sterckx et al (2024, in this issue). These authors propose some practical solutions, while broader structural changes occur, such as the hiring of hydrogeologists in regional institutions, the adoption of open data policies on water, or the prioritization of areas of intervention.

Based on the concept of participation and management of transboundary waters, Hassan et al (2024, in this issue) propose a novel framework for assessing *participatory dynamics* within basins. They consider that the management of transboundary waters in the Nile and Orontes presents different forms of challenges. Despite the existence of legal and regulatory tools, such as the Nile Basin Initiative, the participatory process is not in itself a compatible incentive for the three countries (Egypt, Sudan and Ethiopia), especially on issues such as water allocation.

Sharing experiences across regions is key to improving cooperation in transboundary river basins. An example of this is the "EU Water Initiative Plus" project and the "EU4Environment-Water Resources and Environmental Data" programme, where four organizations (Organization for Economic Co-operation and Development (OECD), International Water Office of France (OiEau), Austrian Environment Agency (UBA) and United Nations Economic Commission for Europe (UNECE)) have been working together since 2016 to bring water management closer to the standards established by the European Union Water Framework Directive (European Union, 2000) in Eastern European countries (Belokurov et al, 2024, in this issue).

Conclusions and future perspectives

Sustainable water management faces challenges such as adapting to climate change, increasing water security, improving efficiency, fighting point source and diffuse pollution, and restoring water bodies. Meeting the growing demands for water while achieving the environmental objectives set in water bodies represents a major challenge.

Adaptation to climate change will be a major concern in countries and regions where water management is already facing water scarcity issues. It is very likely that the authorities in these areas will promote the reuse of treated wastewater and the desalination of seawater and will make a strong commitment to integrated water resources management. River basin management plans will be essential tools for allocating resources equitably and advancing in a greater environmental protection of water bodies. Risk knowledge and monitoring, forecasting and warning systems will be essential in the management of droughts and floods.

Current global financial flows for adaptation in the water sector, from both public and private sources, are insufficient, especially in developing countries, and will need to be increased. Water governance will undoubtedly contribute to improving the design and implementation of water policies, with responsibilities shared between national, regional and local governments, civil society, users, businesses and other stakeholders. As competition for water use increases, sharing water resources will become increasingly difficult and the exchange of experiences between regions will be key to improving cooperation in transboundary basins.

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