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Resource management and sustainable development: A review of the European water policies in accordance with the United Nations' Sustainable Development Goals

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ABSTRACT

Recent policy developments in Europe consider the importance of water ecosystems to human wellbeing and the detrimental effects that multiple pressures may have on them. Several directives and measures which culminated with the design and the implementation of the Water Framework Directive, have attempted to address the issue of sustainable water management while aligning with targets of economic development. We review the European Water Framework Directive keeping in mind the commitment to the United Nation' Agenda to 2030 with the aim to identify complementarities and missing parts in aligning regional policies to global targets for sustainable development. Towards this end the management plans in selected river basins, Ebro-Spain, Adige-Italy, Evrotas-Greece, Sava- Slovenia, Serbia, Croatia and Bosnia and Herzegovina and Anglian-UK, are examined. The analysis shows that despite significant steps towards integrated management of water bodies in Europe, it is still necessary to improve policy design and implementation to align with global sustainable development targets. Appropriate supportive methodologies must be developed that consider the socio-economic and environmental dimensions of water management. Policies should aim for environmental agreements, alternative climate change scenarios, transparent quantitative measures targeting sustainable demand of water and explicit infrastructure and knowledge transfer channels which can accelerate the implementation of sustainable water management at regional and global level.

1. Introduction

Water bodies are undoubtedly linked to human existence and well-being. They provide vital goods and services, support biodiversity and core economic activities (e.g. agriculture, transport and energy production). Human activities, land use, industrialization, urbanization and geomorphological alterations put water bodies under multiple pressures (Vörösmarty et al., 2010; UN Water, 2013). Recognising the existence of many pressures on the water bodies worldwide, the international community has put forward specific policy targets aiming at their protection and preservation. Two out of the 17 United Nations (UN) Sustainable Development Goals (SDGs), SDG number 6: Clean water and sanitation and SDG number 14: Life below water, target explicitly sustainable water policies. The Open Working Group on SDGs puts forward two additional water-related issues: "Sustainable management of oceans and coastal areas" and "Water and sanitation" (Sustainable Development Solutions Network, 2015). The UN SDGs bring forward the interconnection between water management and sustainable development, while acknowledging that the simultaneous attention to the latter is associated with significant management, social, economic and political challenges.

In the European Union (EU), water management policies date back in the 1980s and have been formalized in 2000 in the Water Framework Directive (WFD). The aim of the WDF is to achieve good ecological and chemical status in inland surface waters, transitional waters, coastal waters and ground waters through the establishment of an integrated pan-European sustainable water management approach. The WFD is considered a first systematic effort for integrated water management by

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addressing stressors put on EU water bodies. Despite the actions to implement the EU WFD, challenges remain particularly with regards to addressing multiple stressors in accordance with the SDGs and the holistic system thinking of natural resources (Vörösmarty et al., 2010; Ludwig et al., 2011; Voulvoulis et al., 2017; Apostolaki et al., 2019a).

From a methodological perspective, the development and application of policies that address multiple pressures necessitates the need to consider the economic, social and environmental value of water and of the related costs and benefits of the necessary measures to achieve good water status. From a development perspective, efforts need to look carefully at the social and economic factors that drive multiple pressures and how these can be mapped to a sustainable development roadmap. In other words, it remains essential to identify the links between SDGs, multiple stressors and water management practices. Such efforts can lead to policy recommendations relevant not only to the addressing of multiple pressures on water bodies but also to the integrated sustainable development.

This paper reviews the implementation of holistic management of water resources in accordance with the WFD in selected EU river basins (RBs), namely: Adige (Italy), Anglian (UK), Ebro (Spain), Evrotas (Greece) and Sava (Slovenia, Serbia, Croatia and Bosnia and Herzegovina). The aim is to critically review the management policies and measures adopted in each case and to map them to the relevant SDGs. The objective is to identify the existing and the missing links between the EU WFD and the UN SDGs. The ultimate goal is to derive useful policy insights and recommendations for the design and implementation of the WFD that can support the sustainable management of the water bodies and economic development in the EU but also overcome the fragmentation in regional and global efforts to achieve efficient water management.

The remainder of the paper develops as follows: Section 2 reviews the water management policies adopted in the EU. Section 3 discusses the SDGs related to water management. Section 4 reviews the selected EU cases and the respective management plans and measures. Section 5 critically discusses the management plans and measures adopted identifying the missing links and complementarities between the EU water management policies and the UN SDGs. Last section concludes.

2. EU policies for sustainable water management

The European Commission has put forward several water management directives (European Commission, 1980; 2002; 2007; 2017). The first of these directives regards the 1980 Drinking Water Directive (Directive 80/68EEC) that defines the standards for toxic chemicals and for substances that cause health hazards and occur in drinking water. The Drinking Water Directive was followed by a string of Directives on the chemical and ecological status of the European waters (Nitrates Directive (1991), Urban Wastewater Treatment Directive (1991), Plant Protection Products Directive (1991), Directive for Integrated Pollution and Prevention Control (1996), Biocides Directive (1998), New Drinking Water Directive (1998), Groundwater Directive (2006)). Despite progress in several aspects, policy initiatives and the regulatory framework did not address adequately the multiple stressors on water bodies.

The fragmented addressing of stressors persisted in the EU policies up to the introduction of the Water Framework Directive in 2000 (WFD, Directive 2000/60/EC). The WFD was the first systematic approach to water management that addresses simultaneously multiple environmental, social and economic stressors. The WFD covers water quality, water quantity and aquatic habitat and it considers both the chemical and ecologic status of water. Based on the qualitative and quantitative status, waters are classified in poor, moderate, good and high quality. The WFD timetable develops in three management cycles: the first management cycle ended in 2015, the second runs until 2021 and the third cycle will end in 2027.

Implementation of the WFD in the EU RBs requires that Member States to: i) identify the RBs in their national territories and assign them to individual river basin districts (RBDs), ii) characterize the baseline status of RBDs, including pressures and water uses, iii) inter-calibrate the national systems to assess the ecological status, iv) identify and materialize cost-effective actions so as to achieve the WFD's environmental objectives, v) publish River Basin Management Plans (RBMPs) and vi) implement sustainable water pricing policies (Koundouri et al., 2019a). Each RBMP sets out specific Programmes of Measures (PoMs). The PoMs include technical, non-technical and economic instruments for pollution control, for the achievement and the maintenance of the environmental standards and for awareness and capacity development.

The EU WFD, as per Articles 5 "Characteristics of the RB district, review of environmental impact of human activity and economic analysis of water use" and Article 9 "Recovery of costs for water services", requires the recovery of the total economic cost of water services. This constitutes a first-time recognition of the importance of the socio-economic assessment and tools for achieving good environmental and chemical status in the water bodies. Total water cost recovery necessitates the identification and the monetization of the financial cost (operation and maintenance costs, administration costs and investment costs related to water provisioning), resource cost (the opportunity cost of water use) and environmental cost (the cost of environmental externalities like water degradation) of water use (GLOBAQUA D9.4, 2019). Thus, all water uses should be identified and linked to the respective economic agents and sectors (households, industry, agriculture, etc.). In terms of ease of identification and monetization of the total water use costs, financial costs might be easier to monetise (e.g. through the cost of infrastructure for water provision and maintenance costs). In contrast it remains difficult to identify and monetise the resource and the environmental costs of water use.

3. The UN Agenda to 2030 and the SDGs linked to water management

The UN adopted in 2015 the 2030 Agenda for Sustainable Development, a blueprint for global welfare for current and future generations. At the core of the Agenda lie the 17 SDGs, a follow up to the Millennium Development Goals. Fig. 1 summarizes the SDGs indicating at the same time the primary domain of relevance, i.e. economic, social and environmental. Two out of the 17 SDGs refer explicitly to water-related issues: SDG 6: Clean Water and Sanitation and SDG14: Life below Water. When looking at the threat of multiple pressures on rivers, it becomes evident that more than one SDG are relevant to the sustainable management and to the addressing of multiple pressures on water bodies.

Core targets of SDG1, SDG2 and SDG8 regard the sustaining of per capita economic growth and achievement of higher levels of economic productivity, global resource efficiency in consumption and production with parallel decoupling of economic growth from environmental degradation. Although these SDGs are not directly linked to developments in the EU territories, they are linked to the pressures that water bodies in Europe will be faced with as a result of eradication of poverty and hunger worldwide and increase in living standards and per capita income. These developments will possibly translate in higher demand for EU exports, thus higher economic activity in the EU in a set of economic sectors including agriculture, industry, services and energy. This might be linked to higher sectoral pressures put on the water bodies in Europe.

SDG3 aims for good health and well-being, and more ways to reduce ambient pollution including water pollution. SDG12 targets the efficient use of natural resources, including water bodies. In combination to achieving SDG6, policies need to be put forward with regards to access to safe and affordable drinking water, integrated water resources management, and protection and restoration of the related ecosystems. All the policies need to look beyond national boundaries ensuring at the same time the inclusion of local communities in the decision-making process and implementation phase.

Fig. 1. United Nations' Sustainable Development Goals.

SDG13 calls for taking climate change related actions. SDG15 targets among other conservation, restoration and sustainable use of terrestrial and inland water ecosystems and their services and reduction of the degradation of natural habitats and biodiversity loss. Both SDGs call for the identification of pressures on water ecosystems and of their total economic value in such terms that can enable the identification and implementation of appropriate conservation and sustainable management policies. The achieving of these goals put policy pressures at EU level in order to identify the appropriate cooperation solutions and transboundary mechanisms that will ensure sustainable management of the water bodies. It also stresses the need to identify and apply appropriate economic methods and instruments for the integrated valuation of environmental goods and services provided by the water bodies under different socio-economic and climate change scenarios. Although the theoretical developments in economics propose alternative approaches to this issue, including monetization of the use and non-use value, choice experiments, cost-benefit analysis, benefit transfer (see for instance Koundouri, 2005; Groom and Koundouri, 2011; Davila et al., 2017; Birol et al., 2006, Pearce et al., 2006; Venkatachalam, 2004) their practical implementation remains limited.

Similar difficulties rise with regards to the identification and application of alternative economic instruments such as taxes, subsidies, environmental permits etc. that can be employed for the sustainable management of water bodies (also relevant for SDG8 that targets environmental conservation). Limitations are related to instruments' applicability, to the case-specific requirements that need to be determined a priori and which incur additional policy implementation costs, to the estimation of the optimal level of intervention (e.g. taxes) or time period of implementation, to name a few (Koundouri et al., 2019b).

SDG7 targets affordable, reliable and modern energy services, increased investment in energy infrastructure and clean energy technology. SDG9 aims for resilient regional and trans-border infrastructure, inclusive and sustainable industrialization, access to information and communications technology. In terms of pressures (relevant to water bodies as well), these goals might translate in increasing pressures on the ecosystem services coming from infrastructure projects and the related use of limited space and resources. But these goals provide also an excellent opportunity for the EU to be a first mover in setting sustainability at the forefront of projects related to water bodies. Any infrastructure projects need to be backed up by sound environmental impact assessment, something that it is clearly stipulated in the EU WFD. Also targets with regards to innovation networks and increase in communication and information sharing networks mean that the implementation of the water related policies may be facilitated by the development of information links and more efficient transboundary cooperation.

One the basis of achieving the aforementioned goals lie initiatives and policies targeted in SDG17: Strengthen the means of implementation and revitalize the global partnership for sustainable development. Targets of SDG17 put forward the need for international cooperation in the governance sphere. EU with its democratic and inclusive institutions and proactive stance towards environmental protection and conservation (further formalised with landmark actions like the European Green Deal) can be a good example to follow and a front runner which paves the way for other regions in the world.

The review of the SDGs shows that there are several goals that are directly and/or indirectly linked to the sustainable management of water bodies. Hence, any policies aiming at the sustainable management of the RBs in Europe need to look closely at these links so as to develop an integrated policy framework and set of interventions. This will ensure alignment with the goals of efficient management of water bodies but also with the sustainable management that can ensure economic development, social welfare and environmental preservation.

4. Overview of water management plans and measures in selected EU river basins

4.1. Material and methods

The overview of the selected management plans and measures develops keeping in mind the main goals of the present paper, i.e. the identification of complementarities and missing links between the EU water management policies and the UN SDGs, and the derivation of useful insights for policy making. The summary draws from the extensive review of the relevant documents and literature undertaken for the GLOBAQUA project, funded by the European Commission Seventh Programme for research, technological development and demonstration[1] . The review conducted for the project has been complemented with the detailed technical description and assessment of the PoMs in the selected cases from the project expert partners and relevant

[1] See: www.globaqua-project.eu.

stakeholders during the project implementation period (2014-2019). This entailed an inter-disciplinary approach and understanding of the PoMs that address a range of water-related issues such as pollution differentiated by source (e.g. agriculture and industry), over-exploitation from different uses (residential, energy use etc.), hydro-morphology, habitat status and ecosystem preservation. This work has been documented in the scientific reports for the project that have been peer-reviewed and accepted by the Commission as project deliverables.

The focus of the paper remains with the identification of complementarities and missing links between the EU water policies, as formulated in the EU WFD, and the UN SDGs. The detailed technical presentation of the PoMs extends beyond the scope of this paper. The RBMPs and the PoMs reviewed in this paper are detailed in the documents prepared by the respective authorities (Sava River Basin Management Plan, 2014; Management Plans of Eastern Peloponnese River Basin District, 2013; Piano di gestione dei bacini idrografici delle Alpi Orientali, 2010; Plan Hidrológico del Ebro 2010-2015, 2014Plan Hidrológico del Ebro 2010-2015, 2014; River Basin Management Plan for the UK's Anglian River Basin District, 2009). The RBMPs are multi-page documents and include lengthy presentations of the current status, methods, objectives, financing, economic assessment for water management in accordance with the EU WFD. The documents include numerous measures and differ largely in several aspects, including the detail and the depth of the information and/or the description provided. The presentation of the PoMs varies considerably between the different countries from general description, legal assessment and characterisation of progress (e.g. Adige) to detailed tables of specific measures with details on the cost, implementation period and responsible/involved authorities (e.g. Anglian, Ebro). The length and diversity in content, measures and layout renders difficult the condense few-page presentation for an audience that extends beyond specific disciplines.

In order to facilitate the reader, we provide a summary reference to the selected cases, the relevant RBMPs and the PoMs included therein. Emphasis is given on the use of economic instruments for sustainable water management, which regards a core management novelty in the WFD. In order to further support the understanding of the completed work, selected measures addressing pressures coming from the agriculture sector that is one of the most important sectors in terms of pressures on the water bodies, are summarized in Table 1. The grouping of measures in technical, non-technical and economic measures follows their characterisation as included in the RBMPs but also the expert opinion on whether the outcome is the result of a technical, non-technical or economic intervention in the market (for instance pesticide reduction is categorised as a technical measure following the RBMP details and GLOBAQUA project expert opinion while pesticide taxation, which also may lead to lower pesticide use is categorised as an economic measure as it considers the use of economic instruments, i.e. taxes, subsidies etc). To further facilitate the readers, supplementary material accompanies the paper with summary documentation of the RBMPs and the PoMs discussed herein. In order to make the supplementary material more comprehensive and uniform only pressures/targets to be addressed and measures foreseen towards this end are included (for instance cost information on the measures included in the PoMs for Ebro or Evrotas are excluded). Readers interested in the details of the RBMPs, the respective PoMs and their assessment should refer to the documents that have been reviewed for the purposes of this paper (Sava River Basin Management Plan, 2014; Management Plans of Eastern Peloponnese River Basin District, 2013; Piano di gestione dei bacini idrografici delle Alpi Orientali, 2010; Plan Hidrológico del Ebro 2010-2015, 2014Plan Hidrológico del Ebro 2010-2015, 2014; River Basin Management Plan for the UK's Anglian River Basin District, 2009), to the GLOBAQUA project results (particularly GLOBAQUA Deliverables D010: First integrated models at the basin scale (2018); D016: Final integrated models at the basin scale (2016), D004: Importance of ecosystem services to the economy and socioeconomic development (2016)) and to the related publications (European Environment Agency, 2010; 2014; Koundouri

Table 1
Indicative measures to address multiple pressures as a result of agriculture in Adige, Ebro, Evrotas and Sava RBs and Anglian RBD.

Technical measures	Non-technical measures	Economic instruments
Adige		
• Reduction/modification of fertilizer application • Reduction/modification of pesticide application • Change to low-input farming (e.g. organic farming practices) • Hydro morphological measures leading to changes in farming practices • Multi-objective measures (e.g. crop rotation, creation of enhanced buffer, zones/wetlands or floodplain management) • Technical measures for water saving in agriculture	• Codes of agricultural practice • Farm advice and training • Certification schemes • Specific projects related to agriculture • Environmental permitting and licensing	• Water pricing specifications for irrigators
Anglian		
• Reduction/modification of fertilizer application • Reduction/modification of pesticide application • Hydromorphological measures leading to changes in farming practices • Measures against soil erosion • Multi-objective measures (e.g. crop rotation, creation of enhanced buffer zones/wetlands or floodplain management) • Technical measures for water saving in agriculture	• Codes of agricultural practice • Farm advice and training • Raising awareness of farmers • Measures increase knowledge for improved decision-making • Specific action plans/ programmes • Land use planning • Specific projects related to agriculture and Environmental permitting and licensing	• Compensation for land cover • Co-operative agreements
Ebro		
• Reduction/modification of fertiliser application • Reduction/modification of pesticide application • Change to low-input farming (e.g. organic farming practices) • Hydro morphological measures leading to changes in farming practices • Multi-objective measures (e.g. crop rotation, creation of enhanced buffer zones/wetlands or floodplain management) • Technical measures for water saving	• Additions regarding the implementation and enforcement of existing EU legislation • Controls • Institutional changes • Codes of agricultural practice • Farm advice and training • Raising awareness of farmers • Measures to increase knowledge for improved decision-making • Zoning (e.g. designating land use based on GIS maps) • Specific action plans/ programmes • Land use planning • Environmental permits/ licenses • Others (e.g. new water supply infrastructure)	• Compensation for land cover • Water pricing specifications for irrigators • Fertilizer taxation
Evrotas		
• Systematic monitoring of the levels of nitrates in water bodies • Rational use of plant protection products	• Training / institutionalization of management plans of protected areas Natura 2000 sites directly dependent on water,	• Establish financial incentives for modernizing and improving infrastructure livestock facilities

(continued on next page)

Table 1 (*continued*)

Technical measures	Non-technical measures	Economic instruments
	with special reference to water management issues • Monitoring / evaluation of the conservation status of dependent water habitats and species in areas of the network Natura 2000 • Delineation of new vulnerable areas and Training Programs Action depending on the type of crop • Ban to construct new underground water abstraction projects within areas of collective irrigation systems	treatment of livestock waste • Adapting pricing policy to serve environmental sustainability and avoid water wastage
Sava • Implementation of the Best Available Techniques and Best Environmental Practices regarding agricultural practices (for EU Member States linked to EU Common Agricultural Policy – CAP) • Phasing out all discharges of untreated wastewater from towns with >2,000 population equivalents and from all major industrial and agricultural installations	• Linkage between agriculture measures and national/regional rural development programmes	• Application of economic principles (e.g. the polluter pays principle), economic approaches and tools (e.g. cost effectiveness analysis) and instruments (e.g. water pricing • Compensation for land cover • Cooperative agreements • Water pricing, nutrient trading • A tax on pollution emissions (charges per kg of emission) • Tax on fertiliser inputs (inorganic fertiliser taxes)

Source: Akinsete et al., 2019a; Authors update with inputs from Koundouri et al., 2019a, 2017; Sava River Basin Management Plan, 2014; Management Plans of Eastern Peloponnese River Basin District, 2013; Piano di gestione dei bacini idrografici delle Alpi Orientali, 2010; Plan Hidrológico del Ebro 2010-2015, 2014Plan Hidrológico del Ebro 2010-2015, 2014; River Basin Management Plan for the UK's Anglian River Basin District, 2009.

et al., 2017, 2016; Ludwig et al., 2011; Navarro-Ortega et al., 2015; Koundouri et al., 2019a; 2019b; Pistocchi et al., 2016; ICPDR, 2010; ISRBC, 2009; Jolović and Merdan, 2007; WFD CIS, 2003; 2009; European Commission, 2012; WFD CIRCA2 (2019) "Implementing the Water Framework Directive and the Floods Directive" Library: Croatia, Slovenia, Serbia, Spain, Greece, Italy and UK folders).

4.2. *Brief presentation of the selected cases, management plans and measures*[2]

4.2.1. *Adige*

Adige RB, a sub-basin region of the greater Eastern Alp basin region, covers an area of 12.100 km2 spreading through the provinces of Bolzano (62%), Trento (29%), and the Veneto Region (9%) (Akinsete et al., 2019a). Adige RB has approximately 1.4 million people, with 54.15% of those living in municipalities with more than 10,000 residents. The region has recorded rapid economic development in the last decades. Industry is the most important sector in terms of gross value added while agriculture and construction follow. Key stress factors for the RB include nitrate pollution, pesticides, intensive agricultural (for example around the Adige valley in Veneto) and industrial activities, contaminated areas and salt intrusion. These factors impact mainly on drinking and agricultural water uses.

With regards to the Adige RB, several measures listed in the RBMP originate from previous plans (such as the regional Water Protection Plans). Regarding agriculture the RBMP acknowledges it as an important pressure due to diffuse pollution and abstractions (Koundouri et al., 2017). Thus, it identifies a broad range of measures to address pressures arising from agriculture. These include lower use and modification of fertilizer and pesticide application, low-input farming, crop rotation, and water saving. With regards to economic instruments specific to the agriculture sector only one refers to water pricing for the agriculture sector. As far as non-technical measures are considered, greater controls are mentioned (mainly related to abstraction). Other management plans refer to specific actions and programmes that cover periods of water crisis and reform of irrigation systems. Little information is provided on costs or financing for agricultural measures, the scope of the measures or the timing of their implementation.

With regards to the water pricing policies documented in the RBMP, definition of water services (that follows national legislation) is broad as it covers households as well as all types of economic activities (thus both industry and agriculture). The legislation requires the implementation of the principle of cost recovery for water services, estimated on the ground of the "polluter pays" principle, with prices that provide adequate incentives for efficient use and also take into consideration the environmental and resource costs of water use. In the sub-basin region of Bolzano, the water tariff consists of a basic fee for connection to the network that covers the network costs and a volumetric assessment that is accounting for the protection of the water resource (Akinsete et al., 2019a; Koundouri et al., 2017). In the Province of Trento, the tariff model includes costs related to water supply and sewage services while there is an additional fee on water treatment/purification, which is reviewed on an annual basis. The tariff model also includes costs related to the use of the public water resource (a fixed rate and a progressive rate that depend on consumption). The RBMP provides no details on the calculation and the inclusion to the cost recovery calculation of environmental and resource costs. Additionally, the RBMP provides no explanation on the implementation of incentive pricing. The RBMP also does not make any reference to the international cooperation regarding the implementation of water pricing policies.

[2] For a detailed assessment of the PoMs for the RBs readers should refer to the GLOBAQUA outcomes (http://www.globaqua-project.eu/en/documents/showcategory/&cat=publications). The review in this section draws from GLOBAQUA D010, 2018: First integrated models at the basin scale (2018); GLOBAQUA D016, 2016: Final integrated models at the basin scale (2016), GLOBAQUA D004, 2016: Importance of ecosystem services to the economy and socioeconomic development (2016) and Koundouri et al. (2017). See also: Koundouri et al. (2016); Koundouri et al. (2019a; 2019b), Akinsete et al. (2019a, 2019b); Apostolaki et al. (2019a; 2019b), Terrado et al. (2016) and Navarro-Ortega et al. (2014).

4.2.2. Anglian

Anglian RBD comprises of several river basins (RBs) and it spans over an area of 27,900km2 from Lincolnshire in the north to Essex in the south and from Northamptonshire in the west to the east Anglian coast (Environment Agency, 2015). The district includes the urban centres of Lincoln, Northampton, Milton Keynes and Chelmsford and is home to more than 7.1 million people. More than 50% of land in the district is used for agriculture and horticulture. East Anglia is a tourist destination mainly for water recreation. Pressing water management issues are related to physical changes to rivers, lakes and estuaries that alter the natural flow levels that cause excessive build-up of sediment in surface water bodies and the loss of habitats and recreational uses. Other issues are related to pollution from wastewater from towns, cities and transport, changes to the natural flow and level of water.

The measures listed in the RBMP (River Basin Management Plan for the UK's Anglian River Basin District, 2009)[3] make use of the ecological, chemical and quantitative status assessments for all water bodies. Agriculture pressures are assessed based on water quality, water quantity, eutrophication, and soil erosion. A combination of technical measures, economic instruments and non-technical measures (which remain voluntary in large) has been selected to address these pressures (Akinsete et al., 2019a). The measures have been drafted by national authorities who also oversee the implementation of most of them. Measures are expected to be implemented by relevant stakeholders such as farmers and enterprises. There is a relatively strong emphasis on voluntary measures rather than statutory measures in the plans which are in place if the voluntary measures fail to materialise or achieve the desired goals. Costs have been calculated and broken down by sector and pressure. The management plan refers to the financial support to measure implementation. Nevertheless, the funding sources remain unclear. Rural Development Programmes are in place to fund agricultural measures and agri-environment schemes.

With regards to water pricing measures the definition of water services is narrow and includes only water supply and wastewater collection and treatment. Cost recovery rates are calculated only for water companies providing water supply and sewerage services. Also, the contribution of the different water uses (households, agriculture and industry) remains unclear. Cost recovery calculations include financial costs such as capital costs, depreciation, operational and maintenance costs, and administrative costs. Subsidies have been included in the calculation at district level while the environmental and resource costs have been estimated at national level. The use of the polluter-pays principle is mentioned but given the unclear contribution of each sector the implementation the principle is questionable. Incentive water pricing include volumetric charging and water metering in some areas. It is foreseen to include site-based charges for surface water drainage in the future. Some coordination at national level is reported while no coordination mechanisms at international level are reported.

4.2.3. Ebro

Ebro RB covers a total surface area of 85,362 km2 located to the north-east of the Iberian Peninsula (see Akinsete et al., 2019a). Ebro is a special case within EU, due to the high number of different organizational structures involved in its management as well as the decentralized nature of the management itself. The territory is organized into Municipalities, Provinces, and Autonomous Communities with a range of competencies given in each entity. Agriculture (irrigation and livestock) is the main user of surface water and groundwater resources followed by uses for energy production and industry. Measures in agriculture include fertilizer application, implementation and enforcement of existing EU legislation, water pricing specifications for irrigators, adoption of low-input farming, institutional changes, codes of agricultural practice, awareness raising and land use planning.

An important part of the management plan aims at building knowledge on the impacts of pressures, on ecosystem and hydromorphologic dynamics, climate variability and change. Measures are described at different degrees of scope and location details (river basin or specific water body level). The total cost of the measures is reported as well as the funding sources. Nevertheless, the commitment to fund mobilisation is not clear. Also the timeframe of the implementation of the measures is not clear; it is just stated that the plan includes the actions considered most necessary and likely to be carried out until in the 2015 horizon. The RBMP puts under the same category all water uses, whose supply is facilitated by the connection to the piping system located in city areas. This means that the reporting of residential demand includes the quantity of water used by businesses, shops and other establishments located in cities.

The assessment of the PoMs remains limited due to the lack of data and the level of detail of measures provided in the RBMP. The PoMs classify measures regarding topics/problems: achievement of environmental objectives, satisfaction of water demand, risk management – floods and droughts, and knowledge and governance. It is complex or impossible to understand how the PoMs are linked and respond to the identified pressures and to the status assessment, and how the measures ensure the achievement of objectives. The measures to satisfy water demand –which use on average nearly half of the PoMs budgets - are not targeted to the WFD objectives and might even hamper their achievement (see European Commission, 2015).

The cost recovery principle in Spain is applied in a decentralized way and has the form of water levy, an environmental tax, aimed at recovery of environmental and natural resource use costs that ensures water availability and quality. The levy addresses the domestic and the industrial use, while agricultural use, and livestock farming are exempted, unless there is identified contamination from pesticides, fertilisers or organic material, and pollution discharges, respectively. The pricing mechanisms make use of several legal instruments and depend either fully or partially on volumetric charges and are aimed at enabling moving from partial to total cost recovery. Full cost recovery is not achieved in any case or use (in many uses even the financial cost recovery is not achieved).

4.2.4. Evrotas

Evrotas RB is in Peloponnese. The river has a catchment size of 2240 km2 (Apostolaki et al., 2019b; Koundouri et al., 2019b). Sparta is the largest city in the catchment while the RB has a total population of approximately 80,000 people. Regional economic activity includes mainly agriculture and livestock, industry and manufacturing. Water needs in the catchment are covered by groundwater abstractions and springs connected to the groundwater aquifer while the agricultural activities in the Evrotas RB, are covered mainly via dams and direct stream flows. Considerable degradation is recorded in the chemical status of the water bodies.

Water pricing policy in Eastern Peloponnese is differentiated into 4 to 7 categories defined by priorities regarding local characteristics. Intensive agricultural activity is considered to be the only driver of water demand in the future while over-exploitation of water for agricultural purposes, point and diffuse sources of pollution and the climate change effects are potential threats for the disturbance of the balance between water supply and demand.

Pressures in the RB are related to pollution and water supply needs to satisfy demand. Groundwater pollution is related to agricultural activities. The PoMs aims for both the protection and the restoration of the RBs. Measures foresee to consider the analysis of pressures and their impact on aquatic systems in conjunction with data from the Program Monitoring. Foreseen measures include among other legislative, administrative, financial, environmental agreements, abstractions control and demand management measures. Analysis of Akinsete et al.

[3] See: River Basin Management Plan for the UK's Anglian River Basin District (UK05), including annexes at: http://cdr.eionet.europa.eu/gb/eu/wfdart13/uk05/envs5pffq/.

(2019a) and Koundouri et al. (2019b) show that the RBMP depicts a relatively low financial and total cost recovery for the Evrotas RB indicating the need to put forward several measures to achieve full cost recovery. In the RBMP are not detailed specific measures to address full water costs but just general measures that address specific goals mainly related to pollution and erosion control. Thus, it is difficult to estimate the allocation of full cost recovery burden among agents and sectors in the region. Given the socio-economic characterisation of the region (important agricultural sector in terms of Gross Value Added and employment, limited industrial production, low population density but with seasonal variability) it can be argued that the main effects of achieving full cost recovery are expected to be recorded in agriculture.

4.2.5. Sava

Sava is a transboundary RB, a sub-basin of the Danube River Basin, shared among Slovenia, Croatia, Bosnia and Herzegovina, Montenegro and Serbia. The population in the area of 97,713.2 km2 amounts to more than 8.5 million people (Akinsete et al., 2019b). The management of water resources of the Sava river basin is the objective of the Framework Agreement for the Sava River Basin (FASRB), which is coordinated by the International Sava River Basin Commission (ISRBC). The ISRBC is responsible for the implementation of FASRB and the coordination of the implementation of the WFD in the Sava River Basin. The International Commission for the Protection of the Danube River (ICPDR) is a transnational body, which has been established to implement the Danube River Protection Convention. ICPDR is formally comprised by the Delegations of all contracting parties. In 2000, the ICPDR contracting parties nominated the ICPDR as the platform for the implementation of all transboundary aspects of the EU Water Framework Directive (WFD)[4]. In the RB public sector remains the largest employer followed by industry and agriculture. Slovenia and Croatia offer the greatest contribution to Sava total Gross Domestic Product, followed by Bosnia & Herzegovina, Serbia and Montenegro (Akinsete et al., 2019a). Water uses in the Sava RB include residential, industrial, agricultural, and electricity production. Water use for electricity production accounts for the biggest consumption of water. Major pollutant load comes from the agricultural activity (chemical fertilisers and pesticides, nutrient pollution). Groundwater bodies are at risk due to over-abstraction, chemical pollution from infiltration of diffuse agricultural pollution.

The scope of the application of the management plans for Sava RB varies significantly among the different countries. The RBMPs specify the relevant authorities and other stakeholders responsible for the implementation of measures. Costs have been identified for different types of measures. These measures are funded from the states' budgets, from municipalities' budgets, EU Cohesion and Structural funds. The RBMP does not provide any information on cost effectiveness analysis undertaken during the development of the PoMs, neither adequate data are provided to complete a cost-effectiveness assessment. In the case of Croatia and Serbia, the plans do not provide information on the implementation of economic measures, on the incentive water pricing or on cost recovery.

The PoMs for the Sava RB builds upon the results of the pressure analysis, the water status assessment and includes the measures of basin-wide importance oriented on the agreed visions and management objectives. It is based on the national PoMs, however the specific situation in the accession and non-EU countries is considered. The PoMs identifies significant pressures acting on the water environment (human activity like farming and industry, historic human activity like abandoned mines and contaminated sites, new infrastructure projects,floods, navigation and hydropower) that are considered to put at risk the achievement of the environmental goals of the WFD. With regards to organic pollution that remains an issue in the Sava River due to the lack of wastewater treatment, it is explicitly included in the PoMs with provision for wastewater treatment from towns with population that exceeds 2,000 people.

With regards to the economic instruments, the RBMP makes provision for all involved countries to develop a common cost recovery scheme within the RB. Although the WFD does not provide a clear setting for the cost recovery requirement of transboundary regions, it is recognized that there is need for provision for a basin-level cost recovery of water services. The cost recovery considers primarily the domestic water use (water services and sewerage). Volumetric pricing is the most common pricing scheme with municipalities being the price-setting authorities. Due to the particularities of the RB (transboundary region, 2 EU member state countries and 1 candidate country) the cost recovery provisions can only be examined on a country basis (GLOBAQUA D9.4, 2019).

The assessment survey for Sava (Background paper No 6, 2013) for Croatia identified a complex aggregation of revenue and formulation of water prices for the different uses with the participation of water companies, local, regional and central authorities. Water pricing differs according to use (domestic and commercial) and includes operation and maintenance costs. In contrast capital costs, external environmental cost and water resource costs are not included. Use from the domestic sector is subsidized by the commercial sector (Akinsete et al., 2019b).

In Serbia the Municipal Authorities, that are responsible for pricing, apply a unified component fee for domestic water supply and wastewater services based on volumetric pricing. The industrial fee is set two- or thre-fold higher as compared to the domestic fee so as to subsidise the domestic water use. Prices are adjusted on an annual basis adding unpredictability to the perceived industrial costs.

The Municipalities of Slovenia can provide subsidies for public water supply and municipal wastewater treatment services, for the costs of depreciation of public infrastructure. Cost recovery of financial costs for public water supply and for municipal wastewater collection and treatment is not achieved in Slovenia. Operation and maintenance costs are recovered through tariffs. According to the national legislation on water tariff setting, local governments can subsidize water use through municipal budget spending.

5. A critical review of the EU water management policies with reference to the United Nations Sustainable Development goals

Following the UN Agenda to 2030 and the SDGs targets to be met, countries should put forward robust policy initiatives so as to make meaningful progress. This progress is monitored with appropriately constructed indicators of the Monitoring Framework for the Sustainable Development Goals. Through these indicators countries can see their performance and how they compare against other countries. Fig. 2 shows the overall performance of the selected EU countries in relation to the 17 SDGs following the first round of reporting against the SDG indicators (Sustainable Development Solutions Network, 2015; Inter-Agency and Expert Group on SDG Indicators, 2017). Countries are assessed and their performance is indicated with the use of specific color: Green color indicates SDG achievement (i.e. all indicators under the goal have been rated green), while yellow, amber and red indicate increasing distance from SDG achievement, with red indicating the largest distance away from the target achievement of SDGs.

The selected EU countries perform at various degrees with regards to SDGs achievement. With regards to the water-related SDGs, countries score relatively low. Except for Serbia, which achieved a green rating under SDG 6, all other countries achieved mostly yellow ratings. Under SDG 14, most countries received a red rating excluding Croatia which received an amber rating and Serbia which failed to receive a rating due to insufficient data (Koundouri et al., 2019a). This snapshot indicates that the selected countries must make significant steps towards the achievement of the SDGs to 2030. And this will be related to important outcomes with regards to sustainable resource management. Hence, it is useful to consider the complementarities and divergences between the

[4] See: https://www.icpdr.org/main/icpdr/about-us.

Fig. 2. SDG index dashboard highlighting performance on water-related SDGs 6 and 14 (Source: Koundouri et al. (2019a), adopted from the Sustainable Development Solutions Network (2015)).
Note: Spain (Ebro), Italy (Adige), Greece (Evrotas), Slovenia, Serbia, Croatia, Bosnia and Herzegovina (Sava), United Kingdom (Anglian)

EU policies and the UN SDGs with regards to sustainable water management.

Keeping in mind the SDGs to be met worldwide by 2030 several issues arise that need to be addressed in order to align EU water policy goals to global policy initiatives. Measures related to the water quality (poor, moderate, good, high) should become more precise in order to meet SDGs 3, 6, 12 and 15 and reflect alignment with the WFD defined targets. In order to identify the current state and then define the roadmap that will take the society at a better level of provision of quality ecosystem services and goods, it is important to narrow down as much as possible the focus and the quantitative targets of the measures put forward with the intention to promote accurate intervention policies. This is not an easy task as it necessitates the involvement of different disciplines and expertise given the intra- and inter-disciplinary nature of the goal. On the positive site, policy making may benefit from synergies and knowledge flows generated across disciplines and trigger crosspollination.

As discussed in section 4, measures adopted in the different RBMPs and their presentation varies in large. Indicatively measures against agricultural pollution vary from a string of detailed technical and non-technical measures in the case of Anglian and Ebro to a few and rather general technical measures in Evrotas and Adige RBs. While reading through the RBMPs, one can see in some cases wide stroke measures, generally citing directives that must be enforced (e.g. Ebro, Adige, Evrotas) while other provide detailed descriptions of the measures and set out specific actions with varying degrees of detail regarding the scope and location of the measures (Anglian, Sava).

The management plans and measures vary in detail, sectoral breakdown and water cost recovery approaches. An indicative example is that of the Anglian RB that, differentiating from the other cases examined, employs a narrow definition of water pricing which includes only water supply and wastewater collection and treatment. Cost recovery calculations include subsidies, which are calculated at district level while the environmental and resource costs have been estimated at national level. In the Sava RB discrepancies are identified among countries despite the fact that the management regards the same RB. PoMs differ with regards to the water cost recovery and of the cost components included in the estimations. While financial costs are included in all cases environmental, social and resource costs are not calculated in all cases neither included in the pricing mechanism.

Discrepancies among management plans and the measures therein are expected to some degree as the policies and respective measures put forward the need to consider the particularities and needs at each policy site. Nevertheless, it should be noted that more should be done with regards to the integration of policies and knowledge information flow across cases. Discrepancies across the different management plans and measures, especially with regards to the water cost components, are indicative of the lack of adequate quantified and monetized information. They show the need to have a record system of the relevant costs across the EU and use them in water cost recovery approaches. Their use should follow the necessary adjustments to be made so as findings to be transferable from one policy site to another policy site. This would further align the WFD to the targets set by SDG 2, 6, 8, 9, 15 and 17.

The management plans in the different RBs make explicit reference to the environmental and resource use cost of water moving beyond the mere financial costs of water use. All the selected RBMPs refer to the need to achieve total water cost recovery. This is in line with the requirements of meeting the SDGs 10, 12 and 15. At the same time this explicit reference to non-financial costs indicates the need to capture and monetize the environmental and social costs and benefits related to water use. However, the review of the selected RBMPs reveals that there is neither a common approach nor a consensus on how the environmental and resource costs should be monetized. In addition, no uniform approach exists on who should bear these costs despite the common agreement that the polluter-pays principle should apply.

Policies should aim for integrated water pricing that explicitly take into consideration not only the financial costs of water (e.g. operation and maintenance costs) but also the environmental and resource use costs (in line with SDGs 3, 6, 13, 15). While these costs might significantly exceed the financial costs of water use, they are often difficult to estimate and integrate with the water pricing system in an efficient and fair system. With regards to the estimation of the environmental and resource costs, the literature to date proposes several alternative approaches (e.g. Koundouri, 2005; Groom and Koundouri, 2011; Davila et al., 2017; Birol et al., 2006; Garrod and Willis, 1999; Gollier et al., 2008; Grünenliga, 2011). Several points of policy consideration emerge in this case. The methodologies proposed might be costly in terms of funds, effort and time required. Also, in many cases the transfer of information from one site to another policy site might not be accurate or easy to implement due to structural differentials between the two sites. It is thus important for the policy makers to understand the need to include appropriate methodologies and adequate funds for the estimation of the environmental and resource costs of water use.

Additionally, the WFD indicates the consensus at EU level that knowledge transfer systems, common governance approaches and management systems need to be put in place for the sustainable management in shared water bodies. Indicative of this is the establishment of the International Sava River Basin Commission which is responsible for the implementation of FASRB and the coordination of the implementation of the WFD in the Sava River Basin. Another indicative example is the reference of the RBMPs for the Adige RB and Angian RBD to regional and international cooperation. This understanding is in line with SDGs 9 and 17 that prioritize the establishment of global partnerships and infrastructure projects that can adequately address regional

and transboundary environmental, economic and social pressures to sustainable resource management and economic development. Yet the overview of the RBMPs shows that no coordination or alignment is in place across different EU Member states. Despite the reference to cooperation needs, no specific actions are mentioned on how this cooperation will be established. The review of the RBMPs and the PoMs reveals that different governance structures and levels apply even in the same country (see for instance Adige and Ebro). In addition, a common governance framework approach with regards to EU waters that could facilitate the progress in sustainable water management in Europe or it could provide useful insights for other relevant initiatives worldwide, is still missing.

The PoMs include several sector-specific measures (like agriculture and industry; with special focus on agriculture that seems to be a core sector of pressure on water bodies). Nevertheless, there is no quantitative estimation of the impact at sectoral level. Neither do the RBMPs and the PoMs therein consider alternative scenarios of sectoral development compatible with long-term sector-related policy goals that allows for appropriate capturing and monetization of sectoral impact on the water bodies. Given that SDGs 6-9 consider sustainable economic growth and industrial development putting emphasis on specific sectors, such as energy production and agriculture, sectors-specific scenarios that make use of socio-economic pathways (considering the targets of SDGs 1 and 2) and technology innovation assumptions can be employed so as to allow for a more accurate estimation of sectoral impact on the water bodies. The results of these scenarios can feed quantitative recommendations and measures to be implemented at the RBs. In this respect the policies related to the PoMs should be more forward looking rather than drawing conclusions just from past trends and sources of pollution. This can allow for a timely action and addressing of multiple pressures on water bodies that might be related to industrial diversification and intensification of the related activities as a result of materializing the SDGs to 2030.

Another point of consideration that emerges from the analysis of the selected management plans and measures is the need to harmonize the methods employed for water use control across countries. An example of this could be the generalized use of metering in agriculture. Despite the explicit requirements to install and maintain meters, this may not always be enforced and implemented across countries. In the quest for regional and global sustainable development, policy makers must put forward policies that harmonize the use of resources across countries taking into consideration the development stage and needs of each country. This recommendation goes beyond sustainable water management, but it is also relevant for achieving SDGs 1, 2, 6, 8, 9, 12, 15 and 17 at regional and global level.

The review of the selected cases indicates that legislative measures may often lack proper (or sufficient) documentation. Also, even though in some cases scenario analysis is applied (e.g. urban discharges under alternative scenarios in Sava RBMP), the results are not made available indicating lack of transparency. Managing resources in a sustainable manner while adopting sound climate change mitigation and adaptation measures (in line with SDG13) necessitates transparency, sound governance and information flow. In this respect the EU could be a front runner supporting institutional capacity, transboundary cooperation and transparency in methods and approaches, supporting thus further the achievement of SDG17. Indicative actions into this direction could be policy directives or measures that aim at the development and use of advanced IT technologies and innovation sharing platforms with the aim to accelerate knowledge and good practices transfer at EU, regional and global level. If these IT developments take place first in the EU, then EU could enjoy first mover advantages through exporting technology and innovation in other parts of the world.

6. Concluding remarks

The analysis shows that the EU has made significant steps towards the sustainable management of water bodies and the explicit consideration of multiple stressors on water bodies. Nevertheless, it is still necessary to improve policy design and implementation to align with the SDGs targets and priorities. Appropriate supportive methodologies must be developed that consider the socio-economic and environmental dimensions of water policies.

The EU WFD remains a policy blueprint for sustainable water management in the EU aligning to some degree with the UN Sustainable Agenda to 2030. Implementation of the directive is expected to result in substantial socio-economic and environmental benefits especially when considering the presence of multi-pressures on water bodies. Nevertheless, the magnitude and the importance of the results depend on the design and the implementation of the associated policies and measures. In this direction complementarities with the SDGs can be identified and more can be done to overcome the missing links in meeting the sustainability targets at regional and global level.

Great expectations coupled with the implementation of the EU WFD and of the UNs SDGs can be materialized if adequate and transparent interpretation and mobilisation of measures is put forward. This necessitates the overcoming of administrative challenges while performance indicators, better characterisation (for instance more complete analysis of the pressures and the impacts in the RBs) or improved performance monitoring of the different national entities should be established. In the transformative path put forward with the EU WFD, economics should play a central role. Economic assessment and analysis are important not only to estimate the economic costs and benefits of water related policies, but also to assess the preferences and the budget constraints of the individuals and of the society, that impact on the successful implementation of the WFD.

In an attempt to address these requirements several recommendations can be made to policy makers with regards to the successful implementation of the WFD and achievement of the SDGs. Recommendations include: i) the explicit assessment and introduction of alternative economic instruments in the water management systems that appropriately capture the environmental, social and resource use costs of water, ii) working on and putting forward environmental agreements at regional (and at global level) that consider specific climate change scenarios, socio-economic pathways, the total value of resource use, specific transparent targets to meet performance indicators, iii) adoption of quantitative measures targeting sustainable demand of water that will derive from an integrated assessment of the value of water, and iv) establishment of explicit infrastructure and knowledge transfer channels that will accelerate WFD and SDGs implementation at regional and global level.

CRediT authorship contribution statement

Stella Tsani: Conceptualization, Formal analysis, Investigation, Methodology, Writing - original draft, Writing - review & editing. **Phoebe Koundouri:** Formal analysis, Funding acquisition. **Ebun Akinsete:** Formal analysis, Investigation, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

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