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Using a systemic approach to address the requirement for Integrated Water Resource Management within the Water Framework Directive

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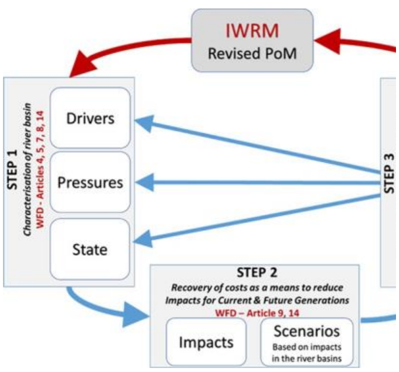
G R A P H I C A L A B S T R A C T

Schematisation of the Globaqua approach that combines well-established methods/concepts: the DPSIR, Ecosys- tem Services Approach and Future Conditions Assessment using Scenario development.



a b s t r a c t

Sustainable management of water resources calls for integration of ideas and approaches and revolves around assessment of causal-effect relationships as tools towards defining informed mitigation options and planning. The current paper presents a new holistic approach developed within the Globaqua Coordination Project that combines indicator-based well-established and tested concepts towards developing informed Programmes of Measures and River basin management plans: a. The DPSIR framework that has been engaged as central instrument to address the Water Framework Directive requirements and the concepts embedded in the Integrated Water Resource Management; b. The Ecosystem Services Approach emphasizing on the links between ecosystem services, changes in ecosystems and human well-being, c. Scenario assessment for valuation of future conditions to ensure the sustainability in the use of water resources. The implementation of the new combined framework in two river basins, Ebro in Spain and Evrotas in Greece, stressed the need for revised options targeting elimination of water pollution, measures to ensure water supply that covers the demand even under conditions of climate change and increased water stress and the need for improved valuation of environmental and resource use costs.

1. Introduction

Holistic management of natural resources, and of water resources in particular, is held high in the EU Agenda, and it is perceived as the means to achieve sustainability. The concept of Integrated Water Resource Management (IWRM), although was first coined in during the first Global Water Conference in Mar del Plata in 1977, it was officially introduced after Agenda 21 and the World Summit on Sustainable Development in 1992 in Rio (WWAP, 2009). According to the Global Water Partnership, IWRM, refers to the process of promoting and coordinating development and management of water, land, and resources to ensure economic and social welfare, as well as securing the sustainability of ecosystems and water resources for future generations. In brief, IWRM provides the way to manage water resources in a sustainable way that takes into account environmental, economic, and society aspects (Cap-Net et al., 2005). One of the main obstacles in the IWRM implementation, lays on how to overcome limitations related to the accurate impact assessment of the proposed strategies. Improvements in the assessment framework that enable accounting of the full range of impacts on natural resources and of the benefits for humans and ecosystems, remains a big challenge (Anzaldua et al., 2018).

Along this line, the European Environment Agency (EEA, 1999) introduced a framework of causal links to enable the elaborate assessment of existing environmental state and the identification of relevant responses. The framework that describes the links between Drivers-Pressures-State-Impacts- Responses (DPSIR), is an indicator-based environmental reporting approach that targets to expand beyond compiling sets of physical, biological or chemical indicators (Maxim et al., 2009). This framework is an underpinning process imbedded in the principles of IWRM and of the Water Framework Directive (WFD – Directive 2000/60/EC), the groundbreaking EU directive, targeting to meet the requirement for good ecological status of all water bodies through engaging into holistic water management. It comprises a holistic approach that takes into account all relevant attributes, identifies the cause-effect relationships between environmental and anthropogenic factors, thus, it links the environmental and the human system (Song and Frostell, 2012; Ness et al., 2010a, b; UNESCO-WWAP, 2003). Following WFD requirements, the DPSIR achieves i) accurate characterization of the water bodies in terms of ecological, chemical and social attributes and impacts, ii) maps the current conditions through quantification of the relevant indicators (UN, 1996; Sun et al., 2016), iii) assesses the risk of failing the WFD objectives (Borja et al., 2006), and iv) supports decision making. The environmental indicators falling under the DPSIR categories, describe and communicate interrelations and interdependencies between the biotic and abiotic factors within an environmental system, they are informing decision making, they enable for timely responses that protect the system, they address the WFD requirement for integrated water management and they comprise a powerful tool in raising public awareness (European Environment Agency (EEA), 1999; Dong and Hauschild, 2017; Elliott, 2002; Kagalou et al., 2012, Gerasidi et al., 2009; Tscherning et al., 2012). The DPSIR scheme has evolved from merging earlier frameworks on Pressures–State–Responses launched by the Organization for Economic Cooperation and on Drivers–Pressures–Responses developed by the United Nations (UN) Commission on Sustainable Development (OECD, 1994). The need for improved management of natural resources has urged for the combination and reshaping of the earlier linear approaches, to the circular DPSIR approach that reflects the aim for informed decision making (European Environment Agency (EEA), 1999) and enables prioritization and target setting. The framework starts with Drivers (driving forces for development, improvement and societal needs), through Pressures (environmental issues that pose stress on the natural resources) to State (physical, chemical, biological, economic, social conditions etc.) and Impacts (on ecosystems, human health and functions), leading to formulating Responses (technical and economic measures, administrative and political responses). It has been widely adopted for the mapping and identification of responses in the water management sector and it is considered a powerful tool for integrated water resource managementwithin IWRM (Scoullos, 2015). Catchment systems constitute management units; all related decisions have interlinked environmental, social, and economic implications (Everard, 2004; Cap-Net et al., 2005; Le Moigne et al., 1994; Ayres et al., 1997). A schematization of the drivers, pressures and state that depict the IWRM goals identifies impacts on the ecosystem integrity and use value of water resources that act as drivers to policy and management responses (Fig. 1).

DPSIR is engaged widely as a WFD tool that achieves the goals of IWRM and identifies policy directions to enhance the sustainable utilization of water resources (Gari et al., 2018); it comprises a dynamic approach, in every step of which stakeholders are actively engaged and consulted (WFD, Article 14) and enables loops targeting to introduce improved measures and decisions (Fig. 2).

The current paper presents a revised DPSIR approach that combines the principles of the Ecosystem Services Approach, an approach that links the direct and indirect contributions of ecosystems to human well-being and emphasizes on the protection and value of ecosystem attributes (Millenium Ecosystem Assessment, 2005). It focuses on the importance of economic assessment of water resources (WFD, Article 5), on the recovery of costs as a means to eliminate impacts (WFD, Article 9) and incorporates scenario assessment to predict future environmental and socio-economic condition towards developing informed Responses (Programmes of Measures – WFD, Article 11) as part of the River basin management plans (RBMPs – WFD, Article 13), through active stakeholder involvement (WFD, Article 14). This new approach has been developed and mobilised within the Globaqua project funded from the European Union's 7th Programme for research, technological development and demonstration under grant agreement No. 603629. The presented approach is seen as a tool for achieving the goals of Integrated Water Resource Management while fully addressing the WFD requirements; it informs decision making and re-shapes responses that form the Programmes of Measures (PoMs) in two river basins of the Globaqua project, namely the Ebro river basin in Spain and the Evrotas river basin in Greece.

2. Methodology

The current paper presents a methodological framework developed and used within the Globaqua CP. The adopted framework of analysis follows a revisited systemic approach to address environmental management in two examined river basins within Globaqua. The Globaqua Case Studies had been selected at the proposal stage of the project, the partners from the relevant river basins acted as Case Study Leaders and collaborated closely with the project research partners in providing data and information on the relevant river basins and in facilitating stakeholder participation processes. The adopted approach combines 2 well-established and accepted approaches, the DPSIR and the Ecosystem Services Approach, thus, enables a more holistic understanding and evaluation of multiple stressors and interactions between the natural environment, the constructed environment and human societies. Analysis of scenarios has been used to validate the ecosystem services and the socioeconomic parameters that affect natural and social well-being in the future. The DPSIR approach is useful in assessing, managing and communicating the impact on the natural environment and depicting the associated problems, towards identifying responses aiming at policy change. It is seen as a tool to breakdown and clarify relationships between the natural and the societal ecosystem, and ultimately increase the benefit to society for future generations.

The Ecosystem Services Approach on the other hand, introduced by the European Commission (Bouwma et al., 2018), uses guiding principles and sustainability indicators which are complementary to DPSIR (Gregory et al., 2013; EEA, 1999). The Ecosystem services (ES), 'the benefits people obtain from ecosystems', are categorised into provisioning, regulating, supporting, and cultural (Millennium Ecosystem

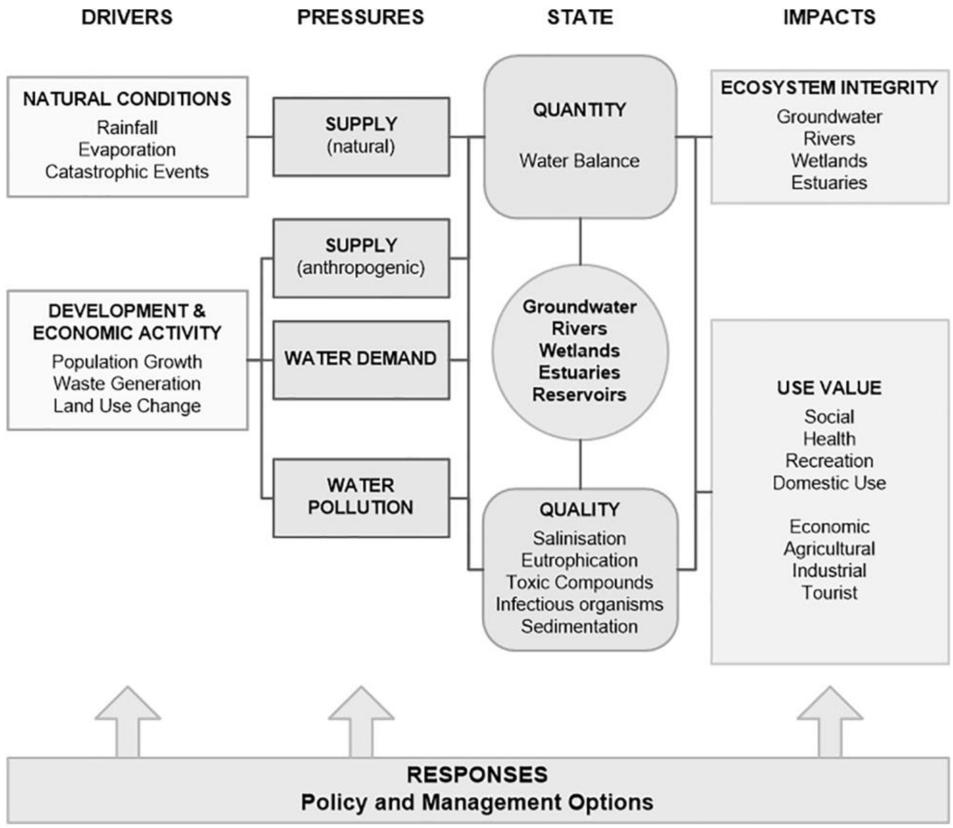


Fig. 1. Schematization of the DPSIR framework depicting IWRM Goals (Walmsley, 2002).

Assessment, 2005; Koundouri et al., 2013). They are engaged to map the impacts of ecosystem changes to human well-being, ultimately aiming at identifying mitigation options or actions for the sustainable use of ecosystems, able to adverse the effects of drivers and pressures and improve quality of life via meeting the sustainable development goals (Ehara et al., 2018). The assessment framework adopted in the presented work, goes a step further from previous relevant work on ES assessment, environmental recovery (Grizzetti et al., 2016; Vlachopoulou et al., 2014) and ecosystem services valuation towards full cost recovery (Pouso et al., 2018; Gerner et al., 2018; Reynaud, 2016; Koundouri and Papandreou, 2013), by combining well defined methodological

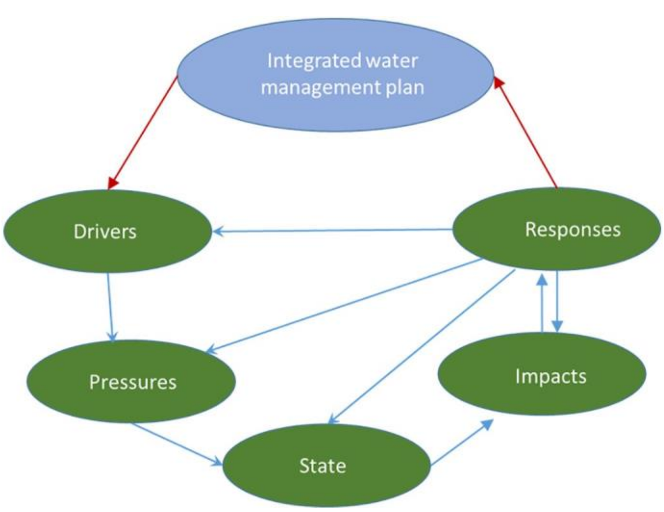


Fig. 2. The DPSIR Framework informs the preparation of the Integrated Plan. Adopted from Scoullos (2015) and Smeets and Weterings (1999).

approaches, thus DPSIR, ecosystem services, cost recovery assessment, and scenario analysis.

In a nutshell, the Globaqua approach (Fig. 4), followed in the 2 river basins of Ebro in Spain and of Evrotas in Greece, was based on the WFD and the WATECO (2003) requirements for economic valuation of water resources to achieve full recovery of costs. The approach engaged and presented in the current paper consists of three generic steps, engulfing the DPSIR components, presented below.

2.1. Step 1 - characterization of the River Basin area

The characterization was materialized by the project partners who gathered information from the local authorities, through literature and extensive stakeholder consultation. Active stakeholder involvement was seen as a central tool for the implementation of the project activities and of the described approach. The combined analysis started with the identification of the *Driving forces*, the actual needs for humans (safe shelter requirement, food security, access to clean water etc.), for the environment (protection of ecosystems, protection of biodiversity, clean air etc.), for the agricultural sector (increase production, turn to organic production etc.), for the industry (low cost production, low carbon production etc.), for a nation (reduction of unemployment rates, GDP increase etc.). The *Pressures* posed on the water resources and the water system of the river basins were then mapped in details. Environmental changes and the pressures that cause them, represent problems and stresses for the resources and for human activities that may also be further intensified by the existing driving forces (EEA, 2007). Detailed characterization of the *State* in the region (mapping of chemical, ecological and biological characteristics of the water) taking into account drivers and pressures, was realized in the examined river basins at the early stages of the Globaqua project, to enable the analysis of the associated impacts on the ecosystem and the society. A baseline scenario that describes the changes from the current state to the future (2050) was developed. The baseline scenario identified a wide gap between the current and the desired state of water resources and the need for improving the programme or package of measures to close this gap. Lack of improved measures is expected to deteriorate the conditions (Fig. 3).

2.2. Step 2 - recovery of costs and impact assessment and scenario development

Assessment of the current recovery of costs of water services to depict *Impacts* in the environment and society. The cost recovery assessment includes analysis of i) financial costs (operational, administrative, maintenance, investment costs of water services), ii) resource costs referring to costs occurring from the overexloitation of water resources beyond the natural replenishment rate, i.e. addressing water scarcity, need for reallocation of uses; the cost of the development of a backstop technology to cover water demand and mitigate scarcity could be used as an approximation for resource cost (Koundouri, 2004), and iii) environmental costs referring to the estimation of the environmental damage caused and the deterioration of water quality. The cost recovery assessment made use of cost information gathered from the Case Study areas and estimations of the actual levels of cost recovery using economic assessment methods. In more detail, the financial cost of water has been retrived from the financial statements of the utility companies and information provided by case study leaders. Information on taxes and subsidies has also been used for the acurate estimation of the financial costs. The assessment of the resource cost is done on the basis of the foregone economic benefits from competitive water uses. The environmental cost has been assessed using quantitative evidence provided in the economic literature, by utility services and estimations provided by case study leaders based on the published RBMPs. In the Ebro river basin, the quantitative data on the water cost and uses have been retrived through the Program of Measures (PoM) that was formulated as part of the WFD implementation, the utility services and the case study leaders. The cost recovery information provided for Ebro river basin are based on the RBMP assessment, made use of information on the different water uses (urban, agricultural/livestock, industry/energy) and the related water services addressing extraction, reservoir, storage, treatment and distribution of surface and ground water, as well as collection and treatment of wastewater for disposal to surface waters.

In the Evrotas river basin, the methodology follows the data and quantitative estimation of full cost recovery for water use in households, irrigation and industry, presented in Koundouri (2008). In this case, cost recovery assessment was done at four levels: cost recovery from sales, from fixed charges of consumers, sewage charges and cost recovery fees (80%) for system maintenance and expansion. Cost recovery for irrigation was based on the irrigation charges per hectare or cubic meters. Industrial water cost recovery has been estimated based on data available from other regions in Greece. The environmental cost recovery estimations have made use of the wide literature on the subject and the quantitative estimations. Resource cost has been estimated as the opportunity cost of best alternative uses of water that reflects the rising opportunity costs in the case of water scarcity.

2.3. Step 3 - identification of revised program of measures

Identification and suggestion of appropriate Programmes of Measures (*Responses*) for sustainable water management over space and time to meet the needs of future generations. The PoMs, taken into consideration were identified by the Case Study Leaders and by the local authorities, following compliance with the WFD requirement to define PoMs that will address the issues at hand in every river basin. The assessment within Globaqua included a combination of technical measures/investments (on green technology or improvement of existing technologies and practices), economic instruments, educational and "awareness" measures.

Despite the fact that the PoMs are targeting to alleviate Impacts that derive from the present State and affect future generations, they are not always tied directly to Pressures in the river basins. The EU member states are currently at the phase of implementing the 2nd cycle of RBMPS and the PoMS (EC, 2018), where some improvements are noticed in comparison to the first one, however, gaps can still be noted in linking the Programme of Measures (Responses) with the Pressures.

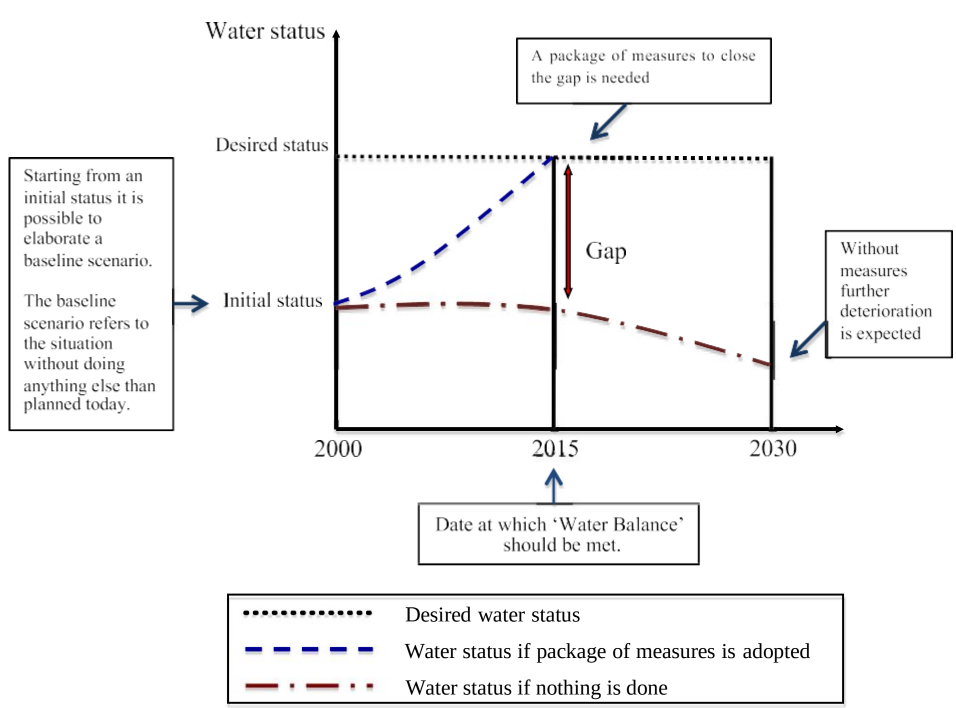


Fig. 3. Development of a baseline scenario for assessing future state (Koundouri and Davila, 2013).

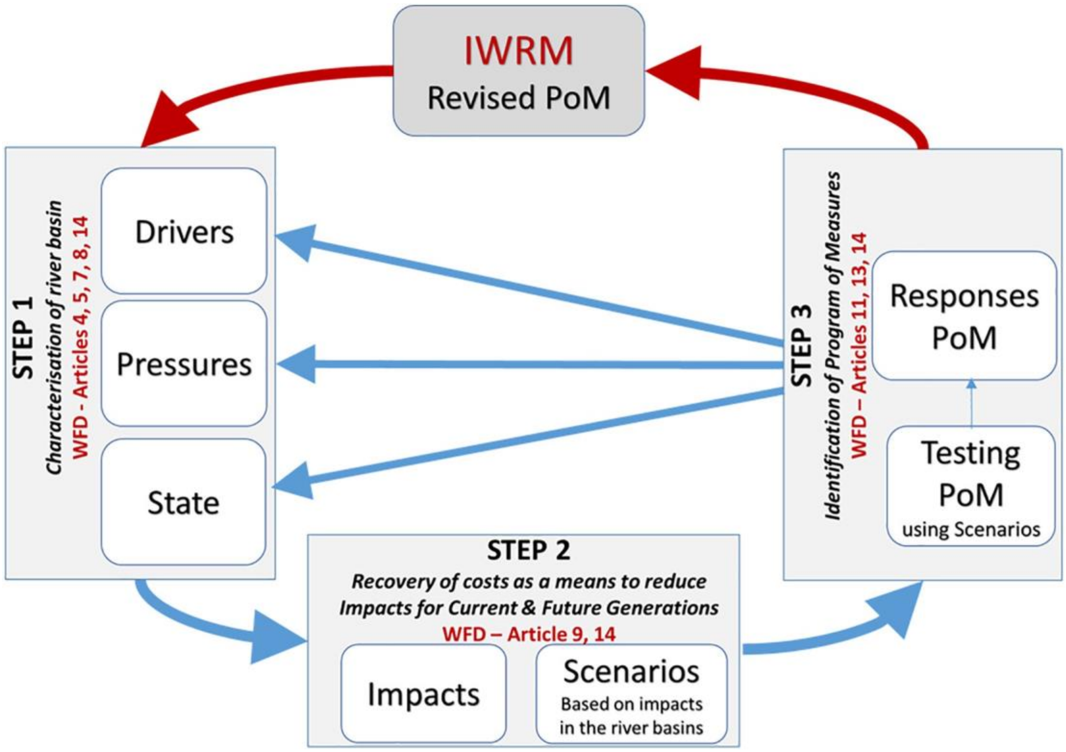


Fig. 4. Schematisation of the Globaqua approach.

Within Globaqua the identified Impacts and current environmental State, as well as the projected future conditions in the river basins, were assessed based on 2 socio-economic scenarios, following the prototype Scenarios developed by the Intergovernmental Panel on Climate Change (IPPC), the 'Shared Socio-Economic Pathways' (SSPs) and the 'Representative Concentration Pathways' (RCPs) portraying

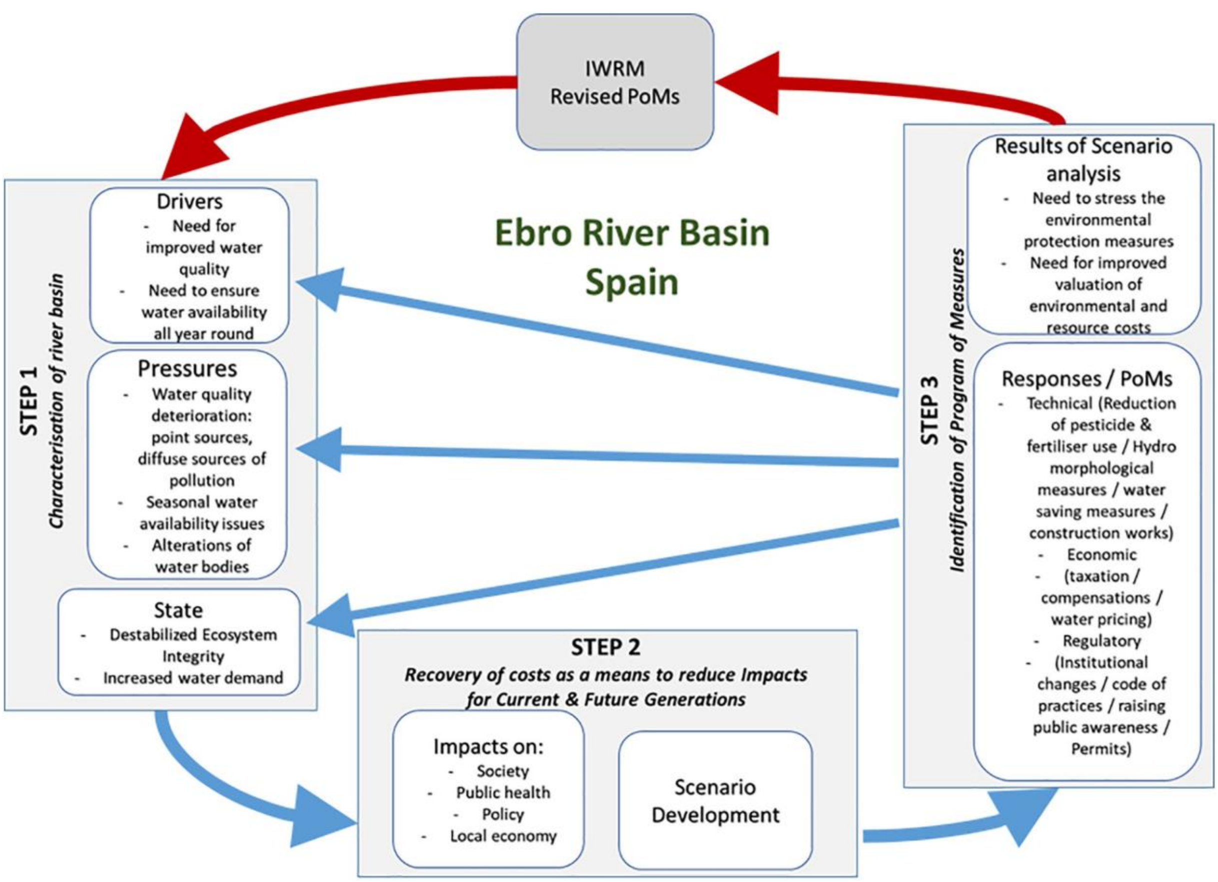


Fig. 5. DPSIR and Ecosystem Services Approach for improved IWRM at the Ebro river basin, Spain.

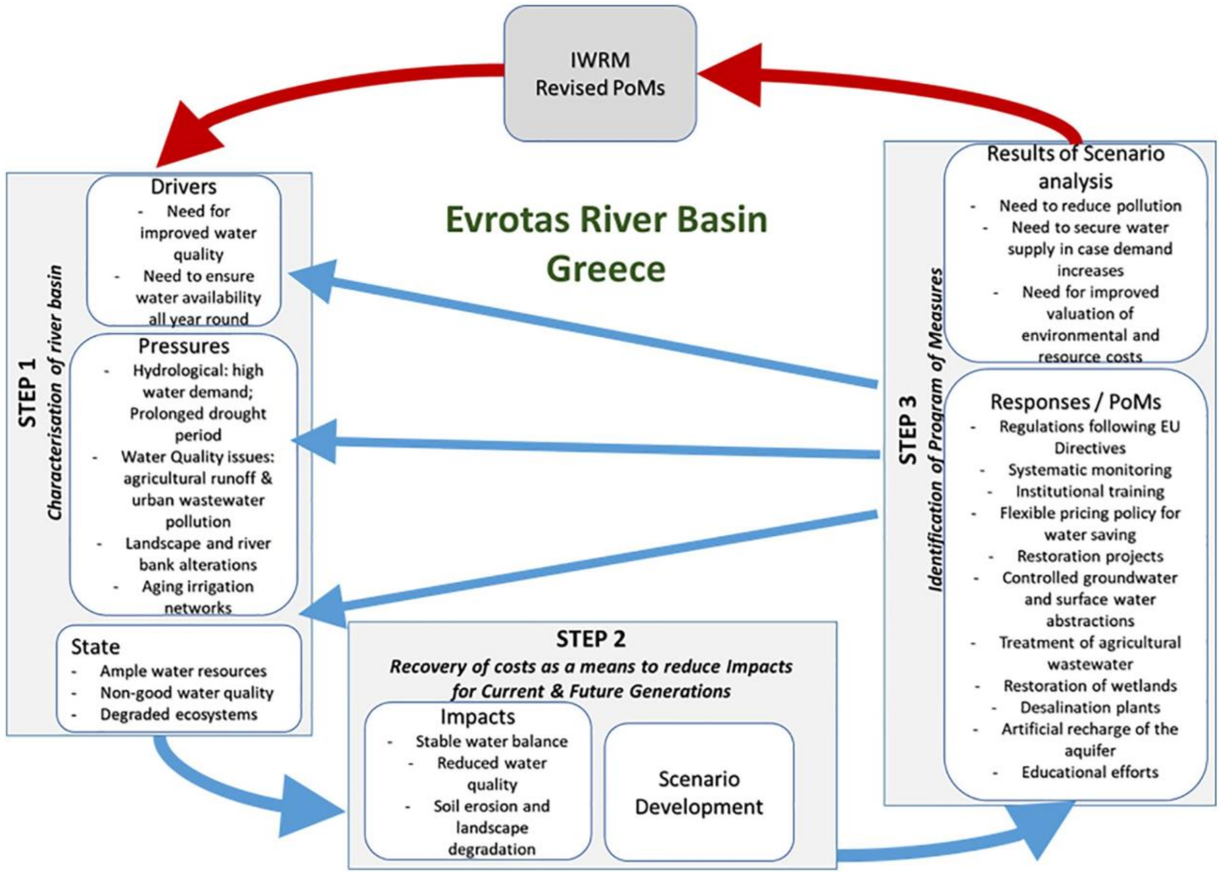


Fig. 6. DPSIR and Ecosystem Services Approach for improved IWRM at the Evrotas river basin, Greece.

different policy futures (IPCC, 2014). This assessment is ultimately aiming at informing the existing PoMs and at supporting the development of next cycles of PoMs. The downscaling of the scenarios to enable the impact and state valuation at river basin level, was materialized by experts and local stakeholders, underlining once more the central role of stakeholder involvement in planning and decision making within the IWRM approach. The stakeholders, whom included end- water users, within the whole spectrum of water related and economic activities, were asked to identify the weight of different parameters, ecosystem and social attributes at river basin level.

Four scenarios were initially developed within Globaqua, namely an environmental friendly one, the 'Sustainable' scenario, an economy friendly, the 'Myopic' scenario, a business-as-usual or reference scenario 'Middle of the road' and one placed in between the first two, the 'Inequality' scenario. For matters of comparison with regard to the available data in the examined river basins of Ebro in Spain and Evrotas in Greece, two scenarios were downscaled. The 'Sustainable scenario' assumes fast economic growth for the first 25 years, and drop in the following years due to emphasis on promoting equity, social capital, natural capital, regional production, investment on environmental technologies and renewable energy sources. Focus is placed on promoting sustainability, reduction of CO_2, environmental protection, financial incentives and regulations for environmental protection, and integrated long-term water resource management. The 'Myopic scenario' portrays faster than the average economic growth for the first 25 years that allows investment and growth in human capital, promotes technological advances that enhance adaptation to climate change but no action on mitigation. The fast economic growth increases energy demand and dependance on fossil fuels, thus, increased CO_2 emissions and projected global warming. Environmental regulation does not take into account long-run or global effects, and ecosystem services (i.e. Regulating, Supporting and Cultural) are only of local short-run economic relevance. Policies are driven by technological advancements and water management is fragmented and does not integrate the effects of water services on water resources.

Downscaling of the scenarios was done collaboratively between the Globaqua experts (scientists engaged within the Globaqua project with a deep knowledge of the different water relevant aspects of environmental, social, economic and policy nature) and local stakeholders (local residents, managers, farmers, industrialists etc.). The list of scenario descriptors (and corresponding factors; '+' or '-') was reviewed for their relevance for the respective case studies, and was shortlisted during Globaqua project work meetings and local stakeholder engagement workshops. Feedback was provided by experts and skakeholders on what factor (from −3 to +3) each descriptor ought to be ascribed under the given scenarios in the context of the respective case study. The descriptors to be weighted included water related categories of attributes such as society and economy, energy, environmental impacts, water management, agriculture, industry, residential, tourism and recreation, policies, institutions.

A downscaled factor weighting for each descriptor was subsequently derived by taking an average of the factor under Global Scenarios, and the equivalent factor provided by stakeholders (where factors were either identical or the magnitude of change indicated was different but in the same direction.). In the case of discrepancies, where factors under Global Scenarios, and those provided by stakeholders were divergent, then a review of the relevant literature was carried out to identify the causes of these differences, and indicate what final downscaled factor ought to be assigned (GLOBAQUA Sub-Deliverable 2.5: Scenario analyses of socio-economic Programmes of Measures for each case study completed).

3. Results

The river basins examined, Ebro in Spain and Evrotas in Greece, are facing similar yet diverse water stress issues. Both river basins share similar *Drivers*, which are linked to the need for improved water quality that is able to ensure safe water use to cover the needs and to the need to secure water availability throughout the year. The river basins of Ebro and Evrotas, located in the Mediterranean region, face high seasonal fluctuaction in the water availability depending on the climatic conditions and the precipitation levels and receive pollution from the intense agricultural activity.

3.1. The Ebro case

3.1.1. Step 1 - characterization of the river basin

In the case of the Ebro river basin, the main factors or *Pressures* are related to a) water quality deterioration due to point (urban discharges, industrial biodegradable discharges, industrial hazardous substances, toxic pollutants, landfill leakages) and diffuse sources of pollution (from transportation, agricultural runoff, mining activity); b) water resources depletion due to water abstractions from the river or the associated surface water bodies and geomorphological alterrations to cover the demand (weirs and dams, diversion works, chanelling etc.);
c) anthropogenic pressures such as invasive species, changes in land uses, recreational activities (CHE, 2015).

The *State* in the Ebro river basin is characterized by the deterioration of water quality, increased levels of hardness, nutrients and chemical pollution are identified in surface water bodies as the results of the constantly increasing water demand due to population growth and the expansion of agricultural and industrial activities. Demand is expected to further increase in the river basin. The current State is affecting the Ecosystem Integrity as it affects aquatic life, it places higher stress on the water resources towards covering the demand and it affects the Water Use Value for current and future generations. The projected stress to the water resources affects the ecological status of water bodies, comprising an issue of critical importance in the implementation of the WFD and is addressed through the PoMs, with technical measures, such as pesticide and fertilizer control and permits.

3.1.2. Step 2 − recovery of costs and impact assessment and scenario development

The high agricultural and touristic activities have direct *Impacts* on the society, public health and local economy, which should be quantified through means of economic valuation of the water resources and uses. This need was identified and depicted in the Programme of Measures (*Responses*), which, however, require refinement to achieve full cost-recovery. The options identified in the Ebro PoM are classified to technical, economic, regulatory and institutional and presented in Fig. 5. The quantitative data analysis on the water cost and uses that have been retrived through the PoM, identified total cost of measures for the period 2009–2015 at an estimated 8728.5 million €, divided into measures addressing water resource hydromorphologic and biological quality (6% of the total budget), measures adopted for the water resources management and for addressing the water demand (49% of the budget), measures for the improvement of water quality (44.8% of the total budget, 16% of which is spent for the improvement of irrigation systems) (CHE, 2015). The estimations for the Ebro River indicate that full cost recovery is not achieved in any use. Cost recovery rates range from a minimum low of 2% in the monitoring and control of floods that includes quality monitoring networks and the public hydraulic domain, to a maximum level of 86% for private water abstractions (CHE, 2015). Indicative of the Ebro case is that even the financial full cost recovery is not achieved in many uses, let alone the total cost recovery.

3.1.3. Step 3 − identification of revised program of measures

Following Riahi et al. (2017), the sustainable scenario, developed to analyse impacts, describes a world where human welfare is one of the drivers for development. Based on that, Ebro is expected to face a drop of unemployment and of the urbanization rate (improvements for the society), high improvements towards organic agricultural production and reduced water consumption in the agricultural sector. Under the Myopic scenario there is prioritization of the economic welfare, which however, places additional stress on the natural resources, increases greenhouse gas emissions and pollution. Water stress issues in the region are driving revised responses on the protection of natural resources and the environment, including the improved valuation of the water resources through estimating the environmental and the resource costs. The intensive agricultural activity to support economic growth is expected to increase pollution, but on the other hand, to ensure food security for the increasing population.

Based on the scenarios analysis and on the fact that real-life conditions fall in between the two scenarios tested, the next round of PoMs, should further stress the need for environmental protection and reduction of pollution, according to stakeholders and experts participating in the assessment. The analysis further underlines the need for accurate valuation of the water ecosystem services and resources as a means to protect water bodies to ensure their vitability for future generations. Social integrity should be prioritized.

3.2. The Evrotas case

3.2.1. Step 1 - characterization of the river basin

The *Pressures* in the Evrotas river basin in Greece can be summarized as a) Hydrological due to high water demand to cover the intensive agriculture and the animal breeding, especially in periods of prolonged drought (summer months); b) Water Quality issues due to agricultural runoff (olive mills and orange juice mills produce the biggest share of agricultural pollution resulting on heavy loads of nutrient pollution, and chemical pollution from pesticide use), urban wastewater with heavy organic pollutant load; c) landscape and river bank alterations that result in soil erosion and flooding as well as in shrinking of the riparian zone; d) aged irrigation networks. The added Pressures to the river basin are attributed to a series of factors: (i) projected climate change (there is an expected 10% decrease in precipitation, a 4% increase in evapotranspiration and a 19% decrease in river water flow in the years 2030–2050, compared to the period between 2010 and 2030), (ii) over-exploitation of water resources for agricultural purposes that pose threats related to diffuse sources of pollution and disrturbance of the water balance between supply and demand, (iii) landscape and ecosystem changes due to deforestation of ample riparian forests, and from the desiccation of the main river course by 80% during 2007, (iv) economic change resulting from the severe financial crisis, as well as the rapid transformation of a traditionally primary sector economy into a tertiary sector economy. Other factors that may pose additional stress are related to demographic changes, socio-economic and water-related trends.

Overall, the *State* in the Evrotas river basin, currently appears to be characterized by ample resources and relatively stable water needs across the various economic sectors, despite the seasonal drought experienced, ensuring a satisfactory water balance. On the other hand, the water quality issues emerging from diverse sources, are significant. Soil erosion and landscape degradation are also characterizing and affecting the river basin (RBD03, 2013).

3.2.2. *Step 2 − recovery of costs and impact assessment and scenario development*

The existing *Impacts* deriving from Pressures are related to the hydrological pressures and the reduced water availability for crops while they are putting additional social and economic strains on the local population. The impact of the current financial crisis on water authorities necessitates even more the accurate valuation of environmental and resource costs towards full cost recovery. In addition, public and ecosystem health issues may arise as a result of the increasing diffuse pollution entering the river while the ecological stability is affected as a result of the landscape and ecosystem changes.

Based on previous estimations (Koundouri, 2008) the water supply cost recovery, in the Evrotas river basin is €68,631,114.254. With regards to industry, it is estimated that the cost recovery amounts to approximately 3 bn Euros, resulting in cost recovery for industry to amount to 0.216€/m^3. Cost recovery for irrigation amounts to €5.740.844. Subsidies to agricultural production are estimated at the level of 29 million Euros. Moreover, the total financial costs for the river basin amount to €186.157.144, the environmental cost amounts to zero and the resource cost amount to €4.688.200. Making use of this information the unit cost recovery is estimated at 0.633 €/m^3 while the total cost recovery amounts to 34.2%. At dissagregate level the total cost recovery for water supply is estimated at 37.89% while for irrigation is estimated at 15.66%.

3.2.3. *Step 3 − identification of revised program of measures*

The Programme of Measures (*Responses*) currently implemented in the river basin corresponds to legislative requirements and EU Directives. The Responses focus extensively on systematic monitoring, institutional training and reform, legislative reforms, adapting flexible pricing policy to ensure environmental sustainability and promote water saving, restoration projects, controlled groundwater and surface water abstractions, treatment of agricultural wastewater and control of relevant pollution loads, emission controls, reconstruction and restoration of wetlands areas, desalination plants to increase water supply, artificial recharge of the aquifer, sediment control, educational, research, development and demonstration activities (RBD03, 2013) (Fig. 6).

The assessment of the Sustainable scenario for the case of the Evrotas river basin, projected an increase in urbanization and in the irrigated land according to the participating scientists and stakeholders; the finding is supported by current literature (Gossop, 2011; Ewing and Cervero, 2001; Hasegawa et al., 2015). Despite the population increase, the scenario analysis foresees a decrease in meat production and in intensive agriculture, crops will be replaced by organic ones as a response to an environmental friendly attitude and to citizens' efforts to reduce their ecological footprint. Accordingly, the energy and water consumption will decrease. Although there are discrepancies between the expert and the stakeholder attitudes with regard to the assessment of the Myopic scenario, it is most likely that agriculture will turn towards less water intensive crops, however, energy use and pollution will remain at present levels due to the projected population increase. Protected areas are expected to increase, following relevant EU Directivs, and quality standards regulated by relevant policy instruments will not demonstrate a significant change from the current state. Based on the scenarios assessments, and following stakeholder and expert suggestions, the revised Responses (PoMs) should focus on the protection of ecosystems and water resources, on a revised water pricing scheme to fully incorporate environmental and resource cost (supported by the extensive monitoring scheme already in place) and on securing water supply that covers the demand, provided the projected changes in the precipitation level.

4. Discussion

Holistic approaches, such as the development of river basin management plans (WFD, Article 13) are in line with the IWRM concept and can only be achieved through adopting holistic interdisciplinary processes and frameworks, and through increasing the integration of water policy targets (European Commission, 2012).

The framework followed in the Globaqua project and presented in the current paper moves a step forward from conventional water managment by combining 2 well-established and acknowledged, for their efficiency, approaches, and by providing an elaborate assessment of future scenarios, developed according to the IPPC's SSPs and the RCPs (Ebi et al., 2013; O'Neill et al., 2013, Rozenberg et al., 2013). It is grounded on systemic thinking, provides a new insight in the decision making process and a restart of the wheel for developing the next rounds of PoMs, as a fundamental WFD requirement (Article 11), while it informs Responses in other sectors of human economic activity (European Environment Agency, 2013). Systemic thinking and acting is also evident in the adoption of the individual approaches within Globaqua, the DPSIR and Ecosystems Approach, both aiming at wide integration of ecosystem services in the implementation process (Spray and Blackstock, 2013). The presented framework can be proven a useful tool in the implementation of the WFD and in informing participatory decision making. Adopting participatory processes that enables actors and stakeholders to co-think the issues at hand, co-create new knowledge (WATECO, 2003), and adapt into new conditions, is a central instrument within the WFD (Article 14) for the identification of major issues related to water stress. It additionally comprises an integral part of the implementation of the DPSIR scheme and the Ecosystem Services Approach. Capacity building is assisting to bridge the gap between research and decision making (Ness et al., 2010a, b).

The analysis in the two selected locations, identified similarities in Step 1 and Step 2, fact that underlines the common European 'ecosystem' and strengthens the need for integration and innovation. Driving forces that define the way forward in both river basins include the need for improved water quality and for supply that covers demand even during the dry summer Meditteranean period. The increasing demand to cover rising population needs and the tourist influx drives efforts to ensure water quantity to cover the need. The existing environmental problems, such as groundwater overexploitation, water shortages and water quality issues from domestic, agricultural and industrial sources, are affected by, and at the same time, influence different components, forming a continuous loop between cause and effect. Combating climate change is identified as a new driving force that adds pressure towards adopting holistic water management approaches for present and the future. The characterization process (Step 1) in both river basins, identified issues related to water quantity, water quality issues, primarily linked with the intensive agriculture and food processing activities (nutrient pollution from fertilisers leading to eutrophication and chemical pollution from pesticides), and with the disposal of domestic sewage. Despite the fact that in the Evrotas river basin the water resources appear ample, water availability to cover the increasing demand is an issue of concern. Step 2 of the analysis indicated the need for accurate valuation of environmental and resource costs to achieve full recovery of costs as a means to reduce the negative impacts of bad management practices of the past, in accordance with Articles 5 and 9 of the WFD. Full recovery of costs, should therefore, be a driver, a means and a response to the present conditions and would provide improved services sufficient enough to reduce impacts to the society, public health, local economy, ecosystems and strengthen policy making with sustainability in mind (Rusca and Schwartz, 2018). Scenario analysis indicated the requirement for improved Programmes of Measures (Step 3) in support of sustainability and benefits for the future generations.

5. Concluding remarks

The innovation element of the described process is on the efforts to combine well-established and widely applied frameworks and concepts that are often implemented individually, into forming a holistic management framework for the identification of issues at hand and for enabling informed responses. The stakeholder driven scenario analysis, in particular, allows for revisiting, reassessing and redefining of the PoMs; it can be utilized as a valuable tool in forming the RBMPs for the future cycles of the WFD implementation. Stakeholder engagement at all stages of the methodology development and implementation, covers a fundamental WFD requirement in accordance with Article 14 on public consultation and information sharing that provides a safety net for the successful implementation of water management plans.

In a glance, the Globaqua approach, as an expression of integrated water resource management, was successful in forming suggestions for responses that are constantly informed and operationalised into an implementable river basin management plan.

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