Background

In 2000 the EU introduced the Water Framework Directive (WFD), with the intention of taking an integrated approach to the management of water resources, setting out a longer-term framework within which Member States would be required to act. All Member States had been required to produce River Basin Management Plans (RBMPs) by 2009, and these provide the basis for protecting, improving and maintaining the environmental condition of surface and ground waters by certain milestone dates: 2015, 2021 and 2027. Member States should aim to ensure that, by the final date of 2027, all rivers and water bodies have reached, or have maintained, "good" or "high" status, and their progress towards that objective is to be reported at the milestone dates.

EU freshwater policy contains other elements, but the WFD is of over-arching importance. The Directive was adopted to succeed and replace traditional management practices predicated upon the command and control paradigm, which looked at pressures in isolation and reduced environmental systems to their constituent elements when setting specific objectives (European Commission, 2012a). It aimed to facilitate a shift from these fragmented policies to a holistic approach integrating all parts of the wider environmental system (Howarth, 2006). Acknowledging that catchments differ from each other in terms of both socio-political and natural conditions (Hooper, 2003), it signified a shift towards river basin management and systems thinking.

However, fifteen years after the WFD was introduced, achieving its objectives remains a challenge. Despite some good progress, nearly half of EU surface waters (47%) did not reach the good ecological status in 2015– a central objective of EU water legislation (European Commission, 2012a). In essence, the WFD has been criticised due to the limited progress in delivering water quality improvements across Europe.

First set of policy briefs

This first set of policy briefs (Figure 12.2.1) forms part of policy analysis and research, undertaken under Work-Package 12 (Policy) of the GLOBAQUA research project that aims to establish how current EU water management practices and policies could be improved. The two main briefs included here review the current EU context, and investigate implementation problems in order to identify areas and policy needs where GLOBAQUA research could deliver benefits.

The first brief reviews the transition of EU water policy that led to the adaptation of the WFD and the expected benefits of its systems approach to water management. It looks at the key concepts of the Directive, and reviews its initial aspirations and systems approach to identify policy needs that the WFD aimed to introduce. The second brief reviews the WFD implementation efforts, and investigates its problems and delays in order to understand why the great expectations that came with the Directive have not yet been fully realised. Focusing on the interpretation of its key principles in the implementation process, and issues identified by the European Commission from the Fitness Check and accompanying WFD

implementation reports, it looks into the extent to which implementation practices might not be aligned to the Directive's initial aspirations and systems approach.

In order to secure a meaningful connection to the catchment scale, the deviation of practices at the GLOBAQUA river basins from the WFD's aspirations is assessed in order to identify areas and policy needs where GLOBAQUA research could deliver benefits. These are included as two additional briefs (appendices) focusing on policy needs related to: water status assessment (D12.2b1); and Programme of Measures (PoMs) for status improvement (D12.2b2).

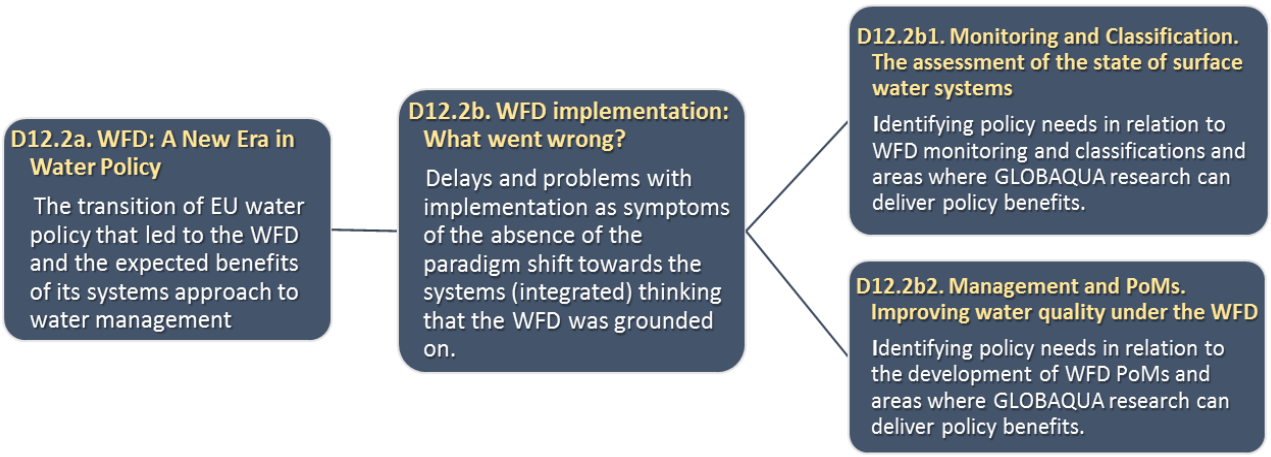

Figure 12.2.1. Elements of the First GLOBAQUA Policy Oriented Brief (D12.2)

GLOBAQUA

GLOBAQUA is a project funded by the Seventh EU Framework Programme under the full title *Managing the effects of multiple stressors on aquatic ecosystems under water scarcity* (2014 – 2019). Its main aim is to study the effects of water scarcity in a multiple stressor framework to achieve a better understanding of how current management practices and policies could be improved by identifying their main drawbacks and alternatives. In this context, a *stressor* captures how the system is affected by pressures causing changes to its state.

GLOBAQUA focuses on six contrasting river basins and follows a cross-scale approach. The basic research element is the kilometre-scale river reach, including the river channel, the alluvial plain and the associated groundwater. Two basins from the Mediterranean European region (Ebro River Basin District — Spain and Evrotas — Greece), as well as one North African basin (Souss Massa — Morocco), where water scarcity is the main current problem, have been selected to obtain a Mediterranean perspective. In order to achieve a wider European dimension, one continental (Sava, transboundary — Slovenia, Croatia, Bosnia and Herzegovina and Serbia), one Alpine (Adige — Italy) and one UK river basin (Anglian River Basin District), where scarcity is a growing issue because of multiple uses and unequal yearly distribution of precipitation, have been included among the case studies.

Overview

Water legislation is one of the European Union's (EU) oldest, most developed and progressive areas of environmental policy (Josefsson, 2012). Early environmental legislation emerged as a response to high profile pollution events, and has evolved to address impacts to human health, and today 'environmental health' as a whole (Anderson, 1994). The Water Framework Directive (WFD) provides a common framework to protect and restore European waters and ensure their sustainable use (Vlachopoulou *et al.*, 2014). The Directive prompted a shift of EU water policy towards an ecosystem-based approach (Kallis and Butler, 2001), while introducing many innovations in the process (Figure 12.2a.1). According to the WFD, member states are required to prevent deterioration of the quality of waters as well as achieve good chemical, ecological, and quantitative status (Chon *et al.*, 2010). Critical to this is the understanding of ecosystem responses to multiple stressors. For that reason, the EU-FP7 project GLOBAQUA aims to identify the prevalence, interaction and linkages between stressors, and to assess their effects on the chemical and ecological status of freshwater ecosystems, in order to improve water management practice and policies.

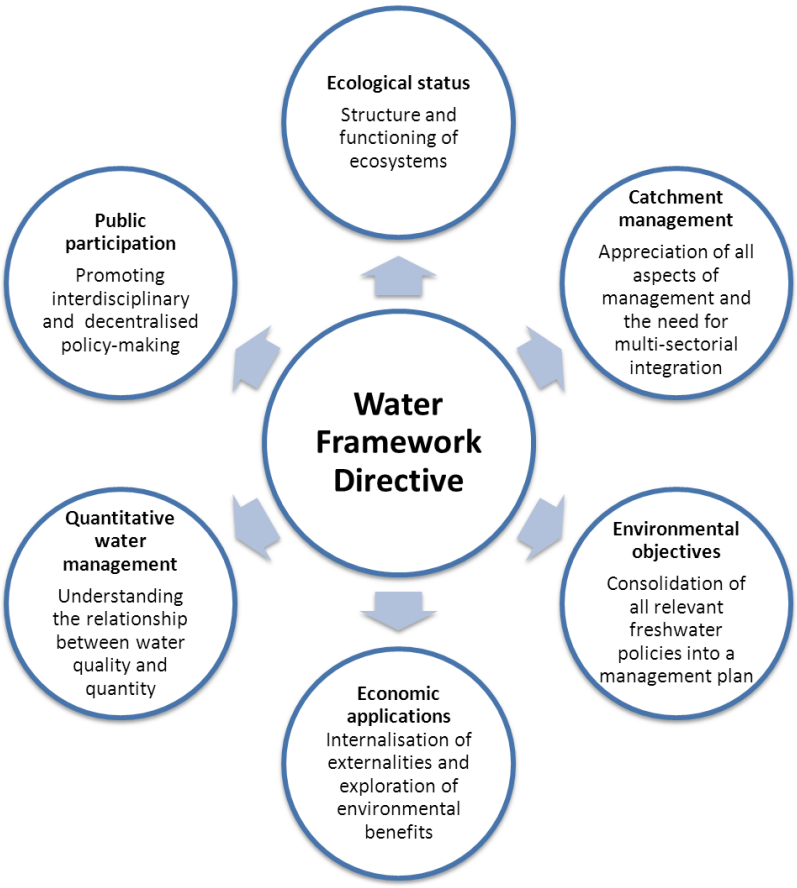

Figure 12.2a.1. The innovations introduced by the WFD.

A Transition towards Integrated Water Management: the Introduction of the Water Framework Directive

Following a series of lengthy negotiations among the parties involved, the WFD was adopted in 2000 to succeed and replace traditional management practices predicated upon the command and control paradigm. Looking at pressures in isolation when setting specific water objectives (European Commission, 2012a) and reducing environmental systems to their constituent elements in an attempt to increase their predictability and stability (Holling and Meffe, 1996), under this paradigm, specific parameters were monitored at the point of discharge from point sources of pollution. These had to be managed in order to not exceed maximum quantities of pollutants allowed to be discharged into the aquatic environment (Figure 12.2a.2). Based on the assumption that managing individually the non-compliant elements could lead to an overall improvement in ecosystem health (Glasbergen and Driessen, 2002), this policy approach was discipline-specific, focusing on compliance of isolated components of an environmental system and controlling the emissions of individual pollutants beyond specified limits (Petersen *et al.*, 2009).

The introduction of the WFD aimed to facilitate a shift from these fragmented policies to a holistic approach integrating all parts of the wider environmental system (Howarth, 2006). With the emergence of integrated watershed management in several countries throughout the world, the growing recognition of the multiple—often competing—uses of water, and the increased awareness of the interrelationships of water systems with other physical and socioeconomic systems (Margerum, 1995) shaped the WFD's systemic intent.

The WFD requires that River Basin Management Plans (RBMPs) must be developed (Figure 12.2a.3), and reviewed on a six-yearly basis, specifying the actions required within each river basin district to achieve set environmental quality objectives. As the main objective of the WFD is for all waters to reach good or high ecological status, monitoring is essential for assessing their current state, in order to establish how far it is from good or high ecological status, therefore indicating the need for management in the process. For that reason, **Programmes of Measures (PoMs)** are required to manage anthropogenic pressures causing such deviation from its undisturbed/reference conditions (European Commission, 2000).

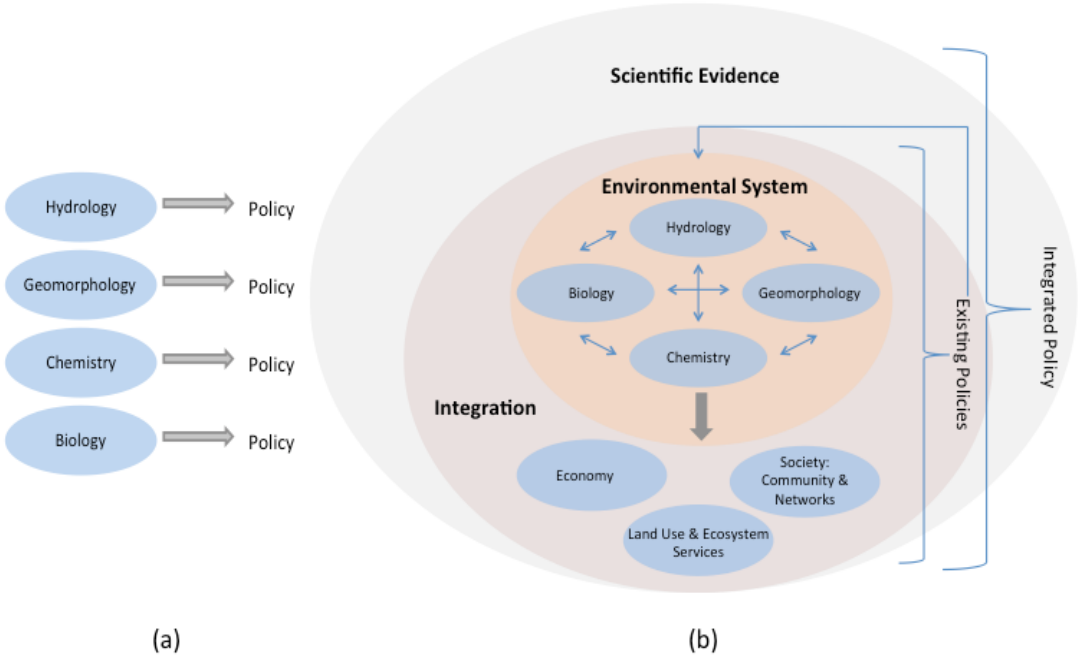

Figure 12.2a.2. Traditional discipline specific (a) versus integrated according to the WFD (b) policy making.

A New Approach to Water Management

The WFD required competent authorities and all relevant parties to define their system of interest (catchment) and have a more tailored understanding of its conditions. This was a pre-requisite for river basin management, away from the standardised instructions of traditional water policies, often not relating to the catchments (Sabatier *et al.*, 2005). **Ecological status or potential**, according to the WFD, is an "expression of the quality of the structure and functioning of surface water ecosystems" (European Commission, 2000) and is therefore expressing the system's health (Figure 12.2a.4). As the main objective of the WFD is for all waters to reach good or high ecological status, monitoring is essential for assessing their current state, in order to establish how far it is from good or high ecological status, therefore indicating the need for management in the process.

Because of ecological variability and in recognition that different water types (e.g. different types of estuaries or lagoons) may be characterised by distinct definitions of quality, with respect to environmental metrics such as phytoplankton biodiversity (e.g. Ferreira *et al.*, 2005), benthic species composition (e.g. Borja *et al.*, 2000, Borja *et al.*, 2004 and Salas *et al.*, 2004) and supporting quality elements (Bald *et al.*, 2005), good ecological status cannot be defined across Europe using absolute standards. The WFD provides the definition of **good ecological status** as the **state of the system in the absence of any anthropogenic pressures,** or a **slight biological deviation from what would be expected under undisturbed/reference conditions** ("no, or only very minor, anthropogenic alterations") (European Commission, 2016). The Directive utilises the reference conditions concept to provide a description of biological quality elements at high status (European Communities, 2003b) to assess deviations of biological communities from the desired "good" conditions. The requirement of a definition of type-specific reference conditions (Vincent *et al.*, 2003) is another innovation of the WFD.

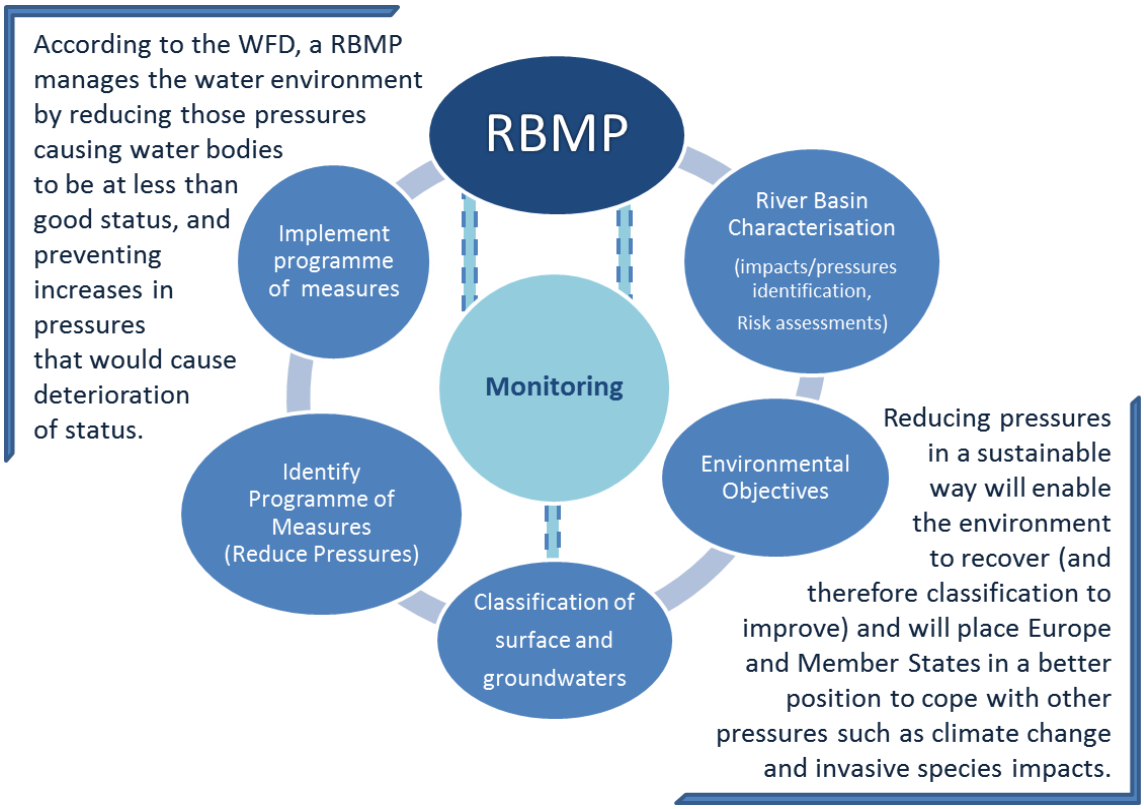

Figure 12.2a.3. The river basin management plans' development process.

In the WFD, ecological status is therefore used as an **environmental indicator** of system performance–the distance between the current state and the desired one (Johnson *et al.*, 2013), in this case, **the deviation of the current state of a water body from its state under undisturbed/reference conditions**.

The process of assessing ecological status is based on several elements that aim to indicate the deviation of the system state from its state under undisturbed/reference conditions, and not to provide an absolute value of ecosystem quality (European Communities, 2003c). Annex V of the WFD outlines three groups of 'quality elements': biological, and two supporting ones, hydromorphological and physico-chemical, to be used in the classification of ecological status (European Commission, 2000). Deciding which particular ecological status or potential class is assigned to a water body depends on whether the quality element worst affected by anthropogenic alterations matches its normative definition for that class (European Commission, 2000). In short, deriving classification follows a one out-all out scheme at the level of the quality elements, meaning that a water body cannot reach good ecological status if any element has a value that deviates moderately or significantly from those normally associated with undisturbed conditions (European Communities, 2005). According to the WFD, as the elements most sensitive to pressures are selected for the classification assessment, and with good ecological status defined as the state of the system in the absence of any anthropogenic pressures, it only takes one element to fail, indicating the presence of pressure(s), to disprove good ecological status. The WFD treats the catchment as a well-connected system, and therefore the **elements** (selected according to the WFD), serve as alarms for the presence of pressures (Figure 12.2a.4).

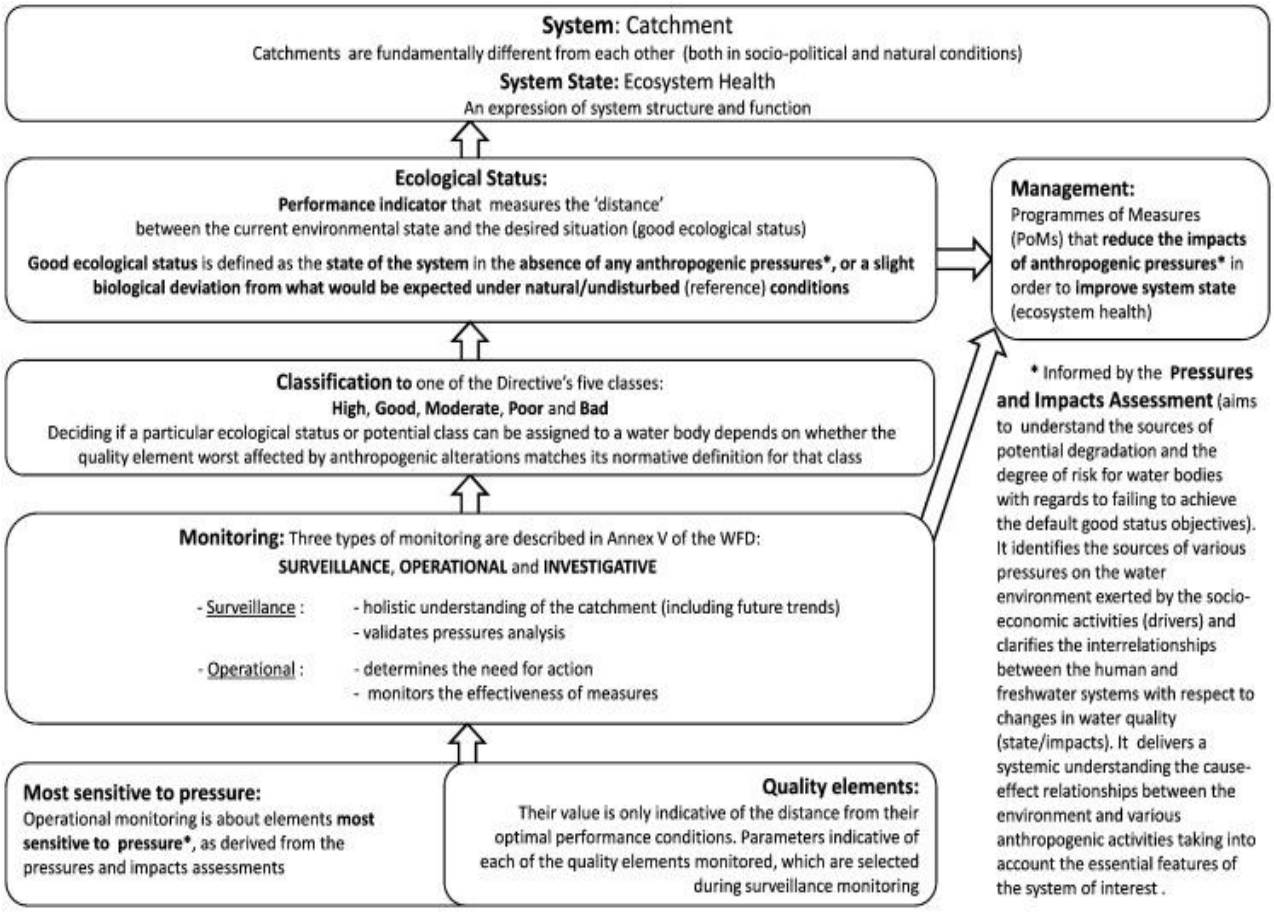

Figure 12.2a.4. The Water Framework Directive in the language of systems thinking (Voulvoulis et al., 2017).

The pressure–impacts analysis and the surveillance monitoring are critical steps in the planning process (EC, 2003a; 2003c), which aim to acquire in depth understanding of the catchment. This is important in order for water bodies at risk, to be monitored (operational monitoring) for selected quality elements, which characterise the most important pressures that are present in a water body (EC, 2003c). Identifying the relevant pressures and assessing their impacts are also integral to the development of Programme of Measures (PoMs), the actions necessary to manage anthropogenic pressures in order to improve water status and achieve the environmental objectives of the Directive (EC, 2015a; EC, 2003a). The pressure and impact assessment that underpins the development of PoMs not only considers the influence of multiple sectors but also facilitates the integration of freshwater policy objectives that were once treated in isolation thereby driving the need to treat water management from an integrated systems perspective (Kaika and Page, 2003).

The need for GLOBAQUA

This policy-oriented brief demonstrates the need for treating catchments as systems, understanding the multiple interactions within them to improve water quality according to the WFD. However, the interaction between stressors can result in complex effects on organisms (Coors and De Meester, 2008), and ultimately on ecosystems (Ormerod *et al.*, 2010), with little known beyond the described effects of single stressors on the chemical and ecological status of water bodies and on their ecosystem functionality. This lack of knowledge limits our capacity to understand ecosystem responses to multiple stressors (Friberg, 2010). For that reason, the EU-FP7 project GLOBAQUA aims at identifying the prevalence, interaction and linkages between stressors, and to assess their effects on the chemical and ecological status of freshwater ecosystems in order to improve water management practice and policies. By bringing together the collaboration of a large group of researchers, stakeholders and policy makers, it aims to identify opportunities to assist policy making, and produce recommendations for improvement, in the current EU context.

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Overview

The introduction of the Water Framework Directive (WFD) signalled a new era of water policy, providing a common framework for water management and protection within the EU. Overall, the WFD was seen as the first European Directive that focused on environmental sustainability (Johnson, 2012; Carter, 2007), and partly because of this, its introduction and innovations created a revolutionary prestige for the Directive, which was considered as a potential template and pilot for future environmental regulations (Josefsson, 2012).

However, fifteen years after the Directive was introduced, and with many problems and delays in its implementation, the WFD has not delivered its main objectives of non-deterioration of water status and the achievement of good status for all EU waters (Figure 12.2b.1). Putting aside the daunting technical and organisational challenges of its adaptation, this brief summarises some of the main findings of policy analysis and research undertaken for the EU Project GLOBAQUA (Voulvoulis *et al.*, 2017). It sheds light on why the great expectations that came with the WFD have not yet been fully realised; investigates the deviation of practices at the catchment level from the WFD's aspirations; and identifies areas and policy needs where GLOBAQUA research could deliver benefits.

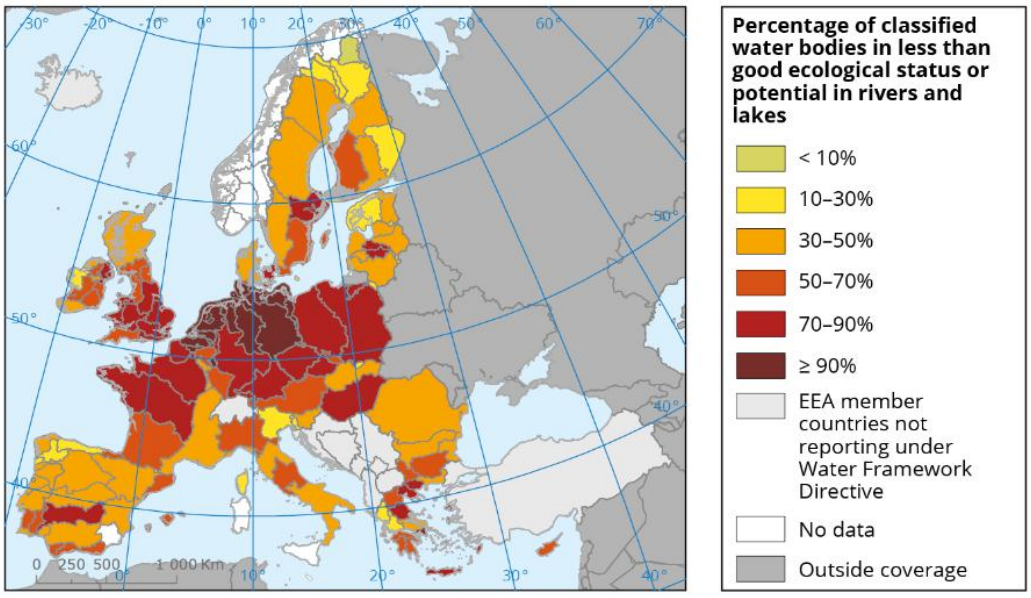

Figure 12.2b.1. Percentage of good ecological status or potential of classified rivers and lakes in Water Framework Directive river basin districts based on the WISE-WFD database (European Commission, 2016).

Problems with implementation

Despite the effort invested for the coordination of the WFD implementation across EU Member States, implementation of the Directive varies considerably between States. With significant differences in the level of ambition, the reliance on exemptions and the application of economic instruments, the implementation process has been very challenging, and progress, towards achieving WFD objectives and improving ecological status of EU waters, has been slow.

The 3rd implementation report revealed that the first River Basin Management Plans (RBMPs) were characterised by significant gaps in many Member States. The gaps in monitoring of the chemical status of surface waters were highly significant to the extent that in 2009 no baseline was established since the status of over 40% of water bodies was unknown (European Commission, 2012a). At that time, the ecological status of approximately 15% of European surface water bodies was unknown (European Commission, 2009). Significant gaps remaining in relation to the pressures and impacts analysis (74% of Member States), the development of appropriate assessment methodologies (sensitivity level to pressure) (85% of Member States) and the monitoring of water status (81% of Member States) were also reported (European Commission, 2015). Apart from the gaps and delays in the implementation of monitoring and the RBMPs there have been problems with the assessments.

The 4th implementation report (Programmes of Measures and the Flood Directive, 2015) also revealed there had been problems with the implementation of pressure and impacts analysis and with the source apportionment in 14 and 15 Member States respectively (Table 12.2b.1). In 21 out of 27 Member States there were no clear links between pressures and the Programme of Measures (PoMs). The gap analysis has not been effectively implemented in 23 out of 27 Member States for the development of appropriate and cost-effective measures. In contrast Member States had often only estimated how far existing measures will contribute to the achievement of the WFD's environmental objectives, which also explained why exemptions had been widely applied but were inadequately justified.

Achieving the WFD's objectives remains a challenge, with 47% of EU surface waters not reaching the good ecological status in 2015 – a central objective of EU water legislation (European Commission, 2012a). During the first WFD cycle, which operated from 2009 to 2015, the number of surface water bodies in "good" state only increased by 10% (van Rijswick and Backes, 2015). This has led to the Directive's effectiveness as a policy tool being questioned; with many reviews further highlighting drawbacks and weaknesses (Josefsson, 2012; Moss, 2008; Rettman, 2007; Boscheck, 2006).

Table 12.2b.1. Common implementation problems for the Member States (European Commission, 2015a).

	Implementation progress	Number of Member States (27 in total)
Monitoring and assessment	Gaps and delays in the implementation of monitoring and RBMPs	18
	Improve methodologies for status assessments	17
	Determine and finalise the reference conditions	8
	Revise, improve and make transparent the designation process of the heavily modified and artificial water bodies	10
Pressures	Improve pressure analysis	11
	Weak pressures and impacts analysis	14
	Establishing clear links between pressures and measures (improving the pressures &impact analysis for developing PoMs)	21
	Apportion pressures to relevant sources and sectors and drivers (including the need for quantitative methods)	15
Integration of policies	Need for better integration of other EU Directives and other legislative drivers in implementing the WFD	20
Gap analysis	Assess the gaps and effectiveness of basic measures	9
	Justify and set out clearly the need for supplementary measures	13
	Improved gap analysis to inform the PoMs for the achievement of objectives	23
	Providing more information regarding the scope of the measure (extent, cost and expected impact on water bodies)	9
Exemptions	Improve the approaches in the application of exemptions in RBMPs	9
	Ensure that exemptions for not achieving objectives are adequately justified	20

Departure from the Directive's Intent

Problems and delays with the WFD implementation were investigated in order to understand why the great expectations that came with the Directive have not yet been fully realised. Focusing on issues identified by the European Commission from the Fitness Check and accompanying WFD implementation reports, underlying problems across all member states were assessed. From a top down perspective, implementation efforts were compared to the Directive's initial intent, and from bottom up; in order to secure a meaningful connection to the catchment scale, the level of deviation of practices to the WFD's aspirations at the selected case studies was investigated.

Findings revealed the absence of the paradigm shift towards the systems (integrated) thinking that the WFD was grounded on, as a fundamental problem with its implementation. With evidence of misunderstandings even of the WFD's core principles (Figure 12.2b.2), in both implementation efforts and some scientific literature this inherent departure from the Directive's systemic intention and methodological approach can be seen either as the cause or the effect of traditional decision-making process and structures continuing to be employed.

Misunderstandings with the definition and the role of ecological status in the WFD process are a major barrier to the implementation process. Ecological status is an indicator that shows the need for action, the deviation of the current system state from its state under undisturbed/reference conditions (European Communities, 2003a) and not an absolute value of ecosystem quality.

As the main objective of the WFD is for all waters to reach good or high ecological status, this affects both monitoring and classification (how far the system is from the desired state) and management (selection of PoMs to reduce that gap).

MONITORING AND ASSESSMENT

Making the transition from established monitoring networks to those that support a more integrated approach to water management, as required by the WFD, has been a real challenge (Collins *et al.* 2012).

Issues with both the pressure-impact analysis and surveillance monitoring (collecting data for all quality elements and validation of pressure-impact analysis) limited the potential of monitoring networks to capture the interactions between stressors and how best to manage them (European Communities, 2003b).

The lack of well-established assessment methodologies appropriate for translating the WFD's intent at the catchment level resulted in problems with the use of elements in status assessment that are sensitive to pressures.

These issues are further discussed looking at evidence from the five GLOABAQUA basins (see appendix D12.2b1).

MANAGEMENT AND POMS

A deviation from the Directive's systemic intention and methodological approach was also observed in the action taken and PoMs developed to improve ecological status. A number of issues indicating the departure from the Directive's intentions were identified and include:

- **The ineffectiveness of measures developed to improve element classifications often without fully understanding the system as a whole:** Partly due to problems with the pressure-impact analysis, PoMs based on the improvement of individual element classifications often assume linear causality, which does not adequately account for the complex conditions operating with the system. In systems, where the elements serve as indicators of ecological status, this approach means that measures target symptoms rather than the causes water degradation, and thus actions taken have been ineffective and become subjected to failure (Hilderbrand *et al.*, 2005).

- **The limited contribution of basic measures for previous water policy legislations towards achieving the objectives of the WFD:** Problems with the implementation of the Directive are also evident in many cases where instead of following the WFD process and designing appropriate and cost-effective measures to reduce the impacts of anthropogenic pressures in order to achieve good status, many Member States have continued with traditional water management practices focusing on regulating individual monitored pollutants.

- **Tendencies to implement measures that do not readily address significant pressures:** when a significant pressure is overlooked during the pressures and impacts analysis, the monitoring will probably not be designed to assess it and the PoMs will not envisage action to address it (European Commission, 2012b).

- **Continuing with centralised decision-making processes:** Most Member States opted to adapt traditional administrative structures and assigned a competent authority through which associated catchment management activities could be made operational (Nielsen *et al.*, 2013). This tendency to favour more traditional practices of centralised decision-making could lead to significant barriers to the enabling of effective multi-sectorial integration and governance championed by the WFD.

These issues are further discussed looking at evidence from the five GLOABAQUA basins (see appendix D12.2b2).

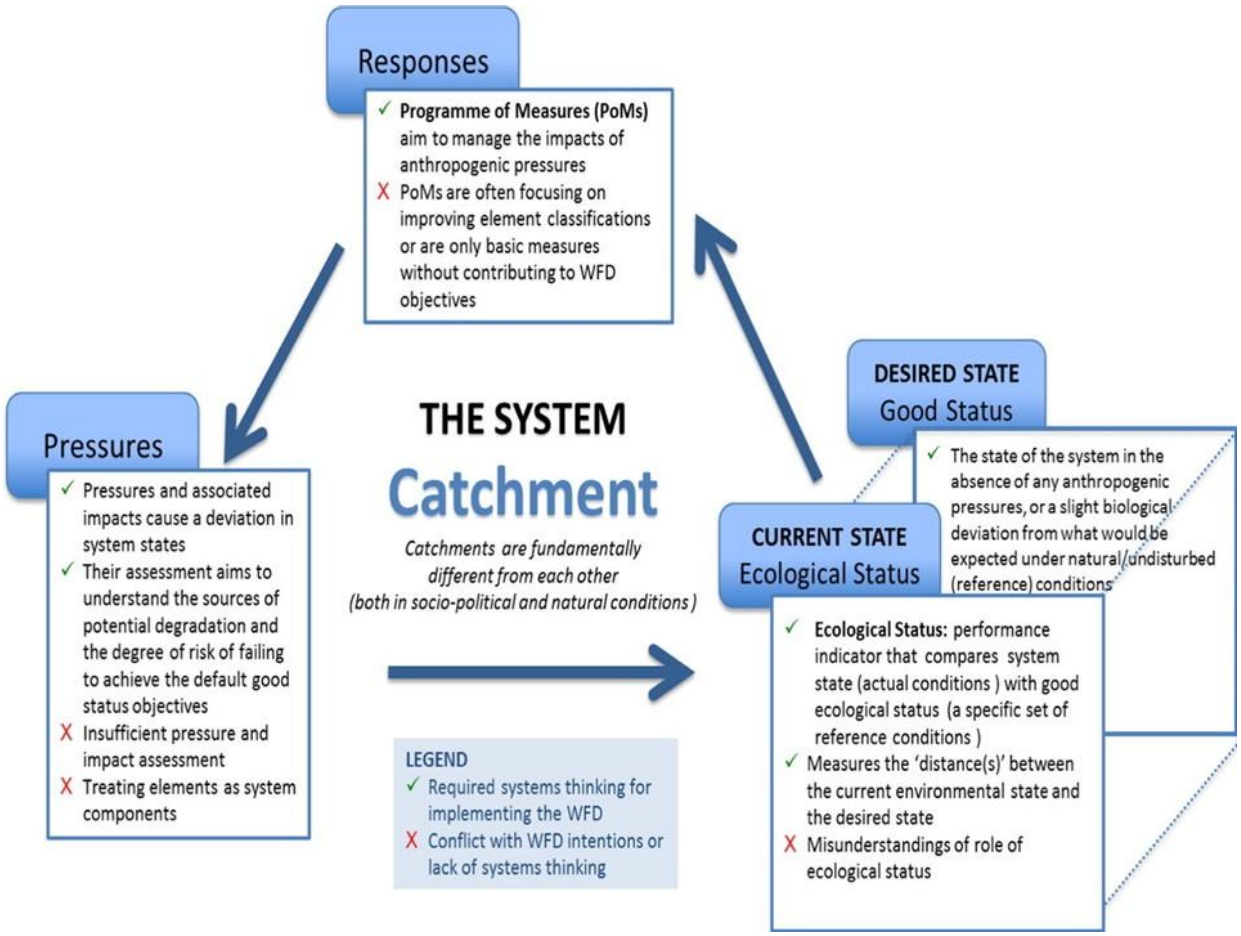

Figure 12.2b.2. Problems and misunderstandings associated with the implementation of the WFD (Voulvoulis *et al.,* 2017).

GLOBAQUA Basins

The challenges identified were also investigated in the context of the GLOBAQUA basins (Figure 12.2b.3), both from the national and catchment scale.

In all GLOBAQUA river basins the major issue was with their **characterisation** and their understanding as catchment systems (including pressures, impacts and economic analysis). This was further evident in the inadequacy of monitoring to capture catchment interactions.

Apart from delays with the RBMPs in most of the GLOBAQUA basins (e.g. Evrotas, Sava, Ebro River Basin District (RBD)), there have been gaps in monitoring in all cases. In the Anglian RBD, despite having one of the most intensive monitoring networks, not all of the relevant quality elements were monitored (not all supporting elements used). The **monitoring gaps in basin quality elements** were greater in Adige, Ebro RBD, Evrotas and Sava, reported also to have inadequate design of monitoring networks (European Commission, 2012c; European Commission, 2015b; European Commission, 2015c; ISRBC, 2013).

Another common problem identified in all the basins is related to the **methodologies for status assessments**. For Adige, Evrotas and Sava methods for assessing ecological status have not been developed for all Biological Quality Elements (BQEs) specified in the WFD. In the case of Ebro RBD there seem to be discrepancies in the assessment methods developed for the biological quality elements. For the Anglian RBD, the main concern was with the large uncertainties resulting from the methodologies followed.

Discrepancies with the **reference conditions** have been identified in all five GLOBAQUA basins. The severity varies; with Evrotas and Sava having not established them in time; in Ebro RBD being incoherent; and with Adige and the Anglian RBD, no information on validation of surface water types with biological data provided. Furthermore, in the Anglian RBD, Ebro RBD and Evrotas, there is a need to revise, improve and make transparent the designation of heavily modified and artificial water bodies.

Adige, Ebro RBD, Evrotas and Sava faced problems with the **methods used for pressure assessments.** For the Anglian RBD on the other hand, large uncertainties regarding the assessment of the pressures were reported. The **pressures and impacts analysis** and its implications to the **identification of the significant pressures** for monitoring, seem to be the greatest issue in all the GLOBAQUA basins, in line with findings from catchments in all EU Member States.

In Adige, as with all Italian catchments, for many measures there was no clear link to the status assessment. In the Anglian RBD, the measures were based entirely or partly on ecological, chemical and quantitative status assessments for all water bodies. However, due to extensive lack of certainty of the pressures, the status of the water bodies and the impact of potential measures, few new specific measures were implemented. Similar was the case with Ebro RBD where such links were not clearly established. Among the measures considered as contributing to the environmental objectives, there were many for which their contribution to achieve good status is unclear. Evrotas suffered from PoMs mainly including administrative acts not expected to make a difference (particularly if implementation is not enforced), as with most of the Greek RBDS. In Sava, basic measures from Slovenia related to hydromorphological pressures were mainly directed towards preventing deterioration of water status because of new modifications in water environment (however, most of them were very general). Only basic PoMs were reported in Croatia, with supplementary measures expected in the second cycle, a limitation, considering that basic measures alone are often not enough to achieve the Directive's objectives.

With regards to Adige, the need for **better integration of policies** (like most Italian catchments) was identified. In addition, further measures for protected areas were required. Although there was some reference to identify measures to address water scarcity and drought and for climate change impacts, most did so in very general terms. For both the Anglian RBD and Ebro RBD there is still a need to implement basic measures that go beyond requirements of existing directives (i.e. Nitrates Directive). For

Evrotas, no specific additional measures in protected areas were part of PoMs, since no specific, additional objectives going beyond the WFD-objectives were included in the RBMPs (beyond what is required for the implementation of "other" Directives, Natura 2000). The need to consider other legislative drivers was also apparent in Evrotas and Sava in the case of droughts and scarcity as well as climate change.

A fundamental problem in all the basins was the lack of **understanding them as catchment systems** (Voulvoulis *et al.*, 2017)**,** best indicated by the lack of **clear links between PoMs and pressures** in their RBMPs (European Commission, 2015a)**.** Improving transparency and the engagement of all parties in the basins is also required, as the lack of acceptance or inertia by stakeholders has been identified as one of the obstacles in the implementation of PoMs (European Commission, 2015a).

Figure 12.2b.3. Basin case studies in the GLOBAQUA project.

The way forward

Environmental problems are complex (Hughes *et al.*, 2016). This is especially apparent in the context of freshwater systems, where aquatic ecosystems are subjected to multiple stress conditions (Ormerod *et al.*, 2010).

Understanding the complex interactions within a catchment, and moving away from the traditional approach of creating a deterministic link between what is monitored and the type of action required are prerequisites for this. Improving system state by managing pressures, improving participation and interdisciplinarity to address the complex issues associated with water management, all call for a transition towards systemic thinking that can only be achieved with real transformational change.

The process of acquiring in depth understanding of the catchment rather than the more traditional focus on policy compliance requires a fundamental shift to managing catchments as systems, acknowledging their differences and developing a tailored approach for their management. In essence, this requires moving away from having a single mandate for management across Europe to a more robust understanding of the essential features of those systems.

The WFD offers a platform for system-level shifts that need to take place, and offers an opportunity for transformative change for the management of risk to the environment caused by anthropogenic pressures.

Implementing the WFD like any other directive is not going to work. Unless current implementation efforts are reviewed or revised, allowing the Directive to deliver its systemic intent in order to reach its full potential, the fading aspirations of the initial great expectations could disappear for good.

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Overview

The river basin approach of the Water Framework Directive (WFD) and the introduction of ecological status represent a shift in the assessment of freshwater systems from discipline-specific to more holistic, catchment-based principles. WFD assessment and classification of European waters (Figure 12.2b1.1) required a new mind-set and procedural elements, that most member states found challenging to address. Gaps in monitoring networks and assessment methodologies and misunderstandings with the definition and the role of ecological status in the WFD process limited the potential of River Basin Management Plans (RBMPs) to clearly identify the gap to good status. As the main objective of the WFD is for all waters to reach good or high ecological status, this affects both monitoring and classification (the gap to good status) and management (selection of Programme of Measures to reduce that gap).

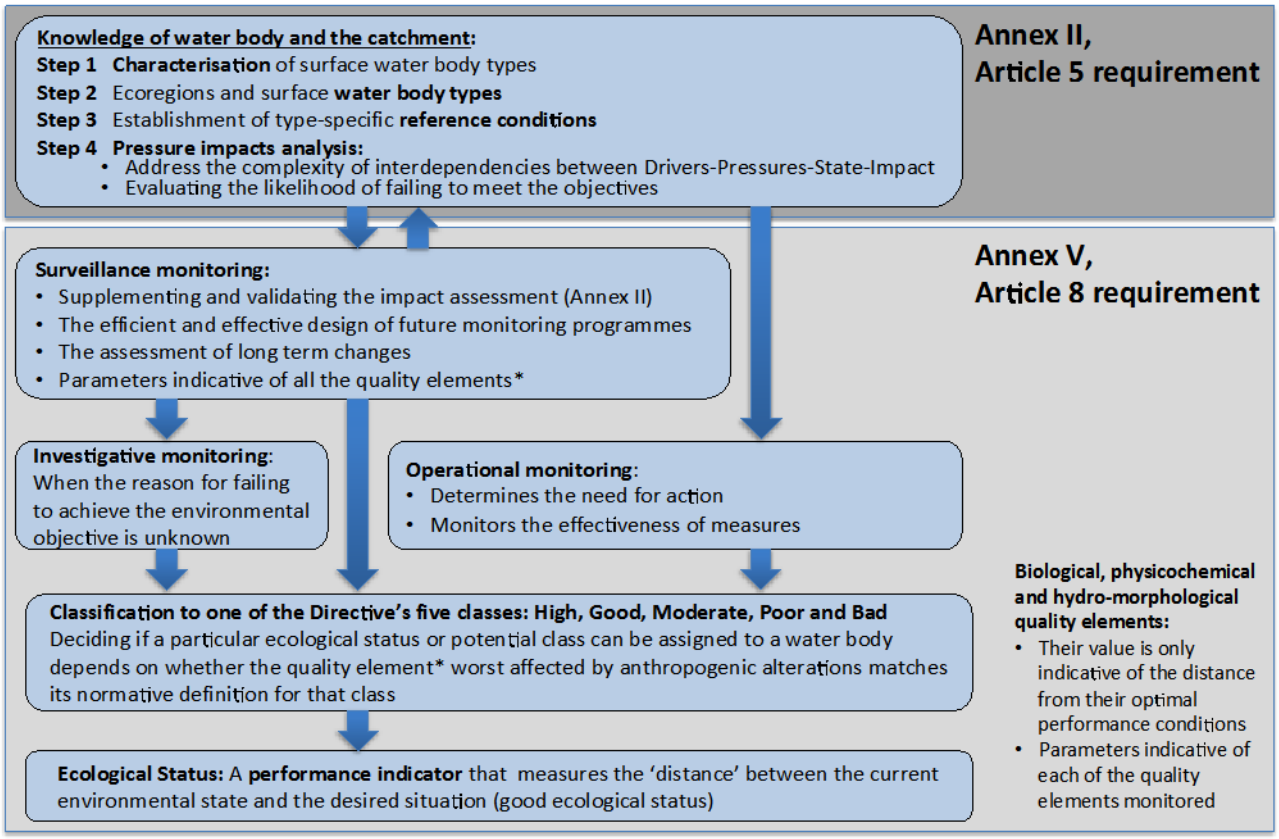

Figure 12.2b1.1. The WFD procedural elements reflecting the systems approach of the monitoring and assessment.

At the catchment scale, evidence from the GLOBAQUA basins provided insights into the complexities and problems of the assessment. Policy needs for effective implementation for the monitoring and classification of ecological status, opportunities for the GLOBAQUA project to deliver benefits and for each work package to deliver policy relevant research outputs are discussed here.

Insights from the GLOBAQUA basin case studies

Opportunities for improvements in monitoring and classification of status have been identified as follows:

Characterisation of water bodies and definition of desired state

In the Anglian River Basin District (RBD) (United Kingdom) high uncertainties were reported in characterisation (European Commission, 2012b). For example, during the first cycle only rivers and lakes were identified. The second cycle brought improvements, making the characterisation of surface water systems more ecologically relevant by charging water body boundaries and designating coastal and transitional types. High uncertainties were also reported with regards to the reference conditions. It is evident that problems or uncertainties at early procedural steps of monitoring and assessment had knock off effects on the subsequent steps reducing the reliability of their outputs. Similarly, in the Ebro RBD (Spain) the lack of coherence in the typology and reference conditions have affected the process of determining the status or setting environmental objectives for transitional and coastal water bodies as well as for heavily modified or artificial water bodies (European Commission, 2015b).

A risk assessment process for targeted and effective monitoring design

The pressures and impact analysis is the process of identifying significant pressures. They are defined as pressures that on their own, or in conjunction with other parameters such as; other pressures or particular characteristics of the catchment, may lead to failure to achieve one of the WFD objectives (European Communities, 2003a). Under the WFD and in contradiction to the previous waves of EU water legislation, the risk assessment process requires a consideration of a much wider range of pressures on the water environment, especially pressures on hydrology and morphology.

Although in the Ebro RBD water quantity has been a significant problem, there is a mismatch with the relatively low numbers of water bodies identified as being affected by significant abstraction pressures. This could be attributed to the fact that Spain reported to the Water Information System for Europe only the result of the qualitative pressure and impact assessment, which is not accurate in case of diffuse sources of pollution or water abstraction (European Commission, 2015b). However, this brings another question from a manager's practice perspective with regards to the reliability of the thresholds of significance used for the pressure inventories and the usability of the information reported. Another important pressure in the region is related to morphology. Despite the large number of dams and river infrastructure existing in Ebro RBD, there have been relatively low numbers of water bodies (<20%) reported as impacted by significant water flow regulations and hydro-morphological alterations (European Commission, 2015b). Although the Directive requires the pressure impacts analysis to be a continuous process validated and supplemented by (surveillance) monitoring, generally in Spanish catchments the final and complete assessment of pressures and impacts was wrongly seen as a one-off exercise that was due only in 2005 as part of the preparation of the first RBMP. This could possibly be attributed to the fact that the risk assessment resulting from the pressure and impact analysis is not required by the Spanish legislation (European Commission, 2015b).

Validation of the pressure impacts analysis by using monitoring data

The validation of the pressure impacts analysis by using monitoring data is especially important in the context of multiple pressure interactions. As freshwater systems are influenced by pressures whose effects are relevant at multiple spatial and temporal scales, the thresholds of significance for example of a certain pollutant may change based on the specific characteristics of the catchment. For example, even low contaminant loads may become relevant to the ecosystem when it is subject to additional hydrological stressors. The identification of 'significant' pressures may be proved to be problematic since it could potentially neglect the combined effects of non-

significant ones. Therefore, ideally managers should hold a good understanding of the individual and combined effects of pressures that operate in their area. Complex synergistic or antagonistic interactions between multiple pressures are very common (Crain *et al.* 2008; Darling and Côté 2008) and therefore they are one of the largest sources of uncertainty when predicting ecological change.

A recent study by Chiogna *et al.* (2016) in the Alpine catchment of Adige (Italy) shows how unpredictable the impacts of such pressure interactions could be. According to the classification data collected by the relevant authorities, the highest quality values were found in the upstream regions compared to the downstream regions where the ecological status deteriorated. Such a north-south gradient of ecological status classifications across the monitoring points of Adige seems to contradict the evidence that hydropeaking has in general a negative effect on the ecosystem as the data demonstrate that the worst ecological status occurs where the effects of hydropeaking are negligible (Chiogna *et al.* 2016).

Status assessment should be based on monitoring of elements sensitive to pressures

The WFD's ecosystems approach for the assessment of surface water system health and the introduction of ecological status represents a shift from disciple specific approaches towards holistic resource performance assessments and requires different mind-set and monitoring practices. The above procedural elements of the assessment process will determine the monitoring for classification of status *via* what has been considered to be "acceptable", "adequate" and "sufficient" levels of "precision" and "confidence" or what is defined as a "significant" risk" (European Communities, 2003b).

Operational monitoring is highly focused on parameters indicative of quality elements most sensitive to the pressures to which the water body or bodies are subject (European Communities, 2003b). However, the reliability of the overall classification of ecological status is based on the selection of those elements that heavily depends on the pressures and impacts analysis. Therefore it could be jeopardised by the limited understanding of the interdependencies between pressures and impacts. Also, if a significant pressure is overlooked during the pressures and impacts analysis, the monitoring will probably not be designed to assess it. In depth understanding of the catchment as a system could secure the appropriate selection of the relevant quality elements that will be used for the assessment of ecological status. A good example that illustrates how the problematic identification of pressures affects the classification of status comes from Ebro RBD. The assessment of pressure impacts in the Ebro RBD identified 77% of the water bodies (635 water bodies) under no pressures. Comparing this to the number of water bodies at good status in 2009 (226 water bodies) it appears to be a much lower number of surface water bodies in good status than the number of water bodies with no pressure (European Commission, 2015b). Another example of problematic implementation of status assessments comes from the Croatian part of the Sava. Although, Biological Quality Elements (BQEs) in operational monitoring were chosen in relation to existing pressures, there is no clear evidence to show which BQEs have been selected to monitor which significant pressures. The RBMP of Croatia also reports that operational monitoring was only carried out in relation to point source pressures, not diffuse sources. Also, in the case of the Anglian RBD there have been, as reported above, problems with the typology as well as uncertainties with reference conditions and the identification of pressures. Those errors could be transferred to the subsequent steps of assessment and subsequently affect the selection of quality elements that will be mentored and used for the overall status assessment (European Communities, 2003c).

Another source of error in operational monitoring practices is the lack of well-established assessment methodologies for all BQEs, compromising the selection of the most appropriate indicators for significant pressures. In the Evrotas basin (Greece) the classification of rivers as far as BQEs is concerned was based on monitoring of benthic invertebrates, and fish (fish were not included in the Evrotas tributaries) since for the rest (macroalgae and phytobenthos)

it was not feasible to determine the class boundary limits (Nikolaidis *et al.*, 2009). In the Anglian RBD despite having one of the most intensive monitoring networks, not all of the relevant quality elements were monitored. Although all relevant BQEs were used in operational monitoring, not all supporting elements were. For example, there is no monitoring of river continuity, tidal regime in coastal waters or fish in lakes according to the information reported to the Commission (European Commission, 2012b).

More severe gaps in elements monitored are present in the case of the Sava trans-boundary catchment, potentially due to differing levels of the WFD implementation among the countries involved. For example, while in Slovenia operational monitoring covers most of the relevant quality elements and frequencies, in Croatia for the development of RBMP, a preliminary assessment of the ecological status was made using only physico-chemical and hydro-morphological quality elements instead. Although the required BQEs were reported being monitored in rivers and lakes, the lack of compliant biological assessment methods meant that they were not used to derive ecological status (European Commission, 2015a). In Serbia the monitoring and assessment of the ecological and chemical status for the Sava RBMP have not been fully compliant with the requirements of WFD, while WFD compliant methods have not been implemented in Bosnia and Herzegovina yet. Monitoring of water quality and quantity is still based mostly on traditional monitoring programs, organized at the same monitoring sites as before 1992 (ISRBC, 2013).

The way forward

Defining the desired state

The suggested approach for establishment of reference conditions and ecological quality class boundaries involves several technical considerations that might not be transparent to the public, water users and stakeholders (European Communities, 2003b). These considerations are, however, crucial for the judgement of the risk that individual water bodies will fail to reach the overall objective good water status. This is why the Directive requires involving the public, water users and stakeholders at an early stage (Article 14 of the WFD) in order to reach acceptance for the quality class boundaries finally set.

Operationalising the WFD's systemic intent for integration of multiple perspectives has a long way to go, with some evidence of a transition towards an adoption of the ecosystems approach through the integration of Ecosystem Services (ES) in the implementation process (Spray and Blackstock, 2013). Even though ES are not explicit in the wording of the WFD, there is a clear connection between the Directive and their delivery (Vlachopoulou *et al.* 2014). Investigating further the relationship between environmental "state" and "impacts" on quality elements monitored under the WFD and how do they link to provision ES could enable greater involvements of the stakeholders in defining the desired freshwater system states. Adopting the ES language a participatory approach for the assessment under the WFD could be facilitated, by translating how changes in water quality status reflects those services and goods they value. The stakeholders could provide a more robust definition on good ecological status based on what they value. Using ES as the proxy of those natural elements of water systems that are ultimately valued by our society, its integration in decision making by explicitly identifying the interdependencies of how human activities within the catchment influence their provision (Asah *et al.* 2014) could support the implementation of the monitoring and assessment under the WFD.

Developing methodologies that could quantitatively assess the effects of multiple stressors on the freshwater ES from a biophysical point of view could signify their potential application as indicators of systems state. This could enable the stakeholders to contribute in the process as they can be a useful source of

information and have expertise of direct use for the reference condition analysis (European Communities, 2003b). Therefore, the nature of the ES as both a concept and as potential indicators of ecosystem state must be further investigated in order to provide the right conditions to effectively achieve the broader objectives of the Directive.

Measuring status of freshwater systems under multiple pressures

The degradation of natural ecosystems has been the result of the impact of several pressures (the so-called multiple-stress situations) with considerable implications on freshwater ecosystems (Ormerod *et al.* 2010). Currently, around 47% of Water Bodies in Europe are threatened by multiple pressures (Schinegger *et al.* 2012) with detrimental impacts to water availability and quality. Because of the scientific limits in clarifying the complexities of environmental systems, more research is needed in this area to enable effective monitoring and assessment. The pressure and impact assessment needs to consider the influence of multiple sectors and also facilitates the integration of freshwater policy objectives that were once treated in isolation thereby driving the need to treat water management from an integrated systems perspective. Pressure impacts analysis is a key procedural element for the assessment of status but more work needs to be done in the following areas:

- There is no clear link between surface and sub-surface hydrological fluxes and the impact of multiple stressors on the ecological status of freshwater ecosystems.
- Limited understanding of how a changing hydrology, land use, and climate could affect sediment transport, channel morphology, physical habitat, and pollutant fluxes in rivers increasing the intensity of their deleterious effects on fluvial communities.
- The fate and behaviour of emerging pollutants and nanomaterials under multiple-stress conditions and their potential impacts on biodiversity has been neglected.
- Limited knowledge of how the multiple stressors impact on structural and functional biodiversity.

Those research areas are currently being investigated by the GLOBAQUA project.

The role of GLOBAQUA: Towards improved assessment of water status

GLOBAQUA is a EU-funded project aiming to identify the prevalence of, and interaction between, stressors under water scarcity in order to improve knowledge of relationships between multiple stressors and to improve water management practices and policies. From understanding current policy challenges to producing scientific results that will be integrated with the demands of policy-makers and national/EU environmental agencies, GLOBAQUA aspires to deliver policy related outputs and benefits (Figure 12.2b1.2).

MODULE: STRESSORS

WP2-SCENARIOS develops climatic, socio-economic, land and water use scenarios to construct possible futures to inform possible options and directions for policy implementation.

WP3-HYDROL; WP4-GEOMORPH & WP5-QUALITYCHEM aims to improve methodologies for better catchment understanding. Their outputs would contribute towards improvements in pressure impacts assessments with regards to the supporting elements that comprise the ecological status as well as optimising monitoring systems.

MODULE: RECEPTORS

WP6-BIOL analyses the effects of multiple stressors on structural and functional biodiversity. Its outputs could deliver improvements in the pressure impact assessments and monitoring.

WP7-ECOSYSTEM analyses the effects of multiple stressors on ecosystem functioning, while

acknowledging catchment variability. Its outputs would improve assessments of freshwater systems, through the identification of critical ecosystem functions as well as related environmental stressor thresholds.

MODULE: IMPLICATIONS

WP8-SERVICES aims to assess the effects of multiple stressors on freshwater ecosystem services, a fundamental step towards the system shift required in the WFD implementation.

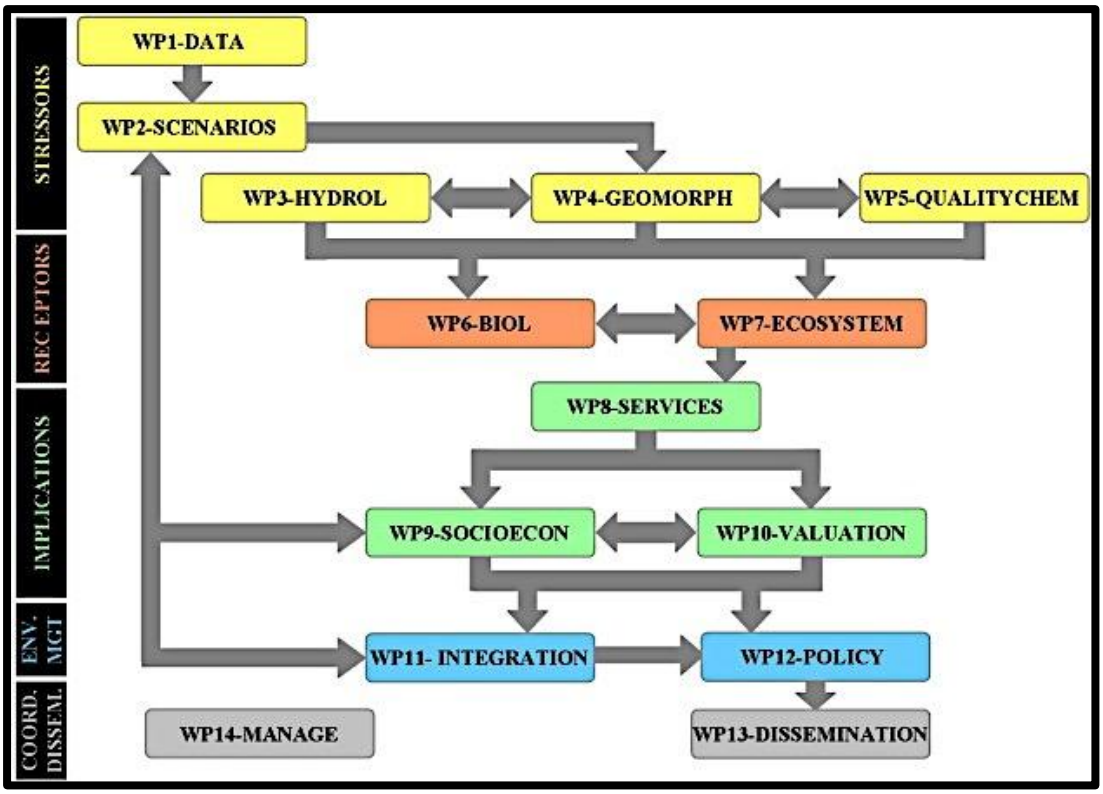

Figure 12.2b1.2. Module and work package structure of GLOBAQUA (Navarro-Ortega et al., 2015)

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Overview

The Water Framework Directive (WFD) presents a catchment-based approach to improving water quality by understanding and managing catchments as highly interconnected systems. Water quality improvements can be delivered by improving ecosystem health (state of the system) by managing the pressures operating within the catchment. For the WFD, the Programmes of Measures (PoMs) are the management responses addressing system pressures in order to reduce the gap to good status (Figure 12.2b2.1). Despite significant investments in measures, progress towards achieving WFD objectives (reducing the gap) has been slow with deterioration in some cases not been halted.

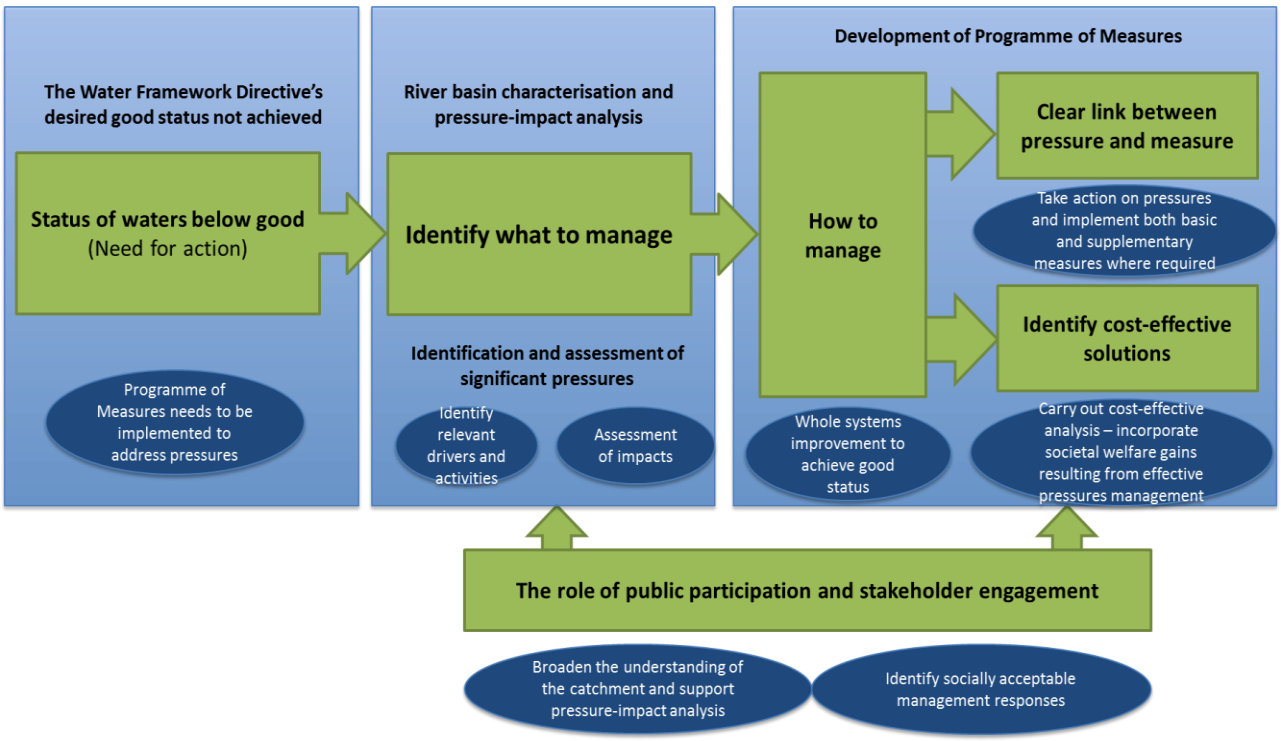

Figure 12.2b2.1. The Water Framework Directive's catchment management approach to water quality improvement.

The policy needs for improvements in water quality are presented in this section, focusing on how river basin managers develop PoMs, while offering opportunities for the GLOBAQUA project to deliver benefits and for each work packages to deliver outputs that are policy relevant and effective in influencing WFD implementation.

Insights from the GLOBAQUA basin case studies

Opportunities for improving the management and development of Programme of Measures (PoMs) have been identified as follows:

Assessment and identification of significant pressures to be managed

The process of assessing and identifying what to manage (i.e. significant pressures) within the catchment is an important process and therefore any limitations associated with the WFD's pressure and impact analysis will affect the overall selection of management responses. For example, if a significant pressure is overlooked during the pressures and impacts analysis, the monitoring will probably not be designed to assess it and the PoMs will not envisage action to address it (European Commission, 2012a).

The European Commission published a policy summary of the first experiences of the initial pressure-impact analysis for Article 5 of the WFD and identified challenges including: lack of (sufficient or the right) data; uncertainties because of lack of criteria for objectives; implications regarding time and spatial scale; time constraints (international coordination, interdisciplinary work) and communication problems (European Communities, 2004). In the Anglian River Basin District (RBD), a preliminary analysis on pressures and impacts revealed some issues including the identification of the impacts of hydromorphological pressures on ecological status, the limitations of the traditional General Quality Assessment to represent impact data as well as the challenges in understanding the relationship to link activities to the pressure (Defra, 2005). Even towards the end of the planning cycle, although UK in general had its pressure and impact analysis largely in place according to the WFD 4th implementation report, there were still uncertainties identified in the review of the first river basin management plans (RBMPs) in relation to the assessment of status, the pressures and the effect of potential measures (European Commission, 2015a). Overall, a fundamental lesson to be learnt, as stated by the IMPRESS policy summary, is that the assessment of pressures and impacts must be seen as an on-going process within the RBMP cycle, and that the process should be kept up to date to enable timely, appropriate and effective water management (European Communities, 2003a).

In determining the significance of pressures, Member States have often used information and thresholds based on existing directives. This is apparent for the RBDs in Greece where the identification of significant pressures adopted the criteria and related thresholds from other relevant Directives supported by results found in scientific literature or inputs from expert judgment (European Commission, 2015b). Consequently, for the Eastern Peloponnese RBD which includes the Evrotas basin, the main pressures identified in the initial pressure-impact analysis included the organic load and the load of suspended solids are primarily associated with the in confined livestock activities and secondarily with urban wastewater and industrial activities based on such thresholds from previous directives (Central Water Agency, 2006). Although this practice provides an initial starting point and baseline for the pressure-impact analysis as it could provide information on pressures that could have a likely impact on the water body (European Communities, 2003b), there is a need to supplement this assessment of pressure significance with an in-depth catchment understanding and especially assessment of impacts to facilitate a more effective management approach. This is especially important considering that the WFD puts more emphasis on the impact of pollution (Hering *et al.*, 2010).

It should also be noted that improving water quality requires an integrated assessment of the system state, considering all potential pressures and stressors simultaneously, to identify the likely causes of deterioration (von der Ohe *et al.*, 2014). Ultimately, this is a process that considers a wider range of pressures on the water environment than previous EU water legislations did. Therefore, relying on thresholds set out by existing directives that pre-dated the WFD and

inherently its holistic and integrated intentions for water management could potentially limit the understanding of the complex conditions of the catchments necessary to inform management decisions. Therefore, when information and data becomes available, such criteria for assessing pressure significance must be actively supported by an integrated assessment of impacts to provide a more robust understanding of the current situation of the system in relevance to its desired state. Indeed, it is worth noting that the preliminary analysis undertaken by Greece for Article 5 was supported by future methodological and analyses to support characterisation and to refine the analysis of pressures and impacts (Central Water Agency, 2006).

Similarly in the case of the Sava basin, the proposed criteria were based mostly on the requirements of the Urban Wastewater Treatment Directive 91/271/EC for agglomerations, Urban wastewater treatment plants including the food industry and Integrated Pollution Prevention and Control Directive 2008/1/EC for assessment of other significant industrial pollution sources were agreed by the Sava basin countries (ISRBC, 2013a). However, there were issues involving thresholds set in the European-scale or in the context of a different basin have been used to assess the significance of a pressure in the catchment. This is apparent in the case of the Sava basin where the criteria for identification of significant urban pollution source and collection data about urban waste water disposal based on Directive 91/271/EEC which requires collecting and treatment of all urban wastewaters from the agglomerations with nominal load ≥2000 population equivalent. Whereas this criterion was selected at the Europe wide scale and also at the Danube river basin wide scale for identification of significant urban pollution sources requiring wastewater treatment, this threshold has been taken also for the Sava river basin (ISRBC, 2013a). Although, such practice presents an important starting point for the assessment of pressure significance, it is important to note that using one set of thresholds across Europe is not ideal since this fails to recognise the particular characteristics of the water body and its vulnerability to the pressure (European Communities, 2003b).

As stated, the WFD requires a broad assessment of all the relevant pressures within the catchment. However, risk assessments that are too narrowly focused on existing pressures within river basins may overlook important but physically remote, indirect or longer-term drivers of water body status (European Communities, 2009). According to Hering and co-workers (2010), current assessment schemes mainly focus on more traditional pressures (e.g. eutrophication, organic pollution), but other pressures have more recently come into focus that needs to be accounted for in catchment management. One of which includes the implications of climate change in water management. As an example, there are issues identified with regards to the impact of climate change associated with the release of chemical pollutants from snow and glacier melting, an occurrence that have not yet been fully investigated in the case of the Adige basin (Chiogna *et al.*, 2016). Additionally, a "climate check" (assessing the risk of climate change and integrating its impacts) of the PoMs identified in Italian RBMPs was not performed during the first cycle (European Commission, 2012b). Climatic change will have an influence on the extent of risk subjected to aquatic ecosystems. It will be essential not only to understand how the risk from pressures will change over time without climate change but also to factor in how climate change will add to or reduce the level of risk in order to effectively plan appropriate measures (European Communities, 2009). Thus, more emphasis should be put on refining our understanding of the catchment and the pressures that operate in order achieve the desired state of the system.

Ensuring effective management action to address those significant pressures to improve system state

Considering that significant pressures within the catchment need to be adequately managed, ensuring clear links between the measures (response) and the pressures is integral to facilitate improvements in ecosystem health and consequently water quality. In other words, investigating the extent to which the reported significant pressures are being managed by a measure is important in order to identify

opportunities in the way catchment managers respond to those pressures and their impacts.

To elaborate further, in the case of the Adige basin in Italy one important stressor identified is streamflow alteration resulting from hydropower exploitation (Chiogna *et al.*, 2016). Looking into the review of the RBMP for the first WFD cycle for Italy and the Eastern Alps RBD in which Adige basin is a part of, the measures identified to address hydromorphology pressures were not only limited but also not clearly linked to the required action as they were only discussed in broad terms (European Commission, 2012b). However, one notable aspect of water management to help address streamflow alterations is the fact that National guidelines on minimum flows have been enforced (European Commission, 2012b).

In the case of the Ebro RBD, the review of the RBMP during the first WFD cycle indicated no information on the measures implemented related to agriculture and hydromorphology pressures (European Commission, 2015c). The lack of measures is especially important in the case of agricultural related pressures considering the occurrence of pesticide contamination within the basin and especially in the Ebro delta (Ccanccapa *et al.*, 2016; Köck-Schulmeyer *et al.*, 2010). Indeed, the lack of measures being implemented could be attributed to the limitations in the previous steps of the WFD planning process including the pressure-impact analysis, and indeed insights from the second RBMP cycle indicate that improvements have been made to ensure that PoMs are focused on addressing those significant pressures (European Parliament, 2016).

Generally, the review of RBMPs for Greece indicated that there was no clear link between the identified pressures, the status of water bodies, and thus the specific needs for the measures to be taken (European Commission, 2015b). In Evrotas the main challenge for water management is the restoration of the hydrological regime (Cazemier *et al.*, 2011). As a result of intense hydromorphological modifications mainly for agricultural purposes (i.e. irrigation), most of the main course of Evrotas River and its tributaries desiccate during the dry period (EnviFriendly, 2009). Despite, measures for irrigation efficiency (as part of water saving measures) have been implemented for the Eastern Peloponnese RBD in which Evrotas is a part of, the review of the Greek RBMPs during the first cycle stated that it was difficult estimate if these measures were sufficient to reduce the abstraction pressures from agriculture to a sufficient degree (European Commission, 2015b). Additionally, despite setting minimum ecological flow requirements as one of the measures related to hydromorphology for Eastern Peloponnese RBD, generally in Greece no reference could be found to national legislation or requirements regarding such flows (or national legislation or guidance regarding other issues related to hydromorphology) as linked to the WFD-objectives in the RBMPs (European Commission, 2015b).

For the Sava basin, given its transboundary nature, the implementation of measures and achievement of objectives will depend on a timeframe that is realistic and acceptable for both EU and non-EU countries (ISRBC, 2013b). For some of the pressures identified including organic pollution, nutrient pollution, and hazardous substances, management action rely solely on the implementation of basic measures from existing directives in water management (ISRBC, 2013b). However, it is important to note that according to the 4th WFD implementation report basic measures alone are often not enough to achieve the objectives of the WFD (European Commission, 2015a). Indeed, in the review of progress of PoMs for Slovenia (one of the countries sharing the Sava basin), the basic measures generally had no explicit information reported on their contribution to the achievement of WFD objectives (European Commission, 2015d). Additionally, in the review of RBMPs for Croatia (another country sharing the Sava basin), only basic measures have been implemented (European Commission, 2015e). Indeed, it should be noted many agglomerations in the Sava basin have no, or insufficient, wastewater treatment and are therefore key contributors to organic and nutrient pollution (ISRBC, 2013a), thereby explaining the focus on basic measures. Nonetheless, in both Member States, assessing the importance of implementing both basic and supplementary measures where

necessary to adequately address those significant pressures is important in future planning cycles in order to ensure that the desired improvements in the state of the system could be achieved.

Finally for the UK and as mentioned previously, there is a need to address the uncertainties identified in the review of the first RBMPs in relation to the assessment of status, the pressures and the effect of potential measures (European Commission, 2015a). In the Anglian RBD, there are often tendencies for measures implemented to be based on addressing pressures to improve element classifications that failed to achieve good status in order to improve the overall system state (Environment Agency, 2009). Such an approach assumes a relationship between pressures and the indicator monitored. Although this approach could provide information to a manager, the inherent limitations and uncertainties associated with the pressure-impact analysis could mean that such relationship is not always clear. In principle, such practices indicate the apparent tendency to base management actions in an assumption of linear causality to improve the actual situation of a system (Voulvoulis *et al.*, 2017). It should be noted that when an element fails, management decisions for the development PoMs should focus on revisiting the pressure-impact analysis in order to ensure that the right pressures are identified and targeted. Also, it is worth noting that this inherent focus on element compliance may lead to tendencies for the wider intent and objectives of the Directive often being overlooked (Vlachopoulou *et al.*, 2014).

Improving the economic appraisal of measures (acquire benefits from effective pressures' management)

Implementing the WFD and the measures required to address those pressures in order to improve the system state must be evaluated in terms of identifying the optimum combination of solutions able to deliver the desired result at the lowest cost. The European Commission's assessment shows that many Member States have not followed the logic of designing appropriate and cost-effective PoMs to achieve WFD objectives and that the focus was largely on measures already in place or in the pipeline and, in some cases, additional measures identified ex-ante as feasible (European Commission, 2015f). Furthermore, there were also some limitations identified in undertaking a cost effectiveness analysis (CEA) required to aid the appraisal and selection of PoMs required to achieve the objectives of the WFD (European Commission, 2015a).

To elaborate further, in Italy the economic analysis including the assessment of cost-effectiveness of measures was only carried out at a preliminary level during the first WFD cycle (Balzarolo *et al.*, 2011). According to Viaggi and co-workers (2010), "one may argue that the approval of basin plans in Italy was undertaken, up until now, without a proper evaluation of measures". Since, this trend was discussed in the context of Italy as a whole, the PoMs implemented for the Eastern Alps RBD (which includes the Adige basin) could also face such limitations. Indeed, according to the review of PoMs for Italy, the Eastern Alps RBD was among the few, which indicated that economic analysis will be undertaken, and already provided some discussion regarding the methods to be used (European Commission, 2015g).

Similar issues can be identified in the other GLOBAQUA basins, for Ebro RBD there were no results provided regarding the CEA, sometimes despite apparent existing references in some of the plans (European Commission, 2015h). In Greece, the cost-effectiveness calculation of measures was not referred to any in any PoMs or RBMPs and at the same time in each RBD some cost-effectiveness calculation was carried out, but they have not been used for the actual prioritisation of measures (European Commission, 2015b). In such cases, what is important is to ensure that the appraisal of measures must adequately account for any environmental benefits or welfare gains that result from improving the system state through adequate pressures management.

For the countries sharing the Sava basin, Slovenia was the only country that was reviewed with regards to the progress of PoMs implementation and it was stated that the RBMPs in Slovenia did not provide any information on CEA undertaken during the development of PoMs (European

Commission, 2015d). During the preparation of the Sava RBMP, the aim of the countries sharing the basin was to identify best procedures for the selection of measures as only very limited information was present on traditional measures at the time (Zinke *et al.*, 2007). In the actual Sava RBMP, it is worth noting that the effectiveness of some of the basic measures to address organic and nutrient pollution was determined using a scenario approach which describes the status in 2007 regarding wastewater treatment in the Sava RB (Reference Situation) and its potential future development (three scenarios) using different assumptions (ISRBC, 2013b).

Lastly, for the UK, the CEA was carried out but with limitations associated with the availability of information on effectiveness of some measures as well as their cost (European Commission, 2015i). In fact, in the context of the Anglian RBMP the preliminary CEA considered the scope and scale of measures on a national basis, and their costs and effectiveness for the first round of RBMPs and the findings meant that very little additional work on cost effectiveness was needed at a more local level (Environment Agency, 2009). Additionally, it should be noted that for the 2015 Anglian RBMP the supporting impact assessment provides more explicit information that concerns the integration of ecosystem service (ES) assessments to support the appraisal of measures (Environment Agency, 2016). The integration of ES assessments to the WFD implementation presents an integral step to acknowledging the Directive's systemic intent and provides value in communicating its process and objectives to wider societal welfare (Voulvoulis *et al.*, 2017).

Improving transparency and stakeholder engagement in the decision-making process

The WFD puts emphasis on public participation and stakeholder engagement to support the development of RBMPs and appropriate PoMs. However, engaging the public and all relevant parties have not been a straightforward task especially in cases where Member States often opted to adopt traditional administrative structures and assigned a competent authority through which associated catchment management activities could be made operational. Water management has been traditionally characterised as centralised (Domènech, 2011), which follows the command and control paradigm for management (Porto and Lobato, 2004). One aspect of this traditional water management is the limited emphasis on the importance of users and stakeholders in decision-making. This tendency to favour more traditional practices of centralised decision-making could lead to significant barriers to the enabling of effective multi-sectorial integration and governance championed by the WFD (Nielsen *et al.*, 2013; Liefferink *et al.*, 2011; Moss, 2004). Improving the transparency and the engagement of all parties in water management is integral considering that the 4th WFD implementation report identified that lack of acceptance or inertia by stakeholders as one of the obstacles in the implementation of PoMs (European Commission, 2015a).

In Italy, the origin of its water policy-making stems from this centralised and hierarchical structure, and despite the reform in water policy, which was later generalised by the WFD, this top-down process is still prevalent (Massarutto *et al.*, 2003). One example can be seen in the case of the Venice lagoon which is part of the Eastern Alps RBD (the district that includes the Adige basin) where experiences in its management revealed that the dominant structure in decision-making was that of top-down and centralised structure which left very little opportunities for stakeholder participation (Munaretto and Huitema, 2012). Consequently, with the advent of the WFD the establishment of catchment management, encompassing the rivers, the lagoon itself as well as the nearshore sea, is hindered by issues of leadership, authority and debates about responsibilities (Munaretto and Huitema, 2012). Nonetheless, evidence of progress towards meeting the participatory requirements of the WFD for the Eastern Alps RBD as a whole is evident especially in public consultation regarding the identification of significant issues of water management (Distretto Alpi delle Orientali, 2016).

Issues with public and stakeholder engagement associated with the traditional centralised and hierarchical water management practices are also seen in Greece. Generally, the centralised

political and administrative structure, the weak civil society and the absence of a consensus-building approach have been one of the impediments to the emergence of the EU-required participatory models of governance in Greece (Demetropoulou *et al.*, 2010; Featherstone, 2005). In the case of the Evrotas basin, the EnviFriendly project (Environmental Friendly Technologies for Rural Development) assisted with the preparation of the basin's integrated watershed plan (Demetropoulou *et al.*, 2010). The project organised the public participation process for the Evrotas basin in full consideration of the centralised and hierarchical nature of the Greek state as well as the limited experience in participatory processes (EnviFriendly, 2009). The project has been successful in providing the foundations for stakeholder consultations and active involvement for the development of the integrated watershed plan. Overall, given the inexperience of Greece in participatory practices (Demetropoulou *et al.*, 2010), actively pursuing opportunities for collaborative governance and adopting the lessons identified from the EnviFriendly project must be the core focus of the future planning cycles to meet the shift towards the collaborative catchment management approach of the WFD.

For the Ebro RBD, the Ebro Hydrographic Confederation has set up the pre-conditions for adopting integrated water management, and despite the basin's experience in water governance at the catchment level challenges still exist in the context stakeholder engagement. For example, in the draft of the Hydrological Plan for Ebro RBD, there is a formal participative process in the preamble and some room for different stakeholders to express their points of view, but the plan is elaborated through a top-down process that is often not conducive of the multiple interests and preferences for water allocation (Bielsa and Cazcarro, 2015). Additionally, insights regarding the public participation process during the first WFD cycle indicated that despite consultations being carried out, there were no opportunities for deliberation or opinion exchange and also it was identified that there has been minimal effort to continue engagement efforts (Ballester and Lacroix, 2016). Indeed, effective engagement is seen as a learning process and in fact, the introduction of the WFD initiated the means for participatory process, providing the means for stakeholder dialogue in the Ebro RBD (Ballester and Lacroix, 2016). However, it should be noted that participatory experiences from the Matarraña sub-catchment of the Ebro RBD indicated some examples of best practice in stakeholder engagement, which emphasised the importance of integrating natural and social sciences for effective catchment management (Bielsa and Cazcarro, 2015).

For the Sava basin, the legal basis for cooperation is the Framework Agreement on the Sava River Basin (FASRB). To operationalise the principles of FASRB, the International Sava River Basin Commission (ISRBC) was established (ISRBC, 2011). The ISRBC has adopted the rules of procedures formalising public participation in the Sava basin following the requirements of the WFD. According to Samardžija and co-workers (2013) extensive stakeholder engagement was carried out to ensure that stakeholders were consulted and their views and interests were presented in the development of the Sava RBMP. However, scope for improvement have also been identified through the development of Sava Water Partnership which would serve as a platform for involving all groups of stakeholders to further enhance stakeholder involvement (ISRBC, 2011).

Generally, water management in the UK has been historically characterised by a top-down, technocratic and exclusionary approach to participation that primarily involved agencies and water companies (Fritsch and Benson, 2013). However, much progress has been done to meet the participatory requirements of the WFD in the UK as a whole and in the Anglian RBD. The UK Environment Agency ensured that the opportunities for the provision of information, consultations and active involvement were in place to meet the WFD's participatory provisions (Benson *et al.*, 2014). However, according to the findings of Benson and co-workers (2014) there were issues regarding the involvement of the public as well as participants expressing their concerns that the actual participatory process had only marginally influenced the plan production and that the planning process generally followed a pre-designed agenda

determined by the Environment Agency central office. Nonetheless, the Environment Agency's provisions for public participatory processes for the UK as a whole already exist thereby creating opportunities for water management to transition towards inclusive community based governance.

The way forward

Effective implementation of the WFD requires acquiring in depth understanding of the catchment rather than the more traditional focus on policy compliance therefore enabling the Directive's systemic intent to be delivered is important in realising its full potential (Voulvoulis *et al.*, 2017). Central to this is managing catchments as systems by understanding the human-nature interdependencies that exist, and having a tailored approach rather than following a single mandate for management. Enabling the systemic intent of the WFD to be realised in its implementation could be facilitated through:

Integration of Ecosystem Services (ES) to supplement the pressure-impact analysis

Overall, there is significant scope for improving the analysis of pressures and impacts in order to identify significant pressures that need to be managed by the WFD's PoMs. According to the WFD Guidance Document on the Analysis of Pressures and Impacts, a successful pressures and impacts study will be one that promotes a proper understanding of the objectives, a good description of the water body and its catchment areas and a knowledge of how the catchment-system functions (European Communities, 2003b). To supplement this, the complex interactions within the catchment need to be explored with the scope of understanding how the pressures affect the overall ecosystem health (state of the system), which could also incorporate potential influences on those benefits or ES that could be received from those ecosystems as a means to assess the significance of those pressures.

Even though ES are not explicit in the wording of the WFD, there is a clear connection between the Directive and their delivery (Vlachopoulou *et al.*, 2014). The link between pressures, status and PoMs needs to be clarified and that the improvement in element classifications should not be perceived as the only end point when PoMs are selected. As stated, the focus on improving element classifications not only assumes linear causalities in improving ecosystem health (state of the system) in order to improve water quality, but also could lead to tendencies for the wider intent and objectives of the Directive often being overlooked. The purposeful integration of ES to the WFD implementation process has been widely acknowledged as an important evolutionary step for the Directive to better achieve its broader goals for sustainability (Vlachopoulou *et al.*, 2014). By establishing the interdependencies between anthropogenic pressures and the provision of those ES, creates additional evidence to support the development of PoMs and in turn shift overall policy implementation towards meaningful outcomes by translating how the WFD objectives and implementation process in the context of broader socio-economic welfare (Everard, 2012). Additionally, the integration of ES is important in supporting the economic appraisals of PoMs for the WFD (Martin-Ortega, 2012). By incorporating potential welfare gains to the management of potentially degrading catchment activities (pressures) then the economic basis for PoMs would be better improved and thus create a more robust justification for their development (Spray and Blackstock, 2013). Also, if the value of those services are available as part the integration of ES assessments in the WFD, such information would further aid in the economic appraisal of measures, as it could inform which pressures are affecting on those most valued services and therefore provides a means to prioritise management action.

Promoting interdisciplinarity in the decision-making process

Catchments are composed of highly interdependent human and natural systems and due to this complex web of interactions; the WFD implementation based on catchment management was never going to be an easy process. Addressing such complexity requires interdisciplinary research and knowledge integration (Voulvoulis, 2012). The WFD considers the importance of public participation as an essential ingredient for a successful river basin planning and management (Steyaert and Ollivier, 2007), and therefore participatory approaches should be at the core of mediating different courses of action. Catering for higher forms of stakeholder involvement would provide opportunities to better frame the WFD's objectives into outcomes relevant to those stakeholders and thus build capacity for facilitating genuine support and commitment in overall policy implementation (Everard, 2012). This means providing opportunities for stakeholders to deliberate and discuss management issues and courses of action as well as to empower those actors by giving them the opportunity to contribute to the development of solutions for those issues within the catchment (Wright and Fritsch, 2011).

By effectively communicating the interdependencies between pressures and ES in order to supplement the pressure-impact analysis of the WFD to support the development of appropriate PoMs could aid in building genuine support from those who live in the catchment and will likely pay for such investments. Facilitating a participatory process where stakeholders and all parties are involved and collaborate in the decision-making process is an integral part of the interdisciplinarity required to implement the WFD effectively. Ultimately, actively pursuing the integration of multiple perspectives not only provides a more robust understanding of the catchment and its interactions necessary to inform an effective management strategy but could also facilitate public acceptance and create opportunities for better policy decisions (Howarth, 2009). Indeed, it should be noted that much progress is happening towards incorporating and improving participatory water management even in cases where public involvement and cross-sectorial cooperation have been previously limited (Jager *et al.*, 2016).

The role of GLOBAQUA: Towards improved policy implementation

GLOBAQUA is a EU-funded project aiming to identify the prevalence of, and interaction between, stressors under water scarcity in order to improve knowledge of relationships between multiple stressors and to improve water management practices and policies. The project's focus on policy, from understanding the policy challenges to producing scientific results that will be integrated with the demands of policy-makers and national/EU environmental agencies, has been an opportunity for integration across all modules and work packages (WPs) of the project (Figure 12.2b2.2).

Supported by the scientific results and information from the STRESSORS and RECEPTORS modules, the more relevant WPs directly associated with informing the selection and development of WFD measures includes WP8-11. The work associated with each of these WPs in relation to the themes identified in order to improve WFD implementation and development of PoMs would be discussed as follows.

WP8-SERVICES aims to assess the effects of multiple stressors on freshwater ecosystem services, which ultimately could supplement the pressure-impact assessment that is required to inform the development of PoMs. As discussed, the concept of Ecosystems approach through the integration of ecosystem services is already considered as a process that would benefit the WFD implementation. The outputs of this WP would directly contribute towards understanding the relationship between the pressures within the catchment and those benefits to societal welfare.

WP9-SOCIOECON supports the economic appraisal and selection of PoMs by integrating those ecosystem services. This work of this WP would provide information on least-cost measures and justify exemptions based on disproportionality, which is also important to support the objectives of the WFD.

WP10-VALUATION protocols introduced opportunities for engaging catchment stakeholders necessary to facilitate the integration of multiple perspectives and disciplines in water management. Also, the WP focuses on integrating ecosystem service valuations into the implementation of the WFD creates a common language for the communication of the benefits for society that could aid in developing PoMs that would safeguard those benefits through an effective pressures management.

WP11-INTEGRATION aims to deliver a model framework that would assess the effects of pressures (stressors) and the effects of management measures complements the objectives of the WFD by supplementing the pressure and impact analysis and in-depth catchment understanding under multiple stress conditions.

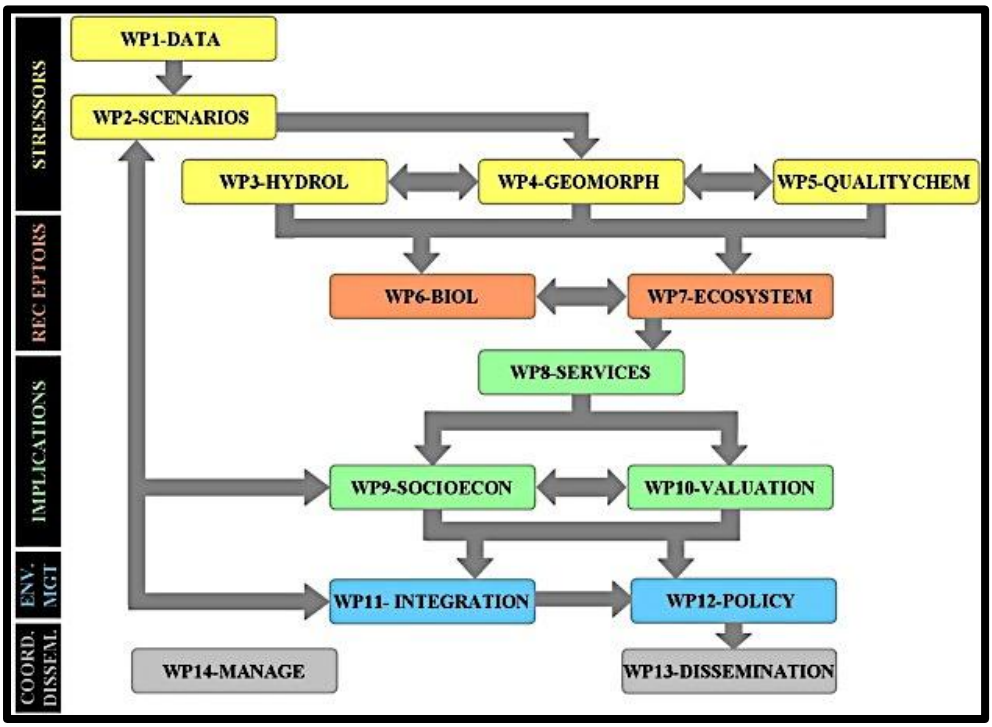

Figure 12.2b2.2. Module and work package structure of GLOBAQUA (Navarro-Ortega et al., 2015).

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GLOBAQUA: PROJECT DESCRIPTION

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GLOBAQUA is a project funded by the Seventh EU Framework Programme under the full title: *Managing the effects of multiple stressors on aquatic ecosystems under water scarcity*. It is active since February 2014 and will continue until January 2019. It assembles a multidisciplinary team of hydrologists, chemists, biologists, geomorphologists, economists and sociologists, including experts in modelling, in socio-economics and governance science, and in knowledge brokerage and policy advocacy. GLOBAQUA comprises 25 partner organisations from 10 EU countries as well as one Associated Country (Serbia) and 2 non-EU partners (Morocco and Canada). Scientific, financial and administrative management of the project is carried out by the Institute of Environmental Assessment and Water Research of the Spanish Council of Scientific Research (IDAEA-CSIC). The team involves researchers, but also practitioners and end-users such as policy-makers and river basin managers.

FURTHER INFORMATION

- For further information on GLOBAQUA, please visit: http://www.globaqua-project.eu/en/home/
- For further information on the Water Framework Directive's innovative approach and issues with implementation, see Voulvoulis *et al.* (2017): http://dx.doi.org/10.1016/j.scitotenv.2016.09.228