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The potential of using the Ecosystem Approach in the implementation of the EU Water Framework Directive

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HIGHLIGHTS

- We investigated how the Ecosystem Approach could facilitate WFD implementation.
- A framework linking ecosystem services and water management objectives is proposed.
- The benefits of using the Ecosystem Approach in WFD implementation are identified.
- The Ecosystem Approach can contribute to more holistic water resources management.

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ABSTRACT

The Ecosystem Approach provides a framework for looking at whole ecosystems in decision making to ensure that society can maintain a healthy and resilient natural environment now and for future generations. Although not explicitly mentioned in the Water Framework Directive, the Ecosystem Approach appears to be a promising concept to help its implementation, on the basis that there is a connection between the aims and objectives of the Directive (including good ecological status) and the provision of ecosystem services. In this paper, methodological linkages between the Ecosystem Approach and the Water Framework Directive have been reviewed and a framework is proposed that links its implementation to the Ecosystem Approach taking into consideration all ecosystem services and water management objectives. Individual River Basin Management Plan objectives are qualitatively assessed as to how strong their link is with individual ecosystem services. The benefits of using this approach to provide a preliminary assessment of how it could support future implementation of the Directive have been identified and discussed. Findings also demonstrate its potential to encourage more systematic and systemic thinking as it can provide a consistent framework for identifying shared aims and evaluating alternative water management scenarios and options in decision making. Allowing for a broad consideration of the benefits, costs and tradeoffs that occur in each case, this approach can further improve the economic case for certain measures, and can also help restore the shift in focus from strict legislative compliance towards a more holistic implementation that can deliver the wider aims and intentions of the Directive.

1. Introduction

The Water Framework Directive (WFD) (2000/60/EC) introduced a legal framework to protect and restore the water environment across Europe and ensure its long-term, sustainable use. It establishes water management based on river basins, the natural geographical and hydrological unit for fresh waters and sets specific deadlines for Member States to protect aquatic ecosystems. The WFD is the most substantial piece of water legislation ever produced by the European Commission, and is the major driver for achieving sustainable management of water in the UK (Collins et al., 2012). It requires Member States to prevent further deterioration of water resources and to protect and enhance the status of water bodies through programmes of measures. Under article 4(1) of the WFD, Member States are required to improve the overall status of water bodies, in order for both the 'ecological status' and 'chemical status' of surface water bodies to be at least good, with 'good groundwater status' (quality and quantity) for groundwater bodies, all by 2015 (European Parliament and Council, 2000).

The goal of WFD implementation is the sustainable management of water resources by taking due account of environmental, economic and social considerations. In doing so, and following the steps of the Dublin

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Principles (1992), the World Commission on Dams 'strategic priorities' (2000) and Aarhus Convention (1998) requirements, the Directive adopts critical principles for water management, including public participation in planning and economic approaches such as the recovery of the cost of water services. It provides a framework that covers all aspects of management of the water environment, with its programmes of measures also including responses required under related Directives such as the Urban Waste Water Treatment (UWWT) Directive (91/271/EEC), the Bathing Water Directive (76/160/EEC), and the Environmental Impact Assessment Directive (85/337/EEC), among others (Collins et al., 2012).

The WFD's economic requirements, including cost-effectiveness analysis, exemptions and disproportionality of costs, cost recovery and incentive pricing, are a considerable administrative challenge for water management, both methodologically and in terms of data (ESAWADI, 2011). Almost all EU Member States have spent considerable time and resources to develop tools to better assess the condition of the aquatic environment, acquire the required data and prepare river basin management plans. In this context, both the EU and its Member States have funded a large number of research projects, particularly in the areas of ecological assessment and catchment modelling (Hering et al., 2010). During the last decade, a variety of indicators, target values, reference setting approaches, and a diversity of schemes relevant to different types of surface waters have been developed for evaluating ecological status for surface water bodies (Van Hoey et al., 2010), and these are still the focus of much continuing discussion. The implementation of the WFD is greatly increasing knowledge about the ecology of European surface waters, particularly in regions which have rarely been investigated: approximately 3742 papers have resulted from associated research projects (query 'Water Framework Directive' in SCOPUS on 04/09/2013). Many methods to sample and investigate aquatic ecosystems have been developed and large amounts of data are being generated (Hering et al., 2010). Challenging aspects of the implementation include the quantification of complex and dynamic biological communities into concise classification systems, the establishment of ecological reference conditions and the determination of the uncertainty in the resulting classification (Hering et al., 2010).

There is an inherent difficulty associated with assessing the value of environmental quality and therefore the benefits of water management measures aimed at improving water body status. This is because the value of environmental quality, the ways in which the natural environment supports human well-being, is often not fully understood or measured, to the extent that support for WFD implementation is often regarded by some as an altruistic task (Everard, 2012). Therefore there is a great need for better demonstration and communication of the benefits of WFD implementation and the impact they have on people's lives (ability to fish or swim in rivers or lakes, the costs of treatment and availability of water for abstraction to public supply, etc.). Taking into account the importance of public participation and involvement as an essential component of WFD implementation, this becomes a very important and challenging task that will require appropriate strategies, often a time-consuming but essential component of policy implementation (e.g. Article 14 of WFD).

Ecosystem services, i.e. the benefits people obtain from ecosystems, have received a lot of attention in recent years, for instance through the UN *Millennium Ecosystem Assessment* (MEA, 2005) or *The Economics of Ecosystems and Biodiversity* (TEEB, 2010) initiative of the European Commission (through the European Environment Agency). The Ecosystem Approach originated from the Convention on Biological Diversity (CBD) and sets a socio-economic context into which a consideration of ecosystems and their multiple services in decision making can be integrated. Ecosystem services therefore form part of the wider Ecosystem Approach.

Unlike the International Guidance for Integrated Water Resources Management (IWRM) (Global Water Partnership, 2000) which embraced the language of ecosystem services at a very early stage, the WFD stayed away from the terminology during the first round of river basin management planning. Though ecosystem services are not explicitly mentioned in the WFD, the Directive is nonetheless ecosystem-focused and has the purpose of protecting future human uses of the

Table 1
Links between WFD principles and the Ecosystem Approach.

WFD	Ecosystem Approach
Article 1 Purpose Prevents deterioration and enhances status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems To promote the sustainable consumption of water To reduce pollution of waters from priority substances Ensures progressive reduction in pollution of groundwater and prevents further pollution Contribute to mitigating the effects of floods and droughts	*Ecosystem services supported*: Freshwater, food, genetic resources, provision of habitat, water regulation, natural hazard regulation, disease regulation, erosion regulation, water purification and waste treatment, all cultural services. *CBD*: (3) Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems; (5) Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the Ecosystem Approach.
Article 3 Coordination of administrative arrangements within river basin districts	*CBD*: (2) Management should be decentralised to the lowest appropriate level
Article 4 Environmental objectives *Surface waters*: Good ecological status, Good ecological potential, No deterioration in status, Good chemical status *Groundwater*: Prevent and limit inputs of pollutants, Good quantitative status, Good chemical status, No deterioration, Reverse trends *Protected areas*: Drinking water protected areas, Freshwater fish and shellfish, Bathing Waters, UWWTD, SACs, SPAs	*Ecosystem Services supported*: Most provisioning, supporting, regulatory, and cultural services. CBD: (5) As above; (6) Ecosystems must be managed within the limits of their functioning; (9) Management must recognise that change is inevitable
Article 5 Characteristics of the river basin district, review of the impact of human activity and economic analysis of water use	CBD: (4) Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context; (5) As above; (6) ecosystems must be managed within the limits of their functioning; (9) as above
Article 7 Waters used for the abstraction of drinking water Reduce level of purification of drinking water, water treatment regime	*Ecosystem services supported*: Freshwater, disease regulation, water purification and waste treatment
Article 9 Recovery of costs for water services Take account of the principle of the costs of water services, including environmental and resources costs	*CBD*: (4) As above
Article 14: Public participation and consultation Encourage the active involvement of all interested parties in the implementation of the Directive, in particular in the production, review and updating of the river basin management plans	CBD: (1) The objectives of management of land, water and living resources are a matter of societal choices; (11) the Ecosystem Approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices; (12) the Ecosystem Approach should involve all relevant sectors of society and scientific disciplines

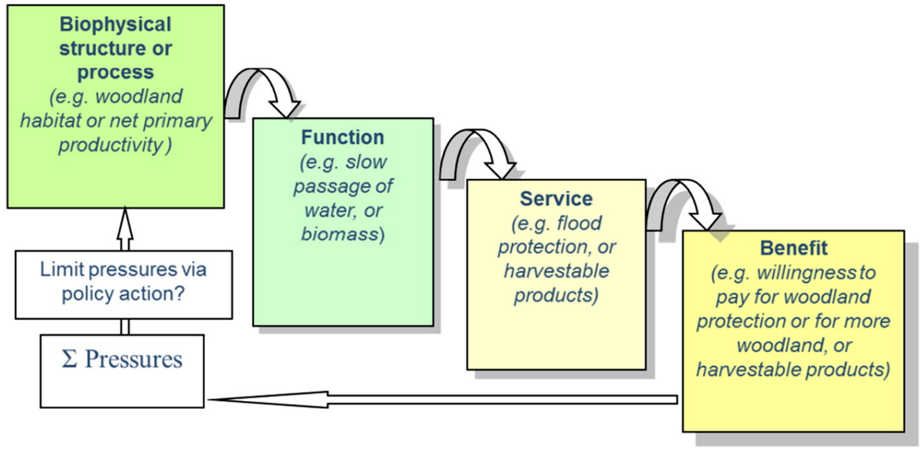

Fig. 1. From ecosystem structure to derived benefits.
Source: Haines-Young and Potschin (2009).

environment when implemented in a social and economic context. There is a clear connection between the WFD and both the delivery of ecosystem services and also principles of the Ecosystem Approach as outlined in the CBD (Secretariat of the Convention on Biological Diversity, 2004) (Table 1).

In this paper, the methodological linkages between the Ecosystem Approach and the implementation of the WFD were reviewed and the possibility of the WFD and the Ecosystem Approach acting in a complementary way was further explored. With a focus on the potential 'added value' of the Ecosystem Approach in the WFD decision-making process, evidence from the literature is considered to provide a preliminary assessment of how it could support future implementation.

2. Relating WFD outcomes to ecosystem services

2.1. Ecosystem structure, functions and services: definitions and links

Definitions of ecosystem functions, much as with ecosystem services, vary in the literature. Functions can indicate some *capacity* or capability of the ecosystem to do something that is potentially useful to people (provide goods and services) (de Groot et al., 2002). In line with this definition, Haines-Young and Potschin (2009) developed a 'service cascade' (Fig. 1) that summarises much of the logic that underlies the contemporary ecosystem service model. In this case, there is a 'production chain' linking ecological structures and processes with elements of human well-being, with a series of intermediate stages between them.

Whether a function is regarded as delivering a service depends on the spatial and temporal context, and on social values. The degree to which an ecosystem service will provide benefits is also context-dependent and it may mean different things to different stakeholders. However, simply stated, ecosystem services are the benefits people obtain from ecosystems (MEA, 2005), with the link between ecosystem functions and services most direct for functions that are regulating or supporting services (e.g. nutrient cycling) within the MEA definition.

Ecosystem functions are also often regarded as being internal processes of the ecosystem, and functional indicators are measures of the rate, or relative importance, of a particular process happening in an ecosystem such as the rates of production, respiration, and material or nutrient cycling. Structural and functional components of ecosystems are elaborately linked and describe different aspects of the same entity, with the number and types of organisms present at a site, for example, being dependent on functional processes. Moreover, many ecosystem functions are responsible for maintaining ecosystem condition in a healthy state (e.g. the buffering capacity of soil prevents acidification by SO_X).

The relationship between structure and function as expressed through measurements of structural and functional indicators can take different forms. According to Matthews et al. (1982), an ecosystem can theoretically respond in three different ways to a human induced stressor: changes to ecosystem structure without changes in functional parameters (such as when a species of a community is lost but the surviving species can perform the same functions as the ones that were lost so that no effect on ecosystem functionality will be seen); changes to ecosystem function without structural changes; and changes to both structural and functional components. Moreover, it is possible that while there are no changes to structure nor function, ecosystem resilience is affected. These relationships demonstrate the importance of combining the use of functional and structural indicators as they work in a complementary way, and the emphasis of WFD implementation could usefully be shifted away from fragmented activity that promotes adherence to the precise wording of articles and towards the use of functional measures in line with evolving world views about connected systems.

2.2. Linking WFD implementation with ecosystem services

Much of the WFD ecological surface water monitoring specifies biological structure rather than function. Structural indicators focus on biological community composition, quantity and distribution of abiotic resources, or the range, gradient, or conditions of existence, such as temperature (Matthews et al., 1982). The requirements of the WFD assessment schemes, as outlined in Annex II and V, predominantly relate to structural elements rather than functional ones. As shown in Fig. 2,

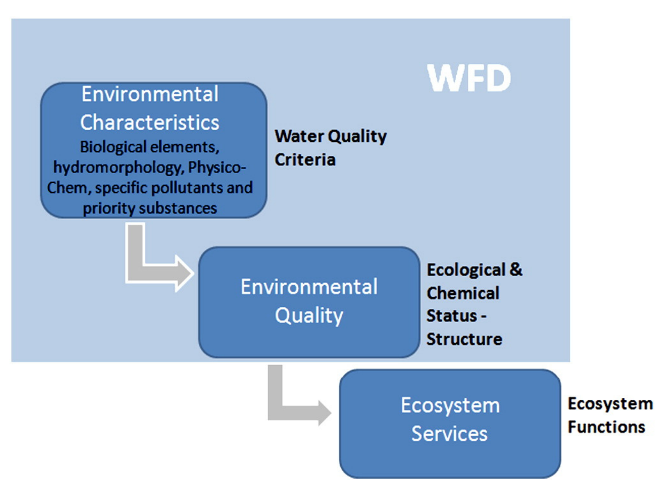

Fig. 2. The link between environmental characteristics of surface waters and ecosystem services in the WFD.

achieving the required structural (environmental) characteristics leads to the achievement of good ecological and chemical status for surface water bodies which together lead to 'good surface water status'. This is equivalent to the environmental quality whereby water bodies have the potential to deliver ecosystem services.

A major link between WFD implementation and ecosystem services is provided by those ecosystem functions which give rise to services, and the assumption that good ecological and chemical status is a prerequisite for ecosystem functions. This becomes even clearer as the presence or lack of ecologically intact watercourses affects the provision of ecosystem services. This relationship is currently more apparent when lacking, such as failing to meet good ecological status, rather than via the ecosystem benefits delivered through broad implementation of environmental management through the WFD. This means that if human pressures result in moderate/bad/poor WFD status for a certain water body, the impact will be felt through the absence or reductions in the quality of ecosystem services (for example, unsuitability of a water body for fishing, swimming, and other recreational activities, reduction in its aesthetic value, or additional costs in service delivery such as additional treatment cost to provide drinking water). On the other hand, if a water body meets WFD objectives, being subject to only minor anthropogenic pressures, the significance of compliance as well as the potential gains from further improvements may not be as noticeable unless the service is valued at the same time. Future improvements caused by progressive improvement in WFD compliance should ensure that the positive link will become more apparent. In other words, improving the status is likely to result in greater ecosystem benefits.

An example of how the deterioration in water quality can directly affect 'ecosystems services' is provided in the case of the Danube River Basin (DRB), Europe's second largest river basin. The river basin supports the supply of drinking water, agriculture, industry, fishing, tourism and recreation, power generation, navigation and the end disposal of waste waters. However, organic pollution, hydromorphological alterations (e.g. water and habitat continuity interruptions and wetland/floodplain disconnection), hazardous substance pollution and nutrient pollution (Schmedtje, 2005), have had a clear impact on its quality and the provision of the above benefits. For example, groundwater quality was degraded by nitrate contamination, leading to an increase in the cost of drinking water treatment. The observed impact on fisheries was a loss of sensitive species, and a loss of recreational benefits and opportunities was noted. Observations were accordingly made for the impact of hazardous substances, microbiological contamination, growth of heterotrophic organisms, oxygen depletion and the competition for available water on water uses.

2.3. The proposed framework

In order to apply the Ecosystem Approach to WFD implementation it is therefore proposed to link WFD objectives to ecosystem services. This involves reviewing individual River Basin Management Plan (RBMP) objectives, qualitatively assessing how strong their link is with individual ecosystem services (scoring) and evaluating whether an objective is a key intended indicator of a specific service (evaluation). All these components brought together in a comprehensive and detailed matrix can provide a basis for direct comparison of benefits and related services. The matrix is presented in Table 2. It includes:

- *Scoring*. The first step is applying a scoring system from 0 to 3 to indicate the extent to which the achievement of a specific objective could help deliver an ecosystem service. The scoring here is only illustrative and subjective and would be best developed with stakeholders so that they are based on a wider set of forms of knowledge and to enhance participation in decision-making in line with principles 1, 11 and 12 of the CBD (Secretariat of the Convention on Biological Diversity, 2004). It is nevertheless a realistic starting point for discussion. For example, achieving good chemical status for groundwater supports the provision of fresh water and to a lesser extent (but still substantially) the provision of food (score 2), but is less directly linked with the provision of fibre and fuel, genetic resources, biochemicals, natural medicines and pharmaceuticals.
- *Evaluation*. This step judges whether an objective is a key intended indicator of a specific service i.e. whether water management objectives were conceived and designed with certain ecosystem services in mind. An objective is either a key intended indicator (shown in dark grey) or a possible indicator (light grey) for an ecosystem service. While, for example, good ecological status of surface waters is a key indicator for freshwater and food, it is judged as a possible indicator for enhancing genetic resources used for crop/stock breeding or biotechnology. Some WFD objectives are directly related to ecosystem services: for example, the objective of not requiring extra treatment of groundwater has a direct link with the provisioning service (water). While linking the benefits of WFD compliance with ecosystem services is particularly useful to encourage public participation, working at the level of WFD objectives is also relevant in a policy and decision making context. The information provided by the proposed matrices could therefore help inform decision making by showing which water management objectives can best target ecosystem services according to existing needs.

Because the interrelationships between environmental components are intricate and complex, the proposed framework only aims to provide a simple and conceptual method to support decision makers and other stakeholders in assessing case studies, aiming to communicate these complex relationships with simplicity and clarity. It does not aim to be a decision making tool but a method to help understand the levels of interactions between water management objectives and ecosystem services, therefore helping to prioritise actions according to need and availability of resources, and to identify trade-offs in a transparent process. Most WFD objectives relate to freshwater provision that links with food production and prevention of poisoning. This includes both quality and quantity aspects. In many ways these are rather obvious and have been the basis of water management for many years. The proposed framework, however, allows for identification of additional ecosystem services such as cultural ones (recreation and tourism, aesthetic value, etc.), and could serve as a good check list for economic assessments under the WFD.

3. Benefits of the Ecosystem Approach

The benefits of using the Ecosystem Approach for WFD implementation are clear in the case of ecosystem structural components which are critical to ecosystem service delivery. Otherwise, understanding the potential of an ecosystem to deliver services requires evaluation of the functioning of the ecosystem and assessment of the quality of the community structure as well as the interrelationships between species, addressed mainly as ecological status by the WFD. Furthermore, linking WFD objectives to ecosystem services, as described earlier, involves reviewing individual RBMP objectives, qualitatively assessing how strong their link is with individual ecosystem services and evaluating whether an objective is a key intended indicator of a specific service. The main benefits of using this process to facilitate WFD implementation are further discussed below.

3.1. More systematic and systemic thinking, and improved evidence collation

The Ecosystem Approach can enrich WFD implementation and can help regulators engage with the public by focusing on meaningful outcomes. It can encourage more systematic thinking as it can provide a consistent framework for identifying shared aims and evaluating alternative water management scenarios and decision making, allowing for a broad consideration of the benefits, costs and tradeoffs that occur in each case.

Table 2
Linking WFD objectives with ecosystem services.

Services	Benefits	Sustainable management and protection of water																											
		Article 4															Article 7		Repealed directives						Article 1				
		1				2					3														Aims				
		a	b	c	d	a	b	c	d	e	a	b	c	d	e	f	a	b	a	b	c	d	e	f	a	b	c	d	e
Provisioning services																													
Fresh water	• Enough clean water for drinking • Water for domestic use (cleaning, washing, toilets, etc.) • Enough water for irrigation • Enough water for industry (manufacturing, power, etc.–cooling, cleaning, products)	3	2	3	3	3	3	3	3	3																			
Food (e.g. crops, fruit, fish, eating birds)	• Farmed food (or material to make drinks) for people and animals which is grown or raised by impacting the environment as little as possible and where the beneficial effects of wild plants and animals (natural pest control, pollination) in farming are encouraged (grains, vegetables, fruit, me at, milk, farmed seafood, sport shooting) • Wild food (or material to make drinks) taken from the environment without impacting natural communities of plants and animals and the places that they live (nuts, berries/ fruit, mushrooms/fungi, fish, shellfish, seaweed, seafood, rabbits)	2	2	2	2	2	2	2	2	2																			
Fibre and fuel (e.g. timber, wool, reeds)	• Cultivated materials used for fuel, building or manufacturing, etc. which are grown by impacting the environment as little as possible and where the beneficial effects of wild plants and animals (natural pest control, pollination) in farming are encouraged (timber, paper, twines, ropes, charcoal, fuelwood, other biofuels). • Wild materials used for fuel, building or manufacturing etc taken from the environment without impacting natural communities of plants and animals and the places that they live (sand, thatch, straw, waxes, dyes and gums, charcoal, fuel, wood, medical materials)	1	2	1	1	1	2	1	2	1																			
Genetic resources (used for crop/stock breeding and biotechnology)	• Genetic variability required to ensure resilience and therefore survival of beneficial plants, animals and fungi. • Genes taken from environment used to ensure future resilience in cultivated plants, animals and fungi.	1	1	1	1	1	1	1	1	1																			
Biochemicals, natural medicines, pharmaceuticals	• Cultivated materials used to extract biochemicals, natural medicines, pharmaceuticals and other medicinal substances (lavender and other essential oils, anti-cancer drugs etc.) • Wild materials used to extract biochemicals, natural medicines, pharmaceuticals and other medicinal materials (perfumes, oils, anti-aging drugs, anti-cancer drugs)	1	1	1	1	1	1	1	1	1																			
Ornamental resources (e.g. shells, flowers)	Flowers, plants, animals, shells etc. taken from the environment without impacting natural communities of plants and animals and the places that they live.	1	1	1	1	1	1	0	1	0																			
Energy harvesting (non–MA)	Hydropower, thermal power, wave power and wind power without significantly impacting natural communities of plants and animals and the places that they live.																												
Supporting services																													
Soil formation	• Enough fertile and healthy soil	2	2	2	2	2	2	2	2	2																			
Primary production	• Biomass	2	2	2	1	1	1	1	1	1																			
Nutrient cycling	• Cycling and transportation of key nutrients (N, P, S and C) and other substances essential for life which ensure fertility and quality of soil, air and water to supply other benefits	2	2	2	2	2	2	2	2	2																			
Water recycling	• Flow of water through ecosystems in its solid, liquid, or gaseous forms. Transfer of water from soil to plants, plants to air, and air to rain	3	2	3	3	3	3	0	3	0																			
Photosynthesis (production of atmospheric oxygen)	• Generation of oxygen through photosynthetic processes	2	2	2	1	1	1	1	1	1																			
Provision of habitat	• A certain level of biological diversity is essential for maintaining all other functions and services	3	3	3	1	1	1	1	1	1																			

Services	Benefits	Sustainable management and protection of water																											
		Article 4															Article 7		Repealed directives						Article 1				
		1				2					3														Aims				
		a	b	c	d	a	b	c	d	e	a	b	c	d	e	f	a	b	a	b	c	d	e	f	a	b	c	d	e
Regulatory services																													
Air quality regulation	• Clean air free of noxious chemicals and particulates.	2	1	2	2	2	0	0	0	0																			
Climate regulation (e.g .local temperature/precipitation, GHG sequestration)	• Capture and storage of carbon dioxide and other green house gases • Prevention of local heat island effects. • Shelter from wind and rain (people, crops/livestock and buildings) • Regulation of local weather • Protection from sun	2	1	2	2	2	0	0	0	0																			
Water regulation (timing and scale of run-off, flooding, etc.)	• Enough clean water for drinking • Water for domestic use (cleaning, washing, toilets etc.) • Enough water for irrigation • Enough water for industry (manufacturing, power etc.–cooling, cleaning, products)	3	2	3	2	2	3	0	3	0																			
Natural hazard regulation (i.e. storm protection)	• Reduced drought risk • Reduced flood risk • Reduced storm risk • Reduced erosion risk	3	2	3	0	0	0	0	0	0																			
Pest regulation	• Reduced incidence of pest and nuisance plants and animals (e.g. rats, aphids, weeds, aggressive plants, etc.)	1	1	1	1	1	0	0	0	0																			
Disease regulation	• Reduced instance of disease	1	1	1	1	1	0	2	2	2																			
Erosion regulation	• Preservation of fertile soils from water and wind • Preservation of natural flood defence structures • Protection of property • Protection of life (from landslides etc)	2	2	2	0	0	2	0	2	2																			
Water purification and waste treatment	• Clean water • Preservation of fertile soils • Prevention of human and animal poisoning and other health effects of pollution • Trapping pollutants	3	2	3	3	3	3	2	3	2																			
Pollination	• Pollination of crops and natural vegetation • Seed dispersal	1	1	1	1	1	0	0	0	0																			
Noise and light regulation (non MA)	• Reduced noise and light pollution from industrial and building sites, roads, entertainment districts, airports, etc.																												
Cultural services																													
Cultural heritage	• Local character • Archaeological interest • Historic mills, ports, landscapes	2	2	2	2	2	2	1	2	1																			
Recreation and tourism	• Recreation and tourism derived from natural and semi-natural environment (incl. walking, camping, swimming, fishing, boating, canoeing, birdwatching, running, site-seeing/driving, photography, etc.)	2	2	2	1	1	1	1	1	1																			
Aesthetic value	• Increased property prices • Amenity and population stability • Beautiful landscapes	3	2	3	1	1	1	1	1	1																			
Spiritual and religious value	• Spiritual fulfilment • Religious uses (holy water, holy springs) • Knowing that natural environment is still there	1	1	1	1	1	1	1	1	1																			
Inspiration of art, folklore, etc.	• Inspiration for folklore and art, including books, movies, photography, fine art, music, dance, fashion, and architecture	2	2	2	1	1	1	1	1	1																			
Social relations (e.g. fishing or cropping communities)	• Focal point for community activities, both through formal (e.g. fishing, walking) and informal (such as volunteer activities) pursuits	2	2	2	1	1	2	1	2	1																			
Intellectual, scientific, knowledge, educational (non MA)	• Formal and informal study and education • Research(general but also life protecting) • Natural inspiration for technology • Influence on knowledge systems																												

Systemic thinking involves looking at all the components of a system and their interactions. Water management problems are often complex, dynamic systems consisting of interdependent factors and multiple stressors. Reductive science was founded on understanding individual disciplines rather than developing an interdisciplinary understanding, while regulatory decision-making has tended to run on a legacy of addressing individual problems by comparing alternative courses of action, rather than on developing a wider understanding of systems and the complex interrelationships within them. In the face of climate change that threatens to cause major alterations to hydrological cycles, adopting a systems approach for water management is of particular importance, and a change in mindset is required to focus on re-assessing what the real problems are from a wider, systems perspective (Voulvoulis, 2012). The Ecosystem Approach provides a framework for establishing systemic understanding, as it underlines the relationship between land and water, promotes the need to view actions proposed to benefit the water environment in the wider environmental, economic and social contexts, and encourages the creation of a stronger and more encompassing knowledge base on the properties, functions (capacity and potential) and the delivery of services with a location-specific approach. It thereby also supports evidence collection, collation and analysis.

Systemic thinking also demands understanding the long-term dynamics of a water body. This can help inform management actions in terms of feasibility, expected outcomes, time, cost, etc. A particularly controversial component of the WFD has been the concept of reference conditions for assessing the status of water bodies. These refer to a state in which there are ‘no, or only very minor, anthropogenic alterations’ to water bodies. Besides the practical difficulty of defining such conditions, it has been suggested that this approach does not take into consideration the fact that river basins fundamentally change over time due to a combination of factors such as natural succession, climate change, invasive species and landscape changes (Baaner and Josefsson, 2011). In fact, the 9th Principle of the CBD explicitly acknowledges that ecosystems inevitably change and that this must be recognised by management which should seek to be adaptive in order to anticipate and cater for such changes and events (Secretariat of the Convention on Biological Diversity, 2004). Long-term ecosystem management should therefore identify the trajectory or direction in which ecosystems change to ensure that concepts such as path dependency and self-organisation are properly accounted for. Although most of these changes are not of the same time frame as the 6 year cycle of river basin management plans, an ecosystem service viewpoint can support understanding of system dynamics and therefore cost-effective decision making by, for example, helping determine what is achievable and indeed socially desirable for a given water body.

By encouraging a framework for systemic thinking, especially one that can make use of the many available tools and techniques of ecosystem restoration, the Ecosystem Approach encourages the consideration of a greater breadth of alternative courses of action for achieving desired improvements of the water environment that go even beyond the scope of the Directive. The introduction of a novel action/approach or combination of approaches brings innovation into the process. For example, in WFD implementation, programmes of measures could be selected to provide added value from ecosystem services on top of benefits from WFD objectives. Measures frequently used for ecosystem restoration which are closely linked to the Ecosystem Approach could be considered in this context, with the potential to offer substantial benefits. Applying an Ecosystem Approach can also help identify wider benefits that may be achieved using a combination of established ‘green infrastructure’ and other landscape and river improvement methods (Everard and Moggridge, 2012). It needs to be noted, however, that the delivery of ecosystem services may also require time as it is based on the recovery of the related ecosystem functions.

3.2. Shift in focus from legislative compliance towards one of delivering and better communicating wider intent and aims of the WFD

There is some current concern that meeting specific WFD legislative compliance requirements has become the overriding priority and that the broader aims and objectives of the WFD, such as the promotion of sustainable water use, are now largely overlooked (Moss, 2008). Ecosystem service assessment can help shift the focus from legislative compliance towards broader benefit delivery by emphasising that the overall desirable outcome is the improvement of environmental quality and the resulting benefits for human communities, including economic viability and social welfare (Everard, 2012). Moreover, the Ecosystem Approach can play a crucial role when communicating the benefits of implementation and for deepening the appreciation of the significance of the WFD. It has the potential to relate ecosystem health to societal benefits, helping to communicate the advantages of achieving WFD aims and objectives and to secure support for environmental priorities.

By using the Ecosystem Approach for communication purposes, public engagement and participation can be enhanced leading to an overall improvement of the decision making process at every stage. Public participation can lead to a transparent planning process, more comprehensive decision making and ultimately ‘permission to act’ on

Notes to Table 2:

Legend
RBM objective is key intended indicator for this service:
RBM objective is possible intended indicator for this service:
RBM is not a significant intended indicator for this service:
Achievement of objective could help deliver this service (1: lesser extent to 3: large extent)

Art4-1a:	Good ecological status
Art4-1b:	Good ecological potential
Art4-1c:	No deterioration in status
Art4-1d	Good chemical status
Art4-2a:	Prevent and limit inputs of pollutants
Art4-2b:	Good quantitative status
Art4-2c:	Good chemical status
Art4-2d:	No deterioration
Art4-2e:	Reverse trends
Art4-3a:	Drinking water protected areas
Art4-3b:	Freshwater fish and shellfish
Art4-3c:	Bathing waters
Art4-3d:	UWWTD
Art4-3e:	SACs
Art4-3f:	SPAs

Art7-a:	Reduce level of purification of drinking water
Art7-b:	Water treatment regime……..

Repealed Directives a:	Dang subs
Repealed Directives b:	Drinking water
Repealed Directives c:	Info exchange
Repealed Directives d:	Sampling drinking water
Repealed Directives e:	Dir 76/464/EEC
Repealed Directives f:	Shellfish waters

Art1-a:	Prevents deterioration and enhances status of aquatic ecosystems and with regard their water needs, terrestrial ecosystems and wetland dependent on aquatic ecosystems
Art1-b:	To promote the sustainable consumption of water
Art1-c:	To reduce pollution of waters from priority substances
Art1-d:	Ensures progressive reduction in pollution of groundwaters and prevents further pollution
Art1-e:	Contribute to mitigating the effects of floods and droughts

behalf of, or together with, stakeholders. The benefits are bidirectional. By demonstrating to the public the direct effects of successful implementation on the quality of life but also on the long term economic benefits of preserving and restoring natural resources, the overall process is facilitated (e.g. better supported and potentially more sustainable stakeholder practices). Also, the public engagement that can be strengthened by the Ecosystem Approach allows for the local public's knowledge and experience to be beneficially utilised thereby satisfying the 11th principle of the Ecosystem Approach which states that all forms of relevant information should be considered (Secretariat of the Convention on Biological Diversity, 2004). It can reduce objections in the formal administrative procedure, and allow people to restore their own small catchments (water bodies) in terms of ecological function, making an important contribution to meeting WFD targets. Importantly, public knowledge can pragmatically determine where and what can be done to enable WFD implementation, and can help identify and more fully consider the real environmental priorities of individuals and communities.

Good communication is vital. It is necessary to demonstrate the diverse benefits that are likely to arise from meeting the WFD's aims and objectives and what this practically means for people's lives, for example preventing disease and providing cultural, aesthetic and recreational opportunities. Ecosystem services provide a good framework for identifying and capturing benefits. One example of a successful initiative at the EU scale that has promoted public awareness of maintaining a healthy water environment for recreational swimming in lakes and rivers, is the “Big Jump” project by the European Rivers Network (2012), its European partners and many local organizers. Since its foundation in 1997, it has aimed at connecting people with their rivers, which is an essential element in gaining their support for the big European restoration effort for rivers and wetlands expressed in the WFD. Through numerous actions on the main European water basins, such as the organisation of a series of trans-boundary swimming days on different European water basins (at one given time and date people across Europe swim in their rivers/lakes throughout Europe), this project inspires citizens to reconnect with their rivers and lakes and to revive the powerful links that bind people to these spaces. Educational events on the theme of water quality or river restoration are also held during these actions. The popularity of these events is considerable with the first European River Swimming Day alone on the 17th July 2005 having an estimated 200,000 to 300,000 participants across Europe and including 31 rivers and 22 countries (European Rivers Network, 2012). In the UK, organisations such as the Outdoor Swimming Society and the River and Lake Swimming Association operate on the same theme, encouraging people to enjoy the water environment and fully appreciate the importance of sustaining its environmental quality.

The Ecosystem Approach can also help sustain restoration efforts and encourage further developments of the WFD. This particularly relates to the current ‘one out, all out’ element of compliance assessment for the WFD whereby failure of a single element means that everything has failed, which makes progress difficult to realise and may discourage restoration efforts. The Ecosystem Approach can have a positive contribution in this area, as the improvements, even without achievement of good status, will be captured as an advancement of ecosystem services that can be appreciated by the public and policy makers. This will provide confirmation that there is a movement in the right direction and will therefore support additional activities towards compliance.

3.3. Improving the economic case for measures

Using the Ecosystem Approach in WFD implementation helps to optimise societal benefits and avert unintended consequences, with ecosystem services central to the design of programmes of measures compared to traditional, discipline-specific management approaches. It can also highlight potential contributions from ecosystem-based technologies to achieving multiple benefits across ecosystem service categories and allow for more beneficial outcomes (and fewer unforeseen costs) per unit of investment, defined as ‘systemic solutions’ by Everard and McInnes (2013), and through monetisation of such benefits it can improve the economic case for restoration actions. Benefits include averting unintended negative outcomes for non-focal services consequent from previous narrowly focused regulatory responses. The benefits determined through ecosystem service assessment can be added to the cost benefit analysis for greater completeness of the process and to provide better justification for implementation of environmental management options, as well as a better understanding of regulatory impact.

Cost analysis can identify characteristic points at which costs rise sharply and where decision-making problems are most likely to arise, and hence where CBAs should be applied to estimate the outcomes of options (Fisher, 2008). For instance, acknowledging that nutrient retention was critical for meeting the aims and objectives of the WFD, Meyerhoff and Dehnhard (2004) calculated the marginal costs of alternative options for the delivery of this vital function. The marginal cost of avoiding nitrogen loads by agricultural measures was significantly lower than the marginal costs of wastewater treatment in sewage treatment plants (2.5 and 7.7 €/kg N respectively). Overall, the Ecosystem Approach allows the identification of multiple benefits so that CBA can pinpoint the preferred, overall least cost management.

Ecosystem assessments and valuations can help illustrate the importance of environmental improvements. The Tamar 2000 SUPPORT (SUstainable Practices Project On the River Tamar) Project is such an example. It represents a holistic, catchment-wide approach to the restoration and rehabilitation of the River Tamar (in Southwestern England) and its catchment. With a strong focus on the economic benefits of environmental interventions, it was estimated that the project delivered gross annual ecosystem services with a value of approximately £3.8 million and a cumulative benefit-to-cost ratio of about 100:1 (Everard, 2009). Changes in land use, farm management, cropping patterns, fertiliser usage and combined drainage operations over the last 30 years had resulted in widespread habitat destruction, degradation and pollution, affecting the water resources and associated species diversity and density within the catchment (UK NEA, 2011). The Tamar 2000 SUPPORT project sought to address these problems and stabilise farm incomes by improving agricultural practices and farm diversification in the predominantly rural River Tamar catchment. It did so by employing a team of advisors trained in water resources and integrated land management planning who visited over 300 individual farms within the catchment, recommending farm interventions and diversification to protect or enhance the river ecosystem, improve land use, reduce costs, improve returns and meet specific conservation needs (Everard, 2009).

The value of ecosystem service assessments within water quality improvement processes has also been demonstrated in a recent study that investigated the role of ecosystem services in Chesapeake Bay (United States) Restoration Strategies. The area faced high nutrient pollutant loads. Under the United States' Clean Water Act, a main mechanism for addressing these problems is the establishment of total maximum daily loads (TMDL) for phosphorus and nitrogen. The study developed a framework that incorporated ecosystem services for evaluating TMDL reduction measures and TMDL-related tradeoffs (cost, ease of monitoring). The aim was to identify what mix of pollution control projects provided the least costly way to achieve water quality goals and to assess how the inclusion of ecosystem services affects the desired mix of projects. Findings suggested among other things that green infrastructure, although more costly, contributed substantial offsetting ecosystem service values to the cost of achieving the TMDL targets, while grey infrastructure i.e. traditional electromechanical solutions contributed ecosystem service disbenefits. The inclusion of monetized ecosystem services in the optimization analysis shifted the solution towards the inclusion of more nonpoint source pollution controls such as natural vegetation and agricultural land, although the extent of the shift was sensitive to the assumed per tonne value of carbon sequestration, with the value of bonus ecosystem services reaching up to $666 million per year (US EPA, 2012). Thus the Ecosystem Approach and ecosystem service assessments are in line with the growing recognition that ecosystem-based engineering solutions including the preservation or acquisition of open space are more effective choice than investing in sophisticated treatment.

3.4. Developing payments for ecosystem services to support WFD implementation

Payments for Ecosystem Services (PES) can be defined in terms of payments to undertake actions, additional to those required by legislation, that increase the levels of desired ecosystem services, and can therefore be broadly defined within market-based approaches (Defra, 2010). In the context of water resources management, many established PES schemes are based on the principle that improving land management is critical for good water quality and quantity. Such a scheme therefore involves making payments to land managers and others to undertake actions that increase the provision of desired ecosystem services such as clean water suitable for abstraction. Developing PES requires: identifying the PES opportunity (establish what ecosystem services are of interest) and the potential relevant actors; assessing the potential for trade; agreeing roles and responsibilities; resolving legal and technical issues; developing win–win markets, i.e. identifying how the scheme can be developed so that it is fair and advantageous for all; formalising the scheme; monitoring, reviewing and evaluating it; and finally identifying potential opportunities for multiple-benefit PES that may have not been initially considered (Westcountry Rivers Trust, 2012). The 'Upstream Thinking Project' is a good example of how PES can be developed to successfully enhance raw water quality and manage the quantity of water at source through improved land management (OECD and European Commission, 2013). In this case, South West Water, a water company and the buyer of the ecosystem services, in partnership with a range of organisations, innovatively developed PES, paying multiple farmers in the south west of England for improved farm infrastructure and agricultural practice that provided significant benefits beyond regulatory compliance with drinking water standards, and included increasing biodiversity, contributing to WFD compliance, improving carbon sequestration and reducing the risk of flooding (OECD and European Commission, 2013).

3.5. The spatial mapping of ecosystem services as an emerging visualisation approach and its use in decision making

Another important benefit of the Ecosystem Approach for WFD implementation is the potential for communicating WFD benefits with novel visualisation approaches such as the spatial mapping of ecosystem services. Mapping ecosystem services, which builds upon and synthesizes information on ecosystem properties such as land cover types, ecosystem functions and services, can have the following benefits:

- It can add value to the Ecosystem Approach by allowing the identification of multiple benefits across a catchment (for example) in a spatially explicit manner (Westcountry Rivers Trust, 2012).
- It can illustrate the results of an ecosystem assessment (monetisation) (Troy and Wilson, 2006).
- It aids understanding and demonstration of the impacts of alternative management scenarios and resulting ecosystem service tradeoffs (Westcountry Rivers Trust, 2012).
- It can help identify data requirements and can bring together the available information in a meaningful way, facilitating WFD decision making.

For all these reasons, mapping of ecosystem services can serve as a useful communication and stakeholder engagement tool. The research on ecosystem service mapping is ongoing and is very promising.

Ecosystem services mapping is an essential component of developing PES for WFD implementation because in order to assess the potential for trade, the land areas that are important for the delivery of the ecosystem services of interest must be identified. Under the WATER Project (Interreg IVA France–England, 2011), the Westcountry Rivers Trust mapped 5 broad ecosystem services in the entire Exe catchment (UK), as an important step in assessing the potential for PES. The ecosystem services mapped were the provision of water quality (fresh water provision) and of water resources/water regulation (flooding and drought), climate regulation, the provision of habitat and ecological networks, and the provision of adequate recreation. It was acknowledged that there is considerable potential for development of PES schemes

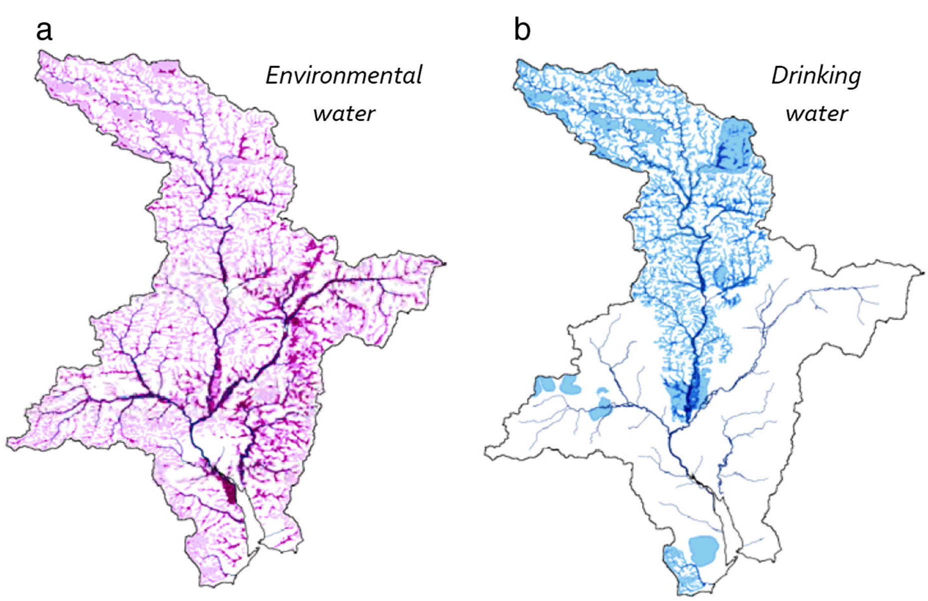

Fig. 3. Mapping critical areas for the delivery of ecosystem services (a) environmental water, and (b) drinking water.
Source: Westcountry Rivers Trust (2012).

around the achievement of WFD ecological status, delivery of clean bathing water, and the provision of drinking water. Establishing the land areas that play a role in the delivery of the service (water) is required in order to assess the potential trade that can be made. Depending on which of the three aspects is examined, different priorities may be given in the mapping process. For example, for achieving good ecological status under the WFD, all of the important land areas upstream of degraded river sections need to be identified (Fig. 3a), whereas in the case of water companies and drinking water provision, the focus is on identifying critical land areas upstream of raw water abstraction points (Fig. 3b). Once areas important for service delivery are identified, the scope for PES could be defined. Evaluation of intervention scenarios requires collection of data for establishing the baseline, identification of scenarios for securing the service, assessment of scenarios' evidence base and modelling of likely benefits (Westcountry Rivers Trust, 2012). A combination of the developed ecosystem service maps for the Exe catchment allowed the identification of multi-functional areas that deliver multiple services. It also revealed areas of potential competing interest or conflict. The study stressed the greater importance of soft engineering and rural land management approaches instead of hard engineering interventions for flood management/protection.

4. Discussion

The implementation of the WFD has been, and still is, a major challenge. In the UK, WFD implementation programmes have been dominated by the daunting technical and organisational challenges of developing, applying and then assessing compliance with the environmental standards of this new integrated framework. One of the potential casualties has been a failure to communicate WFD objectives in language that is meaningful to most stakeholders, or perhaps more accurately, failing to translate WFD outcomes into meaningful social or economic outcomes. However, there has recently been widespread recognition of this shortcoming and there is a move in England & Wales towards a more holistic systems approach that is fully cognisant of the concept of ecosystem services/multiple benefits and sees the opportunity to express the WFD's objectives and outcomes in the language of ecosystem services/societal benefits.

The introduction by Defra of a catchment-based approach which aims to manage land and water in a coordinated and sustainable way in order to balance environmental, economic and social demands at a catchment scale (Defra, 2013) is one such example. This should allow regulators to better communicate the benefits of the WFD in more meaningful ways, and more readily accommodate synergies with complementary programmes e.g. some flood risk management activities, as well as opening up the planning process to wider stakeholder involvement.

In principle, the intention of the WFD was to protect and enhance the water environment for the benefit of society, and in order for the WFD to achieve its high level goals it first required its Member States to develop new, common metrics to assess the current and future desired state of the environment (i.e. new water classification systems) including the development of new ways of assessing biotic health as a measure of environmental quality (expected to be a much more holistic measure of the health of the water environment).

The Ecosystem Approach aims to ensure that society can maintain a healthy and resilient natural environment now and for future generations, by fully considering ecosystems and the services they deliver in decision making. Therefore, the Ecosystem Approach and the WFD are similar in intent and in fact may not be so different in outcome if the economic assessments that are integral to WFD implementation take into account multiple benefits arising from WFD measures.

The classification systems developed for the WFD were designed with the aim of protecting and enhancing the quality of the aquatic environment, which itself fundamentally supports societal benefits (ecosystem services). The main reason they may produce different levels of protection compared to a more modern Ecosystem Approach is likely to be due to the different methodologies. The WFD uses metrics that are proxies of a desired environmental state which in turn is a proxy to societal benefits such as clean and available water, in contrast to the more direct measures of wellbeing incorporated in the Ecosystem Approach. By offering the opportunity to apply systems thinking, an Ecosystem Approach to the implementation of the WFD may lead to different observations and decisions, as shown previously in the paper, offering the potential to maximise value across all ecosystem services. It allows for consideration of a wider range of possible management actions, the creation of a more systematic framework for decision making, and, through the inclusion and monetisation of a broader range of benefits, can improve the economic case in support of measures. Importantly, with current WFD implementation focusing on structural ecosystem components, the Ecosystem Approach can put greater emphasis on functional components that are fundamental for benefit delivery, thus supporting the appropriateness of measures to consider impacts for the whole socio-ecological system.

Successful application of an Ecosystem Approach to the implementation of the WFD across Member States would require further collaboration among countries, between agencies, and across disciplines.

The EU Blueprint to Safeguard Europe's Water Resources, a key policy document that aims to overcome obstacles to safeguard Europe's water resources based on an extensive evaluation of existing policy, acknowledges the importance of actions for protecting ecosystems and delivering ecosystem services in the context of sustainable water management (European Commission, 2012). More precisely, it states that it will aim to achieve a widespread improvement in aquatic ecosystems, thus contributing to the EU Biodiversity Strategy's target of halting the loss of biodiversity and the degradation of ecosystem services. It also supports the further development of PES, and the creation of green infrastructure that will ensure the provision of ecosystem services, a measure to be included in both RBMPs and Flood Risk Management Plans (FRMPs) and to become a priority for financing under the CAP, Cohesion and Structural Funds. It will also require adaptation of current systems of environmental assessment and management to consider a much broader set of impacts on ecosystem status than is currently addressed in most assessments.

There is significant scope for further research to support the use of the Ecosystem Approach in WFD implementation. This involves verifying and/or quantifying the strength of links between WFD objectives and ecosystem services, and selecting and testing the suitability of functional indicators to act as a complement to the structural indicators already used in the ecological status assessments of the WFD framework.

Improved data collection will also be crucial for making best use of the Ecosystem Approach for WFD implementation. This could include the collection of data on ecosystem functions in order to better assess the health of ecosystems, improving the accuracy, appropriateness and quality of data to support sophisticated applications such as ecosystem service mapping. Moreover, the suitability of the language used is crucial for engagement with a wide range of stakeholders. The complexity, accessibility and effectiveness of communication are aspects that need consideration when using terms such as ‘ecosystem services’. The use of clear and well-explained terminology is central to effective communication. Although the language of ecosystem services may itself be complex, the services are intuitive to many non-technical constituencies (tourism, aesthetics, food, soil formation, etc.) and so they can be a tool for better communication of benefits.

5. Conclusion

Methodological linkages between the Ecosystem Approach and the WFD demonstrated the potential of the Approach to act in a complementary way to the Directive and facilitate its implementation, with a potential ‘added value’ particularly for the economic case for certain measures. It can also serve as a consistent framework for identifying shared aims and evaluating alternative water management scenarios and options in decision making. The Ecosystem Approach should help to improve the quality of WFD cost benefit and disproportionate cost assessments by helping to identify the additional benefits that come to light when the Ecosystem Approach is properly applied, allowing for a broad consideration of the benefits, costs and tradeoffs that occur in each case. While great efforts are still required, emerging applications such as the spatial mapping of ecosystem services and the evaluation of multiple benefits aided by the Ecosystem Approach suggest a realm of possibilities for developing more holistic approaches to water management to help us achieve the broader goals of the Water Framework Directive.

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