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Assessing water ecosystem services for water resource management

B. Grizzetti*, D. Lanzanova, C. Liquete, A. Reynaud, A.C. Cardoso

European Commission Joint Research Centre (JRC), I-21027 (VA), Italy

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ABSTRACT

Ecosystem service concepts can offer a valuable approach for linking human and nature, and arguments for the conservation and restoration of natural ecosystems. Despite an increasing interest in the topic, the application of these concepts for water resource management has been hampered by the lack of practical definitions and methodologies. In this study we review and analyse the current literature and propose an approach for assessing and valuing ecosystem services in the context of water management. In particular, to study the link between multiple pressures, ecological status and delivery of ecosystem services in aquatic ecosystems under different scenarios of measures or future changes. This is of interest for the development of River Basin Management Plans under the EU Water Framework Directive. We provide a list of proxies/indicators of natural capacity, actual flow and social benefit for the biophysical assessment of the ecosystem services. We advocate the use of indicators of sustainability, combining information on capacity and flow of services. We also suggest methods for economic valuation of aquatic ecosystem for each service and spatial scale of application. We argue that biophysical assessment and economic valuation should be conducted jointly to account for the different values of ecosystem services (ecologic, social and economic) and to strengthen the recognition of human dependency on nature. The proposed approach can be used for assessing the benefits of conservation and restoration of aquatic ecosystems in the implementation of the EU water policy.

1. Introduction

Ecosystem services are defined as the benefits that people obtain from ecosystems (MEA, 2005a), and the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010). The concept of ecosystem services is relevant for connecting people to nature. It makes visible the key role of ecosystem functioning and biodiversity to support multiple benefits to humans. Understanding the linkages between the natural and socio-economic systems can lead to improved and more sustainable management of ecosystems (Guerry et al., 2015).

In 2010 the parties of the Convention of Biological Diversity adopted a revised Strategic Plan for Biodiversity including the Aichi Biodiversity Targets (CBD, 2010), a reinforced action to halt the loss of biodiversity and ensure ecosystems are resilient and continue to provide essential services. In line with this international framework, in 2011 the European Union (EU) presented the European Biodiversity Strategy to 2020 (European Commission, 2011) that put emphasis on the protection and value of ecosystem services, setting a specific target on maintaining and restoring ecosystems and their services (Target 2).

Aquatic ecosystems (rivers, lakes, groundwater coastal waters, seas) support the delivery of crucial ecosystem services, such as fish production, water provisioning and recreation. Key ecosystem services are also connected to the hydrological cycle in the river basin, for example water purification, water retention and climate regulation. Most of these water related ecosystem services can be directly appreciated by people and quantified, but some, especially regulating and maintenance services, are less evident. Though, all ecosystem services have to be considered for the sustainable use and management of water resources.

In Europe, the development of River Basin Management Plans (RBMP) under the EU Water Framework Directive (WFD, Directive 2000/60/EC) is an actual situation where territorial planning for water management is needed, and where the concept of ecosystem services could be adopted to recognise the multi-functionality of the water systems and account for the benefits people receive from nature, justifying the costs of protection and restoration. The Blueprint to safeguard Europe's water resources (European Commission, 2012) indicated that natural water retention measures can greatly contribute to reduce the effects of floods and droughts ensuring the provisioning of ecosystem services, and

* Corresponding author.
E-mail address: bruna.grizzetti@jrc.ec.europa.eu (B. Grizzetti).

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these measures should be included in the RBMPs and in the Flood Risk Management Plans. In line with the Blueprint, some recent studies have been reflecting on the potential of the ecosystem service approach in the implementation of the WFD, emphasising the opportunity of holistic system thinking to understand the co-benefits of measures and to integrate different sectoral policies (Vlachopoulou et al., 2014; COWI, 2014; ESAWADI, 2010).

However, the lack of agreed definitions of ecosystem services and approaches for their quantification and valuation has limited the uptake by practitioners and policy makers (Polasky et al., 2015). The MAES Working Group (Mapping and Assessment of Ecosystems and their Services), established to support the implementation of the EU Biodiversity Strategy, has suggested an analytical framework for the implementation of the ecosystem service approach in the EU, and tested it in a pilot study on freshwater and marine ecosystems (Maes et al., 2016). Two FP7 projects, OpenNESS (2015) and OPERA (2015), are currently working on the general definition of concepts and methodologies for assessing and valuing ecosystem services, and on the operationalization of the concepts through real case studies. More specifically on water policy, the FP7 projects MARS (2015) and Globaqua (2015) aim to understand and quantify the impacts of pressures on the ecological status of EU waters and the consequent effects on the delivery of ecosystem services.

Understanding the relationship between multiple pressures, conditions and services of aquatic ecosystems would help design measures to achieve the target of good ecological status of water systems, foreseen by the WFD, by considering the benefits of investing in nature conservation and restoration. But the lack of clear definitions and practical methods to assess the water related ecosystem services could hamper the adoption of the approach (Kull et al., 2015; Crossman et al., 2013). Also, while mapping of ecosystem services directly linked to land occupation is quite straightforward, for fresh water ecosystems the assessment is more complex, as the hydrological cycle and the land-water interactions have to be taken into consideration.

The objective of this study was to develop a practical methodology for assessing and valuing ecosystem services relevant for water resource management, considering the links between pressures, ecological status and ecosystem services. The work is based on literature review and scientific partners' consultation. It started from the experience of the MAES freshwater pilot and was developed within the EU FP7 project MARS.

The paper is structured as follows. The first part describes the methodological approach adopted in the study. The second part presents the results of our analysis in the form of a practical approach for assessing and valuing ecosystem services relevant for water resource management. The third part discusses the challenges in valuing ecosystem services and integrating biophysical and economic assessments.

2. Method

We analysed definitions and methods for assessing and valuing ecosystem services to synthesize the current knowledge and propose a practical and flexible approach relevant for water resource management. The use context of the approach is the study of the relationship between multiple pressures, ecological status and delivery of ecosystem services in water systems, with the overall goal to support the EU water policy (WFD).[1] The analysis was based on literature review and consultation of the scientific partners of the project MARS, from 24 research institutes across Europe.

The focus of the analysis is on inland waters and the spatial scale of interest ranges from the water body to the catchment/river basin and the European scale. While for water bodies the main focus is on specific ecosystem functions that support ecosystem services, and their alteration under different stressors, the catchment is the appropriate scale to observe and quantify processes related to the water cycle, and to implement monitoring and management plans to reduce multiple-pressures. The assessment and valuation of ecosystem services at the European scale allows us to address regional trends, identify hot spots in the delivery or degradation of services, test the effectiveness of regional policies (such as EU Directives) and conduct scenario analysis at the large scale. In the development of the methodology we considered these different spatial scales.

The approach that we developed is organised in four building steps: 1) definitions and scoping (Section 3.1); 2) framework (relations between pressures, ecological status and delivery of ecosystem services) (Section 3.2); 3) biophysical assessment of ecosystem services (Section 3.3); 4) economic valuation of ecosystem services (Section 3.4). In the following part of the paper we describe the results of our study proposing guidelines on how to develop these components.

3. Results: approach for assessing and valuing water ecosystem services

3.1. (Step 1) Scoping – Water related ecosystem services

A large variety of ecosystem services have been addressed by assessments such as Millennium Ecosystem Assessment (MEA, 2005a), the Economics of Ecosystems and Biodiversity (TEEB, 2010), MAES (Maes et al., 2016), and national assessments (e.g. Pereira et al., 2006; UK NEA, 2011). In this study we are interested in ecosystem services related to water and aquatic ecosystems. MAES analysed the ecosystem services per typology of ecosystem, considering the services delivered by rivers, lakes, groundwater and wetlands in the freshwater pilot study, and those provided by transitional waters, coastal waters, shelf waters and open oceanic water in the marine pilot study. With a slightly different approach, Brauman et al. (2007) discussed the 'hydrologic ecosystem services', defined as the ecosystem services that "encompass the benefits to people produced by terrestrial ecosystem effects on freshwater", each hydrological service being characterised by the hydrological attributes of quantity, quality, location and timing. Keeler et al. (2012) described in detail water-quality related ecosystem services. Recently, Guswa et al. (2014) have addressed more generally the 'water related ecosystem services', discussing the link between hydrological modelling and the ecosystem services relevant for river basin management. From these studies we can observe two approaches in the organisation of the analysis, one per ecosystem typology (Maes et al., 2016) and the other per hydrological relevant services (Brauman et al., 2007). Both approaches consider the integration of all the services, the first by accounting for all the ecosystems in the analysis, the second by integrating the processes in the river basin. The ecosystem services of relevance for the water management (and the WFD) are those related to the aquatic ecosystems and to the interaction of water and land in different ecosystems, such as forests, agricultural lands, riparian areas, wetlands, and water bodies. In this study we indicate all these services as 'water ecosystem services'.

For the assessment, the identification of the relevant ecosystem services is the first step. We propose a simplified classification of ecosystem services based on the Common International

[1] In the FP7 project MARS this analysis will be conducted at the European scale and in 16 catchments, representing a great variability of pressures and ecosystem services across Europe.