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Using ecosystem services in participatory river basin management: practices, advantages, challenges

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About the author

Abstract

The very nature of the ecosystem services concept, which links human beings with their natural environment, makes it an obvious tool to involve different stakeholders in water management. However, the use of ecosystem services in participatory river basin management is still at an exploratory stage. The aim of this paper is to make a state-of-the-art of existing cases and research and to draw recommendations on how an ecosystem services framework could be operationalized to support water management. 53 scientific articles were found which introduce the use of ecosystem services in participatory river basin management. Most case-studies presented in these articles engage stakeholders in the participatory assessment and valuation of ecosystem services. This use allows to increase the knowledge of participants on their surrounding social-ecological systems and to inform management processes. Fewer cases use ecosystem services as a decision-support tool. Among the latter, most integrate ecosystem services in a participatory modeling process such as scenario planning, participatory mapping of ecosystem services, or role-playing games. Based on this review, several advantages of using ecosystem services in participatory river basin management can be highlighted: ecosystem services constitute a framework to discuss with a common language, they make complex social-ecological systems easier to understand and they engage people in management processes. In parallel, ecosystem services' complexity, variable definitions and multiple classifications are brakes to capture them into models and to use them in operational contexts. The paper concludes by highlighting the need for more systematic monitoring and evaluation of the impacts of the use of ecosystem services on river basin management.

Key words

Participatory valuation, participatory modeling, typologies, impact evaluation, disservices

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1 Introduction

Ecosystem services are defined as the “benefits people obtain from ecosystems” in the Millennium Ecosystem Assessment (Millenium Ecosystem Assessment, 2005). Several other definitions exist as the use and understanding of the notion have changed overtime. The term appeared in the early 1970s and was originally used as an educational notion enabling people to understand the importance of nature in sustaining their lives. The number of studies dealing with ecosystem services grew slowly until the late 1990s. In 2005, the Millennium Ecosystem Assessment (MEA), an international network of more than 1360 experts called for by the United Nations Secretary-General, released their main report aiming at measuring the total value of ecosystem services on Earth (Millenium Ecosystem Assessment, 2005). From that moment, the literature and research on ecosystem services became more and more abundant. In 2009, the European Environment Agency developed the Common International Classification of Ecosystem Services (CICES) to standardize the way ecosystem services are described through a five-level hierarchical structure (Table 1). In 2010, the Economics of Ecosystems and Biodiversity (TEEB), a global initiative aiming at mainstreaming the values of biodiversity and ecosystem services into decision-making, published their conclusions and recommendations (TEEB, 2010). Specifically, they proposed “an economic approach to environmental issues” based on the knowledge, measure and integration into decision-making of biodiversity values. The MEA was also followed by numerous researches and reports which measured the value of ecosystem services at regional and national scales. All these studies aimed at assessing the state of ecosystem services and their contribution to human beings’ wealth and well-being at a given scale. In 2012, an international scientific platform similar to the Intergovernmental Panel on Climate Change (IPCC) was created to support policies: the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

Beyond literature and research, ecosystem services have been more and more mobilized in legal and political frameworks since the beginning of the 21st century. The term appeared in the European Union legislation in 2001 and has been mentioned several times since then, including in the Biodiversity Strategy to 2020 (European Union, 2011). Ecosystem services are also addressed implicitly by the European Union in policy documents, interviews and discussions (Hauck, et al., 2013). On the other side of the Atlantic, in an October 2015 memorandum, the president of the United States Barack Obama directed Federal agencies to incorporate and promote ecosystem services in their planning and decision making. Ecosystem services also appear in the 15th Sustainable Development Goal about life on land. Its target 15.1 aims at “[ensuring] the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services”. Finally, in the context of climate change, the notion of *adaptation services* has emerged and refers to the ability of ecosystem services and processes to increase people’s capacity to adapt to change (Colloff, et al., 2016).

The notion of ecosystem services has been pushed to the center stage in the context of urgent global environmental challenges such as climate change, ocean acidification, chemical pollution and biodiversity loss. The demand to make the concept operational is growing, along with hopes of overcoming these challenges. Policies and strategies for environmental conservation around the world have more and more recourse to the notion.

Table 1: CICES, extract from the version 4.3 (January 2013), https://cices.eu/resources

Section	Division	Group	Class	Examples
This column lists the three main categories of ecosystem services	This column divides section categories into main types of output or process.	The group level splits division categories by biological, physical or cultural type or process.	The class level provides a further sub-division of group categories into biological or material outputs and bio-physical and cultural processes that can be linked back to concrete identifiable service sources.	This column is not part of the CICES five-level hierarchical structure. The fifth level is class type. This column gives examples of each class.
Provisioning	Nutrition	Biomass	One example out of 6 [1/6]: Cultivated crops	Cereals (e.g. rye, barely)
		Water	One example out of 2 [1/2]: Ground water for drinking	Freshwater abstracted from (non-fossil) groundwater
	Materials	Biomass	[1/3] Materials from plants, algae and animals for agricultural use	Plant, algae, grass
		Water	[1/2] Surface water for non-drinking purposes	Abstracted surface water from rivers
	Energy	Biomass-based energy sources	[1/2] Plant-based resources	Wood fuel for burning and energy production
		Mechanical energy	[1/1] Animal-based energy	Physical labor provided by animals
Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	[1/2] Bio-remediation by micro-organisms, algae, plants, and animals	Decomposition, detoxification of waste and toxic materials
		Mediation by ecosystems	[1/3] Dilution by atmosphere, freshwater and marine ecosystems	Bio-physico-chemical dilution of gases
	Mediation of flows	Mass flows	[1/2] Mass stabilization and control of erosion rates	Coastal wetlands, dunes, sea grass
		Liquid flows	[1/2] Flood protection	Mangroves, seagrass, macroalgae
		Gaseous / air flows	[1/2] Ventilation and transpiration	Natural or planted vegetation that enables air ventilation
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	[1/2] Pollination and seed dispersal	Pollination by bees
		Pest and disease control	[1/2] Disease control	In cultivated and natural ecosystems
		Soil formation and composition	[1/2] Weathering processes	Maintenance of bio-geochemical conditions of soils
		Water conditions	[1/2] Chemical condition of	Denitrification, re-

			freshwaters	mineralization of phosphorous
		Atmospheric composition and climate regulation	[1/2] Micro and regional climate regulation	Modifying temperature, humidity, wind fields
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes (environmental settings)	Physical and experiential interactions	[1/2] Experiential use of plants, animals and land-/seascapes in different environmental settings	Whale and bird watching, snorkeling
		Intellectual and representative interactions	[1/5] Entertainment	Viewing
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes (environmental settings)	Spiritual and/or emblematic	[1/2] Symbolic	Emblematic plants and animals
		Other cultural outputs	[1/2] Bequest	Moral / ethical perspective or belief

River basin management and policies are at the core of these environmental challenges, due to current stresses on water resources and their essential character in fulfilling human needs. Ecosystem services are meaningful in these fields and commonly used to describe water contributions to human lives. They relate mainly to the provision of water for drinking and non-drinking purposes. Water bodies' ecosystem services are also numerous as rivers play a major role in maintaining ecosystems, controlling erosion and flood, regulating nuisances such as waste and toxics, and usually providing recreational opportunities and beautiful and emblematic landscapes.

In addition to being strongly linked to water, the concept of ecosystem services also appears to be a relevant lever to involve people in river basin management. Its strong educational value and the "intuitive link" (Wallis, et al., 2013) it can create between human beings and their environment make the concept a useful mean to involve people in river basin management. More broadly, participation is considered as one of the basis for efficient decision-making in the field of water resources management. It has been advocated since the mid-twentieth century as a pillar of adaptive and integrated water management by international organizations and institutions, such as in the 1992 Dublin Statement on Water and Sustainable Development and in the UNECE Aarhus Convention of 1998.

The strong relationship the notion of ecosystem services establishes between human beings and their water-related natural environment raises the possibility to use it as an approach for participatory water resources management. Numerous methods and frameworks, such as Integrated Water Resources Management (IWRM), are already used and recognized to make programs and policies for river basin management as efficient as possible. The emergence of ecosystem services in the global political system, their relationship with participatory methods and their relevance in water management contexts denote their possible use as an operational approach in participatory river basin management. The aim of this paper is then to make a state-of-the-art of the use of ecosystem services in participatory river basin management and to provide recommendations toward their use in such contexts.

2 Method

This paper reviews articles and reports addressing altogether ecosystem services, river basin management and participation. A “Title-Abstract-Keywords” search on ScienceDirect using terms related to ecosystem services (ecosystem service*), river basins (river*, basin*, watershed*) and participation (participat*, deliberat*) was carried out. This search resulted in 56 scientific papers (October 14th, 2016). The keywords “assessment”, “elicit*” and “value*” were also used and combined with the words cited above to carry out searches on several databases including ScienceDirect, Scopus and Google Scholar. Out of these searches’ results, only the case studies introducing the use of ecosystem services in participatory management of river basins were selected. Additionally, articles which also tackled the three subjects were found in the reference part of papers and added to the database.

Finally, 53 papers compose the literature review database, including 21 case studies in which ecosystem services and participatory methods are used in a context of river basin management and 32 papers which tackle either the definitions and utility of the ecosystem services concept for participatory water management, or the methods used around it. Almost half of the cases studied take place in Europe including six Spanish cases. Five case studies are located in Australia and the six remaining cases come from Canada, South Africa, South Korea, Nepal, the Solomon Islands and Columbia. Two thirds of the references have been published between 2013 and 2016 including half in 2015. The remaining third was published between 2002 and 2011 and in 1997.

3 Current practices in the use of ecosystem services for participatory river basin management

The cases studied show various uses of ecosystem services in contexts of participatory river basin management. In more than half of the cases – 13 out of 21, ecosystem services are assessed and used to value the natural environment. They are not directly involved in management but they serve as a basis for decision-making (section 3.1). The other cases show the use of ecosystem services within the management process (section 3.2). Specifically, they are often used to map areas or to plan with a scenario method (section 3.3). Games, which are a recreational modeling and simulation method, are also proposed as a mean to operationalize ecosystem services in participatory management of natural areas (section 3.4). However, these figures should be considered with caution as many case studies aiming at assessing ecosystem services were not considered in the literature review database when assessment work was not directly used as a basis for management. All in all, much more than half of the case studies dealing with ecosystem services conduct an assessment.

3.1 Assessment and valuation of ecosystem services

Since, the famous paper by Costanza et al. in 1997, which estimated the global economic value of seventeen ecosystem services as being equal to 1.8 times the global growth national product at that time (Costanza, et al., 1997), , ecosystem services have been often and largely assessed at different geographical scales by the MEA, TEEB, numerous countries and lots of projects and studies around the world. Those assessments complete the data and highlight the economic benefits and environmental costs of some policy measures (Darvill & Lindo, 2014) (Ceresil, et al., 2015). Therefore they are used to inform and facilitate decision-making (Palomo, et al., 2013) (Van Oort, et al., 2015). Assessments also need to be sound and to incorporate all stakeholders’ points of view, especially as perceptions, knowledge and preferences differ regarding stakeholders, geographical and temporal scales (Hauck, et al., 2013). Participatory methods are used for assessment because the step that consists in assessing ecosystem services has a great impact on the final decisions.

In a first group of 13 papers, participatory assessments intended to measure ecosystem services' values. Participatory valuation approaches are of particular interest to integrate the three types of values that are usually distinguished: socio-cultural values, economic values and biophysical values (Scholte, et al., 2015) (Opdam, et al., 2015) (De Groot, et al., 2002). Kenter et al. (2015) and Scholte et al. (2015) have reviewed how these types of values are conceptualized in the literature and the methods used to assess them (Kenter, et al., 2015) (Scholte, et al., 2015). The use of deliberation in the elicitation of ecosystem services values is advocated based on the assumption that those values are not pre-formed but constructed through learning and exchanged during participatory assessment processes (Liu & Opdam, 2014) (Kenter, et al., 2011) (Bunse et al., 2015). In addition, several other aspects of ecosystem services' are assessed through participatory methods such as their spatial distribution and people's perception of their locations (Garcia-Nieto, et al., 2015), their delivery and uses (Tadaki, et al., 2015), their changes and the changes in their location and delivery (Palomo, et al., 2013) (Palomo, et al., 2014) (Ramirez-Gomez, et al., 2015). Two studies review the tools, definitions and methods used in natural resources management to assess ecosystem services, knowledge and preferences (Grizzeti, et al., 2016-1) (Lynam, et al., 2007).

Assessments and valuation of ecosystem services, though widespread, are subject to controversies around the idea of valuing natural elements, the concept of value itself and the conflicts of interests that might arise (Barnaud & Antona, 2014). Similar controversies apply to participatory assessment of ecosystem services. Ecosystem services are an anthropocentric notion that emphasizes the exchange value of natural elements rather than their intrinsic existence value (Wallis, et al., 2013). The risk pinpointed is the commodification of nature and its possible consequences (Grizzetti, et al., 2016-2).

3.2 Participatory modeling to support decision making

Integration of ecosystem services in water management often involves models that enable to "incorporate social and ecological dynamics into decision-making" (Davies, et al., 2015). Participatory modeling consists in jointly developing a common representation of a reality with local stakeholders. In the field of river basin management, it means representing the social-ecological system at stake in order to highlight its characteristics, its relationships, its issues, the conflicts that might arise between stakeholders and any other element that might support decision-making. Different participatory modeling methods exist including scenario planning, mapping and simulation or role-playing games; they will be further developed in the following sections.

Apart from permitting the construction of a common vision for the system, modeling is also mobilized for its capacity to enhance social learning, build capacities and trust, and provide a platform for discussing and sharing ideas (Davies, et al., 2015) (Malinga, et al., 2013). It can also provide a neutral atmosphere, spot critical moments of competition, and thus increase transparency (Jorda-Capdevila, et al., 2016-1). By doing so, it generates elements of social capital that can improve ecosystem services frameworks (Davies, et al., 2015).

As an example, Jorda-Capdevila, Rodriguez-Labajos and Bardina describe modeling exercises conducted with Ter River Basin's local stakeholders that permitted to model fifteen water flow-dependent ecosystem services. The goal of their study was to explore the method's potential to understand conflicts between stakeholders in the territory, as competition for water flows to generate activities was significant between users. Spotting the hotspots where activities were concentrated was possible during mapping workshops. It showed the geographical distribution of tensions and permitted to identify tradeoffs and synergies. In addition, they observed that the modeling approach was particularly relevant in a context of changes affecting water resources (Jorda-Capdevila, et al., 2016-1).

3.3 Scenario planning and participatory mapping: two modeling approaches

Scenario planning consists in building scenarios for the future to inform decision-making through projections of decisions' consequences. Developing different management scenarios with different water allocation schemes can be used to derive outcomes of decisions, opportunities for action, threats and uncertainties. In a participatory framework, scenarios may be used to identify stakeholders' expectations and ecosystem services that need to be given the greatest attention (Malinga, et al., 2013). Therefore participatory scenario planning enables stakeholders to create different visions of the future and then to determine the best path toward achieving what they desire (Palomo, et al., 2011).

Participatory mapping is the most common type of modeling. It is used for ecosystem services assessment and valuation, and to directly support decision-making. Resorting to participatory mapping permits local stakeholders to identify areas of priority for conservation policies efforts. Local stakeholders gather and build several maps that are compiled in one or agree on a common map which highlights hotspots and spatial dynamics of a given territory according to its users. Areas where ecosystem services are numerous, subject to lots of uses, endangered or have changed in time are pinpointed. The process of participatory mapping also permits to observe the distribution of tensions and synergies through exchanges between participants (Jorda-Capdevila, et al., 2016-1). Participatory decision-making occurs during the mapping process itself.

Participatory mapping requires efficient tools that enable to visualize the spatial distribution of ecosystem services, activities and their synergies. Compromises have to be made between the tools' capacity to be user friendly, their data requirement and their accuracy. Practitioners need to decide on the most appropriate tool to use according to the requirements of the context they act in. For instance, according to twenty-seven respondents from Scotland, ecosystem services mapping tools were considered efficient in local planning when they can provide meaningful output, be user friendly, promote and facilitate stakeholder engagement, be applicable to different organizations and scales, have a transparent and consistent approach, require low costs and make a high range of services available (Vortius & Spray, 2015). Several tools have been specifically designed to map ecosystem services such as InVEST designed by the Natural Capital Project, a partnership between Stanford University, University of Minnesota, the Nature Conservancy and WWF, EcoServ-GIS developed by Durham Wildlife Trust, the Westcountry Rivers Trust's "ecosystem services visualization", and SENSE, developed by Environment Systems Ltd.

Building scenarios for water management in a participatory way has been done extensively using various methods including surveys, workshops and interviews to understand participants' priorities for ecosystem services management (Liu, et al., 2013), to include their proposals for solving problems in scenarios (Jessel & Jacobs, 2005), to prioritize spots for water allocation (Jorda-Capdevila, et al., 2016-2) or to evaluate costs and benefits of water management measures (Borowski-Maaser, et al., 2014). There are also several examples of studies using both participatory scenario planning and mapping. In the Vecht River Basin in Germany, participants were invited to map changes in ecosystem services as results of restoration measures (Borowski-Maaser, et al., 2014). In the Havel Basin in Germany, maps have been used as supports for stakeholders to evaluate future land use scenarios (Jessel & Jacobs, 2005). In the Ter River Basin, scenarios were developed by workshops participants using maps where they marked ecosystem services production areas (Jorda-Capdevila, et al., 2016-1).

3.4 Combining modeling methods through games

Simulation games have been promoted by Verutes and Rosenthal and by Costanza and his collaborators in two 2014 papers (Verutes & Rosenthal, 2014) (Costanza, et al., 2014). The first authors consider games as an easy and effective way to introduce concepts, to reach a broader audience, to reveal people's impact on ecosystem services and to uncover the benefits and costs of management options. The authors of the second paper proposed the development of computer games for educational, research and entertainment purpose around ecosystem services. All in all, both want to combine the benefits of different modeling approaches in one unique user-friendly and entertaining tool. For this purpose, they developed prototype games which possess two major attributes.

The first attribute of those games is to promote participation and to permit learning. Games arouse competition and collaboration; they set a clear goal but let uncertainties remain about the outcomes of actions. Therefore they are able to raise curiosity and interest. Tradeoff! which was developed by Verutes and Rosenthal was an effective learning tool for participants without background knowledge about sustainable development. Costanza and his collaborators highlight the game's ability to make players construct their preferences throughout the game, based on what they learn during the game.

The second attribute is the game's ability to make participants develop their own scenarios based on their preferences revealed during the game. In Costanza and collaborators' ideal game, the choices players make during the game are used to infer their preferences and to deduce the consequences of those choices and preferences on the game's outcomes. The particularity of the game compared to common scenario planning methods is that scenarios are not static and set in advance. They are dynamic: they are built by the players themselves through their behaviors during the game. In a simpler game scheme, scenarios may at least be represented by the game's rounds. At the end of each round, players can picture scenarios' consequences by measuring the round's outcomes in terms of revenues, activities, ecosystem services or impacts on the environment. Players still control the process through the choices they make during the round: their challenge thus consists in making synergistic decisions. In this respect, games have the benefit of offering feedback to users and enabling players to see the consequences of their choices all along the process.

Finally, the authors of both papers highlight the limits of such processes and propose paths for research aiming at improving future tools. First, games are models that necessarily simplify the reality and neglect some aspects of a system that may be important. This contributes to making games accessible to non-experts players but may compromise the outcomes' accuracy and legitimacy needed in decision-making contexts. Second, players' behaviors in the game may not reflect their behaviors in real life situations: the counterpart of a virtual decision-making system is its artificiality. Verutes and Rosenthal identify a future research need to bridge the gap between the advantages of a simple and user-friendly system and its weaknesses in being able to reflect the complexity of the social-ecological systems at stake.

4 Advantages of using ecosystem services in participatory river basin management

The review of these selected papers highlights the advantages and challenges that arise from using ecosystem services in participatory river basin management. Sections 4.1 to 4.4 describe aspects of the ecosystem services concept that prove to be useful for decision-making: its capacity to strengthen people's engagement for nature conservation, the ease to understand the concept, the incentives it gives to protect and restore natural areas and the words and language tools it provides for communication. Despite the significant potential of the notion of ecosystem services to improve participatory decision-making for river basin policies and management, its use is also challenging in several respects that are introduced in sections 5.1 to 5.8.

4.1 Providing a common language

Water systems are composed of complex interactions between a society and its environment. Both the bio-physical elements composing the territory and the various socio-economic components of the society are entwined in what is commonly called a water social-ecological system (Fürst, et al., 2014). Therefore river basin management involves multiple stakeholders. Non-experts citizens and experts from diverse fields such as water sciences, ecology, sociology, economics or conservation policy may have to gather in order to understand the system and its problems, and imagine solutions for its management.

In this plural and multidisciplinary context, the notion of ecosystem services can be used as a communication tool (Febria, et al., 2015). It has the potential to facilitate communication and to improve collaboration between stakeholders (Dufour, et al., 2016). It can also serve as the conceptual basis to get a shared understanding of the system and build a common vision of its future (Maynard, et al., 2015) (Fürst, et al., 2014), ultimately resulting in an improved collaboration and peaceful relationships. In an experiment led in several European estuaries, Jacobs and his collaborators observed that the use of ecosystem services in the participatory process brought together stakeholders from different and often opposing sectors who were able to gain mutual understanding of each other's' points of view and to figure out the advantages of working together (Jacobs, et al., 2015).

4.2 Enhancing people understanding of their environment

Stakeholders involved in participatory decision-making for river basin management usually have unequal knowledge about the mechanisms underlying the functioning of a bio-physical system. The notion of ecosystem services offers an intuitive vision and a simple representation of the complex relationships between human beings and their environment (Blackstock, et al., 2015) (Maynard, et al., 2015). Some argue that an ecosystem services-based approach may be more efficient than traditional conservation measures to deal with a system composed of multiple levels of biodiversity (Febria, et al., 2015). In particular, an ecosystem services approach may integrate knowledge about ecosystems functioning in the decision-making process and therefore reveal linkages between biophysical processes and social benefits. While common frameworks for decision making such as IWRM aim at integrating all human uses of water (agricultural, domestic, etc.), the ecosystem services-based approach adds the idea that ecosystems themselves need to be in a good ecological status to sustain ecosystem services' provision and to satisfy human needs in the long run. In the case of water, ecosystem services are estimated to use 75% of the total of freshwater bodies to fulfill their role, while all human needs combined only need 25% of them (Blackstock, et al., 2015).

Those elements increase people understanding of water-related ecosystems, their processes, the services they deliver and human dependence on nature. Therefore they highlight the benefits of keeping ecosystems in a good health and increase people appreciation of their own interests in protecting nature (Grizzetti, et al., 2016-2) (Leisher, 2015). Moreover, ecosystem services play their educational role and thus help increasing transparency and building capacities (Liu, et al., 2013). This is of great importance because the way human beings understand the role nature plays in sustaining their lives has an impact on the choices and decisions they make (Poppenborg & Koellner, 2013) (Vignola, et al., 2010). As a consequence, decisions made about the environment in the framework of an ecosystem services-based approach tend to be more conservation and restoration-oriented. Liu and her collaborators pinpointed that the planning process implemented in the Murray Darling basin in Australia before an ecosystem services framework was adopted had suffered from a lack of understanding of the benefits associated with some restoration measures (Liu, et al., 2013).

4.3 Helping broaden and diversify people engagement

Decision-makers involved in river basin management can use the ecosystem services notion as a way to involve more stakeholders in the process, thanks to its easiness to be understood. The notion may also be considered as an original approach to river basin management that generates discussions and therefore raises interest for the issue at stake. Additionally, the type of stakeholders involved may be diversified if more people are able to understand the concept or find an interest in the issue through this framework. On the other hand, the opposite effect may be observed if the notion is considered too complicated or not interesting enough (see section 5.2 of this report).

An ecosystem services-based approach may also enable the identification of the stakeholders that would be most impacted by projects or policies and therefore involve them in the decision-making process (Blackstock, et al., 2015). Tadaki, Allen and Sinner emphasize the importance of thinking about the missing stakeholders, meaning those who are not directly involved in the decision-making process and who might even not be represented while some of their interests are at stake (Tadaki, et al., 2015). Ecosystem services might help identify them and, if not include them, at least represent them.

The involvement of numerous and various stakeholders in a process based on ecosystem services has a great impact on the results. Ecosystem services are often used to assess and measure the value people attribute to nature. For assessments to be valid and legitimate, a group of participants as broad and diverse as possible is needed. Once again, the question of which stakeholders are included or represented and which ones are not in ecosystem services assessments is a central concern (Davies, et al., 2015). Involving a large section of society in the assessment provides access to local and traditional expertise and knowledge, enables the integration of numerous social values and preferences into the process and enhances the role and legitimacy of local communities as demonstrated by the work from (Blackstock, et al., 2015) (Bryan, et al., 2010) (Jessel & Jacobs, 2005).

4.4 Analyzing, targeting and financing decisions

Ecosystem services are also analyzed to better understand the state of the system at stake. This helps identifying and characterizing tradeoffs and synergies between management and political options (Blackstock, et al., 2015). By identifying the differences between stakeholders' perceptions of ecosystem services' values and locations, it is also possible to bring to light the potential conflicts that might occur as a result of choices (Darvill & Lindo, 2014). Grizzetti and her collaborators noticed in the cases they analyzed that the concept of ecosystem services was used to produce win-win situations by integrating different policy objectives into measures and emphasizing their multi-functionality (Grizzetti, et al., 2016-2).

Ecosystem services analysis broadens the elements that enable to design policies and to choose among them. It helps prioritizing and targeting management actions toward making the best possible choice according to the tradeoffs and synergies identified. In a context of limited budget, geographic hotspots or social concerns can be identified using people's perceptions of ecosystem services and thus may be designated as priorities (Bryan, et al., 2010) (Raymond, et al., 2009). Ecosystem services may also be used as the basis for cost-benefits analysis. In addition, ecosystem services analysis can help identifying and designing financial tools for action. The monetary value of ecosystem services can thus serve as a reference to set up incentives policies, compensation measures and economic instruments such as payments for ecosystem services (Dufour, et al., 2016). More generally, the recognition of the value of nature for human societies is used to justify the costs of protecting and restoring the environment (Grizzeti, et al., 2016-1).

5 Challenges of using ecosystem services in participatory river basin management

5.1 Multiple definitions, different interpretations

Beyond, the definition of ecosystem services by the MEA, mentioned in the introduction, there exist many other definitions such as "the direct and indirect contributions of ecosystems to human well-being" (TEEB, 2010) or "the aspects of ecosystems utilized (actively or passively) to produce human well-being" (Fisher, et al., 2009). Ecosystem services are part of a network linking biophysical structures to values for human societies through biophysical processes, functions, services and benefits (sometimes denominated "the ecosystem services cascade", Haines-Young et al., 2010). According to definitions and interpretations, some phenomenon may be considered as an ecosystem service or rather as a function or a benefit.

In addition, human institutions and judgments have an impact on the definition of ecosystem services. Perceptions, values, skills, management regimes and power relationships are social factors that may affect the delivery of ecosystem services (Davies, et al., 2015). Ecosystem services are often considered as the result of the interaction between human beings and ecosystems. Therefore two identical ecosystems may deliver different ecosystem services in different contexts according to the beneficiaries who interact with them and who perceive them (Verutes & Rosenthal, 2014). Those elements make ecosystem services difficult to define while their definitions can lead to several interpretations.

5.2 Ecosystem services' complexity

As briefly addressed in section 4.1., the concept behind the notion of ecosystem services is complex. Ecosystem services are very different from one to another. The use of some of them is competitive, such as freshwater provision, while others are non-rivalrous, such as climate regulation. Nevertheless, human behaviors in relation to ecosystem services can have an impact on their availability for others if those behaviors damage the ecological conditions needed by most ecosystem services to be delivered. If the use of ecosystem services has an impact on the global ecological status of the system, because of overexploitation for instance, this would affect or prevent their provision in the long run. This adds complexity to the management decision making process and introduces political concerns.

Ecosystem services' geographical and temporal scales differ a lot as well. All of them do not appear, deteriorate, recover or react to stresses at the same speed. They do not follow the same spatial logic, especially when they are linked to water, as they are part of a hydrological cycle composed of complex land-water interactions (Grizzeti, et al., 2016-1). Contrary to carbon sequestration, water flow regulation service may differ according to the localization of potential beneficiaries, upstream or downstream the river. Other ecosystem services, such as esthetic appreciation, follow different spatial logic according to the cases and perceptions. It is also interesting to note the existence of what human beings consider as disservices. They can be defined as the result of ecological functions that produce an outcome of negative value. Once again, as the value depends on human beings' perceptions, some phenomenon can be considered as services by some people and disservices by others. While urban plants provide aesthetic appeal and well-being to the people living in cities, respiratory allergies to wind-pollinated plants make those same plants being the cause of ecosystem disservices (Von Döhren & Haase, 2015).

Consequently controversies around the notion of ecosystem services are numerous, including about the understanding of the concept and its scientific uncertainties (Barnaud & Antona, 2014). This brings two types of challenges and risks. The first one is the need for multidisciplinary expertise to make an ecosystem services-based approach operational: both natural and social specialists are needed to understand both the biophysical and the socio-economic contexts (Febria, et al., 2015). Practitioners themselves must master the concepts and methodologies before using them. This requests training and a knowledge basis which might be difficult and long to acquire (Fürst, et al., 2014). The second one relies on the fact that it is very likely, in an operational context, that the notion is over-simplified and that definitions and concepts are unclear. This can lead to misunderstandings or misinterpretations which may make public opinion easy to manipulate or lead to inequalities between actors and difficulties to interact (Grizzetti, et al., 2016-2) (Wallis, et al., 2013) (Fürst, et al., 2014).

5.3 Identifying and classifying ecosystem services

The MEA defined a commonly used typology which distinguishes four categories of ecosystem services: provisioning services (food, freshwater, timber, etc.), regulating services (water treatment, climate regulation, erosion control, etc.), cultural services (recreation, aesthetic values, etc.) and supporting services (nutrient cycle, soil formation, etc.). Despite its pedagogical interest, this classification has been abundantly commented and criticized (Wallace, 2007; Fisher et al., 2009; Haines-Young & Potschin, 2010). More recent typologies have been proposed to overcome some of its drawbacks. For ecosystem services valuation purpose, the TEEB framework considers supporting services as ecological processes and replaces them by a habitat services category in order to avoid double counting in the valuation process. In order to support the development of environmental accounting, the European Environmental Agency designed a Common International Classification of Ecosystem Services (CICES), which classifies ecosystem services in a five-level hierarchical structure including three sections similar to the MEA's categories except the supporting services one (cf. Table 1). This typology distinguishes the services provided by living organisms or by a combination of living organisms and abiotic processes. Abiotic services provided only by abiotic processes may affect ecosystem services but are not considered as such. Nevertheless, other major institutions such as environmental departments, NGOs or the Global Water Partnership use the MEA typology slightly modified to fit their context and needs.

In the context of participatory river basin management, the issue is which typology is most appropriate for operationalizing the ES concept in the management process. Lots of authors consider that an efficient typology is needed to support the implementation of an ecosystem services-based approach and many argue that it is more efficient to identify and classify ecosystem services according to the context rather than using existing lists and typologies (Martin-Ortega, et al., 2015) (Asah, et al., 2012) (Costanza, 2008) (Fisher, et al., 2009). The main argument is that existing classification schemes may not adequately reflect the specificities of a social-ecological system and thus may not be relevant to the local problems and to the system's social-ecological context and bio-physical environment (Asah, et al., 2012) (Tadaki, et al., 2015).

Moreover several case studies have highlighted a significant difference between the ecosystem services selected by local stakeholders through participatory methods and those identified in the literature (Malinga, et al., 2013) (Jorda-Capdevila, et al., 2016-1). Ecosystem services identification based on the literature is also considered as insufficient to capture the complexity of local realities (Ceresil, et al., 2015). Those arguments push toward using bottom-up approaches and participatory methods to establish a list and classification of ecosystem services that are efficient for management. Issues of social and procedural equity are then at stake when choosing the methods and actors involved in the selection and classification of ecosystem services as this constitutes political decisions (Tadaki, et al., 2015). On the other hand, ecosystem services complexity and the need for diverse expertise are strong arguments toward deriving ecosystem services frameworks through expert analysis and scientific literature.

However, in our review, out of 21 papers addressing the use of an ecosystem services framework for participatory river basin management, only six, including two studying the same case, use a list of ecosystem services specifically built for the study and based on its context. Among those five cases, only one, in the Lower Ter River Basin in Spain, shows the direct involvement of a specific list of ecosystem services in the management process. The list of ecosystem services was identified by two researchers from the responses to interviews of twenty informants who had good knowledge and experience of the territory (Jorda-Capdevila, et al., 2016-1). In the four remaining cases, ecosystem services are assessed in a participatory way (?) but the assessment outputs are not directly used for decision-making: the Lower Caqueta River in Colombia (Ramirez-Gomez, et al., 2015), the Koshi River Basin in Nepal (Van Oort, et al., 2015), the South Australian Murray-Darling Basin region in Australia (Raymond, et al., 2009) (Cast, et al., 2008) and the Upper Thukela region in South Africa (Malinga, et al., 2013).

5.4 Measuring the impacts of an ecosystem services-based approach

While many elements constitute arguments supporting the use of the notion of ecosystem services in participatory decision-making for water systems, some authors observed that the actual design of policies and implementation of measures have not shown much evidence of the contribution of ecosystem services to the decision-making process (Seifert-Dähn, et al., 2015). A lot of concepts emerged and disappeared or changed after a while because they could not prove to have enough benefits. This was the case of three approaches respectively promoted and used in 2002 by Conservation International ("biodiversity hotspots"), the International Union for the Conservation of Nature ("landscape approach") and the World Wildlife Fund ("Global 200 Ecoregions") which had changed in 2014 compared to their 2002 status (Leisher, 2015). In the case of ecosystem services and their use in participatory management, it seems to be too early to draw a conclusion. In 2013, Liu and her collaborators could not find any study in which an ecosystem services framework had been operationalized to support water management (Liu, et al., 2013). In 2016, Grizzetti and her collaborators qualified the use of the concept of ecosystem services in water policies and management as being in an "explorative stage" (Grizzeti, et al., 2016-1).

A tool has already been developed by Fürst, Opdam, Inostroza and Luque to measure the success of an ecosystem-services approach in facilitating participatory planning. Using a balanced score card, criteria are chosen, strengths and weaknesses are identified and grades are given to assess the success of the approach in a case that has already been implemented. The result may then be used to choose whether the ecosystem services approach should be used in a similar case. The authors tested the tool on two cases that differed regarding their governance scheme and could conclude which governance scheme was best fitted to an ecosystem services approach. It is interesting to note that the ecosystem services approach was more successful in an "integrated land-use planning [system], driven by actors at place" than in a "multi-level governance [system] mainly based on cooperation between hierarchic and institutionalized planning structures at regional or local communities", confirming the tight link between ecosystem services and participation (Fürst, et al., 2014).

6 Conclusions and recommendations

6.1 Practices and outcomes

This literature review permitted to identify that assessment and valuation of ecosystem services constitute the main use of the notion in relation to participatory water management and have already been studied a lot. ES assessment and valuation exercises improve the knowledge of water-related social-ecological systems and therefore may inform participatory water management processes. Cases reporting an actual use of ecosystem services as a tool for participatory management are less common and less documented. Participatory modeling methods based on ecosystem services enable the participants to create a clear vision of a system, to understand its past and to build its future. Those methods, such as scenario planning and mapping, emphasize the aspects of ecosystem services that make them an intuitive and understandable notion. They provide a context that facilitates people's handling of ecosystem services. In parallel, ecosystem services can be used as basic components for modeling approaches as they capture natural systems with quite simple words and provide a framework for discussing with a common language. Both modeling methods and the ecosystem services concept are helpful to understand complex systems functioning. In particular, games seem to have even more potential to operationalize those advantages because of the closeness they are able to create between players and the concepts they wield.

Direct outcomes have been identified from the eight case studies describing the operational use of ecosystem services in participatory management of river basins. First, ecosystem services permitted to identify the places and concerns on which management had to focus by prioritizing the ecosystem services lying behind issues at stake (Jorda-Capdevila, et al., 2016-2) (Liu, et al., 2013) (Malinga, et al., 2013) (Palomo, et al., 2011) and by evaluating and measuring the consequences of different options for the future through their impacts on ecosystem services (Borowski-Maaser, et al., 2014) (Jessel & Jacobs, 2005). Second, ecosystem services have helped to deal with conflicts that arose around usages of water. Locations and causes of conflicts have been identified using ecosystem services as these conflicts were located where many people granted value to nature and as they were caused by this high concentration of value (Jorda-Capdevila, et al., 2016-1). Conflicts were also handled by bringing stakeholders together, who then understood the advantages of discussion and could work on a common desirable future (Jacobs, et al., 2015) (Maynard, et al., 2015).

Those results have shown to come together with the general advantages of ecosystem services cited in section 3: they constitute a framework to discuss with a common language, they make complex social-ecological systems easier to understand and they engage people in management processes.

6.2 Recommendations to move forward

Despite the novelty of using ecosystem services in management processes and the scarcity of literature studying those practices and their outcomes, some recommendations can already be formulated, to overcome the challenges raised in this literature review. Ecosystem services' complexity, variable definitions and multiple classifications act as brakes to capture them into models and to use them in operational contexts. The notion needs to be clarified and strengthened for the models to be accurate and to avoid misunderstandings and their consequences.

However, no conclusion can be effectively drawn concerning the use of ecosystem services in river basin management as it has hardly ever been assessed and compared to similar cases not resorting to ecosystem services. The literature studied offers conclusions on the experiences that have been led but rarely evaluates the effects of ecosystem services themselves on the results. The use of ecosystem services in a water management context should be systematically monitored and evaluated to truly conclude on its impacts. The measurement tool proposed by Fürst, Opdam, Inostroza and Luque is a first step toward evaluating the outcomes of using ecosystem services and could be used as an evaluation tool (Fürst, et al., 2014). Nevertheless, the method created does not allow any comparison between the cases graded and similar cases which would not use ecosystem services. More evaluations and wider comparisons are needed to conclude whether and how the operational use of ecosystem services affects the results of participatory river basin management.

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