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# Theory and practice of water ecosystem services valuation: Where are we going?

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ABSTRACT

Water resources have been widely cited as a prime example of ecosystem services (ES), especially when the issue is valuation. Because of the importance of water ecosystem services (ESw), they are being effectively evaluated in at least three aspects: clarity about the type of valuation employed; adoption of a strong theoretical basis guided by ecological knowledge; and the inclusion of analytical elements that ensure social control and direction in decision making. Our study sought to determine whether these prerogatives are actually relevant, by assessing the emphasis in the valuation of ESw among ES publications. From the literature, we define five types of valuation and five major theoretical principles that can be broken down into 14 indicators that we used in our analysis of ESw studies. Our results indicated that the current knowledge about ESw carry the false impression that the ecosystem services valuation is sufficiently consolidated to support decisions about payments for ESw.

## 1. Introduction

Increasing concern with the sustainability of natural resources and their finite availability have been the focus of numerous research studies (Costanza et al., 2014; de Araujo Barbosa et al., 2015). The substantial increase in the number of scientific publications about ecosystem services (ES) confirms this concern (de Araujo Barbosa et al., 2015). This is a clear indication of the need for greater understanding, evaluation and measurement of different ecosystem services and denotes how ecosystem degradation interferes with resource availability and human well-being (Eigenbrod et al., 2009).

The ES concept, defined by Millennium Ecosystem Assessment (MEA) (2005) as the benefits that humans obtain from nature, besides being the most widely used ecosystem research topic, is seen as a promising approach to making the connection between ecological concepts and human well-being (Millennium Ecosystem Assessment (Program), 2005; Hermann et al., 2011). The concept emphasizes the utilitarian character that humans attribute to processes and natural elements. This concept has been focused on anthropocentric and economic valuation (Schröter et al., 2014), but it has not yet been refined, which generates concerns regarding its arbitrary application (Nahlik et al., 2012; Seppelt et al., 2011; van den Belt and Blake, 2014).

Since the 1960s, when King (1966) and Helliwell (1969) first presented the concept of natural benefits, there has been an interest among researchers to understand and describe how ecosystems internally maintain energy flows and nutrient cycling (Erlich and Money, 1983; De Groot et al., 2002; Kremen, 2005; MEA, 2005). However, it was only in the 1990s that this concept caught the attention of economists, who began to engage in studies to estimate its monetary value (Costanza and Daly, 1992; Costanza et al., 1997; Gómez-Baggethum et al., 2010; Bennett et al., 2014). Since then, researchers have made an effort to try to reach a conceptual agreement between the areas of economy and ecology to define the common essence of natural resource uses for humans, but different meanings have developed for terms used in common (Patterson and Coelho, 2009; Roces-Díaz et al., 2014).

In this respect, several research areas have intensively focused on different approaches to the valuation of ES: economic valuation-estimating the monetary losses and gains of ES (Maia et al., 2004); ecological valuation-assessing ES losses and/or gains by measuring ecosystem or biophysical parameters (Farber et al., 2002); socio-cultural and economic valuation – valuing ES based on the attributes of different social and cultural groups observed under a cultural-social conservation perspective (Wilson and Howarth, 2002; Zander and Straton, 2010); and ethical valuation-valuing "moral sentiments" (Bowles, 2008).

According to the MEA (2005), approximately 40 ES have been described, which are divided between four categories: support, supply, regulation and culture. Among all of the ES, those related to water (ESw) are among the most important for human wellbeing (Brauman

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et al., 2007; de Groot et al., 2010; Keeler et al., 2012; Seifert-Dähnn et al., 2015). Therefore, it is important to identify the ESw at all levels of ecological-economic-social-cultural importance because these properties directly affect the amount and quality of service provided to society (Keeler et al., 2012). Some authors treat the ESw from a transversal knowledge perspective because, unlike other natural benefits, ESw are found in all ES categories described by the MEA (2005), such as drinking water (supply ES), the use of rivers and lakes for recreational purposes and eco-tourism (cultural ES), water cycling (support ES) and climate regulation and water purification (regulation ES) (Pinto et al., 2013). The need to know how to maintain and/or improve the supply of ESw, by determining the necessary focus of ESw studies, led to the development of strategies, methods and tools that can be incorporated into the valuation. Despite widespread recognition of the need to value water resources, existing strategies and methods often do not meet the expectations of planners and decision makers because important elements like data collection, analysis or the dynamics of ecosystems identification data are usually insufficient for real valuation of natural resources (Keeler et al., 2012; Böck et al., 2015; Naeem et al., 2015). Overall, the researchers opt for a valuation approach, sometimes monetary, sometimes ecological or even a combination of both (Brauman et al., 2007; Costanza et al., 2014; La Notte et al., 2015; Ojea et al., 2012). Often this decision reduces the ES categories that can be evaluated. There is a consensus among authors that much still needs to be studied and debated so that professionals from various fields of knowledge can agree on concepts, categories, valuation methods and the correct use of ESw values (Lele, 2009; Doherty et al., 2014; Böck et al., 2015; Van Houtven et al., 2014). As already suggested by Keeler et al. (2012), the great challenge is to integrate biophysical and economic models, which are commonly developed in isolation without considering how the output of one model can contribute to another.

Given this scenario, we believe it is important to recognize the trends and practices used to enrich current knowledge and the methodological approaches and ESw valuation practices, to show, through a literature review, the level of research interest in this subject, as well as the theoretical framework adopted by them when assigning value. For this purpose, we evaluated studies with a central focus on freshwater ES from the perspective of environmental planning using five theoretical principles and 14 indicators presented in the literature review.

## 2. Material and methods

To answer our research question, we applied a literature systematic review based on two main stages that allowed providing evidence base of the theory and methodological practice used by researchers for the valuation of water ecosystem services. Firstly we did a detailed planning to conduct and delimit terms that represented the research aim. The articles that contained the selected terms were categorized, according five types of valuation. After this, we used reproducible criteria for inclusion of the selected articles in major principles and indicators to environmental planning. The selected research articles were evaluated under the motivation and objectives of this review. The stages were based on de Araújo Barbosa et al. (2015).

### 2.1. Literature review

A literature search was used to investigate the use of the terms "ecosystem service" related to water resources. Research has shown that the term is relatively new and has significantly increased over the past 10 years; therefore, the use of only this term could lead to the loss of articles relevant to the literature review (Harrison et al., 2014). Therefore, lists of synonyms were found in several studies (Costanza et al., 1997; De Groot et al., 2002; Lamarque et al., 2011; Lele et al., 2013) and were quantitated to identify the most used terms in the literature.

A literature search was performed on a datasets of indexed scientific data in ISI Web of Science and Scopus in three stages using query selectors: "ecosystem service*" OR "ecosystem good*" or "ecosystem benefit*" OR "nature* service*" OR "nature* good*" OR "nature* benefit*" OR "environmental service*" OR "environmental good*" OR "environmental benefit*" OR "ecological service*", OR "ecological good*" OR "ecological benefit*", and their the following combinations: "ecosystem good* and service*" OR "nature good* and service*" OR "environmental good* and service*" OR "ecological good* and service*". We searched for these terms in the titles, and/or as keywords, and/or in the abstracts of articles published in English and in peer-reviewed scientific journals. This strategy is based on the guidelines from de Araujo Barbosa et al. (2015). Not included were books, book chapters, master's or doctoral thesis, extended abstracts and summaries of scientific events. The lists of selected scientific papers in both databases were compared to eliminate duplicate articles. The second step was to select, among these articles, those related to water resources. In order to achieve this, the keyword search included: “water*” OR "freshwater*" OR "river*" OR hydro* OR “stream*”. The third and final step was to search among these articles, which dealt with the valuation of ESw, by adding the search term “valu*.”

To refine the search, articles containing at least one combination of these terms in their titles and/or abstracts were included. To be included in the analysis, the articles met three basic requirements: (i) specific information on ESw value; (ii) methodological description about ESw evaluation; and (iii) freshwater focus. The articles selected at this stage were classified into five categories: (a) economic valuation; (b) ecological valuation; (c) socio-economic valuation; (d) ethical valuation; and (e) mixed valuation of ESw (economic and ecological) (Table 1).

### 2.2. Literature evaluation

The methodologies presented in the articles were evaluated using set of principles that were presented in the literature and were organized in such a way that the minimum requirements considered by the literature were essential for the analysis and valuation of ES. The principles were highlighted in studies of Albert et al. (2014), Amiri and Nakane (2009), Naeem et al. (2015) and Ojeda et al. (2008) (Table 2).

## 3. Results and discussion

Our study focused on four sequential questions to integrate the assessment of knowledge about ESw valuation, according to Fig. 1. The

**Table 1**
Definition of valuation categories to water ecosystem services.

| Categories | Definition |
|---|---|
| Economic valuation | The monetization and trading of ESw from an economic perspective (Gómez-Baggethun et al., 2010) |
| Ecological valuation | The valuation of ESw based on ecosystem or biophysical attributes of water resources (Farber et al., 2002) |
| Socio-economic valuation | The valuation of ESw based on attributes of different social and cultural groups observed based on a cultural-social conservation perspective (Wilson and Howarth, 2002) |
| Ethical valuation | The valuation of ESw with the inclusion of the "moral sentiments" of the population (Bowles, 2008). |
| Mixed valuation | The valuation of more than one category in the final value of ESw. |