

Evaluation of cultural ecosystem services: A review of methods

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ABSTRACT

Cultural ecosystem services (CES) refer to the nonmaterial benefits people obtain from ecosystems, and they have direct influence on quality of life. Although the concept of CES has been well accepted, they are rarely fully investigated. A significant barrier is the method for evaluating CES. This paper conducts a literature review of CES evaluation methods. Our aims are the following: to provide an overview of existing CES evaluation methods, to classify them, to analyze them, to highlight important challenges and to offer suggestions for future study.

This study has reviewed 293 papers and identified 20 evaluation methods. To conclude, we (i) emphasize considering all CES categories. More specifically, consistent classification systems for CES and unambiguous descriptions of each category are needed; (ii) highlight a combination of methods to enable a better evaluation of CES and call for integrating monetary and non-monetary methods, which does not indicate merely adding the different parts but rather focusing on the interactions between these components, especially by means of deliberative, participatory and mapping techniques; (iii) encourage more stated preference methods, such as the Q-method and narratives, to evaluate neglected services; (iv) propose that in-depth study of CES evaluation process is required to improve evaluation accuracy.

1. Introduction

Over the last 20 years, especially the last 5–10 years, ecosystem services (ES) have become a well-recognized tool for decision-making on various ecological and social issues. ES are defined as the ‘benefits that people obtain from ecosystems’ (MEA, 2005) and are generally classified into provisioning services, regulating services, supporting services and cultural services. Cultural ecosystem services (CES) refer to the nonmaterial benefits people obtain from ecosystem (MEA, 2005) and directly influence the life quality (Plieninger et al., 2013). Both CES and other services reflect what people obtain from the natural environment, and therefore increase the public’s awareness and motivation for environmental protection (Opdam et al., 2015; Orenstein, 2013; Plieninger et al., 2015). Moreover, the outcomes of ES evaluation can support practical application (e.g. urban planning and, landscape design) and policy making (Egoh et al., 2008; Lautenbach et al., 2011; Willemen et al., 2008). ‘Evaluation’ means the process of assessing the value of something. Scientific literature has proposed a number of terms to distinguish specific methodological approaches, often used synonymously, including valuation, assessment, accounting, mapping, quantifying, etc. These different terms often refer to different theoretical concepts, and they apply diverse methods but share the commonality of

assessing ES. For example, economic ‘valuation’ treats values as assigned values; social ‘valuation’ refers to the relative importance or value of an object to an individual or group in a given social context (Scholte et al., 2015).

The evaluation of CES remains relatively neglected and poorly understood as CES are ‘intangible’, ‘nonmaterial’ and ‘invisible’ compared with other material services (Martín-López et al., 2009; Tilliger et al., 2015). Although the low availability of data is significant barrier to the assessment of all ecosystem service, this is especially the case for both quantitative and qualitative data for CES evaluation (Gee and Burkhard, 2010; Brown et al., 2016). Data mainly have to be gathered with detailed and specific surveys (Paracchini et al., 2014). Moreover, the boundary between different CES categories is not clear, which may often lead to double-counting problems. Benefits for recreation, for instance, are linked to other services such as aesthetic values, educational values, and spiritual and religious values. It is very difficult to distinguish and identify the real value of each service (Daniel et al., 2012).

Nonetheless, researchers have been studying CES and their evaluation methods for decades (Katz-Gerro and Orenstein, 2015; Milcu et al., 2013). In the 1970s and 1980s, a growing number of researchers started to use economic terms to address ecological issues (Braat and de Groot,

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2012). Gómez-Baggethun et al. (2010) provided a detailed description of ES history from an economic perspective. Braat and de Groot (2012) summarized this history in terms of economic and ecological roots.

Researchers used various methods to assess ES. TEEB (2010) generally classified these evaluation methods into biophysical methods and preference-based methods. Christie et al. (2012) further divided preference-based methods into monetary method and non-monetary methods. Braat et al. (2015) and Hirons et al. (2016) succinctly classified all the methods into monetary methods and non-monetary methods. There are many papers that have reviewed the monetary methods for assessing ES, see Spangenberg and Settele (2010); Chee (2004); Swinton et al. (2007); Christie et al. (2012); and D'Amato et al. (2016). Although the problem of CES evaluation has been increasingly addressed, few efforts have focused on systematically reviewing the diversity of these methods. Additionally, how CES evaluation is associated with the distribution of CES categories is rarely investigated.

This paper aims to conduct a systematic quantitative literature review on evaluation methods. It discusses the problems and challenges of existing studies, the distribution of the CES categories, the implications and applications of evaluation methods, the advantages and limitations of evaluation methods, and the challenges for future study. We particularly focus on: what and how many methods have been proposed to evaluate CES? Which methods are most frequently used? Which CES category is most frequently examined with these methods? How are the methods applied? What are the advantages and limitations of these methods?

Following the description of the materials and methods (Section 2), this paper aims to address these questions. First, we classify and summarize the evaluation methods, including connotation, scope of application and evaluation process with examples (Section 3). We then discuss the classified methods and their challenges based on this review (Section 4). Finally, we conclude with recommendations for the future research (Section 5).

2. Materials and methods

We conducted a systematic quantitative literature review, which is a straightforward and systematic approach (Pickering and Byrne, 2014). We used the ISI Web of Science (<http://www.isiknowledge.com>) and Scopus (<http://scopus.com>) databases to conduct a comprehensive search based on the search term “cultural service*” OR “cultural ecosystem service*” in titles, abstracts and key words.

2.1. Paper and case study selection

We limited the literature set to items published between 2005 and July 2017. A focus on this period is justifiable since 2005 was the publication year of the Millennium Ecosystem Assessment synthesis reports, in which CES were officially defined as a framework to aid in the understanding of ecosystem functions and processes and the relationship with human benefits and well-being. Since then, the concept gained particular attention, as reflected in the number of scientific publications on CES.

The literature searches were performed from June to July 2017. Non-English language searches were not conducted in this review. These searches resulted in a total of 839 references from Scopus, and 613 references from the Web of Science, including journal articles, reports, books, and conference papers. After eliminating the gray literature and duplicates, 1129 papers remained. We verified their relevance by checking titles, key words, abstracts and the full text to specifically select the publications about methods for evaluating CES. If a paper merely mentioned CES evaluation methods, the work was excluded from further consideration. This screening resulted in 293 papers that were read in detail (Table 1).

Table 1

Literature selection process for systematic review.

Source	Number of papers
Papers searched in Web of science	613
Papers searched in Scopus	839
Removal of duplicates, gray literature	– 323
Title, key words, abstract and full text screening	– 836
Included in review	293

2.2. Analytical framework: Classification of the identified papers and case studies

2.2.1. Classification of CES categories

Based on the Millennium Ecosystem Assessment classification, this study indicated which CES categories were examined (Table 2). Notably, only the categories with in-depth investigation have been included, regardless of those that were just ‘mentioned’, due to their lack of further value. The categories were reorganized to match the MEA classification system because authors have used different terms in accordance with different CES classification systems (e.g., TEEB or CICES classification systems). ‘Symbolic’ (CICES v4.3) and ‘information and cognitive development’ (TEEB), for example, all refer to ‘spiritual and religious values’ (MEA). In addition, we identified the categories when an author used different terms, such as learning for education (Brown and Hausner, 2017) and place attachment for sense of place (Khakzad and Griffith, 2016). Furthermore, information concerned with the classification categories was not recorded if it was not provided or not applicable to our classification, such as therapeutic (Schmidt et al., 2016a), life sustaining (Sherrouse et al., 2014), and cultural significance (Ives et al., 2017). These terms have not been included in our research.

2.2.2. Classification of CES evaluation methods

Each paper was first screened for CES evaluation methods. Based on the study of ES, and on whether the result was expressed monetarily, the CES evaluation methods were first classified into monetary methods and non-monetary methods (Hirons et al., 2016; Christie et al., 2012). Then, the revealed preference and stated preference classifications were distinguished for each method (Spangenberg and Settele, 2010; Christie et al., 2012). Based on monetary methods, the revealed preference method means, observing the actual markets related to the CES to assess the CES value. The stated preference method means, building a hypothetical market and asking respondents to directly state their willingness to pay, receive, accept, or give up some services. Based on non-monetary methods, the revealed preference method means, observing behavior or analyzing documents, including written texts and advertisements, to indirectly determine human preference for CES. The stated preference method means, directly asking about one’s values to assess CES. Based on this classification, an iterative approach adapted the future categories and analyzed the papers, yielding a final classification after the analysis of the total set. Finally, we counted the number of studies that applied each of the CES evaluation methods distinguished (242 studies of the 293 selected papers). Additionally, if different methods were applied in one paper, it was scored multiple times, once per method used.

3. Results

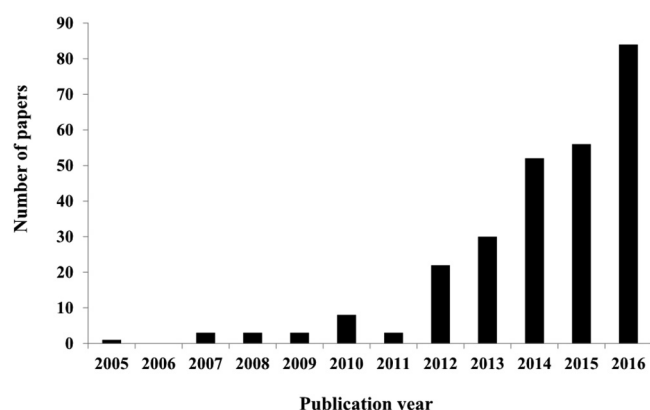
3.1. Overview of reviewed papers

The study shows that papers on CES evaluation methods increased considerably from 2005 to 2017 (Fig. 1). The average rate of publication was 3 papers per year from 2005 to 2012, and it rose to the average rate of 54 papers per year after 2012 based on our calculation. In the following sections, further characteristics of the reviewed studies are

Table 2

Categories of cultural ecosystem services. Classification and definitions quoted from the Millennium Ecosystem Assessment (MEA, 2005).

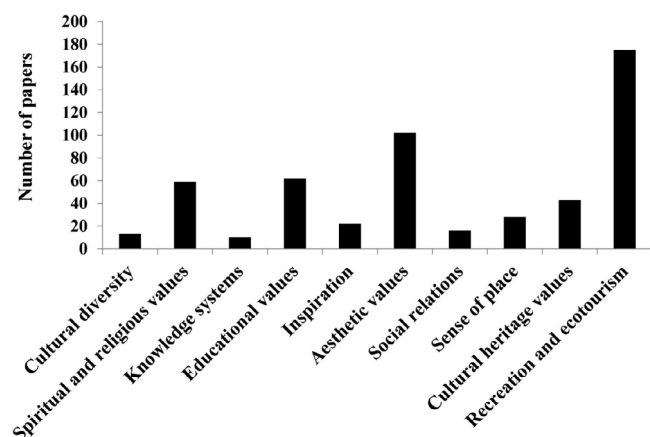
Category	Concept
Cultural diversity	The diversity of ecosystems is one factor influencing the diversity of cultures.
Spiritual and religious values	Many religions attach spiritual and religious values to ecosystems or their components.
Knowledge systems	Ecosystems influence the types of knowledge systems developed by different cultures.
Educational values	Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.
Inspiration	Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising.
Aesthetic values	Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, 'scenic drives,' and the selection of housing locations.
Social relations	Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies.
Sense of place	Many people value the 'sense of place' that is associated with recognized features of their environment, including aspects of the ecosystem.
Cultural heritage values	Many societies place high value on the maintenance of either historically important landscapes ('cultural landscapes') or culturally significant species.
Recreation and ecotourism	People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area.

**Fig. 1.** Number of papers per year from 2005 to 2016.

presented in more detail, which include the CES categories and CES evaluation methods. The results are generally presented as a percentage of the papers and case studies.

3.2. CES categories

The evaluation of CES categories was highly uneven (Fig. 2). Recreation and ecotourism were evaluated by the majority of studies, followed by aesthetic values, educational values and spiritual and religious values. Social relations, knowledge systems and cultural diversity received the least attention. Recreation and ecotourism, as well as aesthetic values, were evaluated more often than the other eight

**Fig. 2.** Number of papers investigating different categories of cultural ecosystem services.

subcategories.

In all, 116 of 242 studies only assessed a single cultural service, of which the studies on recreation and ecotourism accounted for 62. The remaining 126 studies evaluated multiple services, of which the combination of recreation and ecotourism, with aesthetic values was the most common. Of these 126 studies, only 29 simultaneously evaluated at least 5 services (see Appendix A).

3.3. CES evaluation methods

This study included twenty CES evaluation methods which employed different procedures, started from different theoretical backgrounds and applied different techniques (Table 3, Table 4). The number of studies using each method is shown in Fig. 3. The distribution of each CES category corresponding to different methods is shown in Fig. 4. The number of studies per year using monetary and non-monetary methods is shown in Fig. 5. Non-monetary methods significantly increased compared with monetary methods.

3.3.1. Monetary evaluation methods

Seven monetary evaluation methods were identified (Table 3, Fig. 4), of which the first four methods employed revealed preference, and the rest applied stated preference. (1) The 'market price method' is employed to calculate CES directly in line with the product market. For instance, Sumarga et al. (2015) calculated recreation and ecotourism based on both the entrance fees paid to the parks and on the revenue generated in the local ecotourism sector. (2) The 'travel cost method' evaluates the recreation and ecotourism benefits of a resource using data calculating the costs associated with travel to a destination (Christie et al., 2012). For example, by assuming that visitors travel by car to an area, van Berkel and Verburg (2014) calculated a time cost demand curve for the sample group (34 eurocent/km rate). (3) The 'hedonic pricing method' exploits the relationships between a house price and its characteristics, and estimates the partial economic value of changes in an ecosystem service and amenity based on the sale prices of similar properties (Spangenberg and Settele, 2010). For instance, Garcia et al. (2016) found that the marginal benefit originating from a CES could be estimated from an increase in housing rent prices caused by an improvement in water quality due to river restoration. (4) The 'benefits/value transfer method' evaluates economic values by transferring existing benefit estimates from studies that have already been completed for another case (D'Amato et al., 2016). For example, to determine the recreation value of Cape York Peninsula, Preece et al. (2016) estimated the value based on the results from de Groot et al. (2012) and Costanza et al. (2014) who estimated the mean monetary value of eight biomes. (5) The 'deliberative valuation method' integrates the benefits of deliberation with the advantages of monetary values (Kenter et al., 2016). This technique originates from social

Table 3
Summary of the monetary evaluation methods.

Classification	Method	Description of method from the perspective of CES
Revealed preference	Market price	Estimates economic values of CES based on the price of products that can be bought and sold on the market. For instance, it uses entrance fees paid to parks to calculate recreation and ecotourism values.
	Travel cost	Estimates economic values of CES with travel costs. This method is a way to value recreation and ecotourism in ecosystems by using the travel cost to destinations where recreational activities, such as wildlife viewing, hunting, and fishing, are available.
	Hedonic pricing	Estimates economic values of changes in CES based on the sale prices of similar properties. In essence, hedonic approaches can measure values that become capitalized into the asset value of property; additionally, buyers and sellers are aware of the effect that relevant CES have on housing price.
	Benefits/Value transfer	Estimates economic values by transferring existing benefits to CES evaluation. For instance, the cost per trip per person in an existing study is adjusted and transferred to a new study for the calculation of recreation and ecotourism services.
Stated preference	Deliberative valuation	Combines the deliberative process with monetary methods. By integrating scientific or technical forms of analysis with deliberation, both facts and values can be made more transparent, allowing them to be contested and thus helping to inform CES preferences.
	Contingent valuation	Asks people to directly state their willingness to pay for specific CES. Unlike other methods, the contingent valuation method is capable of measuring passive use values that people may hold regardless of whether or not they will directly use a CES.
	Choice experiment	Asks respondents to choose between different bundles of CES described in terms of their attributes and attribute levels.

science and is often employed to address complex issues. The deliberative valuation fixates on better expressing preferences by providing more time for interaction and discussion, to become familiar with CES based on adequate information provided by researchers. For instance, this method was used by [Kenter \(2016\)](#) to discuss a series of CES in nine workshops. (6) The ‘contingent valuation method’ asks respondents for their willingness to pay for some services ([Ginsburgh, 2017](#)). As an example, [Gandarillas et al. \(2016\)](#) interviewed householders to determine their willingness to pay in labor time for protecting the CES of wetlands in the Bolivian Altiplano. This method covered the majority of services except for cultural diversity, knowledge systems and social relations. (7) The ‘choice experiment method’ asks individuals to choose their preferred alternative from several options in a choice set. These choices are described with a number of CES characteristics. For example, [Ungaro et al. \(2016\)](#) estimated the contributions of different landscape features to the overall landscape preference in a case study region in North-East Germany to assess CES using a visual choice experiment.

3.3.2. Non-monetary evaluation methods

As monetary methods can be challenging especially when a situation is complex and not all the CES can be expressed monetarily ([Christie et al., 2012](#)), non-monetary methods have attracted increasing attention (see [Fig. 4](#)). This study identified thirteen methods ([Table 4](#), [Fig. 4](#)), of which the first three methods used revealed preference, and the rest used stated preference. (1) The ‘observation method’ directly looks at human actions and behavior. For instance, [Unnikrishnan and Nagendra \(2015\)](#) observed people who are engaged in a particular activity such as fishing, representing recreation. (2) The ‘document method’ estimates CES values from certain individuals or groups by analyzing texts, images, or other forms of materials ([Scholte et al., 2015](#)). For instance, by evaluating the number of photos taken by the public and in advertisements, [Mark Everard \(2010\)](#) evaluated the aesthetic values of sand dunes. (3) The ‘social media-based method’ is a relatively new method via web platforms including Flickr, Panoramio, and Instagram ([Czembrowski et al., 2016](#)). To assess CES, this method often integrates social media with interviews, questionnaires, etc. ([Milcu et al., 2013](#); [Hernández-Morcillo et al., 2013](#); [Richards and](#)

Table 4
Summary of the non-monetary evaluation methods.

Classification	Methods	Description of method
Revealed preference	Observation	Directly looks at human action and behavior to reflect the social value of CES. For instance, observes the number of visits to a park to derive the recreational importance of the area.
	Document	Looks at texts, images, or other forms of materials to obtain information about human preferences on CES. For instance, analyzes the number of photos taken by the public and in advertisements to indicate the aesthetic value.
	Social media-based	Based on the social media data from various resources to assess CES. For instance, uses the number of wildlife pictures posted on a photo-sharing website such as Flickr as a proxy to obtain the recreation and ecotourism values.
Stated preference	Interview	Directly gains a deeper understanding about how and why people value CES through face-to-face interaction or other techniques. People are allowed to speak freely about their feelings and thoughts to obtain better understanding of services such as sense of place or inspiration.
	Questionnaire	Consists of a series of questions for the purpose of gathering information about CES from respondents. For instance, researchers use a Likert scale ask people to select from a given set of CESs can reveal important benefits.
	Narrative	Tells stories, and describes a scene by respondents to obtain information on CES. Analyzes the stories narrated by people to determine their sense of place.
	Focus group	Provides an opportunity to respondents to obtain more information and allows time for reflection or group discussion. In group discussion, facilitators help participants discuss their opinions about CES. The focus group is not so much about gathering individual opinions or thoughts but rather observing how the interaction happens and how a group creates discourse on the topic of CES.
	Expert-based	Uses experts’ professional knowledge and rich experience to evaluate CES. Experts who are familiar with jargon and techniques to state what they find important regarding CES issues.
	Q-method	Uses written statements to categorize stakeholders into groups, corresponding to certain value orientations. By analyzing individual beliefs, interests and attitudes, through the Q-sorts and post-sort interviews, respondents’ distinct values regarding CES are revealed.
	Participatory mapping	Combines the tools of modern cartography with participatory methods to map the CES. For instance, asks people to indicate or mark where they perceived the CES in a given map.
	Participatory GIS (PGIS)	Combines participatory mapping methods with geographic information systems (GIS).
	Public participation GIS (PPGIS)	Emphasizes the local level to promote knowledge production by local and nongovernmental groups.
	Scenario simulation	Simulates future scenes with different CES capacities to provide advice to support policy making and planning.

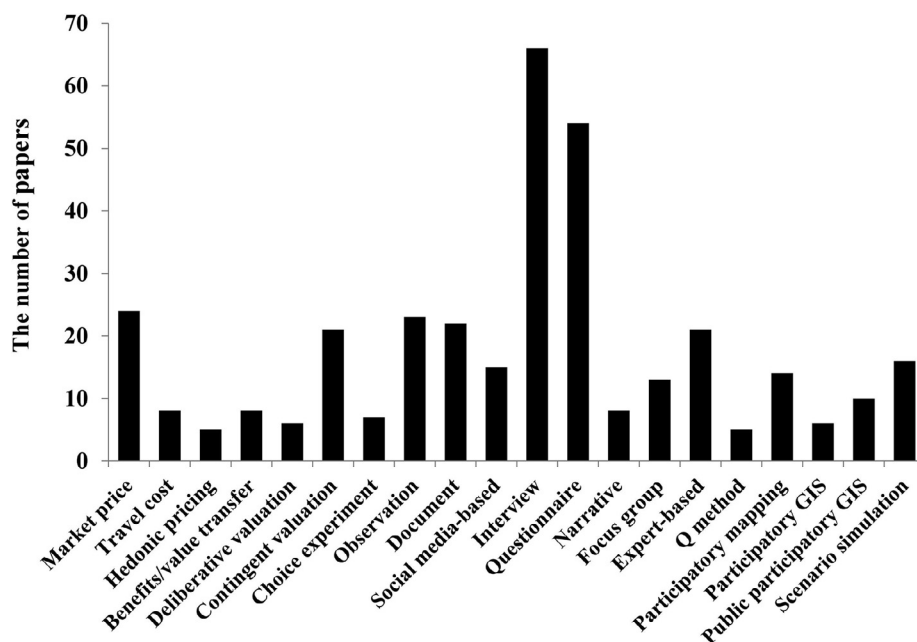


Fig. 3. Number of papers using different methods to assess cultural ecosystem services.

Friess, 2015). Willemen et al. (2015), for instance, represented recreation and ecotourism services using the number of wildlife pictures posted on a photo website as a proxy. (4) The 'interview and (5) questionnaire methods' were the most frequently used method to assess CES in a non-monetary way in the research. Schmidt et al. (2016b), for example, used face-to-face interviews to ask participants to assess 8 parks' benefits, which included recreation, sense of place and inspiration. Questionnaires usually consist of individual rankings by giving a certain value to CES. For example, Bryce et al. (2016) created an online questionnaire with 1220 participants to reveal multiple CES benefits that contribute to human well-being in a large-scale area, such as 'I feel a sense of belonging in these sites' to determine a service of sense of place. (6) The 'narrative method' systematically gathers and studies the stories provided by respondents. This method typically fixates on the lives of respondents capable of providing rich evidence. For instance, Bieling (2014) analyzed stories collected from local residents. The statement, 'I, by contrast, am a child of the Swabian Alb - through and through (...) I'm at home here, I belong here' demonstrates the sense of place service. (7) The 'focus group method' provides respondents with an opportunity to obtain more information and allows time for

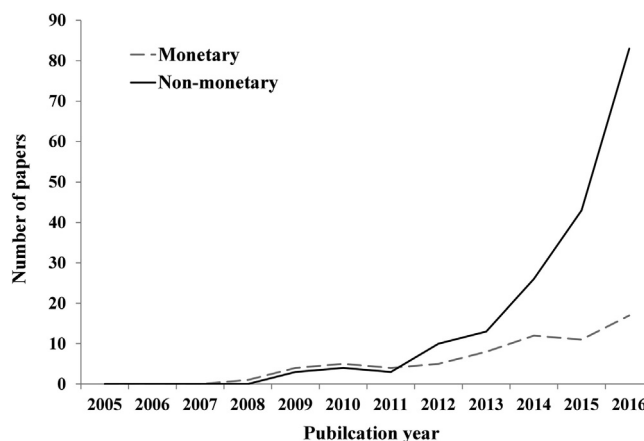


Fig. 5. Number of papers per year using monetary and non-monetary methods. The trends of both monetary and non-monetary methods applied by researchers are shown in this figure. Non-monetary methods show a significant increase compared with monetary methods.

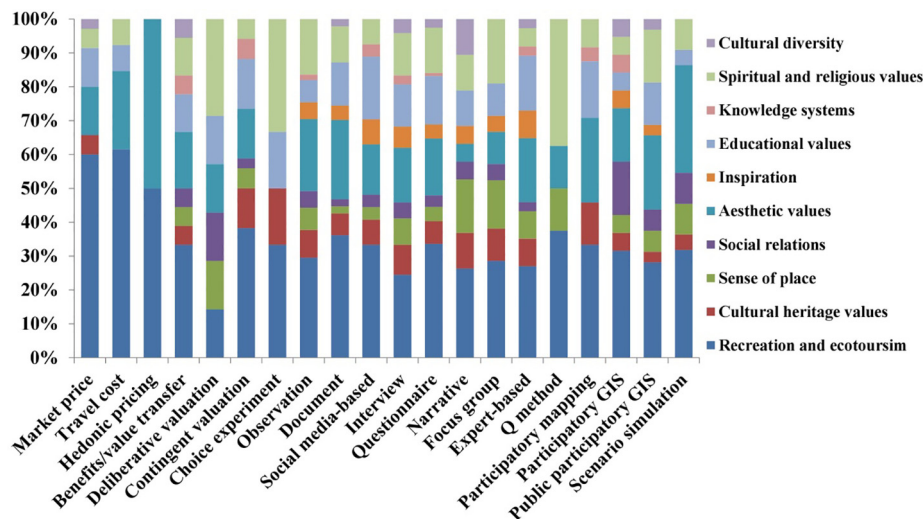


Fig. 4. Proportional distribution of CES subcategories corresponding to each evaluation method. This figure consists of 20 bars representing 20 evaluation methods, each of which shows the CES subcategories evaluated by method. Notably this figure does not represent the absolute number, but the distribution of CES evaluated by each method. The absolute numbers of each method are shown in Fig. 3.

reactions and discussion in a group (Spash, 2007). Ajwang' Ondiek et al. (2016), for instance, organized a focus group comprised of local residents, village elders, rice fields' block leaders, and farmers to ensure that policy formulation considers all stakeholders. (8) The 'expert-based method' draws upon the knowledge of experts to deal with complexities and uncertainties, which is often supported with information from literature and secondary data. The Delphi survey method (Nahuelhual et al., 2013), a structured communication method, is an example of this method and is based on a panel of experts. All experts remain anonymous, and they are allowed to comment on the responses of others and on the progress of the panel as a whole and to revise their own forecasts and opinions in real time. After several rounds of investigation, the process is stopped and reaches to a certain consensus regarding the CES issue at hand. (9) The 'Q-method' is a qualitative method using factor analysis to identify all the existing perspectives on a topic (Winkler and Nicholas, 2016). This method allows participants to generate their own topics instead of categories made by researchers (Pike et al., 2015). In contrast to more typical survey-based methods, the outcome of a Q-method study is a set of factors explaining the perceptions that exist among people. As an example, MacDonald et al. (2015) used the Q-method to characterize different perspectives about what is valued about the ocean and seafood by a coastal community in Canada, including recreation and education values. They first created a 'concourse', which represented the full range of things people say or think about the issue being investigated, and then selected 40 statements through an iterative process. Subsequently, 42 respondents were asked to choose from a 9 point chart ranging from 'least like the way I think' to 'most like the way I think' for each statement and to state their reasons, and finally, the factor analysis performed on the 42 sorts revealed five factors. (10) The 'participatory mapping method' links the CES perceived by people to a specific location (Brown and Raymond, 2007; Dramstad et al., 2006). (11) To support spatial planning decision making, the 'Participatory GIS (PGIS) method' integrates technology, including geographic information systems (GIS), global positioning systems (GPS) and remote sensing image analysis software, with human perception through interviews or questionnaires and human spatial knowledge, expressed with maps. (12) The 'Public participation GIS (PPGIS) method' stresses the voice of the public, through geographic technology education and participation. For example, Brown and Hausner (2017) identified the type, intensity and distribution of CES in a coastal area across diverse physical and social settings using PPGIS. In the absence of official data, volunteered geographic information (VGI) (Upton et al., 2015) gained attention as a database provided by volunteer individuals to complement more traditional data sources to identify recreation services. (13) The 'scenario simulation method' provides alternative images of how the future may play out. For instance, Frank et al. (2014) used this method with GISCAME, a software for simulating and assessing land use changes and the impact of land management scenarios on the provision of ES (Furst et al., 2011).

Fig. 3 shows the frequency of each method was used, and overall, interviews and questionnaires used most frequently, far more than the other methods. Of the monetary method, the market price and the contingent valuation methods rank first and second, respectively. Other monetary methods are used at a similar frequency. The non-monetary methods, in addition to interviews and questionnaires, frequently employed observation, expert-based, and document methods, followed by social media-based, participatory mapping and scenario simulation methods.

Fig. 4 shows which CES categories are evaluated with these methods. In general, all methods were used to evaluate recreation and ecotourism services. Most methods were used to evaluate aesthetic values, followed by spiritual and religious values and educational values. The monetary method was used to evaluate relatively few services compared with the non-monetary method. Among the monetary methods, contingent valuation and benefits/value transfer were employed to evaluate more services than other monetary methods. The

non-monetary method was applied to evaluate a wide range of services. Interview, questionnaire, expert-based and PGIS methods were able to evaluate all the services. Less addressed services such as social relations mainly used non-monetary methods, especially PGIS.

3.3.3. Evaluation method combinations

There were 86 studies using only one method in their study, and 96 studies adopted more than one method to assess CES. There were three main combinations as follows.

(1) The combination of non-monetary methods

We found that 68 studies used a combination of non-monetary methods. Among them, interviews and questionnaires form the most common combination. This combination is used as the main evaluation method or as a supplement. Calvet-Mir et al. (2012), for instance, evaluated ecosystem services provided by home gardens. The methods included an in-depth literature review, participant observation, semi-structured interviews, a valuation questionnaire, and a scientific panel consultation. Through observation, they observed the work performed by gardeners to improve the understanding of activities related to the provision of home garden ecosystem services. They then used a Likert scale designed for their interview to assess stakeholder agreement on statements about the importance of home garden ecosystem services, such as 'Home gardens are important because they allow to create and maintain relations between people' to assess social relations. In this case, the author assessed CES by a triangulation of information obtained from a literature review, observations, and interviews. Non-monetary methods were often used to enhance evaluation results.

(2) The combination of monetary methods

We found one case using a combination of monetary methods. Garcia et al. (2016) evaluated recreation and ecotourism by using the hedonic pricing method and travel cost method corresponding to local and regional scales. Concretely, if the hedonic pricing method derived benefits were the only benefits included, that option would not consider the benefits obtained at a larger scale reflected in the presence of visitors from nearby towns. Contrarily, considering only the travel cost value estimation would disregard the benefits provided to those who have a house nearby. In other words, using a combination of monetary methods can improve the accuracy of evaluation results. However, the combination of monetary methods is often limited to recreation and ecotourism, which are more materialistic services.

(3) The combination of monetary and non-monetary methods

There were 27 methods found to use a combination of monetary and non-monetary methods. Market price and WTP are the most common monetary methods in such combinations, while interviews and questionnaires are the most common non-monetary methods in these combinations. Baulcomb et al. (2015), for instance, identified and valued the CES of marine food webs. They first created an open-ended workshop to collect the existing knowledge and experiences of the project team regarding potential points of connection between elements of Turkish culture and various components of the Black Sea. Then, they expanded upon and verified the contents of the cultural briefing using the outcomes of 18 semistructured interviews with residents. The interviews provided evidence that noncommercial fishing is perceived as an important component of Turkish cultural heritage, and they proposed a hypothesis that values associated with this population attribute – as the attribute that reflects the regional ecosystem underpinning the extractive activities – would capture a portion of the consumptive use value associated with cultural heritage and identity. The final questionnaire was formed by these attributes. For each attribute, an economic value was calculated based on the annual household water bill,

and the price attribute that accompanied these attributes had six levels, which were determined based on responses to an open-ended question within the pretest that elicited the maximum annual WTP, over eight years, for the scenario with the most significant environmental change. Based on the results of the workshop and interviews, the final questionnaire used in their study was pretested in a workshop, and in this respect, the workshops were both semi-deliberative and participatory. In another example, García-Llorente et al. (2012) used face-to-face questionnaires to investigate the social factors that influence people's WTP for landscape aesthetics. Meanwhile, an expert focus group was arranged to analyze the capacity of services provided by the selected ecosystems. These two case studies combined monetary and non-monetary methods.

4. Discussion

This section discusses the existing CES evaluation methods and the challenges for future study.

4.1. The application of evaluation methods in CES categories

In CES evaluation, all services are equally important and must receive attention (Schaich et al., 2010). However, this study shows how the evaluation methods focus mostly on assessing recreation and ecotourism, while allocating much less attention to other services. This uneven distribution might be likely to be induced by lack of clear definitions. Recreation and ecotourism or cultural heritage has rather clear and demarcated definitions, which is much less the case for more ambiguous CES categories like inspiration or sense of place. This coincides with the observation that the existing primary international definitions (e.g., MEA, CICES, and TEEB) are still controversial (Wallace, 2007; Czúcz et al., 2018; Costanza et al., 2017). Moreover, the lack of a consistent classification system is a barrier for CES evaluation (Baulcomb et al., 2015; Chan et al., 2012). For example, we can easily determine the recreation category in different classification systems such as 'recreation and ecotourism' in MEA, 'recreation and tourism' in TEEB, and 'physical and experiential interactions' in CICES v4.3. However, for some other services, it is hard to find corresponding categories in the three international classification systems. Consequently, comparative studies are difficult if researchers use different classification systems.

Because of these difficulties, some researchers focus on a single clear category – like recreation – to represent CES as a whole, while ignoring all the other categories. It shows how the practical application of methods to evaluate the CES as a whole may still be problematic. Admittedly, within each category of CES there are interdependent and causal relations or overlaps. However, classification is interdependent to measure the total value of ecosystem services (Fu et al., 2011). Therefore, we suggest negotiating consistent classification systems and unambiguous descriptions of each category.

4.2. CES evaluation methods

4.2.1. Monetary vs. non-monetary

Both monetary and non-monetary methods have received extensive attention, as indicated by a significant increase in the related published papers (Fig. 5). The advantage of monetary methods is that they raise the awareness of economic risks involved in CES evaluation for policymakers and increase public concern about CES. Most economists agree that the evaluation of CES by means of monetary methods can make a compelling economic case for conservation (Spangenberg and Settele, 2010). Furthermore, monetary methods can be used to compare and conduct trade-off evaluation between CES and other ES (i.e., regulating services, provisioning services, and supporting services). It is a significant way to integrate CES into an ES evaluation framework. However, the real valuation of ES is often inadequate, which is

especially the case for CES (Hernández-Morcillo et al., 2013; Kumar and Kumar, 2008), and is poorly reflected in monetary metrics. Additionally, cultural diversity, knowledge systems, and social relations are rarely investigated by monetary methods. This is one reason why more and more researchers use non-monetary methods. Fig. 5 shows a steep growth of papers adopting non-monetary methods especially in the last ten years (Scholte et al., 2015; James et al., 2013; Sagie et al., 2013). But non-monetary methods have many other advantages. For instance, the 'expert-based method' uses skilled and experienced experts to solve complexities and uncertainties, especially in data-poor environment; the 'narrative method' can help capture the ambiguity and complexity of human feelings; 'participatory mapping' is a powerful tool to link the physical features with human perceptions of a place, which can identify the distribution of CES. It is widely used in urban planning and decision making (Bryan et al., 2010; Plieninger et al., 2013). However, non-monetary methods normally require large time consuming databases, trained enumerators, highly trained facilitators and advanced processing skills to avoid the dominance of individual influences in focus groups.

We call for integrating monetary and non-monetary methods to obtain a better evaluation of CES. Monetary and non-monetary methods are not necessarily mutually exclusive. Non-monetary methods can supplement monetary methods as shown in Section 3.3.3. However, this process does not mean just adding the different parts but rather focusing on the interactions between them. 'Deliberative valuation', for instance, is a good example combining the benefits of the deliberative process with the advantages of monetary methods. Similarly, 'willingness to pay' can integrate deliberative techniques into questionnaires or interviews by providing additional information to participant discussions through the evaluation process. Additionally, we have emphasized the social media-based method, which uses relatively freely available and spatially explicit data, to provide a good overview of CES mapping. In addition, we have emphasized participatory techniques for CES, which develop reasoning and effective CES evaluation methods through group debate and learning, which shows the importance of crowd wisdom, such as focus group and expert-based methods. In any case, however, we should be aware that an appropriate combination can generate individual and community benefits to help public decision-making.

4.2.2. Revealed preference vs. stated preference

Stated preference methods have gained more attention than the revealed preference methods. Additionally, stated preference methods can cover all the CES categories (Christie et al., 2012). As shown in Fig. 4, neglected services like social relations, cultural diversity, and knowledge systems were mainly evaluated by stated preference methods, such as interviews, questionnaires and PGIS, since those services are more abstract and depend heavily public perception. However, these methods rely on the answers generated by people with different demographic and socioeconomic backgrounds, which complicates the CES evaluation process (Villamagna and Angermeier, 2015). For instance, different cultural backgrounds may have different heritage associations with the same ecosystem features (Daniel et al., 2012; Power, 2010). Moreover, in some cases, the services provided by ecosystems are 'either never (or only vaguely) perceived or may be perceived at a future time (Costanza et al., 2017)'. Heritage, for instance, takes a long time to produce and prove its value. A potential solution is to provide more information for people to have full knowledge of CES. In this study, we have highlighted stated preference methods, such as the Q-method, focus groups and the Delphi survey, as well as their combinations, to improve evaluation accuracy. In contrast, gathering the required data for revealed preference methods is relatively easy, and they are often used in cross-regional studies because understanding the local language is not necessary. However, some services, such as knowledge systems and social relations, are rarely assessed without interviewing people. Moreover, reflecting people's

thinking, causing inaccuracy since there is a difference among human attitudes, preferences and use (Bertram and Rehdanz, 2015). Accurate evaluation is the largest challenge, mainly because of the subjectivity of human perceptions of CES. Therefore, we suggest that in-depth study of CES evaluation methods is required to improve the accuracy of evaluation results and to provide a well-designed evaluation process controlled by experienced researchers. Certainly, whether or not CES are perceived and how well or accurately they can be measured, these services are important issues for the future (Costanza et al., 2017).

4.2.3. CES evaluation as a process

Evaluation refers to the process of assessing the value of something. We found that more than half of the studies used more than one methods in this process, mainly manifested in three combinations of methods (see Section 3.3.3). Our research learns that different methods are applied in similar sequence in the assessing process. To be more specific, (1) at the beginning of an evaluation, information is generally obtained through non-monetary methods, such as document, observation, and expert-based methods. This was confirmed by the cases mentioned in Section 3.3.3. (2) Then, monetary and non-monetary methods are used to assess CES, such as WTP, interviews, questionnaires and PGIS. Among them, non-monetary methods are often used repeatedly to verify and improve the research accuracy, such as in the case study from Baulcomb et al. (2015) in Section 3.3.3, in which workshops and interviews were conducted several times during the evaluation process to formulate the final questionnaire. Other non-monetary methods, such as the Q-method and Delphi survey, also involve a multistep process. These methods do not require large population samples to obtain statistically valid results as this process produces an in-depth view from different perspectives that exist in a given situation. However, in this process, the need to develop a deliberative democratic approach has been highlighted as the body of evidence grows concerning the prejudgment and design bias in many traditional expert-led information transfer approaches to environmental valuation (Orchard-Webb et al., 2016). Additionally, there is increasing recognition of the need to unite analytical and participatory methodologies to establish more comprehensive valuations of CES and move beyond individual conceptions of value (Kenter, 2016). (3) Finally, monetary methods are often used in the questionnaires as well as directly in the final estimation of economic value of CES since monetary methods are considered the most effective way to integrate into the ES framework at present.

We have discussed the advantages of integrating monetary and non-monetary methods, as well as stated and revealed preference methods in Section 4.3.1 and Section 4.3.2. Here we highlight what we learned about how researchers combine different methods in the course of an evaluation process. First, non-monetary methods are mostly used at the beginning of the study to collect information and identify and classify CES, such as document, observation, expert-based methods, etc. Second, questionnaires, interviews, the Q-method, participatory mapping, etc., or monetary methods such as WTP and choice experiments, are used to evaluate CES. Finally, monetary methods, such as market price or benefit/value transfer, are used in the final calculation of the economic value of CES. This process shows great potential for accurate CES evaluation and it provides a clear process to researchers. However, we should acknowledge the challenges of conducting this process. First, skilled researchers are needed who are familiar with all the methods and techniques. Secondly, although monetary methods are encouraged to be used in the final step, it is difficult to find the market or replaceable value of some special service, thus leading to the inability to integrate CES into the ES framework. That is why we encourage interdisciplinary and transdisciplinary cooperation in CES evaluation and its study, with special attention for the methods and skills from sociology so as to better support the evaluation process. Also more monetary methods and techniques should be developed to assess those more intangible services. Finally, there is a need for more research on

how the outcomes of non-monetary methods can be integrated into the ES framework and practice. For instance, mapping, which is widely used in CES evaluation, can be integrated into other ES evaluation (e.g., mapping agricultural products, mapping flood control).

5. Conclusions

This study has presented an overview of CES evaluation methods and challenges for future study. We have classified and analyzed 20 CES evaluation methods in this review. In conclusion, the following recommendations are offered for future research on CES evaluation:

1. In addition to recreation and ecotourism, we emphasize the consideration of all CES categories, especially those that are under-evaluated and under-exposed, e.g., cultural diversity, knowledge systems, and social relations. To favorise this, we suggest establishing consistent classification systems for CES and unambiguous descriptions of each category.
2. We highlight the combination of methods to yield a better evaluation of CES. Additionally, we call for integrating monetary and non-monetary methods, which does not indicate merely adding the different parts but rather focusing on the interactions between them, especially deliberative, participatory and mapping techniques.
3. We encourage more stated preference methods in addition to interviews and questionnaires, such as the Q-method and narratives that can be used to evaluate neglected services.
4. We suggest that in-depth research on CES evaluation process to improve the accuracy of evaluation results.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ecoser.2019.100925>.

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