POLISH JOURNAL OF NATURAL SCIENCES
Abbrev.: Pol. J. Natur. Sc., Vol 36(3): 333–358, Y. 2021

OVERVIEW ANALYSIS OF CULTURAL ECOSYSTEM SERVICES: MAPPING INDICATORS AND CATEGORIES CLASSIFICATION

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Key words: cultural ecosystem services, mapping indicators, mapping methods, classification group, stated preference, revealed preference.

Abstract

Mapping of Cultural Ecosystem Services (CES) emphasizes the spatial contribution to landscape characteristics like land cover and human wellbeing. This review paper aims to build an overview of CES mapping indicators and methods. This goal comprises many objectives; to provide an overview of existing mapping indicators and methods, to analyze and classify them, and to emphasize important challenges that researchers face whilst mapping them. This study reviews 45 publications from the last ten years and identifies eight common CES mapping methods and various mapping indicators. In conclusion, we highlight that: 1) It is necessary to utilize a symmetric classification systems for each CES category and a clear specification of each category of CES. 2) there are various combinations of CES mapping indicators and methods. 3) it is important to combine different mapping methods, to map neglected services like education and culture heritage.

Introduction

Millennium Ecosystem Assessment (MEA) defines the concept of Ecosystem Services (ES) as a tool for sustainable development and mentions that ES consists of main four categories: cultural services (CES), regulating, supporting, and provisioning (Lee et al. 2019, Martin et al. 2016). Moreover, the first category of CES are defined as non-material ecosystem's benefits which contribute to human wellbeing like recreation, aes-

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thetic, and education services (CHENG et al. 2019). Although CES contribute to increase national economies by promoting recreation and tourism industry, recent research has indicated that researchers and policymakers pay limited attention to CES compared to the other categories of ES (LEE et al. 2019). CES mapping methods have functional and practical application (e.g. landscape design and urban planning) and support policymaking (MARTIN et al. 2016). In the context of culture services, 'Mapping' means the process of measuring, modeling, and quantifying the non-monetory and monetory value of something. Scientific literature has shown various specifications and expressions to recognize particular methodological approaches, the most common synonyms of mapping, including measuring, modeling, accounting, quantifying, valuation, etc. There are many different classifications of CES mapping methods. For example, The Economics of Ecosystems and Biodiversity (TEEB) mostly has classified these methods into preference-based and biophysical methods (TEEB. 2010). Moreover, BROWN et al. (2017) and LINDHOLST et al. (2015) have classified preference-based mapping methods into the monetary method and non-monetary method.

Since CES are inherently invisible and nonmaterial services, the mapping of CES remains poorly understood and relatively ignored (MARTIN et al. 2016, LANGEMEYER et al. 2015). Furthermore, the limited availability of indicators and data connected with mapping culture services are a considerable challenge for quantifying all categories of ES, especially CES (MARTIN et al. 2016). According to MEA natural ecosystems are degrading, and CES is being utilized unsustainably and that result in increasing ecosystem degradation around the world. Because of the urgent need to protect CES, new policies have been established. Furthermore, the necessity of CES mapping indicators to measure and quantify them is growing around the world. Therefore, scientific research on CES has increased basically in the past decade (HUTCHESON et al. 2018, STANIK et al. 2018).

Due to grows the interest in CES, the need to quantify and account for them is also growing through modeling and mapping. There are various benefits of mapping and modeling CES. For instance, the information from modeling can be used to estimate establish trends and costs and trade-offs (e.g. SINCLAIR et al. 2019, PARACCHINI et al. 2014). Thus, CES scientific research around the world must share one main goal: maintenance of practices and policies to ensure the sustainable provision of CES and related humans' wellbeing benefits. Unfortunately, most of CES cannot be mapping directly, therefore consider the utilize of mapping indicators necessary and classified them based on their natural for accounting and measuring of CES categories. Due to produce reliable and accurate results in

CES modeling, strong quantification is desired. Thus, it is necessary to indicate the proper indicators utilized for modelling and mapping CES as a first step in order to develop reliable and feasible indicators for modeling and mapping of each category of CES. In that regard, this review paper aims to collect, and overview analysis of previous studies concentrating on CES mapping indicators and classified them based on each CES category. These indicators will be utilized for mapping and quantifying various categories of CES and identify used data sources to enable visualize CES on maps by illustrating; 1) the most common CES mapping indicators and mapping methods; 2) the availability of data source and the extent of data. To achieve the research aims, we addressed the following research questions; 1) what indicators can be utilized in mapping CES categories? 2) what are the methods can be used for mapping different types of CES? 3) what indicators are used for all types of CES? And 4) what indicators are specific to one type of CES?

Materials and Methods

Paper selection

In this study a comprehensive search of ScienceDirect and of Scopus was conducted, using the search terms "mapping cultural ecosystem services", "quantifying methods of cultural ecosystem service", "valuation cultural ecosystem service" and "mapping indicators" in order to identify existing literature dealing specifically with mapping CES by applying this search keywords in main titles and abstracts. The literature review was not be limit by a fixed period or performed in a specific country. The search was perfumed from November 2020 to January 2021. The utilized search terms bring about a total of 220 publications including conference papers, journal articles, reports and thesis. After, in-depth screening of papers, we conducted 45 papers that have been read in-depth and considered in our analysis and comparison. From each analyzed paper, data about the CES mapping methods and indicators have been extracted, and extract general data about the used study area, such as data extent, data source, study area (for more details see App. 1, Table App. 1)

Analytical framework. Mapping indicators and methods classification

The analyzed literature review contained information about measuring CES by using appropriate indicators and methods. In case of mapping

methods, in our paper selection we only focusing on paper utilized non-monetary methods for mapping CES categories, therefore, in this review, we discuss all kind of non-monetary mapping methods. According to non-monetary methods which classified to revealed preference and stated preference method, the revealed preference method means, analyzing documents or monitoring behavior including advertisements, pictures, and written data, to indirectly locate human's preference for CES (SINCLAIR et al. 2019). In contrast, the stated preference method means to, directly asking people about their preference to measuring CES (WARTMANN and PURVES 2018). Based on our analysis, there are different papers conduct and general review of publications addressed various categories of CES. For example, FIGUEROA-ALFARO and TANG (2017) reviewed 36 publications associated with CES mapping. COOPER et al. (2016) also performed a comparative review of 97 articles about the characteristics and availability of CES mapping methods. However, In this review, we:

a) update the list of CES mapping methods;
b) classify and group the CES mapping indicators;
c) indicate the utilized indicators in mapping each category of CES;
d) highlight the common utilized data source and extent in mapping various category of CES.

Mapping methods classification

We classified all considered publications based on their mapping method and only focusing on papers which used non-monetary methods. In this classification, we distinguished the mapping methods using revealed preference from the mapping methods using stated preference method (SCHIRPKE et al. 2016, RIECHERS et al. 2018). Based on this classification, in this review paper, we intend to scan each paper to classify them according to used methods, and number of indicators used in mapping each CES category, then after the analysis of the total set of selected publications, we give a list of mapping indicators that could be used in mapping various category of CES.

Results

CES categories

According to our analysis, all CES categories have received some attention in the selected literature. Out of the 45 publications, 29 studies have addressed outdoor recreation and tourism category, so, they received

the greatest attention among other categories, and only 11 studies mapped aesthetic enjoyment value. However, spiritual and inspirational value have received the least attention among other CES categories (3 and 2 studies mapping them respectively) – Table 1.

Table 1

Number of studies per each CES category

Culture services	Number of studies
Aesthetic enjoyment	11
Inspiration value	3
Recreation and tourism	29
Spiritual value	2

Classification groups of indicators

In this paper, we review existing indicators for the assessment of CES categories and provide a critical overview of how indicators can be used for mapping CES categories. Different indicators can be used to map different categories of CES. Based on indicators identified by gathered literature review, in this review, we divided the type of CES mapping indicators into four groups, namely active-physical interactions with the natural environment (Gr1), passive-physical interactions with the natural environment (Gr2), representative and intellectual interactions with the natural environment (Gr3), and spiritual, symbolic interactions with the natural environment (Gr4), based on Common International Classification of Culture Ecosystem Services (CICCES) (HAINES-YOUNG and POTSCHIN-YOUNG 2018)

The Classes/groups definitions indicating the different kinds of CES have all been addressed in Table 2. At the classification level of CES based on the characteristics of living systems, there are two kind of CES division which is between those characteristics of living systems that are experienced either 'in-situ' or 'remote'. For example, divide 1 is "Direct interactions with living systems that depend on presence in the environmental setting'. However, the second divide is 'Indirect interactions with living systems that do not require presence in the environmental setting' (HAINES-YOUNG et al. 2016).

Table 2
International Classification of culture ecosystem services (CICCES) (HAINES-YOUNG et al. 2016)

Division	Group		Classes
Direct interactions with living systems	Gr_1	active-physical interactions with the natural environment	living systems characteristics that enable activities which promote public health and enjoyment through interactions
	Gr_2	passive-physical interactions with the natural environment	living systems characteristics that enable activities promoting health and enjoyment through passive interactions
	Gr_3	representative and Intellectual interactions with the natural environment	living systems characteristics that enable education and training
			living systems characteristics that are resonant in terms of culture or heritage
			Characteristics of living systems that enable aesthetic experiences,
Indirect interactions with living systems	Gr_4	spiritual, symbolic interactions with natural environment	elements of living systems that have sacred or religious meaning

Mapping indicators

In this section, we provide an overview of the mapping indicators used in the literature for mapping different categories of CES. The majority of mapping indicators have been used to map different CES categories (ABUALHAGAG and ISTVAN 2020). To be more specific, a various kind of indicators such as number of visitors, photographs, tourist attractions and landscape aesthetics, utilized for measuring recreation and tourism. Moreover, there are many indicators could be used for mapping different kind of CES categories such as land cover, and accessibility/ distance. Table 3 illustrate CES mapping indicators and the group of CES categories.

CES mapping indicators utilized as input data for mapping and evaluation CES category. Outdoor recreation and tourism had the greatest different number of mapping indicators account around 29 different kinds of indicators compared to all other CES categories (Table 3). Based on our result, land use and land cover indicators demonstrate to be a necessary indicator for mapping all CES categories. Land use indicator is commonly defined as a series of operations on land, carried out by humans. However, the land cover indicator is commonly defined as the vegetation (natural or planted) or man-made constructions (buildings, etc.) which occur on the earth surface. Land use and land cover have some fundamental differences. Land use refers to the purpose the land serves, for example, recre-

ation, wildlife habitat, or agriculture; it does not describe the surface cover on the ground like a land cover indicator (TENERELLI et al. 2016). Vegetation types is an important map for mapping recreation and tourism while land use can be used for quantifying suitable and non-suitable areas for create new recreation services (UPTON et al. 2015, STANIK et al. 2018, TENERELLI et al. 2016).

In this paper, we review existing indicators for the assessment of CES categories and provide a critical overview of how indicators can be used for mapping CES categories. Different indicators can be used to map different categories of CES. Based on indicators identified by gathered literature review, this study identified four aspects to group the collected mapping indicators. These indicators comprise environmental aspects (including temperature, pollution, topography indicators such as DEM and slope, landscape settings); physical aspects (including the accessibility indicators such as distance indicator, which include distance to resources, distance to scenic site, flower viewing indicator, tourist attractions, population density, and roads); socio-economic aspects (including photographs, number of visitors, accommodation, footpaths, visitors stay, and visitors expenses); and urban aspects (including land cover and land use, resource availability, vegetation cover, rare species, green spaces, recreation potential, ecotourism potential, and protected areas – see Table 3 which illustrates the indicators for mapping CES resources).

Table 3

Classification groups of culture ecosystem services and related indicators

Division	Groups	Culture services (CES)	Number of studies	Mapping indicators aspects	CES mapping indicators	Number of studies
Direct interactions with living systems	passive-physical and experiential interactions with natural environment	aesthetic enjoyment value	11	environmental aspects	DEM	4 out of 11
				environmental aspects	slope	3 out of 11
				environmental aspects	temperature	1 out of 11
				physical aspects	distances	1 out of 11
				physical aspects	distance to resources	1 out of 11
				physical aspects	distance to scenic site	1 out of 11
				urban aspects	land use	1 out of 11
				urban aspects	green spaces	1 out of 11
				urban aspects	land cover	3 out of 11
				urban aspects	rare species	1 out of 11

cont. Table 3

Direct interactions with living systems	active-physical and experiential interactions with natural environment	recreation and tourism	29	socio-economic aspects	number of visitors	9 out of 29
				socio-economic aspects	photographs	3 out of 29
				socio-economic aspects	tourist attractions	2 out of 29
				environmental aspects	landscape aesthetics	3 out of 29
				urban aspects	recreation potential	1 out of 29
				urban aspects	ecotourism potential	1 out of 29
				environmental aspects	fresh water	2 out of 29
				urban aspects	recreation fishing	3 out of 29
				urban aspects	land cover	14 out of 29
				physical aspects	accessibility/ distance	7 out of 29
				physical aspects	traffic census	1 out of 29
				socio-economic aspects	footpaths	1 out of 29
				socio-economic aspects	population density	4 out of 29
				urban aspects	urban green space	1 out of 29
				socio-economic aspects	tourist attractions	2 out of 29
				environmental aspects	rare species	1 out of 29
				socio-economic aspects	accommodation	4 out of 29
				environmental aspects	resource availability	1 out of 29
				socio-economic aspects	flower viewing	1 out of 29
				socio-economic aspects	visitors expenses	1 out of 29
Indirect interactions with living systems	spiritual, symbolic and other interactions with natural environment	inspiration value	3	urban aspects	land cover	2 out of 3
				urban aspects	landscape value	1 out of 3
				urban aspects	land use	1 out of 3
Indirect interactions with living systems	spiritual, symbolic and other interactions with natural environment	spiritual value	2	socio-economic aspects	photographs	1 out of 2
				urban aspects	landscape settings	1 out of 2
				physical aspects	distance to resources	1 out of 2

The most common mapping indicators are the accessibility and the distance (e.g. distance from roads, distance to resources, distance from exist recreation site, and distance from water supply) and both are used for mapping nearly all CES categories. Table 3 highlights many examples of mapping indicators utilized for mapping different CES categories. Aesthetic enjoyment value has received more attention than other CES categories except recreation and tourism, and around a quarter of the selected studies addressed aesthetic enjoyment. Thus, our results show that 11 studies have mapped aesthetic enjoyment. So, aesthetic enjoyment has approximately 20 mapping indicators. However, it still less than indicators used for mapping outdoor recreation and tourism. Distance (include distance to resources and distance to Scenic site) was the important indicator utilized for mapping aesthetic enjoyment value. Land use and land cover data were also necessary information for measuring and quantified this service.

According to inspiration value, various kinds of indicators could be utilized for mapping this kind of service. Approximately, three indicators have been utilized to map inspiration category (Table 3). Recreation and tourism category received the most attention between other CES categories (approximately 64% of the analyzed studies mapped them) (Table 2). Thus, it is obvious that there are various kinds of mapping indicators related to the recreation and tourism category compared to other CES categories. For example, in case of recreation and tourism category, our results identified that there are 29 indicators have been utilized to quantifying and measuring them (Table 3) (VAN BERKEL and VERBURG 2014). Many studies approve that spiritual value is more difficult to measure and quantify. Therefore, it has been received the least attention among all CES categories. All mapping indicators utilized for quantifying this category were connected to the diversity of habitat. Moreover, fewer indicators utilized to map this service compared to other CES categories (Table 3). The significantly lower numbers of mapping indicators for spiritual value could be the cause of the limited data and indicators on these services. Because of these challenges, spiritual experience value received the least attention based on our analysis.

CES mapping methods

In this section, we give a general overview of CES mapping methods typically utilized to measure and map CES categories. By analysis the 45

collected studies included in this review we conclude that many different sets of non-monetary mapping methods, like revealed preference and stated preference methods, were found. The non-monetary mapping methods utilized to map CES categories received most attention in all the analyzed studies. Based on that, eight non-monetary mapping methods have been identified, of which the first 3 mapping methods utilized revealed preference methods for measuring and quantifying CES categories namely; observation, document, social media-based, and the rest utilized stated preference methods namely; interview, questionnaire, participatory mapping, participatory GIS (PGIS), public participation GIS (PPGIS), and scenario simulation. The descriptions of non-material methods for mapping CES as the following:

1) Revealed preference; this method consist of three main kinds:

a) observation: looks at user and locals' behavior and actions to reflect the social value of CES. For instance, remarking the number of visits to the park to evaluate the significance of recreation value in this area;

b) document: collecting information about human preferences on CES by looking for images, texts, or other kinds of materials. For instance, analyzes the kind and number of pictures taken by users to assess the aesthetic value;

c) social media-based: utilizing the data collected from various social media to evaluate CES. For example, analysis of the pictures of wildlife uploaded on a picture-sharing online website.

2) Stated preference: this method consist of five main kinds:

a) interview: directly understanding the perception of the public about why and how users are value CES by using face-to-face interviews. through this interview, participants talk freely about their thoughts and feelings to gain a better understanding of CES services like a sense of place;

b) questionnaire: a combination of questions is distributed to obtain information about CES from participantprze, for example, the planners ask users to choose from the set of selections;

c) participatory GIS (PGIS): in this method, the researcher integrates geographic information systems (GIS) and the participatory mapping method in the mapping process;

d) scenario simulation: predict future scenarios of CES capacities to help decision-makers and planners in the planning strategies

According to the non-monetary methods, overall, participatory GIS (PGIS) and observation were most frequently used for mapping CES categories far more than the others, followed by questionnaires, document and scenario simulation methods (Figure 1). Moreover, questionnaires and interviews frequently utilized observation and document methods to col-

lect data for mapping CES. Figure 2 shows which of these methods are utilized to map different categories of CES. Overall, all mentioned mapping methods were utilized to map and quantify tourism and recreation categories, followed by aesthetic enjoyment value. In that regard, the above-mentioned mapping methods were utilized to measure and quantify different kinds of CES. Moreover, interviews, questionnaires, and participatory GIS methods have the capability to map all CES categories.

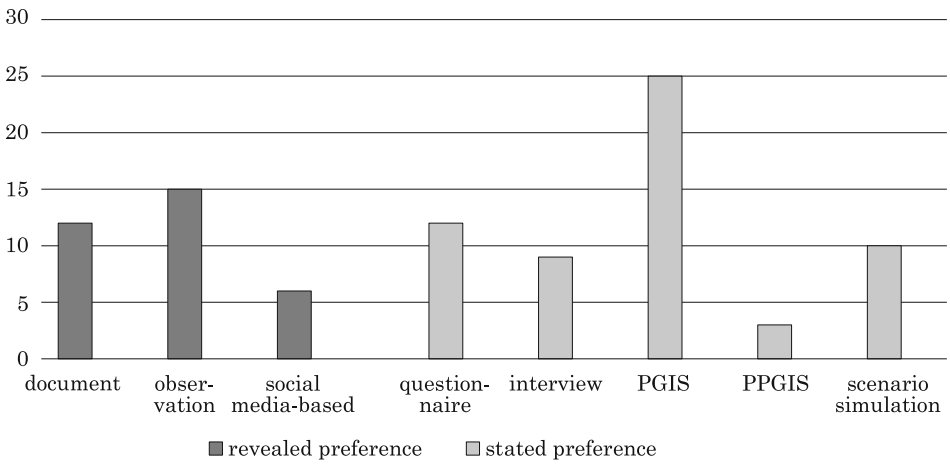

Fig. 1. Numbers of papers using various non-material methods to map culture ecosystem services

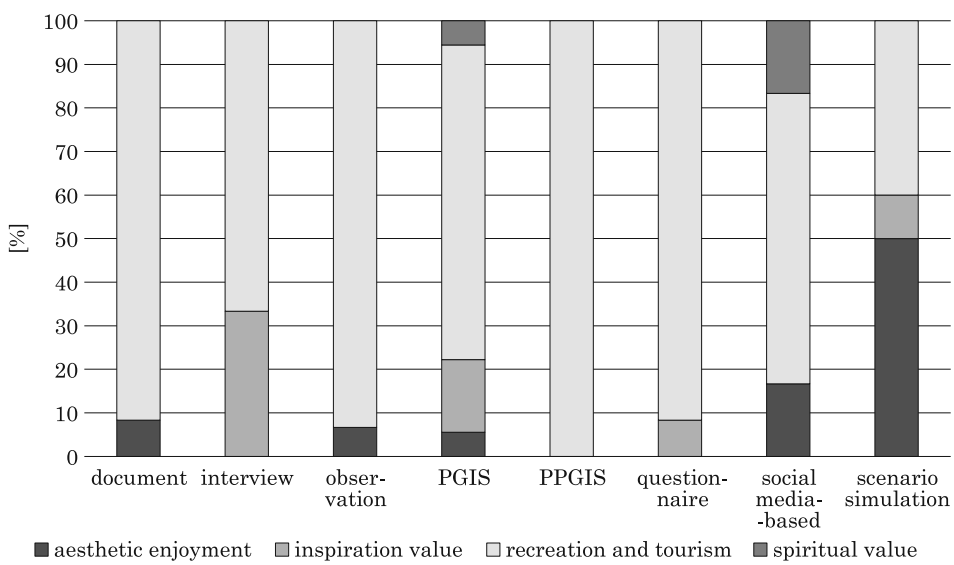

Fig. 2. CES various category per different mapping methods

Table 4 illustrate which CES category are mapping with revealed preference, and which of them are mapping with stated preference. Overall, recreation and tourism are used most frequently in case of revealed preference (29 out of 65) and stated preference methods (36 out of 65), followed by aesthetic enjoyment, in which stated preference methods are used more than revealed preference. Specifics of the quantification mapping methods' numbers per CES are given in App. 1, Table App. 1

Table 4

Number of mapping methods of CES per category

Culture services	Methods classifications		Total
	revealed preference	stated preference	
Aesthetic enjoyment	3	11	14
Inspiration value	0	8	8
Recreation and tourism	29	36	65
Spiritual value	1	1	2

Utilized Data Sources

The essential element in the mapping of the culture ecosystem categories is the availability of data sources and information. In that regard, this section gives an overview of kind information and data source utilized for measuring and mapping CES categories in the analyzed studies. So, we have focused on identifying the mapping indicators and analyzing them in order to indicate the type of data and information utilizing for mapping various categories of CES. Moreover, we first gathered the mapping indicators as these were utilized as a basis for mapping CES categories. After gathering the mapping indicators, the collected data source has been classified into three main groups namely; sub-national scale data, national scale data, and local data which is created for evaluation special study area (Table 5). These groups help the planners to identify the proper data type for each planning scale.

Table 5

Extent of data used in the reviewed literature, linked with the CES categories

Extent of data	CES categories				Total [%]
	aesthetic enjoyment [%]	recreation and tourism [%]	inspiration value [%]	spiritual value [%]	
Local scale	2	25	0	0	27
Sub-national scale	8	28	0	2	38
National scale	10	19	4	1	34

Overall, based on the analyzed literature review, many different types of data sources have been addressed, these data sources have been divided into three main types, as we mentioned before; sub-national data (e.g. specific case study, states, cities, regions, or watersheds), local data (e.g. monitoring and observations of study area features), and data covering national extents (e.g. countries). Of the 45 studies analyzed in this review, 38% mapped CES using sub-national data and 34% used national data and 27% used local data (Table 5). According to the sub-national data sources, there are a wide variety of data sources used to mapping a different kind of CES categories such as land use/cover map, pollution data, visitor numbers, etc. So, Cultural services, like aesthetic enjoyment and spiritual value, are very regional service with diversity from cultural groups to individuals; thus, sub-national data sources are mostly used for mapping and quantifying process.

The kind of data used in the analyzed studies had various nature and sources and utilized quantified method (see App. 1, Table App. 1). According to the most common data sources, there are various kind of sources used to map and evaluate various categories of CES, such as interviews and field data (FIGUEROA-ALFARO and TANG 2017), and other researchers used surveys which based on photographs or pictures. Furthermore, others utilized spatial source of data, such as maps about vegetation, land cover, or land use map. And the most and accurate source of data is written data and maps which can be directly collected from local public and private institutions. The number of studies used the various kind of data source have been reported in Table 6 linked with utilized extent of data and each CES categories. Overall, of the 45 studies included in this review (Table 6), 80% mapped CES using GIS and paper-based maps or GIS file maps such as using PPGIS method in case of paper-based map and using PGIS methods in case of GIS file maps. And around 24% used picture for mapping CES categories and only 40% used written data (see App. 1, Table App. 1 for more details).

Table 6

Type of data used in the reviewed literature, linked with the CES categories

Type of data	Utilized extent of data	Number of studies				Total (45)	Percentage
		aesthetic enjoyment [%]	recreation and tourism [%]	inspiration value [%]	spiritual value [%]		
Maps	local, national, sub-national	10	21	3	2	36	80
Pictures	sub-national, local	2	8	0	1	11	24
Written data	local	1	17	0	0	18	40

Discussion and Conclusions

Challenges of mapping methods application in ces categories

In this section, we give an overview about; firstly, discuss challenges of mapping CES; secondly, discuss the existing CES mapping indicators and the most common methods.This study identified various possible indicators and data sources for mapping each CES categories in practical applications. In the CES mapping process, all CES categories have the same necessity and the researchers should pay more attention to all CES (RIBEIRO and RIBEIRO 2016). In this study, our overview shows how the mentioned methods utilized for mapping CES concentrate mostly on measuring and mapping tourism and recreation values. Due to achieving a better addressing of all culture service in practical application, it is necessary to refer to the most common classification frameworks of CES categories which are MEA and TEEB frameworks. Thus, in many cases, the assessment of CES ends up as a symbolic evaluation of the CES concept, concentrating on demonstrating the utilization of CES classification framework without conceptual clarification like what kind of indicators should map or measure. The recreation category can easily be defined in various kind of classification systems, for example in in case of TEEB classification systems it called 'recreation and tourism', while it named 'recreation and ecotourism' in case of MEA classification systems classification systems and Common International Classification of Ecosystem Services (CICES), so it is important to refer to all CES to the most common classification frameworks.

Moreover, for other CES categories, it is hardly finding definitions or synonyms in the mentioned two international classification systems. Therefore, the comparison and analysis of these studies could be difficult, in the case of researchers utilize different classification systems. Due to these challenges, some scientific researchers addressed only a single clear CES category, such as NAHUELHUAL et al. (2013) addressed recreation value and ZARKESH et al. (2011) conducted a land evaluation of ecotourism value, at the same time all the other CES categories have been ignored. Based on the mentioned challenge, it appears that the practical application of CES mapping methods may still be problematic. CES are more than just 'recreation and tourism. Thus, the field of CES research needs to apply more rigorous definitions in the various case studies by single and clear classification systems and unambiguous descriptions of each CES category.

CES mapping indicators

Cultural ecosystem services (CES) are strongly connected with human well-being. However, up to now specific definitions and strong measurements of the necessity of cultural services for people have been elusive. A better understanding of this kind of service could offer feedback changes in ecosystem service, in general, and contribute to sustainable use and improvement. Our review paper indicates that there is an increase of literature addressed evaluating and mapping CES. Despite these advances, the sources of utilized data and information and mapping methods are varied, and in the majority of the analyzed studies, detailed methodological information and mapping indicators were missing.

Our review exposes some clear trends. Key CES that are today being utilized for decision-making in urban planning have been frequently mapped, as is the case of outdoor recreation (SINCLAIR et al. 2019) and tourism facilities (NAHUELHUAL et al. 2013). Yet, it is notable that CES that may be critical for the maintenance of human well-being, such as education and economic value, are rarely addressed. There is a clear lack of formal research on many of these kind of cultural services

Regarding the type of indicators aspects found in the review, indicators assessing urban aspects were the most frequently used for mapping aesthetic, inspiration, spiritual, and recreational services. For example, KOMOSSA et al. (2018) utilized accessibility and distance as urban indicator for mapping outdoor recreation. However, BEECO et al. (2014) conduct evaluation of recreation by using tracking number of visitors as a Socio-economic aspect's indicator.

Yet indicators measuring impacts on human well-being were only rarely addressed, although existing research connecting recreational activities and human well-being. In term of the CES quality assessment, it is evident that the reviewed cultural services indicators are generally lacking in terms of public participants of the subject to be measured, which may lead to confounding outcomes (SCHNEIDER and LORENCOVÁ 2015). For example, in case of Ives et al. (2017) and BIELING (2014), they Invested more effort for involving relevant stakeholders in the evaluation and mapping process, and that would likely improve their quality. Communication strategies to disseminate indicators were barely apparent in the literature, although the indicators assessed seemed to sufficiently reach their target audiences by using suitable communication means (FIGUEROA-ALFARO and TANG 2017).

Our results approve the fact that recreation and tourism services are mapped utilizing many various indicators (BERNETTI et al. 2019, BIELING

2014). Therefore, the number of indicators using in map recreation and tourism services significantly increased. In that regard. the possibility of using the obtained indicators for mapping all categories of CES are ambiguous and need more research to prove that. As we mentioned in the result section, there are different mapping indicators collected from the analyzed studies, and some of the obtained indicators can be suitable for one study area and non-suitable for others. Moreover, in this review, we confirm and referred to a list of CES mapping indicators with related groups and aspects.

CES Mapping Methods and data source

The stated preference methods, as a kind of CES mapping methods, have received more attention compared to other mapping method. Moreover, stated preference methods could be utilized to map many different categories of CES (Brown et al. 2016). Neglected CES services like education and cultural heritage can be mainly measured and modeled by the stated preference methods, like questionnaires, interviews, PGIS, and PPGIS, since these categories are depending mainly on user's perception (Clemente et al. 2019). Additionally, these mapping methods depend on the answers directly gathered by users with various socioeconomic and demographic backgrounds (D'amato et al. 2016, Ribeiro and Ribeiro 2016). Moreover, collection of the required information for revealed preference mapping methods is comparatively easy. They are often utilized in the cross-regional study area since there is no need to understand the local languages in this type of mapping. Accurate and precise measuring is the major challenge, due to people's personalities and perceptions of CES value. This result highlights that little is known about the accuracy of data collection, thus, improving the accuracy of quantification results and providing a well-designed measuring process controlled by a well-experienced researcher is required (Dou et al. 2017).

Mapping mainly refers to the process of quantifying the value of something. From the short review above, the results demonstrate two things. Firstly, we found that most of the analyzed studies utilized more than one mapping method for measuring a single category of CES. Secondly, many different methods were applied in a similar sequence in the mapping process. For example, for mapping CES categories, two main steps have to be followed; firstly, data evaluation has to be obtained by utilizing revealed preference methods, like observation and document methods; secondly, measuring CES categories has to be applied by using state preference methods, like questionnaires (e.g. Richards and Tunçer 2018), interviews (e.g. Riechers 2018), and PPGIS (e.g. Rall et al. 2019). Among

them, various data source – like photo, maps, and written data- are often utilized repeatedly to verify and improve the research accuracy. Additionally, revealed preference mapping methods are frequently utilized to improve and verify data accuracy. For example, PARACCHINI et al. (2014) conducted interviews and workshops several times during the field survey and mapping process to better design the final questionnaire and to increase the accuracy of the obtained data. Additionally, these methods do not require a large sample set to collect accurate data, because the mapping process can be done by gathering in-depth perspectives from many people who live in a particular study area.

The kind of data utilized in the analyzed studies had different sources and nature, according to the used mapping method. As stated above, most of the selected publications utilized data acquired from personal interviews and field surveys. For example, USAMA (2015) conduct an interview with locals to discuss urban design guidelines in Cairo, Egypt that promote the physical activity of users and to motivate and change social behavior towards healthy living. The personal interview could be an online interview or face-to-face. Moreover, other surveys were based on various photographs or pictures. For example, RICHARDS and TUNÇER (2018) used a social media photographs for cultural ecosystem services assessment. Moreover, others utilized spatial data such as maps about vegetation cover and land use/land cover, and others collect mapping data from written sheets (e.g. WEYLAND and LATERRA 2014). In general, most of the obtained studies utilized a combination of data sources; for example, NESBITT et al. (2017) use picture sources as the data source and used maps to conduct the spatial analysis on the selected picture of the CES by using social media photographs as a measurement unit. Thus, few studies used one data source in the evaluation process, like, PENG et al. (2019) used written data as the primary data source to evaluate CES values by using a questionnaire. Therefore, we support interdisciplinary and transdisciplinary collaboration in the CES mapping process, with particular attention to the skills from social sciences and its' methods to better advance and support the assessment process techniques. Furthermore, more mapping methods and procedures must be developed to evaluate neglected CES like education and economic values which obtained from recreation and tourism services. Finally, more research is required on how to integrate the results of the mapping methods into the practice framework of reality.

To sum up, in this review the advantages of the combination of stated and revealed preference methods have been discussed through our previous analysis. Moreover, this review was given a general overview of common CES mapping/quantify indicators and methods and used data types.

We can conclude as the following; firstly, at the beginning of the mapping process, the researcher used, e.g., document, observation, expert-based methods to obtain information about CES and clarify and classify them. Secondly, questionnaires, interviews, participatory mapping, etc., are used to assess CES as the final step in the mapping process. This combination addressed a clear and accurate process for researchers to follow it. However, we must know the challenges of conducting this mapping process. Therefore, we emphasize many of challenges, which have been addressed above, facing researchers through the mapping process. The first challenge is that a well-experienced researcher is needed who is familiar with a various mapping methods and techniques, and the obtention of the proper data source and measuring method need a well-recognized researcher. Second, although questionnaires, interviews, participatory mapping, etc., are strongly encouraged to be utilized in the final step of mapping process, it is challenging to find accurate indicators and data sources of some particular service, consequently, it results in the inability to CES integration into the ES framework.

Accepted for print 29.10.2021

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Appendix 1

Table App. 1

Summary of studies and mapping indicators and method of the literature review

Ecosystem service		Primary indicator (P)		Secondary indicators (S)		Extent of data	Type of data source	Used method non-monetary)	Extent of study area	Reference
1	aesthetic enjoyment (A)	PA_1	landscape aesthetics	SA_1	DEM	national	maps	scenario simulation	national	(GOSAL et al. 2020)
				SA_2	slope	national			national	
				SA_3	site	sub-national			local	
2	aesthetic enjoyment (A)	PA_2	aesthetics	SA_1	DEM	national	pictures	social media-based	local	(CLEMENTE et al. 2019)
3	aesthetic enjoyment (A)	PA_3	spiritual, aesthetic,	SA_2	slope	national	written data	observation	local	(BIELING 2014)
				SA_4	distance	sub-national	maps	PGIS,	local	
				SA_5	green spaces	sub-national	maps	PGIS	local	
4	aesthetic enjoyment (A)		aesthetic value	SA_3	site	local data	maps	scenario simulation	local	(SHERROUSE et al. 2011)
				SA_1	DEM	national			national	
				SA_2	slope	sub-national			national	
5	aesthetic enjoyment (A)	PA_4	nature appreciation	SA_6	rare species	local data	pictures, maps	document	local	(RAUDSEPP-HEARNE et al. 2010)
6	aesthetic enjoyment (A)	PA_1	aesthetic landscape	SA_7	land cover	national	maps	scenario simulation	local	(VIHERVAARA et al. 2010)
7	aesthetic enjoyment (A)	PA_5	nature reserves basin	SA_8	distance to resources	sub-national	maps	PGIS	local	(SHI AND CUI 2009)
		PA_6	national scenic spot	SA_9	distance to scenic site	sub-national	maps	PGIS	local	
8	aesthetic enjoyment (A)	PA_7	scenic beauty	SA_1	DEM	national	maps	scenario simulation	local	(GRÊT-REGAMEY et al. 2008)
				SA_7	land cover	national			local	
				SA_{10}	temperature	sub-national			local	
9	aesthetic enjoyment (A)	PA_2	aesthetics	SA_{11}	land use	national	maps	PGIS	national	(SANDHU et al. 2008)
10	aesthetic enjoyment (A)	PA_8	aesthetic and amenities	SA_7	land cover	national	maps	PGIS	local	(TROY et al. 2006)
11	aesthetic enjoyment (A)	PA_3	spiritual, aesthetic, recreational services	SA_{12}	protected areas	sub-national	maps	scenario simulation	local	(VAN JAARSVELD et al. 2005)
12	recreation and tourism (R)	PR1	scenic beauty, heritage, leisure	SR_1	number of visitors	*local data*	written data	observation,	local	(BACHI et al. 2020)

				SR_2	photographs	local data	pictures	social media-based,	local	
				SR_3	tourist attractions	local data	maps	participatory gis (pgis),	local	
13	recreation and tourism (R)	PR2	aesthetic and recreation	SR_4	landscape aesthetics	national	maps,	participatory gis (pgis), observation	local	(RALL et al. 2019)
				SR_1	number of visitors	local data	written data		local	
14	recreation and tourism (R)	PR2	recreation and aesthetic	SR_2	photographs	local data	pictures	social media-based, interview,	local	(WARTMANN and PURVES. 2018)
				SR_1	number of visitors	local data	written data	interview, observation	local	
15	recreation and tourism (R)	PR3	recreational	SR_5	recreation potential	national	maps	scenario simulation	local	(LIMAEI et al. 2017)
				SR_6	ecotourism potential	national	maps		local	
16	recreation and tourism (R)	PR4	recreational and ecotourism	SR_3	tourist attractions	local data	maps , pictures,	observation , interview, participatory gis (pgis)	national	(TENERELLI et al. 2016)
				SR_7	rare species	local data	maps, pictures,		national	
				SR_8	tax value of accommodation	local data	written data		national	
				SR_9	forested cover	national	maps		national	
17	recreation and tourism (R)	PR3	recreation	SR_{10}	fresh water	national	maps,	participatory gis (pgis), questionnaire	national	(COOPER et al. 2016)
				SR_{11}	recreation fishing	local data	written data, pictures			
18	recreation and tourism (R)	PR5	forest recreation	SR_{12}	accessibility	sub-national	maps	participatory gis (pgis),	national	(VAN BERKEL and VERBURG 2014)
				SR_{13}	land cover	national	maps		national	
				SR_{14}	distance	sub-national	maps		national	
19	recreation and tourism (R)	PR3	recreation	SR_{15}	urban green space	sub-national	maps	questionnaire	local	(KENWARD et al. 2011)
20	recreation and tourism (R)	PR6	tourism	SR_{16}	flower viewing	local data	pictures, written data	social media-based, observation	local	(O'FARRELL et al. 2011)
				SR_{17}	viewsheds	local data			local	
				SR_1	visitors numbers	local data			local	
21	recreation and tourism (R)	PR3	recreation	SR_{18}	water fowls	sub-national	maps	participatory GIS (PGIS)	local	(GASCOIGNE et al. 2011)
22	recreation and tourism (R)	PR7	land cover	SR_9	forest cover	national	maps	PPGIS	local	(HUANG et al. 2011)
23	recreation and tourism (R)	PR3	recreation	SR_{13}	land cover	national	maps	scenario simulation, PGIS	local	(HELIAN et al. 2011)

24	recreation and tourism (R)	PR8	outdoor recreation	SR_{13}	land cover	national	maps	PPGIS, questionnaire	local	(Lautenbach et al. 2011)
				SR_{19}	traffic census	local data	maps	observation	local	
25	recreation and tourism (R)	PR6	ecotourism	SR_{20}	resource availability	national	maps	document	national	(Naidoo et al. 2011)
		PR9	trophy hunting	SR_{20}	resource availability	national	maps		national	
26	recreation and tourism (R)	PR2	aesthetics and recreation	SR_{13}	land cover	national	maps	scenario simulation	local	(Brenner et al. 2010)
27	recreation and tourism (R)	PR3	recreational use	SR_{1}	visitors numbers	local data	written data	observation	national	(Eigenbrod et al. 2010)
28	recreation and tourism (R)	PR10	potential recreational use	SR_{21}	footpaths	sub-national	maps	participatory GIS (PGIS), questionnaire, document	local	(Posthumus et al. 2010)
				SR_{22}	cultural heritage	sub-national	written data		local	
				SR_{22}	distance to resources	sub-national	maps		local	
				SR_{23}	population density	sub-national	written data		local	
29	recreation and tourism (R)	PR11	number of tourist attractions	SR_{1}	visitors numbers	local data	written data	document, interview, observation	local	(Raudsepp-Hearne et al. 2010)
		PR5	forest recreation	SR_{9}	forest cover	national	maps	participatory GIS (PGIS), questionnaire, document	local	
30	recreation and tourism (R)	PR3	recreation	SR_{13}	land cover	national	maps	participatory GIS (PGIS), questionnaire, document	local	(Vihervaara et al. 2010)
31	recreation and tourism (R)	PR12	accommodation suitability	SR_{13}	land cover	national	maps	participatory GIS (PGIS), questionnaire, document	local	(Willemen et al. 2010)
				SR_{14}	distance	sub-national	maps		local	
					distance to resources	sub-national	maps		local	
				SR_{12}	accessibility	sub-national	maps		local	
					accommodation	local data	written data		local	
32	recreation and tourism (R)	PR3	recreational use	SR_{1}	visitor numbers	local data	written data	document, interview, observation	local	(Müller et al. 2010)
33	recreation and tourism (R)	PR13	potential leisure cycling population	SR_{22}	distance to resources	sub-national	maps	participatory GIS (PGIS), questionnaire, document	local	(Willemen et al. 2010)
				SR_{24}	roads	sub-national	maps		local	
				SR_{23}	population density	sub-national	written data		local	

		PR12	accommodation suitability	SR_{13}	land cover	national	maps		local	
				SR_{14}	distance	sub-national	maps		local	
				SR_{22}	distance to resources	sub-national	maps		local	
				SR_{12}	accessibility	sub-national	maps		local	
				SR_{25}	accommodation	local data	written data		local	
34	recreation and tourism (R)	PR14	potential tourism	SR_{17}	viewsheds	local data	pictures	questionnaire, observation	local	(REYERS et al. 2009)
35	recreation and tourism (R)	PR15	recreational fishing opportunities	SR_{26}	fish abundance	sub-national	pictures, written data,	observation	local	(LARA et al. 2009)
36	recreation and tourism (R)	PR16	international tourism	SR_{1}	visitors numbers	local data	written data, pictures	observation	national	(LANGE et al. 2009)
				SR_{27}	visitors stay	local data		interview	national	
				SR_{28}	visitors expenses	local data		interview	national	
		PR17	fishing	SR_{26}	fish abundance	sub-national		social media-based	national	
				SR_{29}	fish consumption	sub-national			national	
37	recreation and tourism (R)	PR12	accommodation suitability	SR_{13}	land cover	national	maps	scenario simulation questionnaire, participatory GIS (PGIS)	local	(WILLEMEN et al. 2010)
				SR_{14}	distance	sub-national	maps		local	
				SR_{22}	distance to resources	sub-national	maps		local	
				SR_{12}	accessibility	sub-national	maps		local	
				SR_{25}	accommodation	local data	written data		local	
		PR13	potential leisure cycling population	SR_{22}	distance to resources	sub-national	maps	observation, questionnaire	local	
				SR_{24}	roads	sub-national	maps	questionnaire	local	
				SR_{23}	population density	sub-national	written data	document, interview	local	
38	recreation and tourism (R)	PR3	recreation	SR_{15}	natural areas	national	maps	questionnaire	local	(CHAN et al. 2006)
				SR_{12}	accessibility	sub-national	maps	participatory GIS (PGIS),	local	
				SR_{23}	population density	sub-national	maps, written data	document	local	
39	recreation and tourism (R)	PR3	recreation	SR_{1}	visitors numbers	local data	written data	document, observation	local	(HEIN et al. 2006)

40	recreation and tourism (R)	PR3	recreation	SR_{13}	land cover	national	maps	public participation GIS (PPGIS),	local	(Troy et al. 2006)
41	inspiration value (I)	PI_1	cultural and spiritual	SI_1	land cover	national	maps	interview, participatory GIS (PGIS)	local	(Brenner et al. 2010)
42	inspiration value (I)	PI_2	landscape value	SI_2	landscape value	national	maps	interview, participatory GIS (PGIS)	local	(Posthumus et al. 2010)
				SI_3	land use		maps		local	
43	inspiration value (I)	PI_3	authenticity landscape	SI_3	land use	national	maps	interview, participatory GIS (PGIS)	local	(Willemen et al. 2010)
				SI_1	land cover	national	maps	scenario simulation, questionnaire	local	
44	spiritual value (S)	PS1	education value	SS_1	photographs	sub-national	pictures	social media-based,	local	(Langemeyer et al. 2015)
				SS_2	landscape settings	national	maps	participatory GIS (PGIS)	local	
45	spiritual value (S)	PS2	research and educational bases	SS_3	distance to resources	sub-national	maps	participatory GIS (PGIS)	local	(Shi and Cui 2009)