MAPPING INDICATORS OF CULTURAL ECOSYSTEM SERVICES: REVIEW AND RELEVANCE TO URBAN CONTEXT

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Received: 17th October 2019, **Accepted:** 14th December 2019

ABSTRACT

Over decades human well-being has recognized from ecosystems, not only through material goods but also through nonmaterial assets namely cultural ecosystem services (CES). Regardless of increasing Ecosystem Services (ES) research over the last decade, cultural services assessment still remains neglected and is mainly limited to marketable services such as recreation and ecotourism. Obvious challenges in standardizing definitions and measurement units have brought about numerous difficulties in accounting cultural services and specific related indicators in decision-making processes. In that regard, the current review intends to create a reference list of CES categories and related measurement units with commonly used indicators. To put it another way, we analysis 80 publications to identify the most common CES indicators using in mapping various categories of CES approaches. Results prove that there are various methods can be used in assessing CES categories, whereas we found 57 indicators can be used for that and most of these indicators can be utilized in urban planning context as spatial indicators. Moreover, it is obvious that almost the same indicators can be used in evaluating most CES categories. For instance, in case of recreation and tourism indicators almost 50 % of all collected indicators can be used for mapping it, on the contrary, in case of spiritual and religious values. In conclusion, while there are various mapping methods of CES and different indicators, most of CES categories have relatively ignored by the planner and decision-makers such as education and inspirational values. Therefore, we recommend the use of the collected indicators and relevant measurement units in assessing neglected values in future research.

Keywords: Culture ecosystem service, Non-material values, Assessment indicators, Urban context.

INTRODUCTION

Ecosystem Services (ES) concepts have obtained dragging on the scientific research agenda and have found its way into research on urban context and environmental. Towns and cities and ecosystem, such as any other complex ecosystem, supply specific kind of ES services to their residents and society (Dou *et al*., 2017) as well as they are benefited by the surrounding ecosystem services. In urban contexts, various kinds of land use and ecosystems supply different services inclusive noise reduction, gas regulation, micro-climate regulation, water regulation, sewage treatment, recreational, educational and cultural values. Other services like erosion control and food production usually have lower importance within

urban contexts, however, they may become relevant to the urban context in case of looking at more expanding contexts (i.e. regional areas), especially under the resulted pressures that climate change might effect on urbanised areas (Ho Huu *et al*., 2018).

Nowadays, Cultural ecosystem services (CES) approach has become a well- recognized tool for decision-making on different social and culture issues. Cultural ecosystem services are defined by Millennium Ecosystem Assessment (MEA) in 2005 as the subset of ES that provide nonmaterial benefits that people obtained from ecosystem services (ES) such as spiritual, education, recreation, and aesthetic values. Due to both CES and other ES reflect what people gain from the surrounding natural environment, it is urgent to increase public awareness of CES to protect the environment from future degradation causes (Wallace, 2007). The following CES categories and definitions were established by the MEA (2005) and are used in the present study to illustrate their mapping indicators:

- Recreation and ecotourism: locals/people often choose where to spend their leisure time depending on the characteristics of the natural landscapes or cultivated areas in a special area.
- Spiritual and religious: almost all societies respect spiritual and religious values to ecosystems or their components.
- Aesthetic: locals find aesthetic value in the various sides of the ecosystem services, as that appears in support of scenic drives, parks, and selection of accommodation locations.
- Inspirational: CES values supply a rich source of inspiration for architecture, art, architecture, and advertising, etc.
- Sense of place: ecosystem values as the main pillar of "sense of place", this value often used in indicating the relation of those characteristics that make the site unique or special, also to those that enhance a sense of real human belonging and attachment.
- Cultural heritage: The diversity of ecosystems is one factor contributing to the diversity of cultures between societies. So, many countries that are known as a historical destination pay more attention to place a high value on the maintenance of either historically important landscapes or culturally significant species.

Recently, communities and decision-making policy have paid more attention to mapping CES to support practical application of CES (e.g. urban planning of recreation sites, and landscape planning) (Christie *et al*., 2012). Due to CES are 'nonmaterial' and 'invisible' services compared with other material services, the evaluation of CES remains relatively ignored and poorly understood (Fu *et al*., 2011). Moreover, the low availability of data and indicators related to mapping CES are a considerable barrier to evaluate all kinds of ecosystem service, especially CES (Richards *et al*., 2015). On the other hand, the limitation between various CES categories are not evident, which caused to double challenges facing the determination of CES mapping indicators. For instance, the recreation value indicators are related to other CES mapping indicators like aesthetic and spiritual value indicators. Therefore, it is very difficult to realize and determine the real value of each service (D'Amato *et al*., 2016). Scientific research has been addressed CES assessment indicators and their evaluation methods (Czembrowski *et al*., 2016). Furthermore, different methods and indicators have been used to assess and map CES (D'Amato *et al*., 2016). In general, CES mapping methods have been classified into biophysical methods and preference-based methods. On the contrary, these methods have been classified into monetary and non-monetary methods (Sumarga *et al*., 2015). Because of analyzing, mapping, or assessment of CES, CES indicators classified into primary and secondary mapping indicators (Hernández-Morcillo *et al*., 2013). In that regard, current review collects a various literature

based on study area to discuss CES mapping indicators. For example, there are more studies which using various primary and secondary indicators to evaluate or map CES, like O'Farrell et al. studied flower viewing as secondary indicator in evaluate the recreation areas in South Africa by using special analysis (O'Farrell *et al.*, 2011), and Naidoo et al. examined potential recreational use by using footpaths, cultural heritage, distance to resources in rural area in UK (Naidoo *et al.*, 2011). Willemen et al. presented a methodological framework for evaluate recreation and tourism services through accommodation suitability as a primary indicator and use a various secondary indicator like; distance to resources, land cover, and accessibility (Willemen *et al.*, 2008). Moreover, Naidoo C. et al. explore the use of number of tourist attractions as a primary indicator to assess the recreation areas by using visitors' numbers as a secondary indicator (Naidoo *et al.*, 2011). So, it is necessary to collect the related indicators used for mapping CES as the first step towards assessing and mapping CES.

In the urban context, CES research is even more poorly developed and its real applicability in urban planning is still a pledge (Haase *et al.*, 2014). This is because of two main reasons, firstly mismatches between areas benefiting from these services and areas providing services should be highlighted in the context of urbanized regions. Because ecosystem services stream from production sites to sites where they are consumed this makes CES evaluation and assessments more difficult. However, the situation changes when we refer to individual kinds of CES, such as those provided by historical sites, monuments and other cultural services elements that are naturally concentrated in cities, and consequently recently addressed in the urban planning contexts. Thus, the second reason is that urban ecosystems are described by very high complexity, and requiring precise selection of evaluation methods, indicators, and approaches. The complication in urban ecosystems is specific in many different aspects, such as a large number of various land-cover types. This makes CES evaluation based on land-use information especially challenging and it is requiring data sources with a high resolution and that is not always available (Dou *et al.*, 2019). Moreover, the problems related to mapping of CES have been increased because of CES are nonmaterial services compared with other material services. So, in this review paper, we focus on collecting and analyzing CES mapping indicators and illustrate spatial and non-spatial mapping indicators with the relevance of these indicators with urban context. To achieve the main goal, it is important to address the following objectives: indicate the most common CES mapping indicators and related categories and illustrate the type of mapping indicators and availability of data source. Based on the previous referred objectives, we raise the following research questions: what and how many indicators have been addressed to map CES? Which CES category is most extremely examined with these indicators? How these indicators can be measured? Which indicators are most related to each CES categories and how many? Which indicators are most relevance to urban context? And how many indicators have minor or major modification for applying in urban planning?

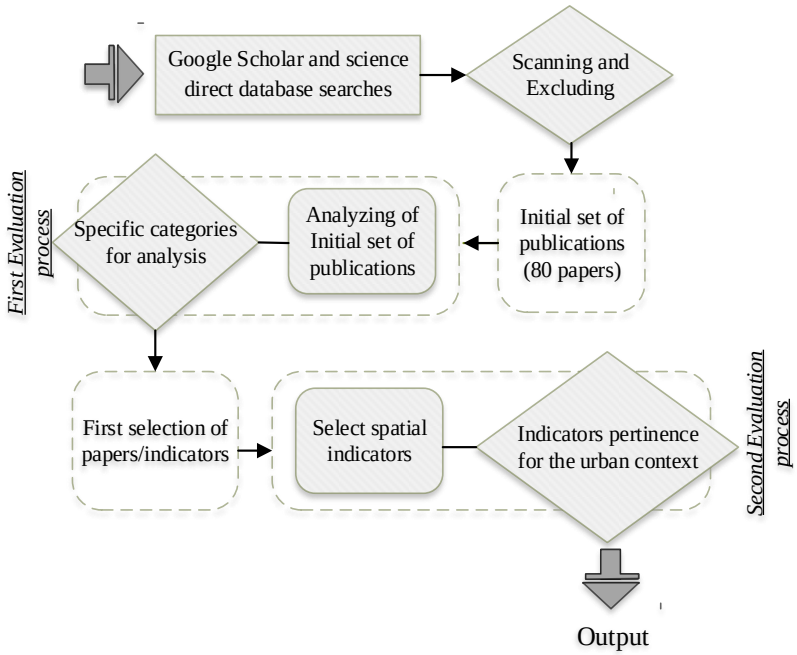
MATERIAL AND METHODS

We applied a comprehensive examination of literature that exactly addressed CES evaluation indicators. Two search terms are used to select the literature addressed "CES evaluation methods" and "CES indicators". Google Scholar and Science Direct database were used to apply the search terms in titles, abstracts and keywords. The search was not be limit by a fixed period or performed in a specific country or published in a specific journal. It was perfumed from November 2018 to May 2019. In our search, we focused on literature

exactly addressed CES mapping indicators. Almost 80 papers were involved in the analysis in a total of 154 papers through the search times. An established technique divided into two evaluation process have been used, to analyze and compare the results related to the selected publications (Fig.1). As previously stated, the aim of the review was to create a reference list of CES evaluation indicators for being used in mapping CES in the future in urban and peri-urban areas. The first evaluation process of the selected articles has been divided into the following categories:

- Overview of the publications: involve the publish year and number of papers addressed every CES categories.
- Classification of CES categories: determine the categories of CES addressed in the selected publications.
- Grouped the collected indicators: identify two groups like the primary and secondary indicators used in the evaluation.

Fig. 1: Analitical process of paper evaluation



Each paper was analysis according to the above-mentioned categories. In the initial stage, we selected those publications whose evaluation indicators might be used in urban contexts for urban planning purposes. Papers were considered pertinent if they used indicators that were exactly spatial indicators. Those papers were then used for the second evaluation stage which aimed to indicate the possible use of the selected indicators to inform planning procedure in urban contexts. The second evaluation was based on a comprehensive combination of two main criteria: “ability of communication” and “relation to urban context” within the referred case studies presented in the papers. “Ability of communication” was understood as the ability to transfer the results from indicators to decision making tools. The following sub-criteria have to obtained from the selected studies: (1) using a clear theoretical framework for CES mapping, (2) appearance of the spatial results of the study area (i.e.

tables, maps, charts, etc.), (3) usability of the evaluation method. Thus, indicators used in the obtained papers had the ability of communication if all of the above three sub-criteria were addressed.

We checked the "pertinence for urban context" of used indicators by evaluating the predominance of the urban context within the study area. The prevalence of the urban context have been evaluated by using three grades of a qualitative scale L, M, H: (L) Low prevalence – in this case, the case study did not contain urban areas such as Brown *et al.* (2012) addressed a study area which has only 8,000 citizen, so in this case, the study addressed landscape context, therefor, the used indicators have a low relevance with urban context (Brown *et al.*, 2012); (M) Medium prevalence: that mean urban areas have been more prevalent but not so much, like in the case of Broekx et al. who addressed study area which is has vast rural areas with also significant levels of urbanisation (e.g. country scale, regional and national scale) (Broekx *et al.*, 2013); (H) high prevalence: that means the urban areas were most predominant within the study area, such as address specific case studies of cities like Davis *et al.* who involved one city in CES evaluation (Davis & Kidd, 2012) or more one city like Escobedo study who involved four cities.

Table 1: The combination between two criteria values of the second evaluation

Pertinence for urban context criterion	Communicability criterion	Usability in urban planning
L (Low pertinence)	Y (Yes)	Used with major modification
M (Medium pertinence)	Y (Yes)	Used with minor modification
H (High pertinence)	Y (Yes)	Used as it is
L (Low pertinence)	N (No)	Used with major modification
M (Medium pertinence)	N (No)	Used with major modification
H (High pertinence)	N (No)	Used with minor modification

Table 1 summarized the combination of the above criteria to illustrate the usability of the indicators for planning in urban context. For instance, in case of indicators fulfilling "ability of communication" criterion and performed in a study area that has a high prevalence of urban context (H) were considered usable as it is. On the other hand, when indicators fulfilling "ability of communication" criterion and performed in a study area that has a medium pertinence of urban context (M) were considered usable with minor modification. On the contrast, in case of the indicators not fulfilling "Ability of communication" criterion and performed in a study area that has a low prevalence of urban context (L) were considered usable with major modification (i.e. update in measurement methods and/or type of data used, or the resolution of dataset)

RESULTS

The results collected from the Science Direct and Google Scholar database in terms of the number of analyzed papers and the terms used in the search query are mentioned to above.

Moreover, the use of different and more specific terms in the queries affected directly on the number of obtained studies about the topic. Obviously, results obtained from using "culture ecosystem services" and "evaluation methods" showed a limited set of papers dealing explicitly with the evaluation of CES (45 for the two databases) out of the total literature about CES evaluation (95 for the two databases). Moreover, combining the terms "cultural ecosystem services" and "indicators" in the second search time indicate the results down further (60 for the two databases) and excluded the duplicate papers as well (-20 papers). In general, we identified over 80 peer-reviewed papers that reported 12 empirical cases of various methods used between 2008 and 2019. We analyzed 25 case studies publications that exactly relevance to CES evaluation indicators (Table 2).

The first analysis/evaluation

In this stage, we selected those publications whose evaluation indicators might be used in urban contexts for urban planning purposes. Papers were considered pertinent if they used indicators that were exactly related to spatial context. The result of the first evaluation process shows that papers referred to CES evaluation methods and related indicators increased frequently from 2008 to 2019 (Fig. 2). The publication average rate was 3 papers per year from 2008 to 2013, and the average rate was increased by 6 papers per year after 2013 based on our evaluation. In the following sections, the first evaluation process presented in more detail, which include the CES categories and related indicators and data source type with measurement units and brief description of used methods. The results are generally presented as a percentage of the papers and case studies. The selected papers and their descriptive attributes have been shown in Table 2 after applied the first evaluation process, and we can indicate the first evaluation categories in the following sections.

Fig. 2: Number of publication per the years

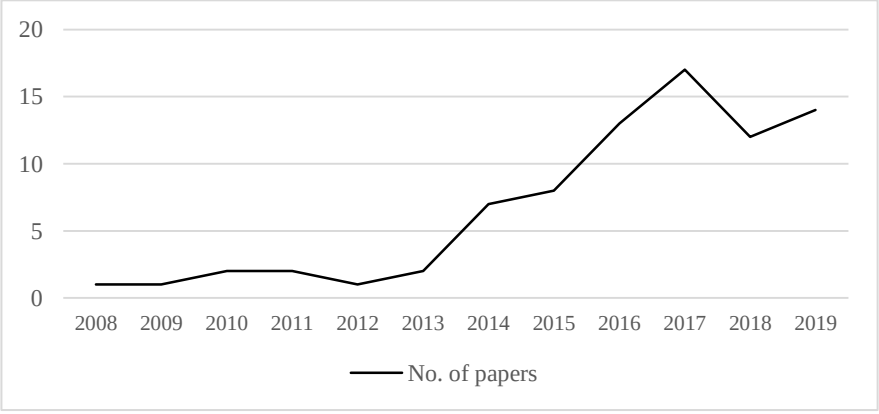


Table 2: Example of literature review used in this analysis

Source	**Primary indicators**	**Indicator code**	**Secondary indicators**	**Data sources for the analysis**		
				Pictures	Maps	Written sources
(Lee *et al.*, 2019)	All CES	-	Non-fixed	+	-	-
(Brown et al., 2016)	All CES	1 2	- Population - Land cover	-	+	-
(Ives *et al.*, 2017)	All CES	3	- Distance	+	(+)	-
(Zwierzchowska *et al.*, 2018)	All CES	4 5	- Travel costs - Accommodation	-	(+)	+
(Langemeyer *et al.*, 2015)	All CES	6 7	- Photographs - Landscape settings	+	(+)	-
(Rewitzer *et al.*, 2017)	Heritage inspiration	-	Not specified			+
(Clemente *et al.*, 2019)	Aesthetic	8	- Viewpoint	(+)	+	
(Bieling, 2014)	All CES	9 3 10	- Number of visitors - Distance - Green spaces	-	-	+
(Wartmann and Purves, 2018)	Recreation and aesthetic	6 9	- Photographs - Number of visitors	-	(+)	+
(Schirpke *et al.*, 2016)	Sense of the place	11 12 13	-Sense of satisfaction of interests and needs - Sense of happiness - Sense of care with the place	-	(+)	+
(Figueroa-Alfaro and Tang, 2017)	All CES	10 7	- Green spaces - Landscape settings	-	(+)	-
(Riechers et al., 2018)	Cultural heritage	14	- land use	-	-	+
(Dou *et al.*, 2017)	Education value	9 3 15	- Number of visitors - Distance - Income	-	-	+

(Cooper *et al.*, 2016)	Recreation	16 17 18	- Fresh water - Recreation fishing - Bird watching	(+)	-	-
(Stålhammar and Pedersen, 2017)	Recreation	-	Not specified	-	(+)	-
(Ribeiro and Ribeiro, 2016)	All CES	19 20 21	- Site location - Accessibility - Perception with the public.	+	(+)	-
(Van Berkel and Verburg, 2014)	Forest recreation	20 2 3	- Accessibility - Land cover - Distance	-	+	-
(Rall, Hansen and Pauleit, 2019)	Aesthetic and Recreation	21 9	- Landscape aesthetics - Number of visitors	-	+	(+)
(Stanik et al., 2018)	Aesthetic	6	- Photographs	+	-	-
(Hutcheson et al., 2018)	All CES	22 23	- Monetary value of CES - Number of threats	-	+	(+)
(Upton *et al.*, 2015)	Cultural heritage	-	Not specified	-	+	-
(Soleiman et al., 2017)	Recreational	24 25	- Recreation potential - Ecotourism potential	-	+	-
(Tenerelli et al., 2016)	Recreational and Ecotourism	26 27 28 29	- Tourist attractions - Rare species - Tax value of accommodation - Forested cover	-	(+)	+
(Richards and Tunçer, 2018)	All CES	30 4	- Willingness to pay (WTP) - Travel costs	-	-	+
(Paracchini *et al.*, 2014)	Recreation	9	- Number of visitors	-	+	(+)

+: data sources used for the analysis; (+): data sources partly used for the analysis; -: data sources not used

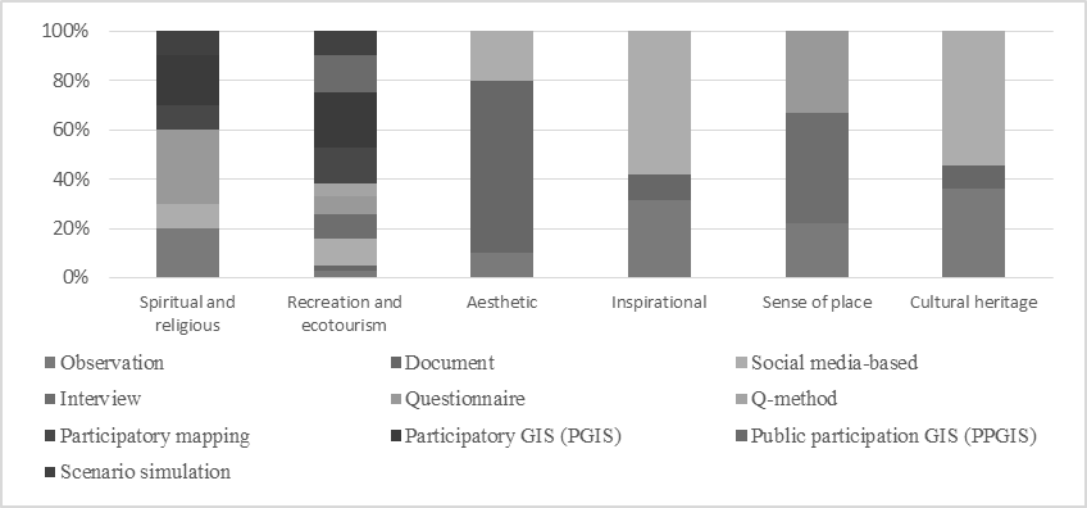
Categories of CES

The most frequently evaluated category of CES was "recreational and ecotourism", which was referred to in 8 papers of 25 papers, Within this category, you can find other terms such as "forest recreation" (Bielinis *et al*., 2019) or related categories like "leisure-activities" (Lizana *et al.*, 2019) are included. Two-second most referred to CES category (6-5 references respectively) are "cultural heritage" and "aesthetic values" services, sometimes specifically named "landscape aesthetic" (Schirpke *et al*., 2019). Other CES categories referring to MEA framework (2005) are reported in Table 3. Therefore, recreation and ecotourism were evaluated by the most of selected studies, followed by cultural heritage and aesthetic values. On the contrary, education, sense of place, and inspirational have received the least attention of the selected papers. And only five of them evaluate multiple CES categories, and the remained evaluated all CES categories (Table 3).

Table 3: Number of papers referred to all or individual CES categories

Categories of CES	Number of refered papers
Cultural heritage	3
Education	2
Recreation and ecotourism	6
Inspirational	1
Sense of place	1
Aesthetic values	4
Multiple CES	3
All CES categories	5

Fig. 3: The distribution of each CES category corresponding to different methods



CES evaluation methods

The analysis results illustrated a various set of methods for CES evaluation were found, mainly due to the wide vision of aims the studies expressed. This study collected ten CES

evaluation methods which employed different procedures, started from different theoretical backgrounds and applied different techniques. For instance, GIS based mapping (e.g. Ives *et al.*, 2017; Zwierzchowska *et al.*, 2018; Ribeiro *et al.*, 2016; Upton *et al.*, 2015), participatory mapping (Brown *et al.*, 2016; Van Berkel *et al.*, 2014; Rall *et al.*, 2018), field observations, and expert-based scoring (Dou *et al.*, 2017; Cooper *et al.*, 2016; Stålhammar *et al.*, 2017). Most of these assessment methods were GIS-based, including GIS tools developed appositely for the purpose. The distribution of each CES category corresponding to different methods is shown in Fig. 3.

Type of data

Type of data used in the papers had diverse sources, nature and used measurement unites (Table 4). In that regard, most of the analyzed studies used data obtained directly from interviews and field data, and the interviews methods were online and face-to-face surveys. While some were described as "semi-structured interviews", others used field surveys which based on different pictures or photographs. Likewise, we can find papers used spatial data like maps about land use/land cover, and others used written data and maps available from different local public and private institutions. Therefore, three main types of data source have been used in evaluation CES in the selected papers (pictures, maps, and written sources), and these data can be collected from semi-structured interviews, face-to-face surveys, or spatial data like land use/land cover maps. The number of papers used the different types of data source have been reported in Table 4 with the related secondary and primary mapping indicators. Every paper and indicators have a code number to be used in the second evaluation process (Table 4).

Table 4: Type of data and measurement unites used in selected papers

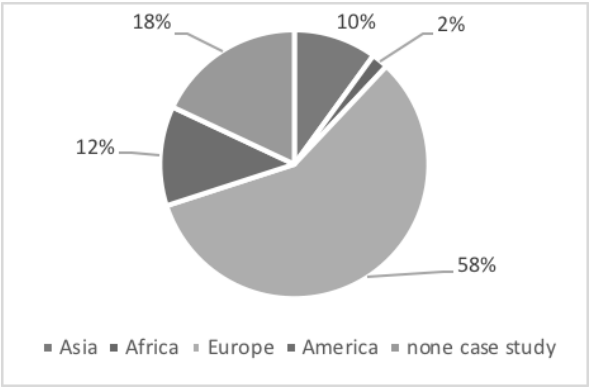
Code	**Indicator name**	**Spatial indicators**	**Measurement unit/method used**
1	- Population	Y (Yes)	- PPGIS
2	- Land cover	Y (Yes)	- PPGIS and Map analysis
3	- Distance	Y (Yes)	- Spatial analysis, Questionnaire
4	- Travel costs	Y (Yes)	- Travel Cost Method
5	- Accommodation	N (No)	- Travel cost method
6	- Photographs	Y (Yes)	- Social media photographs
7	- Landscape settings	Y (Yes)	- Questionnaires and Observations - Social media photographs
8	- Viewpoint	Y (Yes)	- Photo based questionnaire
9	- Number of visitors	Y (Yes)	- Questionnaire - Social media photographs
10	- Green spaces	Y (Yes)	- Questionnaire, Participatory
11	- Sense of satisfaction	N (No)	- Questionnaires and GIS
12	- Sense of happiness	N (No)	- Questionnaires and GIS
13	- Sense of care with the place	N (No)	- Questionnaires and GIS
14	- Land use	Y (Yes)	- Analysis
15	- Income	N (No)	- Travel cost method
16	- Fresh water	N (No)	- Analysis
17	- Recreation fishing	N (No)	- Analysis
18	- Bird watching	N (No)	- Analysis

19	- Site location	Y (Yes)	- Social media photographs
20	- Accessibility	Y (Yes)	- Social media photographs
21	- Landscape Aesthetics	Y (Yes)	- Spatial analysis
22	- Monetary value of CES	N (No)	- Spatial analysis
23	- Number of threats	N (No)	- Spatial analysis
24	- Recreation potential	Y (Yes)	- Spatial analysis
25	- Ecotourism potential	Y (Yes)	- Spatial analysis
26	- Tourist attractions	Y (Yes)	- Number of tourist attractions
27	- Rare species	Y (Yes)	- Number of visitors of rare species
28	- Accommodation	N (No)	- Number of visitors of rare species
29	- Forested cover	Y (Yes)	- Number of visitors of rare species
30	- Willingness to pay (WTP)	N (No)	- Travel costs

The spatial extent of the study areas

In this section, we examined the case study feature (e.g. geographical distribution, a case study scale) related to the collected papers. First of all, we will describe the results of the review related to the continent of the study, which show that about two-third of the studies (58 %) presented case studies located in Europe. In contrast, less than a quarter of studies (22 %) were located in America and Asia, and only one of the studies were located in Africa (2 %) and no article from 80 selected publications finding in Australia (Fig. 4). It is worth mentioning that the reminding 9 studies (18 %) were review and theoretical papers about CES and these kinds of papers do not have geographical context or study area.

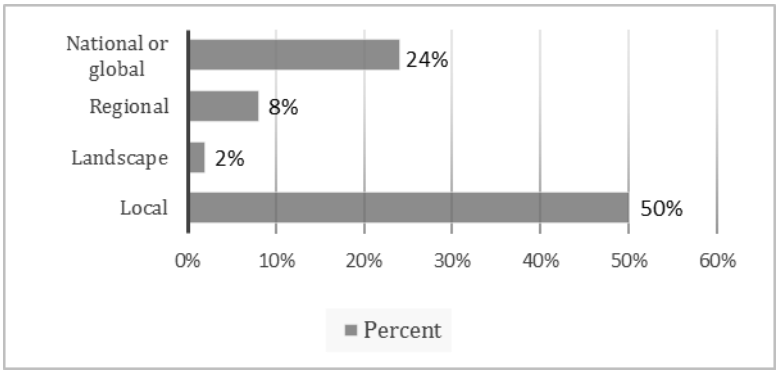
Fig. 4: The proportion of the publication per continent



In most case studies, papers addressed very small geographical areas (e.g. local scale). Planned comparisons related to the country of the study revealed that the majority of the studies were in Germany; followed by China, then the UK and USA both of them had the same number of publications. From the last results, it is observed that there were differences in the geographical distribution of the publication on the same continent. Based on the scale of study (Fig. 5), there were also some important differences between the publications in the scale of the study area. It is apparent that a half of publications were at the local scale. In contrast, only 2 percent of publication represented landscape scale from all the publications (Fig.5). By comparing the results, it must be pointed out that the majority of the case studies were located in Europe on a local scale and followed by a global scale. Most of the case

studies addressed non-urban ecosystem services such as coastal/marine areas (Bermejo, *et al*., 2018) and forests (Ghasemi *et al*., 2018). As known by MEA (2005) boundary limits for mapping of urban ES are limited to "known human settlements with a population of 5000 or more". None of the analysed case studies can be described as "urban ecosystems". More detailed analyzing of the relevance of the urban context is provided in Table 6.

Fig. 5: The percentage of publications per case study scale



The second analysis/evaluation (indicators pertinence for urban context)

As showed by the third column of Table 4, almost 30 secondary indicators were used in the reviewed studies. Within these indicators, about 18 indicators were spatial and the rest of them are non-spatial indicators. These indicators are reported in Table 5 with referred code. Depending on the second evaluation process of the selected studies which was based on the criteria of "ability of communication" and "pertinence to urban context". The number of indicators with their pertinence to the urban context have been reported in Table 6. Regarding to "the ability of communication" criterion, about 65 % of the spatial indicators included in Table 5 fulfilled the "ability of communication" criterion. But, in case of "pertinence to urban context" criterion, nearly 35 % presented a low pertinence (L) of urban context, and the rest of the spatial indicators reported in Table 6 present medium pertinence (M) of urban context" and no indicators were found to be of "High pertinence of urban context". So, by the end of this evaluation process, we can illustrate that none of all indicators could be used for planning in urban context without modification: about more than third of the spatial indicators reported in Table 6 could be usable after major modification and the rest of indicators could be used after minor modification. In term of CES categories, more of CES categories were addressed in previous studies. Moreover, various indicators have been used for evaluating CES categories. Table 5 report how the 30 selected indicators identify to the MEA (2005) categories indicate big differences in addressed categories: but almost 76 % of all indicators referred to "recreational and ecotourism", followed by 53% referred to "cultural heritage and sense of the place" (Table 5).

Table 5: Number of papers referred to CES indicators

CES Categories	**No. indicators**	**Indicators code**
Cultural heritage	16 (53%)	1, 2, 3, 4, 5, 6, 7, 9, 10, 14, 19, 20, 21, 22, 23, 30,
Spiritual and religious	15 (50%)	1, 2, 3, 4, 5, 6, 7, 9, 10, 19, 20, 21, 22, 23, 30,
Recreation and ecotourism	23 (76%)	1, 2, 3, 4, 5, 6, 7, 9, 10, 15, 16, 17, 18,19, 20, 21, 22, 23, 24, 27, 28, 29, 30
Inspirational	15 (50%)	1, 2, 3, 4, 5, 6, 7, 9, 10, 19, 20, 21, 22, 23, 30,
Sense of place	18 (60%)	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 19, 20, 21, 22, 23, 30
Aesthetic values	16 (53%)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 19, 20, 21, 22, 23, 30,
Education values	16 (53%)	1, 2, 3, 4, 5, 6, 7, 9, 10, 15, 19, 20, 21, 22, 23, 30,

Table 6: The usability of indicators in urban planning

Code	**Spatial indicators**	**Related to urban context**	**Ability of communication**	**Possibility for using in urban planning**
1	Population	L (landscape context)	N	Y, major modification
2	Land cover	L (landscape context)	Y	Y, major modification
3	Distance	M (Regional scale)	Y	Y, minor modification
4	Travel costs	M (Regional scale)	N	Y, major modification
6	Photographs	M (county scale)	Y	Y, minor modification
7	Landscape settings	L (landscape context)	N	Y, major modification
8	Viewpoint	M (county scale)	Y	Y, minor modification
9	Number of visitors	M (National scale)	Y	Y, minor modification
10	Green spaces	L (country scale)	Y	Y, minor modification
14	Land use	L (landscape context)	N	Y, major modification
19	Site location	M (Regional scale)	Y	Y, minor modification
20	Accessibility	M (county scale)	Y	Y, minor modification
21	Landscape Aesthetics	L (landscape context)	Y	Y, major modification
24	Recreation potential	L (landscape context)	Y	Y, major modification
25	Ecotourism potential	L (landscape context)	Y	Y, major modification
26	Tourist attractions	M (Regional scale)	N	Y, major modification
27	Rare species	M (county scale)	Y	Y, minor modification
28	Accommodation	M (county scale)	Y	Y, minor modification
29	Forested cover	L (landscape context)	N	Y, major modification

L- (Low relevance), M-(Medium relevance), N- (No), Y-(Yes)

DISCUSSION

Within this section, we discuss CES indicators usability for planning in urban contexts, at the light of our review results. The current review indicates a lack of conceptual distinctness and mismatching in using CES categories for planning in urban contexts. As a result of that, the selection of proper indicators is complex and difficult for particular CES categories. There are various examples of CES indicators with unclear CES categories, for instance: (a) "species value" (Burkhard & Gee, 2012); (b) "biodiversity", "social values", "historic sites" (Sherrouse *et al*., 2014); (c) "value identity" (Tengberg *et al*., 2012); (d) "landscape beauty" (Van Berkel & Verburg, 2014). References/publications with above-mentioned CES indicators were not included in research results indeed, because of these CES indicators were just utilized as theoretical references, without specifying these indicators nature and their obvious relation to the CES categories using MEA or another similar framework. A better description and addressing of CES categories are needed to simplify and better utilize for selecting the most effective CES indicators for planning in the urban context. This might be achieved by referring to the most two prevailing frameworks of CES categories namely: MEA (2005) or TEEB frameworks and using a proper urban scale to address and evaluate the spatial distribution of CES. Therefore, in many cases, the evaluation ends up as an emblematic reference of the CES concept, focusing on proving the utilization of the framework without conceptual distinctness such as what the indicator especially should measure.

This study describes various possible indicators for evaluating CES in environmental sciences and applications. Referring to the role of CES indicators, there are - of course - many constraints and problems that we hope to reduce and solve in the future (Soleiman *et al*., 2017). As well, our analysis detects that there is an increasing of publications focused on evaluate and map CES. In spite of the advances in the CES mapping method, the sources of modeling methods and information are various; as well as, in most of the studies, detailed methodological information was missing (Van Berkel & Verburg, 2014). So, in this study, we analyzed and showed a lack of conceptual clarification and ambiguity in the use of CES categories for urban contexts. This makes the selection of suitable indicators very complicated for CES categories (Van Berkel & Verburg, 2014). By using the proposed analytical approach the obtained publications have been analysed and compared to collect the proper indicators which can be used in mapping various categories of CES and reported them in Table 6 with indicating the relevance of these indicators to the urban context and the possibility of using in urban planning as spatial indicators. The analysis presented in this study has revealed that recreation and ecotourism are the most evaluated CES category, while inspiration and heritage values were the least investigated categories. Even though many obtained studies included mapping one or more categories of CES, only half of the references were used spatial mapping indicators. This different distribution might be due to a lack of clear definitions of other CES categories (Weyland *et al*., 2014).

Regarding to the referred studies, recreation and ecotourism have rather clear definitions. On the contrast, we can realize that the inspiration or sense of place are most of CES categories mysterious. This fact can be seen as being problematic, because the existing primary international definitions of CES (e.g.,TEEN) are still dialectical (Weyland *et al*., 2014). Moreover, CES categories have a various barrier of evaluation like the lack of a specific classification system. For example, in MEA classification system, the recreation category can be determined easily as 'recreation and ecotourism' and determined as 'recreation and tourism' in TEEB . On the other hand, for other CES categories, it is hard to find equivalent classification categories in the three mentioned international classification systems. Because of that, the studies analysis and comparing in some cases is difficult if

authors use different classification systems (Weyland *et al*., 2014). Due to all of these problems mentioned above, more researchers focus on a single clear CES category – like recreation and ecotourism – to mapping CES categories in separate researches. Admittedly these results caused in ignoring more other categories. In terms of urban planning, evaluation defined as a matter of policy discussion on the basis of assessment and measurements were already done (Schirpke *et al.*, 2016). An assessment method does not necessarily lead to a valuation. For example, some methods were clearly used to lead to specific types of valuation, like travel cost or willingness to pay for landscape conservation which gives economic benefit as valuation result.

When it comes to the possibility of using refereed indicators in urban planning, the conclusions are ambiguous. On the one hand, the lack of mapping indicators is associated with the definition of CES categories are still dialectical, while neglecting the economic categories of CES increase the problem of mapping CES categories, which is in line with our initial assumptions. As we mentioned above, there are about 18 spatial indicators have been obtained from the analysed publications that mean these indicators may be changed from site to other. To put it another way, some of analysed indicators can be proper for one study area and non-suitable for other. So, we proposed in future research, the researcher should emphasize on illustrating which indicator could be associated to every category of CES. Furthermore, in this review, we confirm and addressed a list of spatial indicators and illustrate the relevance of each categories to urban context based on the compared studies. This comparative study brought together multiple primary and secondary indicators that can be used in mapping CES categories especially recreation and ecotourism. Given the complexity of the study, there were limitations that provide direction for future research, the most important was mapping indicators definition for the recreation and ecotourism values. Our selection of indicators based on the relevance of these indicators to urban context and analyses which indicators have major or minor modifications to applied directly in urban planning.

All the final 18 analysis indicators were communicable to the decision-making process, thanks to the comprehensive utilization of related maps. This emphasizes the current and well-developed trend of scientific research in terms of mapping of CES (Sherrouse *et al*., 2014). As regards which level of the decision-making process related to CES is proper for planning in the urban context, Sherrouse *et al*. (2014) discussed that CES are mostly addressed at the country scale, but the benefits that they produce are addressed both internationally and locally (Sherrouse *et al*., 2014). Because of this cause, it is likely at the local level (i.e. country scale) that the decisions for urban planning about CES categories might be more efficient for improving the overall quality of the urban planning environment. Between the final 30 CES mapping indicators indicated in Table 2, just 18 indicators can be used as spatial indicators. However, urban areas have never been the specific contexts of these indicators, that was mostly addressed for three-level; national (Weyland & Laterra, 2014), regional or continent (Nahuelhual *et al*., 2014) level. Furthermore, planning in urban contexts was usually utilized as a part of a large geographical context and their link with CES indicators was so extremely limited for the development and evaluation of CES categories. Therefore, no particular indicator was addressed in the analysis papers which was high relevance with the urban context or dominant within the study area. Moreover, the lack of proper data used in the selected papers was reflecting the limited relevance of the urban context, that might be because of most of the data used in the analysis studies had a very general level of detail not suitable for analysis specific urban items such as architectures or configurations of land uses, etc. Such items, as elements of the urban context, obviously impact the capability of such planning in urban context to supply CES.

The previous discussion references a lot of difficulties achievement CES for planning in urban context and decision making, proving incompatibility between the possibilities of prepared data by spatial indicators which developed for CES so far and their real utilizing for developing planning in urban contexts. Results from our analysis indicate that there is an urgent need for some modification for CES indicators applicability and applied in urban planning, for example, by using various type of spatial information/data (e.g. density of tourist sites, data about urban items, etc.) or by increasing the resolution of the used special information (i.e. land cover and land-use datasets). Moreover, the analysis illustrates that nearly all proposed indicators can be used for evaluating/mapping CES (Table 7), for example, accessibility and other physical features of CES (Nahuelhual *et al*. 2014) or a group of indicators used within pricing evaluation like Willingness to pay (WTP) ((Nesbitt *et al.*, 2017). On the other side, there are some indicators were used to evaluate CES only within using multi-indicator approaches (Villamagna *et al*., 2014). The common use of these indicators highlighted the difficulty of changing the concepts from an ecosystem services framework in spatial terms into the cultural framework and the complexity in finding and addressing quantitative indicators able to express in a spatially clear way the cultural dimension of particular ES. This result also demonstrates that there are spaces for new assessment indicators express CES features in the future.

Our results also indicate that most of CES categories, especially education and spiritual and religious are rarely mapped because of the problems which have been mentioned above. Recreation and ecotourism are the most common categories of CES, and the researchers have often widely addressed it in their research. Across the 80 selected studies, there were some examples of using spatial indicators in mapping CES (Van Berkel & Verburg, 2014; Brown *et al.*, 2016; Soleiman *et al*., 2017), but in the absence of relevance of these indicators to the urban context, there was no greater prevalence of using mapping indicators in urban planning.

CONCLUSIONS

CES mapping indicators are an important, though under-quantified set of these indicators for mapping all CES categories. Spatial indicators could provide useful information for managing CES at multiple spatial scales, and the novel content analysis of mapping indicators presented here may help us to understand the different CES indicators could be used in evaluating CES in the urban context, and thus differentiate between various cultural uses of the environment. CES indicators derived from spatial indicators could be rapid and cost-effective tools for researchers, managers, and decision-makers to quickly assess CES provision at fine spatial scales, helping the future management and maintenance of culturally important ecosystems.

This study presents a review of CES indicators for the evaluation of CES, based on current literature selecting from scientific academic databases. Publications gathering from database queries were analysed, due to providing a list of CES evaluation indicators appropriate for using in urban planning context. Three main criteria were chosen as particular characteristics for indicators that should be used for planning in urban context (e.g. indicators with spatial features, the ability of communication to planning, and relevance of urban context). The results referred that no indicator particularly express CES in an urban context. From the initial group of selected papers, we selected just 18 indicators that might be used for planning in an urban context with minor or major modifications, according to the chosen evaluation criteria.

CES indicators analytical framework provides a powerful tool that can inform about the CES mapping indicators and their relevance to urban context. By classify the obtained indicators to spatial and non-spatial indicators, we can illustrate the potential measurement unites and type of data can be used in mapping CES categories for every indicator based on the referred literature. To conclude, this study has presented an overview of CES evaluation indicators and their relevance to urban context, and challenges and problems facing mapping CES categories for future study. We have classified and analyzed 25 case studies papers in this review. In conclusion, the following recommendations are offered for future research on CES evaluation:

- In addition to recreation and ecotourism, we emphasize the consideration of mapping all CES categories, especially those that are under-exposed and under evaluated, e.g., cultural heritage, inspiration values. To do this, we suggest a harmonious classification system for all categories of CES and suggest the same descriptions of the same category in all the proposed classification systems.
- We explain above the combination of spatial and non-spatial indicators used in evaluate CES and indicate the measurement unites and type of possible data source can be used for collection data about these indicators. Additionally, we call for integrating spatial analysis of these indicators by using nonmonetary evaluation methods like participatory and mapping techniques, and non-spatial analysis of these indicators by using monetary evaluation methods like travel cost. Applying that not to indicate just adding the different parts but rather focusing on the combination and interactions between them.
- We recommend focusing more on other evaluation methods in addition to interviews and questionnaires, such as the Q-method and narratives that can be useful in evaluate neglected services.
- We suggest more research have to focus on CES mapping indicators and how can be applied in the reality to improve the accuracy of evaluation results, and that can be applied by collect the possible data source like maps and photos and written data.

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