Ecosystem Services 58 (2022) 101495

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

Full Length Article

A tag is worth a thousand pictures: A framework for an empirically grounded typology of relational values through social media

Fulvia Calcagni [a,b,d], Júlia Nogué Batallé [c], Francesc Baró [c,e], Johannes Langemeyer [c,d,*]

[a] Department of Natural Resources and Environmental Management, University of Haifa, Israel
[b] Natural Resources and Environmental Research Center, University of Haifa, Israel
[c] Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona (UAB), Edifici Z (ICTA-ICP), Carrer de les Columnes s/n, Campus de la UAB, 08193 Cerdanyola del Vallès, Spain
[d] Department of Geography, Humboldt Universität zu Berlin, Germany
[e] Vrije Universiteit Brussel (VUB), Geography Department, Pleinlaan 2, B-1050 Brussels, Belgium

ARTICLE INFO

Keywords:
Cultural ecosystem services
Relational values
Social media data analysis
Empirically grounded values typology
Landscape planning and management

ABSTRACT

Environmental values depend on social-ecological interactions and, in turn, influence the production of the underlying biophysical ecosystems. Understanding the nuanced nature of the values that humans ascribe to the environment is thus a key frontier for environmental science and planning. The development of many of these values depends on social-ecological interactions, such as outdoor recreation, landscape aesthetic appreciation or educational experiences with and within nature that can be articulated through the framework of cultural ecosystem services (CES). However, the non-material and intangible nature of CES has challenged previous attempts to assess the multiple and subjective values that people attach to them. In particular, this study focuses on assessing relational values ascribed to CES, here defined as values resonating with core principles of justice, reciprocity, care, and responsibility towards humans and more-than-humans. Building on emerging approaches for inferring relational CES values through social media (SM) images, this research explores the additional potential of a combined analysis of both the visual and textual content of SM data. To do so, we developed an inductive, empirically grounded coding protocol as well as a values typology that could be iteratively tested and verified by three different researchers to improve the consistency and replicability of the assessment. As a case study, we collected images and texts shared on the photo-sharing platform Flickr between 2004 and 2017 that were geotagged within the peri-urban park of Collserola, at the outskirts of Barcelona, Spain. Results reveal a wide spectrum of nine CES values within the park boundaries that show positive and negative correlations among each other, providing useful information for landscape planning and management. Moreover, the study highlights the need for spatial, temporal and demographic analysis, as well as for supervised machine learning techniques to further leverage SM data into contextual and just decision-making and planning.

1. Introduction

Worldwide trends of urbanization place an increasing pressure on natural ecosystems, leading to decreased opportunities for and experiences of social-ecological interactions in green urban and peri-urban spaces, e.g. recreational uses of natural ecosystems (Miller 2005). In turn, besides the direct impacts on human health and wellbeing, fewer social-ecological interactions can result in shrinking environmental values, a looser sense of co-dependence with the local environment and environmental stewardship, eventually jeopardizing global endeavours towards sustainable transformations (Dickinson and Hobbs 2017; Andersson et al. 2014; Gaston and Soga 2020).

In order to unveil the interlinked co-production of Ecosystem Services (ES), attention has been brought to understanding people's interactions with and within green spaces, and the nuanced values arising therein (Dickinson and Hobbs 2017) which inform sustainable environmental planning and management (Kremer et al. 2016; Arias-Arévalo et al. 2018; Ilieva and McPhearson 2018). This is especially true for the socio-cultural values ascribed to the benefits derived from Cultural Ecosystem Services (CES) (Oteros-Rozas et al. 2017), particularly in

* Corresponding author at: Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona (UAB), Edifici Z (ICTA-ICP), Carrer de les Columnes s/n, Campus de la UAB, 08193 Cerdanyola del Vallès, Spain.

E-mail addresses: fulvia.calcagni@hu-berlin.de (F. Calcagni), francesc.baro@vub.be (F. Baró), johannes.langemeyer@uab.cat (J. Langemeyer).

https://doi.org/10.1016/j.ecoser.2022.101495
Received 29 June 2021; Received in revised form 3 November 2022; Accepted 7 November 2022
Available online 23 November 2022

metropolitan areas where the majority of the global population lives (United Nations 2018). Yet, methodological hurdles in deploying consistent qualitative and quantitative assessments of multiple socio-cultural values challenge their integration in a planning praxis, one that is attentive to the underlying drivers of social-ecological co-production (Dickinson and Hobbs 2017; Plieninger et al. 2015).

Social Media (SM) data, namely pictures, tags and texts, have started to be explored as a source of values ascribed to social-ecological interactions (Ghermandi and Sinclair 2019). In particular, SM were found to reveal multiple, "non-authoritative", subjectively expressed and collectively negotiated values (Heikinheimo et al. 2017; Calcagni et al. 2019) made available at a bigger scale and a finer spatial and temporal granularity than traditionally collected data (Huang, Gartner, and Turdean 2013; van Zanten et al. 2016; Tieskens et al. 2018). In addition, the steadily increasing number of SM users across the world (Kemp 2020), with the majority living in urban areas (Auxier and Anderson 2021), gives SM data an especially prominent potential in urban studies, which is still to be further developed (Ilieva and McPhearson 2018; Ghermandi and Sinclair 2019; but also see Zapata-Caldas et al. 2022 for potential limitations). The high density of SM data in urban and peri-urban areas can offer a complementary and less biased perspective than traditional socio-cultural valuation techniques, as already has been demonstrated in the rural context (Oteros-Rozas et al. 2017; Pastur et al. 2016) and thereby broadening the scope for assessing multiple subjective values ascribed to social-ecological interactions in urban and peri-urban areas.

In this study, we explore this potential using data from a peri-urban park at the outskirt of Barcelona for which we develop a methodological framework to increase consistency and replicability of the analysis.

2. A framework for assessing multiple CES values

2.1. The role of CES values for sustainable planning

Arguably, city dwellers have little occasions to experience the several life-supporting roles that ecosystems have, especially those depending on an advanced understanding of ecological processes (Kumar and Kumar 2008), and instead mainly value ecosystems by experiencing what has been defined as Cultural Ecosystem Services (CES). CES, namely non-material benefits such as landscape aesthetics, outdoor recreation, spiritual and educational experiences (Dickinson and Hobbs 2017; MEA, 2005a; Andersson et al. 2015), have been found to be critically important to provide liveable conditions under the scenario of increasing economic growth (Guo, Zhang, and Li 2010) and high urbanization rate (Dickinson and Hobbs 2017). CES are less substitutable by technical or other means (Hernández-Morcillo, Plieninger, and Bieling 2013) compared to other Ecosystem Services (ES) such as, among others, flood regulation, air and water purification, or carbon capture (Andersson et al. 2015; Braat 2014). Moreover, presenting a strong dependency on place-specific and subjective human perceptions and identities, CES derived benefits are more cognitively and sensory accessible and, thus, hold a prominent role in the transfer of other ES benefits to people (Chan et al. 2016; Fish, Church, and Winter 2016; Hirons, Comberti, and Dunford 2016). This ES-CES co-production links and bundled relations, together with CES resistance to practices of nature commodification and to the consequential erosion of intrinsic motivations for conservation, enable a non-exploitative inclusion of ES in research and practice (Plieninger et al. 2015). Therefore, CES represent key drivers for green stewardship and pro-environmental behaviour (Andersson et al. 2015; 2014; Martinez-Harms et al. 2018), as well as a gateway toward sustainable transitions across society. This crucial role resonates with the increasing attention that CES are receiving within the ES literature (Milcu et al. 2013; Fish, Church, and Winter 2016; Small, Munday, and Durance 2017) as well as for environmental policy and decision-making at different scales (Hirons, Comberti, and Dunford 2016), especially in urban areas (Riechers, Barkmann, and Tscharntke 2016; Dickinson and Hobbs 2017). Yet, the inherently subjective, intangible and incommensurable nature of CES constitutes an operational challenge for consistently assessing the multiple values ascribed to the benefits we derive from them, consequently hampering an informed sustainable ecosystem management and planning (Small, Munday, and Durance 2017; Morán-Ordóñez et al. 2019).

Values ascribed to CES have been defined as inherently relational (Chan et al. 2016; Chan, Gould, and Pascual 2018; Arias-Arévalo et al. 2018). Claimed to challenge the predominant, binary understanding of intrinsic and instrumental motivations for protecting nature, relational values are defined as non-instrumental but still anthropocentric values. This concept connects value scholarship to qualitative social science (Stålhammar and Thorén 2019; Díaz et al. 2018) and helps overcome the nature/society dichotomy (Muraca 2016; Stålhammar and Thorén 2019), positing essential premises to dealing with multiple value articulations and plural valuation languages in an inclusive way between knowledge systems and among different disciplines within the same knowledge system, further increasing the effectiveness and social legitimacy of the derived planning policies (Díaz et al. 2018).

2.2. Relational CES values and social media data

Studies on CES valuation from the perspective of the beneficiaries' subjective appreciation have employed different value-articulating methods depending on the ontological and epistemological stances of the authors, with direct consequences on decision-making (Arias-Arévalo et al. 2018; Hirons, Comberti, and Dunford 2016). Yet, while, on the one hand, most of the CES studies narrowly privilege those amenable to quantification, i.e. landscape aesthetics and physical recreation (Calcagni et al. 2019; Milcu et al. 2013; Kosanic and Petzold 2020; Casado-Arzuaga et al. 2013), relational values, on the other hand, are mainly assessed through qualitative approaches. While this ensures representation to the plural value-holders and their context-dependent multiple values, it fails in achieving policy relevance (Schulz and Martin-Ortega 2018; Stålhammar and Thorén 2019). Acknowledging that every method has its blind spots and causes biases in decision-making, non-monetary mixed-methods and multi-disciplinary approaches are regarded as promising to integrate multiple socio-cultural values in real-life decisions (Arias-Arévalo et al. 2018; Stephenson 2008).

The use of social media (SM) data analysis in environmental science, especially for urban and peri-urban settings, is increasingly established (Ghermandi and Sinclair 2019) and, in particular, SM data assessment of relational CES values is emerging as a new research frontier (Calcagni et al. 2019). As information that is actively shared within a digital community, SM data reporting social-ecological interactions reveal CES values that are doubly relational, both in their content and in their process of co-construction (Calcagni et al. 2019; Himes and Muraca 2018; Langemeyer and Calcagni, 2022). In their content because SM data reveal values emerging from societal or individual relationships with and within nature that have the additional feature of being shared within a digital community, arguably aiming for the appraisal of its fellow members. Therefore, we assume the value-holder to associate characters of appropriateness, desirability, and care to those values. These same values are co-constructed on digital platforms, whereby negotiation occurs in a non-deliberative and collective manner by spreading tags, emotionally reacting or generating threads of comments (see Guerrero et al. 2016) which then results in agreed-upon, shared values. In addition, SM data were found to provide the space for multiple value articulation that reveal embodied and contingent values arising at the moment of the corresponding benefits realization. During this process, a netnographic data collection approach that is neither intrusive nor solicited (Akemu and Abdelnour 2020) allows for unbiased research approaches and purposes that are exempt from traditional data collection biases (e.g., interviewer effect) (Ghermandi and Sinclair, 2019; Armstrong et al., 2021; Charmaz, 2006; Chen et al., 2018). Yet, the unstructured, arguably interpretive, and ambiguous nature of these data, as well as positivity biases (i.e., tendency to show only positive aspects of life) due to the so-called observer effect still challenge its full and consistent operability in relational value and sustainability research (Ghermandi and Sinclair 2019; Ilieva and McPhearson 2018).

Among the wealth of empirical studies using SM data for CES values assessments, the majority performs visual content analyses of pictures (Havinga et al. 2020; Calcagni et al. 2019). Yet, there is no common approach or methodology to assess context-specific multiple relational CES values that aims for comparability or replicability of the results. Moreover, only a few CES studies have started to complement pictures with the accompanying tags and texts, i.e. keywords and descriptions directly added by users (Alieva et al. 2022), despite the explicit recognition of this methodological gap in the context of social-ecological sustainability research (Oteros-Rozas et al. 2017; Gliozzo, Pettorelli, and Haklay 2016; Ilieva and McPhearson 2018; Hale, Cook, and Beltrán 2019; Ghermandi and Sinclair 2019; Armstrong et al., 2021) as well as the growing implementation of textual data in a wide variety of related disciplines (Dunkel 2015; Jeawak, Jones, and Schockaert 2017; Barry 2014; Ghermandi and Sinclair 2019).

In order to harness the peculiarities as well as overcome the limitations of SM data research, this study implements a mixed-method approach. This approach consists of combining the qualitative nuances of visual and textual content of SM data with analysis borrowed from social science approaches of the quantitative feature of this data, allowing to perform statistical and numerical analyses, as is recommended for CES and relational values studies (Klain et al. 2017; Stålhammar and Thorén 2019; Leszczynski 2020). Building on grounded theory principles of drawing the analytical framework inductively from data (Moghaddam 2006), we coded the retrieved data in a crowd-based and reflexive fashion. We did this in parallel with the quantification of statistically relevant co-benefits and trade-offs in the bundled uptake of CES benefits, an assessment that is still uncommon in the literature however is becoming of increasing interest to social-environmental sustainability scholarships and multifunctional ES management (Turkelboom et al. 2018; Plieninger et al. 2015; Jorda-Capdevila et al. 2021; Dickinson and Hobbs 2017).

In particular, this study aims at (i) capturing the multiple relational CES values resulting from social-ecological interactions as revealed on SM data, including co-benefits and trade-offs; (ii) establishing and highlighting the advantages of using a consistent and replicable method and protocol for manually assessing multiple relational CES values through combined SM pictures and texts.

3. Data & methods

3.1. Case study

This study is based on the case study of Collserola, a large peri-urban park and nature reserve located at the outskirts of Barcelona, Spain (see Fig. 1). Collserola was declared a Natural Park in 2010 and encloses an area of about 8.300 ha. It is part of the Catalan Coastal Mountain Range (Serralada Litoral), running Southwest-Northeast parallel to the Mediterranean Sea, and is situated between the rivers Llobregat and Besòs, and the plains of Barcelona and Vallès. Collserola is mainly covered by Mediterranean forest and scrubland and embeds two natural reserves, La Font Groga and La Rierada-Can Balasc, protected explicitly for the scientific interest of the natural ecosystems therein (namely oak forest and riparian vegetation) (Depietri et al. 2016).

The Special Plan for the Protection of the Natural Environment and Landscape of Collserola Natural Park (PEPNat), pending final approval, aims to ensure the conservation of biodiversity, habitats, and ecological processes. In addition, it favours the increasing social use of the park (e.g. running, cycling, etc.) while accounting for trade-offs and environmental stress risk (Comissió institucional del Pla especial de Collserola 2019; Turkelboom et al. 2018). Located across nine municipalities, Collserola leans on the centre of the Metropolitan Area of Barcelona, one of the most densely populated urban areas in Europe. In addition, the park allows multiple social-ecological interactions to the urban dwellers living in its surroundings as well as to numerous and diverse yearly visitors (Farías-Torbidoni and Morera Carbonell 2020). Its uniqueness in terms of location and size, as well as the variety of users and possible uses it enables, gives Collserola a strong relevance for this study.

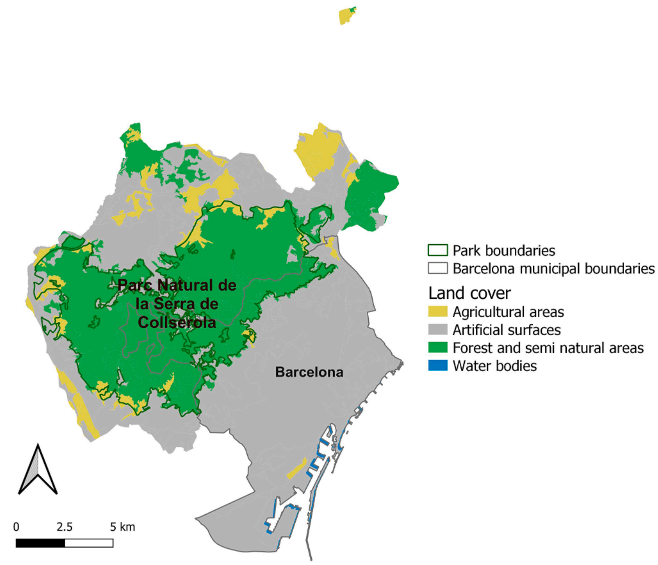

Fig. 1. Land cover within Collserola and in the surrounding municipalities.

3.2. Data cleaning and coding

In total, 5170 pictures uploaded between 2004 and 2017 on the photo-sharing platform Flickr and geotagged within the boundaries of Collserola were retrieved through the Flickr Application Programming Interface (API) (script available at this link). To date, Flickr is still the most used platform in CES studies (Ghermandi and Sinclair 2019) as it has shown to contain more relevant images than other platforms (Oteros-Rozas et al. 2017), has an open data policy (Hale, Cook, and Beltrán 2019; Ghermandi and Sinclair 2019) and a seemingly broader demographic representativity (Cox, Clough, and Marlow 2008). Therefore, data from other popular platforms were ruled out for this study. Each sample unit includes the user identification, the geotag and either the photo url, associated textual data (titles, descriptions, and tags), or both.

After verifying that the whole dataset fell within the case study boundaries, a photo and text content examination was manually conducted to filter out all those not focusing on social-ecological interactions, e.g. selfies, close-ups on buildings or infrastructures with no heritage value, indoor pictures (following Langemeyer, Calcagni, and Baró 2018; Tenerelli, Demšar, and Luque 2016) and/or text with no mention to ecosystem appreciation. If one or both of the textual and visual contents of the analysed units of data did not depict or refer to natural environments, the entire unit of data was excluded from the analysis. In a subsequent step, we limited the number of similar units of data of the same owner to five per location (following (Oteros-Rozas et al. 2017) as a means to avoid biases from very active users (Ghermandi and Sinclair 2019) but also, given the relatively low amount of data shared in the study area, to avoid the risk of losing an excessive amount of content by applying the 'photo-user-days' approach (Wood et al. 2013). Finally, 1692 units of data published by 471 single users were considered relevant for the analysis.

3.3. Qualitative analysis

In order to operationalize and make reproducible an otherwise discretionary and subjective assessment of passively crowdsourced data, the coding was performed in different steps and by three different researchers (following and expanding the procedure proposed for inter-coder reliability in qualitative research by O'Connor and Joffe 2020). In order to measure the inter-coders agreement through the Cohen's Kappa coefficient, we sized the minimum sample for this purpose following the CIBinary (*Confidence Interval Approach for the Number of Subjects Required for a Study of Interobserver Agreement with a Binary Outcome*) method (Rotondi 2018). With the intention to obtain a fair to excellent level of inter-coder agreement beyond chance – that corresponds to a kappa coefficient value between 0.40 and 1 (Fleiss, Levin, and Cho Paik 2003) – we set the different parameters required by the method as follows:

- the preliminary value of *k* – *kappa0* = 0.8
- the desired expected lower bound of k – *kappaL* = 0.4;
- the desired expected upper confidence limit of k – *kappaU* = 0.99;
- the anticipated prevalence of the desired trait – *props* = 0.07;
- the number of raters that are available – *raters* = 2; and
- the desired type I error rate – *alpha* set for default to 0.05.

In order to calculate *props*, we used the proportion of the CES coded in a first multi-label coding performed by a first researcher in a pre-analytical step. Building on the principle of "constant comparative procedure" from grounded theory (Moghaddam 2006; Charmaz 2006; Creswell 2002), we adopted a bottom-up, inductive, data-driven approach, similar to Hale, Cook, and Beltrán (2019), to customize the CES categories of the analysis to the specific case study. We manually coded each sample unit by looking at either or both their visual and textual content, depending on what was available. To do so, we used the Common International Classification of Ecosystem Services (CICES) version 5.1 (Haines-Young and Potschin 2018) as a reference as it is comparable with earlier classification systems (MEA, 2005b; TEEB 2010) and can clarify the conflation of terms between services, benefits, and values which is often seen as a challenge for the operationalization of CES into policy (Blicharska et al. 2017). Following this approach, the first researcher proceeded with the analysis gradually adding a new category every time the unit of data contained elements which could not be coded with any of the previous until reaching theoretical saturation after 500 units of data analysed (i.e. "state in which the researcher makes the subjective determination that new data will not provide any new information or insights for the developing categories") (Creswell 2002, p.450). Eventually, as allowed by CICES taxonomical structure, some CES classes were aggregated and some others added. This was completed with the purpose to ensure robustness and coherence to the assessment, as well as to improve its replicability, following protocol of Oteros-Rozas et al. (2017). Observing a higher level of detail given the bigger number of CES analysed, a coding protocol was initiated at this stage and iteratively enriched while completing the assessment (see Annex A). From this first assessment, *spiritual value* reported the lowest values for *props* (i.e. 0.001), requiring a sample size of 4,125 data for assessing the inter-coder agreement, a number that exceeded the full dataset available. Therefore, we finally decided to use *cognitive value's props* = 0.07, corresponding to a sample size of only 67 units of data. The obtained agreement is thus verified for every CES except *spiritual value*.

After having received a short training on the protocol by the first researcher, the second researcher proceeded to perform the assessment on the defined sample of the coded dataset, curating to annotate any doubts or comments which would arise during the coding.

After calculating the Cohen's kappa between these first two assessments, the first researcher went through the second researcher's coding and solved the questions raised in the comments. This meant changing the first or the second researcher coding together with the protocol when needed. Then, in a second alignment phase, the first researcher went through all the units of data in which there was disagreement between the two assessments and corrected alongside the other researcher, refining the protocol.

Having reached an acceptable level of agreement (Cohen's Kappa = 0,84), the first researcher proceeded with the manual coding of the full sample. This involved iteratively updating the coding protocol with information in the three most common languages encountered (i.e., English, Spanish, Catalan, and Latin for the scientific names of species) on the several ways people depict or describe the relational values corresponding to the different CES (see Table 2 and Annex A for more details). Finally, as a further test, a third researcher performed a new assessment on a sample of the size defined above while using the updated protocol. Then, we calculated the agreement with the coding performed by the first researcher (see Fig. 2).

3.4. Quantitative analysis

After having developed a protocol to perform, verify the consistency and improve the replicability of the qualitative assessment of the multiple relational CES values held in the specific context of study, we conducted two quantitative analysis: the first to assess the correlation between CES, the second to calculate the relative performance of textual over visual analysis.

Acknowledging that CES are generally enjoyed in bundles (Plieninger et al. 2015) and that estimating the relationship between the different coding categories is of fundamental importance to properly informing spatial planning, we first calculated the average number of co-occurring categories in data coded with each relational CES value category; then, through the *corrplot* function in R, determined the statistically relevant co-occurrence between categories as a proxy for co-benefits (positive co-occurrence) or trade-offs (negative co-occurrence).

Finally, in order to estimate the relative contribution of Flickr pictures and texts in capturing relational CES values, we performed a double evaluation: first, accounting for the values assessed only through textual data (T), namely title, descriptions, and tags; and second, coding only the visual photo content (V). Finally, we used the combined result of the two evaluations (TV) to perform further analyses so as to account for the most comprehensive number and variety of relational CES values revealed within Collserola.

In order to estimate the added value of this combined assessment, we

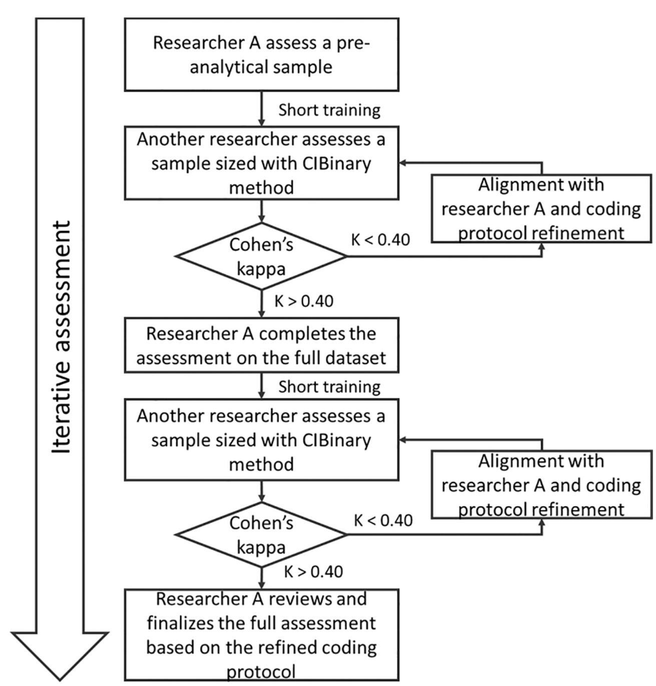

Fig. 2. Inter-coder agreement procedure and protocol development (adapted from O'Connor and Joffe 2020).

calculated the substitutability index per coding category *I* between the two assessments (S_i) and the relative performance of textual compared to visual analysis (Trp_i). We did this by applying the following eq. (1) and (2) respectively:

$$S_i = \frac{(T_i + V_i) - TV_i}{TV_i} * 100 \quad (1)$$

$$T_{rpi} = \frac{T_i - V_i}{TV_i} * 100 \quad (2)$$

The former calculates, per each category, the percentage that can be assessed indifferently through either textual or visual analysis, the latter, in turn, shows how better or worse textual analysis performs compared to visual analysis.

4. Results

4.1. Coding protocol and multiplicity of relational CES values

Since the pre-analytical step, through the alignment process and then proceeding with the successive analysis, the coding protocol (see Table 1 and Annex A) was continuously updated and fine-tuned.

The protocol enables a thorough and robust accounting of the multiple relational values ascribed to CES in the case study area. The most coded categories are those of *built cultural heritage* and *natural cultural heritage*. This is followed by *landscape aesthetics, experiential recreation, existence value and physical recreation* amounting to similar quantities, while *cognitive value, spiritual value* and *social relations* were less coded (see Fig. 3).

4.2. CES trade-off and co-benefit analysis

Fig. 4 shows the rate of co-occurring categories for each unit of data coded with a specific relational CES value category. *Physical recreation* seems to be the category with the highest probability to be enjoyed in bundle with other services (at least 2 on average), followed by *natural* and *built cultural heritage* that bundle with at least another service, and *experiential recreation, existence value* and *landscape aesthetics* that are sometimes enjoyed with another service. Finally, *cognitive value, social relations* and, above all, *spiritual* value, are services more commonly enjoyed exclusively.

The trade-offs and co-benefits analysis helped us to better parse out the relationship between the different coding categories (see Fig. 5). On the one hand, the enjoyment of *existence value* positively correlates with that of *experiential recreation* and *cognitive values.* As well, as we might expect, pictures depicting *built cultural heritage* often include *landscape aesthetics*, while practicing *physical recreation* correlates with co-occurring *social relations*. To a smaller degree, *experiential recreation* pairs with *cognitive* and *spiritual values*, while *natural cultural heritage* is occasionally enjoyed together with *existence* and *cognitive value*. On the other hand, the analysis reveals negative associations between *experiential recreation, existence* and *cognitive values* with *physical recreation, landscape aesthetics* and *built cultural heritage*. Activities involving *physical recreation* appear also negatively correlated with *spiritual values* and *built cultural heritage*. The latter, in smaller proportions, seems dissociated from *social relations,* which is also negatively correlated with *existence value* and *cognitive value.*

4.3. Inter-coders agreement

Across the nine categories of relational CES values selected through the pre-analytical step, the initial inter-coder agreement resulted in a Cohen's kappa between fair and good for most of the categories but was 0 for *spiritual value* and even negative for *cognitive value* and *social relations*. After revisiting and correcting the coding and the protocol based on the assessment of the second researcher, we calculated the kappa

Table 1
List of SM data coding categories and their descriptions. Adapted from CICES version 5.1 classes in Haines-Young & Potschin (2018). Summary of the textual and visual information compiled in the coding protocol per category.

Coding categories	Description	Text coding	Picture coding
Physical recreation (ph)	The engagement, use or enjoyment of the biophysical characteristics or qualities of species or ecosystems in ways that require physical and cognitive effort. It denotes an active involvement with nature.	Biking-, Walking- or Running-related tags; Other tags related to outdoor physical activities	Bikes, people biking, people walking, or walking gear; People running or running gear People horseback riding, horses, horsing facilities; People riding a segway
Experiential recreation (exp)	The engagement or enjoyment of the biophysical characteristics or qualities of species or ecosystems through passive or observational interactions. It is an experiential use of plants, animals, and landscapes. It denotes a passive engagement.	Feelings, sensations and emotions (not related to scenic beauty); Photography and exploration; Emphasis on observation, moment in time, meteorological conditions	People performing observational or passive activities: relaxing, observing, thinking; People taking artistic pictures of nature (close-up pictures of species will be categorized also as *Existence value*)
Existence value (exi)	Characteristics or features of living systems that have an existential value. The things in nature that people seek to preserve because of their non-utilitarian qualities and that want to be kept for future generations to enjoy or use.	Common names of species (animal or vegetation)	Close-up pictures of species
Cognitive value (cogn)	Intellectual interactions with the natural environment that foment scientific investigation, the creation of traditional ecological knowledge, education or training. It is the in-situ research and study of nature.	Scientific name of species (animal or vegetation)	Demonstrations of knowledge transmission, people studying outdoors, taking samples
Natural Cultural Heritage (nch)	Intellectual interactions with the natural environment that help people identify with the history or culture of where they live and come from.	Natural landmarks with symbolic significance that are iconic	
Landscape aesthetics (ae)	Intellectual interactions with the natural environment that enable aesthetic experiences. It is the appreciation of the inherent beauty of the biophysical	Tags related to landscape scenic value	Pictures with a wide landscape framing. No close shots.

(*continued on next page*)

Table 1 (*continued*)

Coding categories	Description	Text coding	Picture coding
	characteristics or qualities of species or ecosystems. It is the beauty of nature.		
Spiritual value (sp)	Elements of living systems that have sacred or religious meaning. Things in nature that have spiritual importance for people.	Expressions of attachment to religious values, relating to or involving spiritualism, denoting a spiritual state or relating to sacred matters.	
Social Relations* (soc)	Pictures and text capturing social interactions in the engagement or enjoyment of the biophysical characteristics or qualities of species or ecosystems.	Tags denoting that the activity is shared with others	Images of people sharing time and activities in nature.
Built Cultural Heritage* (bch)	Intellectual interactions with the built environment that help people identify with the history and culture of where they live and come from. Cultural heritage or historical knowledge.	Built human infrastructure and landmarks	

*Note: Coding categories not included in the CICES reference system.

coefficient again and improved the agreement considerably. The iterative process to reach agreement between the two researchers allowed the Cohen's kappa value to more than double (from k = 0.4 to k = 0.84, see Table 2).

On average, across coding categories, the alignment improved the agreement to 57.2 %, with the highest impact on the categories that scored the lowest agreement at first. Regarding the final test performed by the third researcher, for all categories the agreement was good to excellent (kappa between 0.663 and 0.893), except for *experiential value* for which it was little above fair (kappa = 0.505).

4.4. Comparative textual vs visual content analysis

Performing a combined picture and associated texts analysis allowed us to include a higher number of samples (453 units of data were missing the picture url and, therefore, could be coded only through textual analysis) and more detailed information that complements the visual content analysis. This data improvement provided a wider empirical base allowing us to include multiple CES values whose codification had been challenging in previous visual-only assessments (e.g. *cognitive*, *existence* and *spiritual value* and *natural cultural heritage*) (Richards and Friess 2015).

The comparative analysis per CES (see Fig. 6) illustrates that textual data analysis performs better than visual content analysis in all coding categories except *landscape aesthetics* and *social relations*. As further evidence of the significant contribution of textual data analysis to CES values assessments, the substitutability index per each CES (see Table 3) – i.e., the percentage that can be assessed indifferently through either textual or visual analysis – between the two analyses remains below 35 % throughout all categories. The index reaches its minimum for *cognitive value*, *natural cultural heritage* and *spiritual values* (0 %, 3.4 % and 11.1 % respectively). These values are, therefore, almost exclusively retrievable through textual analysis in the context of this study.

5. Discussion

5.1. Digital traces of multiple relational CES values

The qualitative analysis of social media data within the boundaries of the peri-urban park of Collserola offers a novel view on the multiplicity and bundles of relational CES values that are ascribed to benefits obtained by accessing green spaces in the surrounding area of densely populated cities. In particular, in line with other studies (Oteros-Rozas et al. 2017), the predominance of values ascribed to services such as *built cultural heritage*, *natural cultural heritage*, and *landscape aesthetics* reflect the peri-urban nature, still embedding anthropogenic elements, and hilly topography of Collserola. The Tibidabo Monastery on the top of the Collserola hill is an attractive landmark which supports the enjoyment of the beautiful scenery in which it is embedded and contributes to the whole park identity, for both local and foreign visitors. In addition, the hilly park provides a privileged landscape view on the city of Barcelona and on the sea. *Experiential* and *existence value* are also enjoyed in considerable amount, followed by *physical recreation* and *social relations*, arguably representing the daily use that it allows to people living in the surroundings.

Moreover, the non-monetary quantification enabled by the coding process allows determining recurrent and statistically relevant bundles of co-beneficial or mutually exclusive CES. The combined photograph

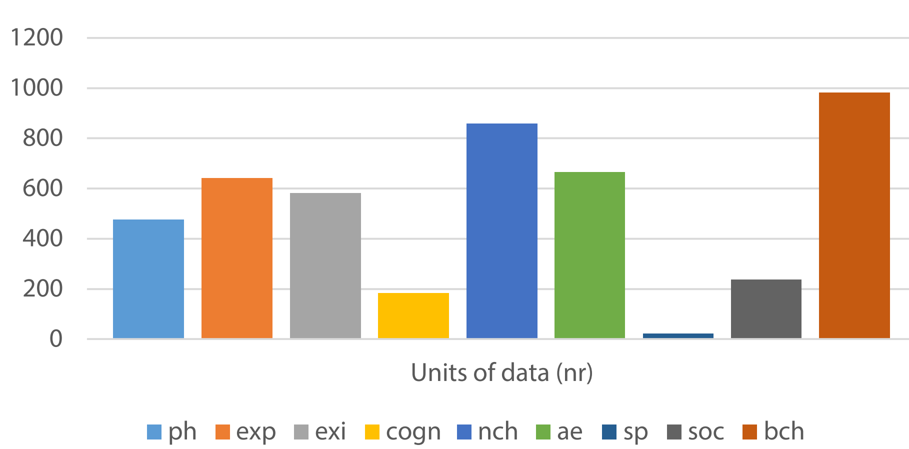

Fig. 3. Number of data units per coding category.

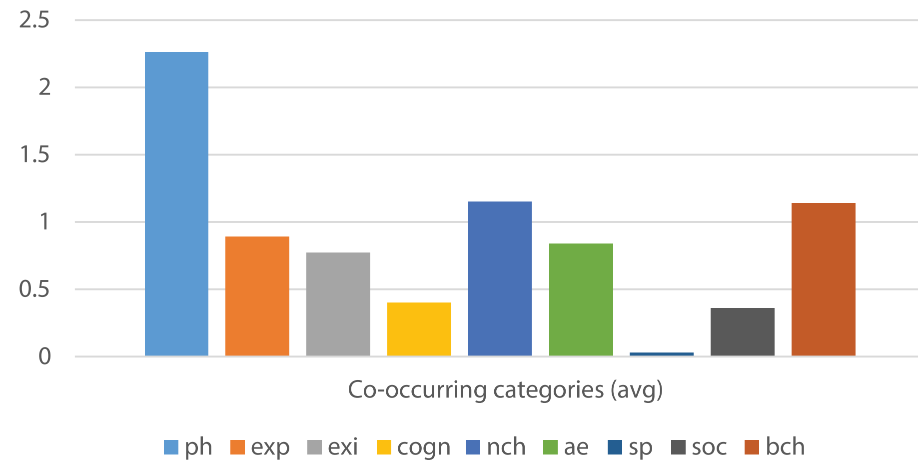

Fig. 4. Average co-occurring coded category per coding category.

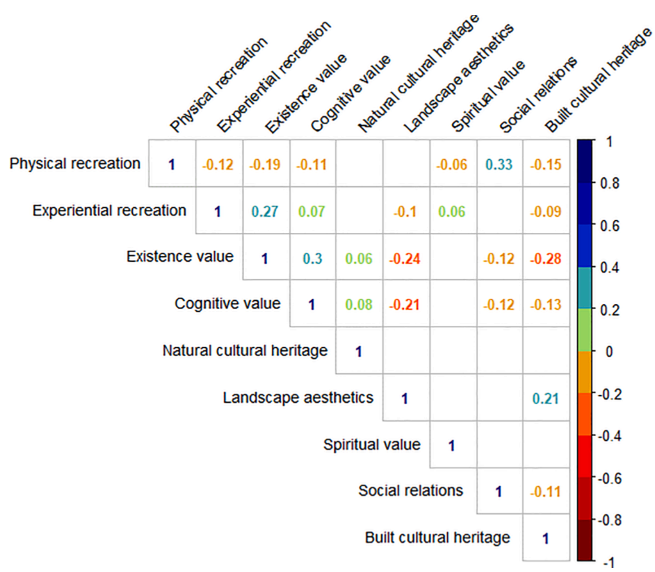

Fig. 5. CES correlogram. Positive correlations are displayed in blue and negative correlations in red colour. Colour intensity is proportional to the respective correlation coefficients indicated in each cell according to the legend on the right. Correlations with p-value > 0.05 have been removed.

and text analysis confirmed previous studies in terms of both the predominance of anthropogenic CES (*built cultural heritage*) in the analysed pictures, also in line with other CES studies (Dickinson and Hobbs 2017), and their most frequent co-occurrence with the appreciation of *landscape aesthetics* (Langemeyer, Calcagni, and Baró 2018; Amorim-Maia et al. 2020). Interestingly, this does not seem to be valid more generally: CES such as *experiential recreation, existence* and *cognitive values* show a negative correlation with both *built cultural heritage* and *landscape aesthetics* while positively co-benefitting each other, showing the importance of less urbanized and probably snugger spots for properly enjoying those services.

These insights reveal the importance of analysing SM data for informing landscape planning from a nuanced and statistically sound crowd-sourced perspective, overcoming potential biases of expert-based-only decisions and leveraging information elicited through qualitative assessments.

5.2. An iterative, inductive, and combined coding process

The framework proposed here is innovative in that it applies principles from netnography and grounded theory to ensure solidity and comprehensiveness to the assessment of the multimedia data retrievable from SM. The process of coding and verifying the agreement between different coders which relied on a protocol iteratively improved and updated proved suitable to the data-driven definition of coding categories required by the specific unstructured and unsolicited nature of these data. In addition, besides previous findings proving agreement between visual and textual data analysis (Ghermandi, Camacho-Valdez, and Trejo-Espinosa 2020), we showed the complementarity potential of their combined application for assessing multiple relational CES values. While the categories assigned through the two separate assessments coincided in some cases, one assessment provided richer information than the other did for some other categories. In this study we assessed the extent to which textual data complement or substitute visual information in relation to the different CES. Results show that textual data allow for spotting a larger amount and a wider range of CES than has been possible by performing exclusively visual data analysis (Levin, Lechner, and Brown 2017; Thiagarajah et al. 2015; Calcagni et al. 2019). Besides *landscape aesthetics* and *social relations*, textual data are crucial to detect the large spectrum of subjective, context-dependent and relational values that people ascribe to social-ecological interactions as well as to the benefits derived from CES. Therefore, the more nuanced information that can be extracted through textual data analysis allows for tailoring the coding protocol to the case-specific necessities and peculiarities. In this sense, some tweaking of CICES was optimal for applying a data-driven assessment of CES in the study area, allowing for condensing overlapping categories (e.g. *entertainment* with *physical recreation*, *existence* with *bequest value)* (Haines-Young and Potschin 2018) and adding missing ones. In particular, the CES category *social relations* was lacking and appointed as a gap in CICES (Haines-Young and Potschin 2018) and in previous studies (Riechers, Barkmann, and Tscharntke 2016; Calcagni et al. 2019); however, by including *built cultural heritage* which draws on the principle of social-ecological co-generation or co-production of benefits through cultural practices – material or immaterial – in environmental spaces (Huntsinger and Oviedo 2014; Fischer and Eastwood 2016; Fish et al., 2016), we accounted for the importance of anthropogenic infrastructure reflected in many pictures and interpreted as 'enabling factors' for the appreciation of CES (see (Andersson et al. 2019; Langemeyer, Calcagni, and Baró 2018).

5.3. Opportunities and limitations of SM research

Social media is a useful metric to quantify relational CES values, primarily because of the vast amount of subjective and reflexive data it provides. However, significant limitations need to be considered when

Table 2
Inter-coders agreement through Cohen's kappa per coding category before and after the alignment between coders. The red colour highlights CES for which the Cohen's kappa value is lower or equal to 0 and has a p-value > 0.05 or not defined (NaN).

	Before alignment k = 0.4: fair agreement	***After alignment k = 0.84: excellent agreement***	***% of improvement***	***Test with 3rd researcher k = 0.73: very good agreement***
Physical recreation	Kappa = 0.792 z = 8.96 p-value = 0	Kappa = 0.841 z = 9.44 p-value = 0	6.2	Kappa = 0.893 z = 13.5 p-value = 0
Experiential recreation	Kappa = 0.477 z = 5.35 p-value = 8.73e-08	Kappa = 0.706 z = 7.91 p-value = 2.66e-15	48.0	Kappa = 0.505 z = 7.57 p-value = 3.6e-14
Existence value	Kappa = 0.592 z = 6.65 p-value = 2.88e-11	Kappa = 0.716 z = 8.17 p-value = 2.22e-16	20.9	Kappa = 0.729 z = 10.9 p-value = 0
Cognitive value	Kappa = -0.00813 z = -0.0905 p-value = 0.928	Kappa = 1 z = 11.1 p-value = 0	> 100	Kappa = 0.705 z = 10.6 p-value = 0
Natural cultural heritage	Kappa = 0.727 z = 8.14 p-value = 4.44e-16	Kappa = 0.839 z = 9.42 p-value = 0	15.4	Kappa = 0.663 z = 9.98 p-value = 0
Landscape aesthetics	Kappa = 0.573 z = 6.73 p-value = 1.65e-11	Kappa = 0.649 z = 7.45 p-value = 9.02e-14	13,3	Kappa = 0.778 z = 11.8 p-value = 0
Spiritual value	Kappa = 0 z = NaN p-value = NaN	Kappa = 1 z = 11.1 p-value = 0	> 100	Kappa = 0.676 z = 10.1 p-value = 0
*Social relations**	Kappa = -0.0154 z = -0.386 p-value = 0.699	Kappa = 1 z = 11.1 p-value = 0	> 100	Kappa = 0.842 z = 12.6 p-value = 0
*Built cultural heritage**	Kappa = 0.448 z = 5.05 p-value = 4.45e-07	Kappa = 0.811 z = 9.03 p-value = 0	81.0	Kappa = 0.759 z = 11.4 p-value = 0

*Coding categories not included in the CICES reference system

*Coding categories not included in the CICES reference system.

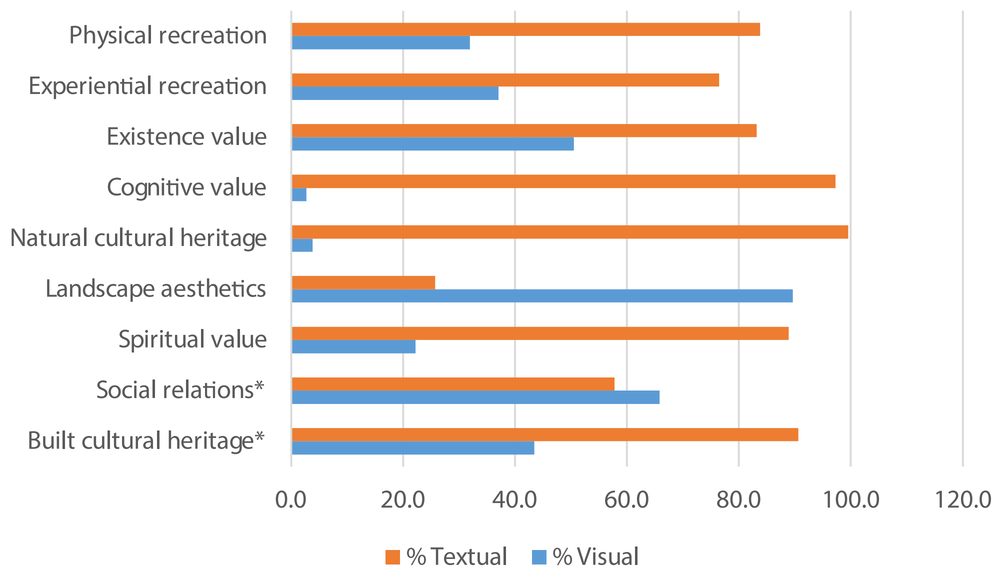

Fig. 6. Comparative performance between textual and visual content analysis in relation to the total number of pictures analysed per CES. * Coding categories not included in the CICES reference system.

Table 3
Substitutability and textual relative performance indexes.

	Textual and Visual (TV_i)	Substitutability index (S_i)	Textual relative performance (T_{rpi})
N° of data units	1692		
Physical recreation	476	15.8	51.9
Experiential recreation	642	13.6	39.4
Existence value	582	33.7	32.6
Cognitive value	183	0.0	94.5
Natural cultural heritage	858	3.4	95.7
Landscape aesthetics	665	15.3	−63.9
Spiritual value	21	11.1	66.7
Social relations*	237	23.6	−8.0
Built cultural heritage*	983	34.1	47.2

*Coding categories not included in the CICES reference system.

applying this approach to urban and peri-urban planning.

In the first place, there is a question of SM data suitability and bias in revealing only certain kinds of relational CES values. For instance, recreational activities, such as trail running (Winder et al. 2022) can hinder users from sharing online the values associated with them. Moreover, the observer effect could influence the content shared over the entire set of pictures and texts produced after benefitting from a social-ecological interaction (Ghermandi and Sinclair 2019). Particular types of CES, especially those more intimate and less dependent on a physical interaction with the service such as *cognitive value* or *spiritual value* (as argued in (Richards and Friess 2015), can therefore be less represented. However, mixed-method approaches based on combined photo-tag-interpretation of Flickr data seem to have amplified the spectrum of relational CES values retrievable from SM.

Secondly, the question of SM data representativeness of real-world experiences is still open. Scholars call for a feminist digital epistemology and methodology, aimed at accounting for what is usually invisible in SM data assessment (Leszczynski and Elwood 2015; Elwood and Leszczynski 2018). In particular, the use of SM proved to be unevenly distributed across social groups due to issues of digital divide, regarding both the access to devices, technologies and infrastructures and the knowledge of the skills needed to make proper use of them (Ghermandi and Sinclair 2019). Results would, for instance, benefit from being contrasted with other case-studies or surveys conducted with the same or new users to validate the information derived from SM content (for example as in (Lenormand et al. 2018). Therefore, in line with other studies (Vaz et al. 2020; Ghermandi and Sinclair 2019), we call for an approach based on multiple data sources, both traditional (e.g. survey, interviews) and digital, when performing relational CES values distribution for landscape and urban planning. In addition, as outlined in Blicharska et al. (2017), we acknowledge the need to expand the analysis including an assessment of the spatial, temporal and demographic determinants for relational CES values in order to provide space- and time-explicit planning recommendations and to account for the plural languages of valuation through which people pertaining to different social groups reveal their situated values and needs (Riechers, Barkmann, and Tscharntke 2016).

Finally, data interpretation has always been another point of concern in SM studies. This study represents a first attempt to define a consistent method for multiple relational CES values assessment through SM data. Nevertheless, it is important to acknowledge that some degrees of arbitrariness and subjectivity in data interpretation remain, especially for some CES (e.g., for *experiential recreation, natural cultural heritage*, and *spiritual value*, kappa coefficient remained below 0.7 after the final test of the protocol). In addition, ambiguous statements and data that lack homogeneity and structure, due to the inherently diverse and subjective modes of experiencing and expressing relational CES values, are still challenging the consistency and time-consumption of SM data analysis. Regarding the latter, most of the SM data assessments within the environmental sciences have been done manually (Jeawak, Jones, and Schockaert 2017; Calcagni et al. 2019). In some cases, manual SM data assessments have been positively validated through traditional data, such as surveys, PPGIS or official statistics (Upton et al. 2015; Levin, Lechner, and Brown 2017; Hamstead et al. 2018). These methods are rapidly changing with the availabilty of machine learning and related approaches (Ghermandi and Sinclair 2019), whether based on supervised (where the algorithms are trained on a set of data that contains both the inputs and the desired outputs) or unsupervised approach (where the algorithms take a set of data that contains only inputs and find structure based on pre-defined database and pre-trained models). Several studies are starting to test automatic data processing technologies (visual-recognition, text mining, etc.), with both visual (Richards and Tunçer 2018) and textual data assessments, reaching a relatively high percentage of accuracy compared to manual assessments (Jeawak, Jones, and Schockaert 2017). By proposing a sound and replicable framework for manually coding multimedia data building on netnograhy and grounded theory principles, we tried to increase the consistency of the manual photo-text combined assessment proposed here and to pave the way for more sound future supervised learning analyses. The inductive and iterative approach for defining the CES categories to use for the study was considered suitable to avoid biases introduced by the use of *ad hoc* dictionary of keywords (Ghermandi and Sinclair 2019) and to harness the flexibility of the CICES classification for adapting the boundary definition of the different CES to the visual and textual context-specific elements identified in the data. The iterative and tested process through which the coding categories are established, then, ensures its validity and adaptability to other contexts.

6. Conclusions

This study confirms that social media platforms are useful data sources for multiple relational CES values assessment and demonstrates the methodological contribution and solidity of inductive, iterative, and combined photo-content and textual data analyses. The inclusion of qualitative information provided by SM textual data proves crucial to advancing the understanding of relational CES values that tie people to natural environments, e.g. by capturing values ascribed to CES that require a high degree of reflexive interactions, such as *cognitive* and *spiritual value*. If this is not taken into account, SM-based assessment approaches might lead to highly unequal representations of the actual relational CES values in place and would thus not serve to properly guide landscape policy and planning. While issues related to the representativeness bias inherent to these specific data remain, in this study we tried to reduce the interpretation biases that arise from the unstructured and unsolicited nature of the data by performing and testing a mixed-method assessment approach. Our approach answers the call for space-, time- and demographic-explicit analyses to increase the inclusivity and social legitimacy of the deriving planning recommendations in order to apply supervised learning techniques for harnessing the full potential of the volume of these data.

Ethical statement

Flickr data were collected through the Flickr API complying with Flickr's terms of service. To account for users privacy, each user ID was stored separately and eventually removed. To reinforce the anonymity guaranty to Flickr users, we applied safety precautions to the only computer containing all data. In addition, in compliance with copyright regulations, only pictures or texts shared under creative commons license can be reproduced. Therefore, not being able to determine the license attributed to the analysed data, we could not reproduce any of them. It should be noted that the retrieval and use of SM data require strong ethical considerations (Boyd and Crawford 2012; Ghermandi and Sinclair 2019). Concerns on whether data should be considered public or private underlies an ongoing ethical debate that to date restricts data access to SM researchers. Even in the absence of a common and clear ethical framework, given the relevant information that it facilitates, the debate about the scientific use of SM data must continue in motion.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

A link ot the code is shared in the manuscript.

Acknowledgements

We thank Damiano Calcagni for his support with data collection and analysis, Camille Soson-Texereau for her help with picture interpretation and Dr. Margarita Triguero-Mas for her suggestions on statistical analysis. We acknowledge financial support from the 2015–2016 BiodivERsA COFUND call for research proposals through the Spanish Ministry of Science, Innovation and Universities (ENABLE project - PCIN-2016-002) and by the Laboratory for the Analysis of Social-Ecological Systems in a Globalized world (LASEG), Universitat Autònoma de Barcelona and Generalitat de Catalunya (2017-SGR-775). F.C. thanks the AGAUR Catalan governmental agency (Grant number 2018FI_B00635) and the German-Israeli Foundation (GIF grant no. I-1533-500.15/2021) for the funding received to support this study. JL acknowledges additional funding from the European Research Council (ERC Consolidator Grant: 818002-URBAG and INTERLACE grant agreement: 869324). FB has received funding from the H2020-project NATURVATION (grant agreement ID: 730243). This research also contributes to the "María de Maeztu" Programme for Units of Excellence of the Spanish Ministry of Science and Innovation (CEX2019-000940-M) at ICTA-UAB. The manuscript was proof-edited by Emilia Oscilowicz.

Annex A.

CODING PROTOCOL

Filtering

Prior to the categorization, a filtering is needed to eliminate all units of data whose visual and/or textual content does not relate to the natural environment.

DISMISS pictures that are:

1. Centered in objects or mainly built environment
2. Taken indoors
3. Images no longer available
4. Images centered on signals, adds or panels
5. Humans or built in the foreground, with few or no natural elements in the background
6. Incomprehensive images

7. Wrong locations
8. Copies of the same picture

Categories

CICES-derived CES.

1. Physical Recreation

2. Experiential Recreation

3. Existence Value

4. Cognitive value

5. Natural Cultural Heritage

6. Aesthetics

7. Spiritual Experiences

Supplementary Categories.

8. Built Cultural Heritage

9. Social Relations

CICES-DERIVED CES

1. PHYSICAL RECREATION

The engagement, use or enjoyment of the biophysical characteristics or qualities of species or ecosystems in ways that require **physical and cognitive effort**. It denotes an active engagement with nature.

SERVICE: e.g. forest paths that give the opportunity of outdoor recreation

USE: e.g. cycling, walking, running, horsing

GOODS/BENEFITS: good health, physical and mental wellbeing

What to code (text):

Biking-related, walking-related or running-related tags	*ENG *btt – mtb – mountainbike – bike – cycl* – probike – bicycle – trail* – hik* – touring*bike – probike – mavic – running – race – fotohik* – walking*tour – path** *SPA *Estren* – bici – la*vida*en*bici – bicicleta – ruta* – mavic – de paseo* *CAT *Sender – mavic – patinatge – passeig*
Other tags related to outdoor physical activities	*ENG *outdoor*life – journey – trip* *SPA *excursion – Juga** *CAT *volta – sortida*

What to code (picture):

- Bikes, people biking, walking, or walking gear
- People running or running gear
- People horsing, horses, horsing facilities
- People riding a Segway, segways

2. EXPERIENTIAL RECREATION

The engagement or enjoyment of the biophysical characteristics or qualities of species or ecosystems through **passive or observational interactions.** It is an experiential use of plants, animals, and landscapes. It denotes a passive engagement.

SERVICES: e.g., bird species interesting to birdwatchers

USES: e.g., birdwatching, nature photography, gastronomic activities, therapy

GOODS/BENEFITS: enjoyment, mental wellbeing

What to code (textual):

Feelings, sensations and emotions except those related to scenic beauty	*ENG *Relax – love – remember – Happy – feeling* *SPA *miedo – temor – alegria – curiosidad – lugar* – tranquilidad – Resplandece – bucólico* *CAT *Relaxació – Després d'un dia llarg de feina*
Photography and exploration	*ENG portrait – gopro – hdr – Macro – Micro – photoshop – digital*camera – reflections – Nikon – canon – closeup – explor*– Haze – adventure – osm (OpenStreetMap) – zoom *SPA *reflex* – exposicion* – blancoynegro – camara* *CAT Fotògraf
Emphasis on observation, time of the year, the day or the week or meteorological conditions	*ENG *beautiful*day – cloud* – spring – windy – summer – autumn – sun –-morning – night – sunset – sunrise – sky – Sunday – fog – rain – colour – yellow – blue – red – glowing – light* – shadow – moon – storm – rainbow – wet* *SPA *Atardecer – verano – invierno – Agosto – Lluvia – niebla – sol – Alba – color* – amarillo – nevada – frio – nocturne* – noche – amanecer – Luz – cielo – arcoíris – tormenta* *CAT *Otoñ* – primavera – tard* – nit – fred – estiu – hivern– bon*dia – arameteo – vent – puesta – albada – groc – cel – llum – Vermell – florit – humit*

What to code (photo):

- People performing observational or passive activities in a natural environment: relaxing, observing, taking pictures, thinking
- People taking particular pictures of nature (with filters, artistic framings, etc.)

3. EXISTENCE VALUE

Characteristics or features of living systems that have an existence value. The things in nature that people seek to preserve because of their non-utilitarian qualities and that want to be preserved for future generations to enjoy or use (bequest value).

What to code (text):

Common names of species or natural elements	*ENG Water – mountain – bird* – tree – nature – insect – animal – valley – meadow – flower – snow – forest – children – lake – cat – leaf/leaves – horse* *SPA Cascada – insecto – naturaleza/ natura – seta* – animal* – pajaro* – bosque* – Jabali – montaña – mar – prado – planta* – flor – agua – hongo* – árbol – corteza – nieve– niñ* – Pato – Cantera – Telaraña – erizo* – hierba – rocío – raíces/raíz – parquet – gato – lichen – hoja* – caballo* *CAT Cireretes de bosc – senglar* – muntanya – mont – plant*– floresta – Pedrera – Cuc – Lagartija – amfibis – Ocell* – fauna – flor – molsa – lichen – gos – xinxa – cavall* – Fusta – turó

What to code (photo):

- Close-up pictures of species

4. COGNITIVE VALUE

It is an intellectual interaction with the natural environment. Scientific investigation, creation of traditional ecological knowledge, education and training enabled by the characteristics of the natural environment. It is the in-situ research and study of nature.

SERVICES: e.g. the opportunity to study

USES: nature as a subject matter of research or teaching

GOOD/BENEFITS: knowledge about the environment

What to code (text):

Name of the species (animal or vegetation)	*ENG barley – grasshopper – Fig – evergreen oak – Aleppo*pine – dandelion – blackredstart – plumbago *SPA Visita guiada – Can Coll – saltamontes – insecto palo – parus major – carbonero – picapinos – Jara blanca – Jara negra – saúco* – Petirrojo – Ruiseñor del Japón – Herrerillo* – Álamo – Higuera – Encina – Roble – Espliego – colirojo – Libélula roja – Chumbera– almendro– pin* – abet* – arácnido – diente de león – mantis – mosca*caballo – Vértice geodésico – astronomía – meteorología – climatología – sismologia *CAT Can Coll – Mallerenga blava – Rossinyol del Japó – Cotxa fumada- ametller – Atzavara – aprenent *LAT phasmatodea – cyanistes caeruleus – Parus caeruleus -ca red soldier beetle (Rhagonycha fulva) – pinus*pinea – pinus*halepensis – Cistus albidus (Estepa Blanca) – Convolvulus althaeoides – lachnaia pubescens – aquilegia*vulgaris – arbutus*unedo – Oedemera*nobilis – papaver*somniferum – adormidera – ranunculus*repens – rosa*canina – alcornoque – cistus*albidus – psilothrix – Erithacus rubecula – Leiothrix lutea – Cyanistes caeruleus – Leiothrix lutea lutea – Eucaliptus – Ascalapus libelluloides – Phoenicurus ochruros – Chrysomela herbacea – smilax*aspera – Limenitis Reducta – Coreus marginatus – myrmeleon formicarius – Psammodromus algirus – Sympetrum Fonscolombii – Argiope bruennichi – dipsacacea – Salida Macrera – Pteridophyta – Papilio machaon – Luzula juncáceas – Euonymus europaeus – Hypericum perforatum – Silene vulgaris – Geranium robertianum – Lliri blau – Pezizal Sarcoscypha – Cladonia fimbriata – Mixomicetes – hemípters – volucella zonaria – phlegra – Galactites tomentosa

What to code (photo):

- Demonstrations of knowledge transmission, people studying outdoors, taking samples, taking guided visits.

5. NATURAL CULTURAL HERITAGE

Intellectual interactions with the environment that help people identify with the history or culture of where they live and come from. Cultural heritage or historical knowledge. And elements of living systems that have symbolic meaning. It is the use of nature as a local emblem. Elements that are recognized by people for their cultural, historic or iconic character and which are used as emblems or signifiers of some kinds.

SERVICES: characteristics of living systems that are resonant in terms of heritage (native species)

USES: e.g. tourism / social cohesion

BENEFITS: e.g. identity

What to code (text and photo):

Natural landmarks with symbolic significance, that are iconic	*ENG Tibidabo mountain *SPA Mediterraneo *CAT Collserola – sant*pere*martir – la*rierada – valles*occidental – Santa Creu d'Olorda – Turó d́en Segarra – Serralada de Marina – Turó de la Magarola – Pla dels Maduixers – Les escletxes del Papiol – Pi d'en Xandri – Puig Madrona – Sant Cebrià – Penya del Moro – Can Caralleu – Carretera de les Aigües – Turo de la Magarola – forat del Vent – parc*del*laberint– Arrabassada – sant*just*desvern – Puig d'Olorda

6. LANDSCAPE AESTHETICS

Intellectual interactions with the natural environment that enable **aesthetic experiences**. It is the appreciation of the inherent beauty of the biophysical characteristics or qualities of species or ecosystems. The beauty of nature.

SERVICES: e.g. panorama site

USE: e.g. contemplation

BENEFITS: pleasure, artistic inspiration

What to code (text):

Tags related to landscape scenic value	*ENG View* – Landscape – beautiful – corners – skyline – panoramic – nofilter – postcard* *SPA Mirador – Vist* – Panorámica – Rincon* – paisaje *CAT Racò – racons

What to code (photo):

- Pictures with a wide landscape framing. No close shots.

7. SPIRITUAL VALUE

Elements of living systems that have sacred or religious meaning. Things in nature that have spiritual importance for people.

What to code (text and photo):

Expressions of attachment to religious values, relating to or involving spiritualism, denoting a spiritual state or relating to sacred matters	*ENG Piece of poetry – feelsthemagic – zen – peace – spirit *SPA Campo*Santo – cementerio – aires de cambio – Incertidumbre – Esperanza – plenitude – future – Templo expiatorio *CAT

SUPPLEMENTARY CATEGORIES

8. SOCIAL RELATIONS

What to code (text):

Tags denoting that the activity is shared with others	*ENG Instagramers – with*@name – we – friend* *SPA Nuestra – verbo al plural *CAT Amb @nom

What to code (photo):

- Images of people sharing time and activities in nature

9. BUILT CULTURAL HERITAGE

Intellectual interactions with the environment that help people identify with the history or culture of where they live and come from. Cultural heritage or historical knowledge.

What to code (text and photo):

Built human infrastructure and landmarks	*ENG Birds' Quarry – Harbour – fountain – ferris*wheel – amusement*park – architecture – farmhouse – Bcn – Barcelona – Tibidabo – astronomical*observatory – fabra*observatory – Collserola*Tower – communications*tower *SPA Cantera de los Pájaros – Attraction* – Fuente – Masía* – Bcn – Barcelona – Tibidabo – observatorio*fabra – observatorio*astronómico – torre*de*Collserola – pont – torre negra *CAT Pedrera dels Ocells – campanar – ermita – Bcn – Barcelona – Tibidabo – Sant Cugat – Vallvidrera – torre*de*collserola – Sant*Pere*de*Romaní – Font*de*l'Espinaga – sant*Adjutori – Font dels Àngels dels ulls pintats – Casa Verdaguer – Ribas–La Budellera – Can Mandó – Quinta Juana – Castell*ciuró – Font del Canet – Can Rabella – Can Torres – Can Parellada – Sant Medir – Can Llevallol – font de Sant Pau – Can Pascual – Can Calopa – Santa Creu d'Olorda – Sant Iscle – Casa Arnús – Torre "BONES HORES" – colegio hogar juan xxiii – Can Canaletes – Llars Mundet – Palau de les Heures - Can Borrel – Can Camprecios – Torre Miralluny – Torre Negra – sant adjutori – Pantano de Vallvidrera – Valldonsella – Santa Victòria de les Feixes – Font d'En Sert – Can Catà – Torre Negra – Vila Joana – Velòdrom d'Horta – Font d'en Ribes – Font de ca n'Esteve – font dels Avellaners – font groga – El papiol - Cerdanyola

References

Akemu, O., Abdelnour, S., 2020. Confronting the digital: doing ethnography in modern organizational settings. Organizational Res. Methods 23 (2), 296–321. https://doi.org/10.1177/1094428118791018.

Alieva, D., Holgado, D., de Juan, S., Ruiz-Frau, A., Villasante, S., Maya-Jariego, I., 2022. Assessing landscape features and ecosystem services of marine protected areas through photographs on social media: comparison of two archipelagos in Spain. Environ. Dev. Sustain. 24 (7), 9623–9641. https://doi.org/10.1007/s10668-021-01841-y.

Amorim-Maia, A.T., Calcagni, F., John, J., Connolly, T., Anguelovski, I., Langemeyer, J., 2020. Hidden drivers of social injustice: uncovering unequal cultural ecosystem services behind green gentrification. Environ. Sci. Policy 112 (May), 254–263. https://doi.org/10.1016/j.envsci.2020.05.021.

Andersson, E., Barthel, S., Borgström, S., Colding, J., Elmqvist, T., Folke, C., Gren, Å., 2014. Reconnecting cities to the biosphere: stewardship of green infrastructure and urban ecosystem services. Ambio 43 (4), 445–453. https://doi.org/10.1007/s13280-014-0506-y.

Andersson, E., Tengö, M., McPhearson, T., Kremer, P., 2015. Cultural ecosystem services as a gateway for improving urban sustainability. Ecosyst. Serv. 12, 165–218. https://doi.org/10.1016/j.ecoser.2014.08.002.

Andersson, E., Langemeyer, J., Borgström, S., McPhearson, T., Haase, D., Kronenberg, J., Barton, D.N., et al., 2019. Enabling green and blue infrastructure to improve contributions to human well-being and equity in urban systems. Bioscience 69 (7), 566–574. https://doi.org/10.1093/biosci/biz058.

Arias-Arévalo, P., Gómez-Baggethun, E., Martín-López, B., Pérez-Rincón, M., 2018. Widening the evaluative space for ecosystem services: a taxonomy of plural values and valuation methods. Environ. Values 27 (1), 29–53. https://doi.org/10.3197/096327118X15144698637513.

Armstrong, Melanie, Monika M. Derrien, and Hannah Schaefer-Tibbett. 2021. 'The Dynamics of Trail Use and Trip Reporting: Understanding Visitor Experiences within Social-Ecological Systems'. Journal of Outdoor Recreation and Tourism, December, 100456. 10.1016/j.jort.2021.100456.

Auxier, Brooke, and Monica Anderson. 2021. 'Social Media Use in 2021'. Pew Research Center, no. April: 1–6.

Barry, S.J., 2014. Using social media to discover public values, interests, and perceptions about cattle grazing on park lands. Environ. Manage. 53 (2), 454–464. https://doi.org/10.1007/s00267-013-0216-4.

Blicharska, Malgorzata, Richard J. Smithers, Marcus Hedblom, Henrik Hedenås, Grzegorz Mikusiński, Eja Pedersen, Per Sandström, and Johan Svensson. 2017. 'Shades of Grey Challenge Practical Application of the Cultural Ecosystem Services Concept'. Ecosystem Services 23 (November 2016): 55–70. 10.1016/j.ecoser.2016.11.014.

Boyd, D., Crawford, K., 2012. Critical questions for big data: provocations for a cultural, technological, and scholarly phenomenon. Information Commun. Society 15 (5), 662–679. https://doi.org/10.1080/1369118X.2012.678878.

Braat, L., 2014. Ecosystem services: the ecology and economics of current debates. Econ. Environ. 4 (51), 20–35.

Calcagni, F., Maia, A.T.A., Connolly, J.J.T., Langemeyer, J., 2019. Digital co-construction of relational values: understanding the role of social media for sustainability. Sustain. Sci. 1–13 https://doi.org/10.1007/s11625-019-00672-1.

Casado-Arzuaga, I., Onaindia, M., Madariaga, I., Verburg, P.H., 2013. Mapping recreation and aesthetic value of ecosystems in the Bilbao Metropolitan Greenbelt (Northern Spain) to support landscape planning. Landscape Ecol. 29 (8), 1393–1405. https://doi.org/10.1007/s10980-013-9945-2.

Chan, K.M.A., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E., Gould, R., et al., 2016. Why protect nature? Rethinking values and the environment. Proc. Natl. Acad. Sci. 113 (6), 1462–2145. https://doi.org/10.1073/pnas.1525002113.

Chan, K.M.A., Gould, R.K., Pascual, U., 2018. Editorial overview: relational values: what are they, and what's the fuss about? Curr. Opin. Environ. Sustainability 35 (December), A1–A7. https://doi.org/10.1016/j.cosust.2018.11.003.

Charmaz, Kathy. 2006. Constructing Grounding Theory - A Practical Guide Through Qualitative Analysis.

Chen, Yan, John R. Parkins, and Kate Sherren. 2018. 'Using Geo-Tagged Instagram Posts to Reveal Landscape Values around Current and Proposed Hydroelectric Dams and Their Reservoirs'. Landscape and Urban Planning 170 (December 2016): 283–92. 10.1016/j.landurbplan.2017.07.004.

Comissió institucional del Pla especial de Collserola. 2019. 'Pla Especial De Protecció Del Medi Natural I Del Paisatge Del Parc Natural De La Serra De Collserola'.

Cox, A.M., Clough, P.D., Marlow, J., 2008. Flickr: a first look at user behaviour in the context of photography as serious leisure. Information Res. 13 (1), 1–17.

Creswell, J.W., 2002. Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. Merrill Prentice Hall, New Jersey.

Depietri, Y., Kallis, G., Baró, F., Cattaneo, C., 2016. The urban political ecology of ecosystem services: the case of Barcelona. Ecol. Econ. 125, 83–100. https://doi.org/10.1016/j.ecolecon.2016.03.003.

Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R.T., Molnár, Z., Hill, R., et al., 2018. Assessing nature's contributions to people: recognizing culture, and diverse sources of knowledge, can improve assessments. Science 359 (6373), 270–322. https://doi.org/10.1126/science.aap8826.

Dickinson, D.C., Hobbs, R.J., 2017. Cultural ecosystem services: characteristics, challenges and lessons for urban green space research. Ecosyst. Serv. 25, 179–194. https://doi.org/10.1016/j.ecoser.2017.04.014.

Dunkel, A., 2015. Visualizing the perceived environment using crowdsourced photo geodata. Landscape Urban Plann. 142, 173–186. https://doi.org/10.1016/j.landurbplan.2015.02.022.

Elwood, S., Leszczynski, A., 2018. Feminist digital geographies. Gender, Place and Culture 25 (5), 629–644. https://doi.org/10.1080/0966369X.2018.1465396.

Farías-Torbidoni, Estela Inés, and Serni Morera Carbonell. 2020. 'Estudi d'afluència, Freqüentació i Caracterització Dels Usuaris- Visitants Del Parc Natural de La Serra de Collserola'. 10.13140/RG.2.2.27890.12485.

Fischer, A., Eastwood, A., 2016. Coproduction of ecosystem services as human-nature interactions-an analytical framework. Land Use Policy 52, 41–50. https://doi.org/10.1016/j.landusepol.2015.12.004.
Fish, Robert, Andrew Church, and Michael Winter. 2016. 'Conceptualising Cultural Ecosystem Services: A Novel Framework for Research and Critical Engagement'. Ecosystem Services 21 (January 2015): 208–17. 10.1016/j.ecoser.2016.09.002.
Fleiss, Joseph L.;, Bruce; Levin, and Myunghee Cho Paik. 2003. 'The Measurement of Interrater Agreement'. In *Statistical Methods for Rates and Proportions*, 3rd ed. John Wiley & Sons, Inc.
Gaston, K.J., Soga, M., 2020. Extinction of experience: the need to be more specific. People and Nature 2 (3), 575–581. https://doi.org/10.1002/pan3.10118.
Ghermandi, Andrea, Vera Camacho-valdez, and Hector Trejo-espinosa. 2020. 'Social Media-Based Analysis of Cultural Ecosystem Services and Heritage Tourism in a Coastal Region of Mexico'. Tourism Management 77 (September 2019): 104002. 10.1016/j.tourman.2019.104002.
Ghermandi, A., Sinclair, M., 2019. Passive crowdsourcing of social media in environmental research: a systematic map. Global Environ. Change 55 (March), 36–47. https://doi.org/10.1016/j.gloenvcha.2019.02.003.
Gliozzo, G., Pettorelli, N., Haklay, M., 2016. Using crowdsourced imagery to detect cultural ecosystem services: a case study in South Wales, UK. Ecol. Soc. 21, (3). https://doi.org/10.5751/es-08436-210306.
Guerrero, P., Møller, M.S., Olafsson, A.S., Snizek, B., 2016. Revealing cultural ecosystem services through instagram images: the potential of social media volunteered geographic information for urban green infrastructure planning and governance. Urban Planning 1 (2), 1. https://doi.org/10.17645/up.v1i2.609.
Guo, Zhongwei, Lin Zhang, and Yiming Li. 2010. 'Increased Dependence of Humans on Ecosystem Services and Biodiversity'. PLoS ONE 5 (10). 10.1371/journal.pone.0013113.
Haines-Young, Roy, and Marion Potschin. 2018. 'Common International Classification of Ecosystem Services (CICES) V5.1 Guidance on the Application of the Revised Structure'.
Hale, R.L., Cook, E.M., Beltrán, B.J., 2019. Cultural ecosystem services provided by rivers across diverse social-ecological landscapes: a social media analysis. Ecol. Ind. 107 (July), 105580 https://doi.org/10.1016/j.ecolind.2019.105580.
Hamstead, Z.A., Fisher, D., Ilieva, R.T., Wood, S.A., McPhearson, T., Kremer, P., 2018. Geolocated social media as a rapid indicator of park visitation and equitable park access. Comput. Environ. Urban Syst. 72 (January), 38–50. https://doi.org/10.1016/j.compenvurbsys.2018.01.007.
Havinga, I., Bogaart, P.W., Hein, L., Tuia, D., 2020. Defining and spatially modelling cultural ecosystem services using crowdsourced data. Ecosyst. Serv. 43 https://doi.org/10.1016/j.ecoser.2020.101091.
Heikinheimo, V., Di Minin, E., Tenkanen, H., Hausmann, A., Erkkonen, J., Toivonen, T., 2017. User-generated geographic information for visitor monitoring in a national park: a comparison of social media data and visitor survey. ISPRS Int. J. Geo-Inf. 6 (3), 85. https://doi.org/10.3390/ijgi6030085.
Hernández-Morcillo, Mónica, Tobias Plieninger, and Claudia Bieling. 2013. 'An Empirical Review of Cultural Ecosystem Service Indicators'. Ecological Indicators 29 (August 2016): 434–44. 10.1016/j.ecolind.2013.01.013.
Himes, Austin, and Barbara Muraca. 2018. 'Relational Values: The Key to Pluralistic Valuation of Ecosystem Services'. Current Opinion in Environmental Sustainability 35 (March 2019): 1–7. 10.1016/j.cosust.2018.09.005.
Hirons, M., Comberti, C., Dunford, R., 2016. Valuing cultural ecosystem services. Annu. Rev. Environ. Resour. 41 (1), 545–574. https://doi.org/10.1146/annurev-environ-110615-085831.
Huang, H., Gartner, G., Turdean, T., 2013. Social media data as a source for studying people's perception and knowledge of environments. Mitteilungen Der Österreichischen Geographischen Gesellschaft 155, 291–302.
Huntsinger, L., Oviedo, J.L., 2014. Ecosystem services are social-ecological services in a traditional pastoral system: the case of California's Mediterranean Rangelands. Ecol. Soc. 19 (1) https://doi.org/10.5751/ES-06143-190108.
Ilieva, R.T., McPhearson, T., 2018. Social-media data for urban sustainability. Nat. Sustainability 1 (10), 553–565. https://doi.org/10.1038/s41893-018-0153-6.
Jeawak, S.S., Jones, C.B., Schockaert, S., 2017. Using Flickr for characterizing the environment: an exploratory analysis. Leibniz International Proceedings in Informatics, LIPIcs 86 (21), 1–21. https://doi.org/10.4230/LIPIcs.COSIT.2017.21.
Jorda-Capdevila, D., Iniesta-Arandia, I., Quintas-Soriano, C., Basdeki, A., Calleja, E.J., DeGirolamo, A.M., Gilvear, D., et al., 2021. Disentangling the complexity of socio-cultural values of temporary rivers. Ecosystems and People 17 (1), 235–247. https://doi.org/10.1080/26395916.2021.1912186.
Kemp, Simon. 2020. 'Digital 2020: Global Digital Overview'. https://Wearesocial.Com/Blog/2020/01/Digital-2020-3-8-Billion-People-Use-Social-Media.
Klain, S.C., Olmsted, P., Chan, K.M.A., Satterfield, T., 2017. Relational values resonate broadly and differently than intrinsic or instrumental values, or the new ecological paradigm. PLoS ONE 12 (8), 1–21. https://doi.org/10.1371/journal.pone.0183962.
Kosanic, A., Petzold, J., 2020. A systematic review of cultural ecosystem services and human wellbeing. Ecosyst. Serv. 45 (July), 101168 https://doi.org/10.1016/j.ecoser.2020.101168.
Kremer, P., Hamstead, Z., Haase, D., McPhearson, T., Frantzeskaki, N., Andersson, E., Kabisch, N., et al., 2016. Key insights for the future of urban ecosystem services research. Ecol. Soc. 21 (2) https://doi.org/10.5751/ES-08445-210229.
Kumar, M., Kumar, P., 2008. Valuation of the ecosystem services: a psycho-cultural perspective. Ecol. Econ. 64 (4), 808–819. https://doi.org/10.1016/j.ecolecon.2007.05.008.
Langemeyer, J., Calcagni, F., Baró, F., 2018. Mapping the intangible: using geolocated social media data to examine landscape aesthetics. Land Use Policy 77 (May), 542–552. https://doi.org/10.1016/j.landusepol.2018.05.049.
Langemeyer, J., Calcagni, F., 2022. Virtual spill-over effects: what social media has to do with relational values and global environmental stewardship. Ecosyst. Serv. 53 (2022), 101400 https://doi.org/10.1016/j.ecoser.2021.101400.
Lenormand, M., Luque, S., Langemeyer, J., Tenerelli, P., Zulian, G., Aalders, I., Chivulescu, S., et al., 2018. Multiscale socio-ecological networks in the age of information. PLoS ONE 13 (11), 1–16. https://doi.org/10.1371/journal.pone.0206672.
Leszczynski, A., 2020. Digital methods III: the digital mundane. Prog. Hum. Geogr. 44 (6), 1194–1201. https://doi.org/10.1177/0309132519888687.
Leszczynski, A., Elwood, S., 2015. Feminist geographies of new spatial media. Can. Geogr. 59 (1), 12–28. https://doi.org/10.1111/cag.12093.
Levin, N., Lechner, A.M., Brown, G., 2017. An evaluation of crowdsourced information for assessing the visitation and perceived importance of protected areas. Appl. Geogr. 79, 115–126. https://doi.org/10.1016/j.apgeog.2016.12.009.
Martinez-Harms, M.J., Bryan, B.A., Wood, S.A., Fisher, D.M., Law, E., Rhodes, J.R., Dobbs, C., Biggs, D., Wilson, K.A., 2018. Inequality in access to cultural ecosystem services from protected areas in the chilean biodiversity hotspot. Sci. Total Environ. 636, 1128–1138. https://doi.org/10.1016/j.scitotenv.2018.04.353.
MEA, 2005a. Ecosystems and human well-being – synthesis. The Millennium Ecosystem Assessment Series 1. https://doi.org/10.1007/BF02987493.
MEA, 2005b. Ecosystems and human well-being: current state and trends. The Millennium Ecosystem Assessment Series 1. https://doi.org/10.1007/BF02987493.
Milcu, A.I., Horcea, J.H., Abson, D., Fischer, J., 2013. Cultural ecosystem services: a literature review and prospects for future research. Ecol. Soc. 18 (3), 44. https://doi.org/10.5751/ES-05790-180344.
Miller, J.R., 2005. Biodiversity conservation and the extinction of experience. Trends Ecol. Evol. 20 (8), 430–444. https://doi.org/10.1016/j.tree.2005.05.013.
Moghaddam, Alireza. 2006. 'Coding Issues in Grounded Theory' 16(1) (Issues In Educational Research): 52–66.
Morán-Ordóñez, A., Roces-Díaz, J.V., Otsu, K., Ameztegui, A., Coll, L., Lefevre, F., Retana, J., Brotons, L., 2019. The use of scenarios and models to evaluate the future of nature values and ecosystem services in mediterranean forests. Reg. Environ. Change 19 (2), 415–428. https://doi.org/10.1007/s10113-018-1408-5.
Muraca, B., 2016. Relational values: a whitehedian alternative for environmental philosophy and global environmental justice. Balkan J. Philosophy 8 (1), 19–38. https://doi.org/10.5840/bjp2016813.
O'Connor, C., Joffe, H., 2020. Intercoder reliability in qualitative research: debates and practical guidelines. Int. J. Qual. Methods 19 (January). https://doi.org/10.1177/1609406919899220.
Oteros-Rozas, E., Martín-López, B., Fagerholm, N., Bieling, C., Plieninger, T., 2017. Using social media photos to explore the relation between cultural ecosystem services and landscape features across five European sites. Ecol. Ind. 94 (2), 74–86. https://doi.org/10.1016/j.ecolind.2017.02.009.
Pastur, Guillermo Martìnez, Pablo L Peri, Marìa V Lencinas, Marina Garcı-Llorente, and Berta Martìn-Lopez. 2016. 'Spatial Patterns of Cultural Ecosystem Services Provision in Southern Patagonia'. 10.1007/s10980-015-0254-9.
Plieninger, T., Bieling, C., Fagerholm, N., Byg, A., Hartel, T., Hurley, P., López-Santiago, C.A., et al., 2015. The role of cultural ecosystem services in landscape management and planning. Curr. Opin. Environ. Sustainability 14, 28–33. https://doi.org/10.1016/j.cosust.2015.02.006.
Richards, D.R., Friess, D.A., 2015. A rapid indicator of cultural ecosystem service usage at a fine spatial scale: content analysis of social media photographs. Ecol. Ind. 53, 187–195. https://doi.org/10.1016/j.ecolind.2015.01.034.
Richards, D., Tunçer, B., 2018. Using image recognition to automate assessment of cultural ecosystem services from social media photographs. Ecosyst. Serv. 31 (C), 318–325. https://doi.org/10.1016/j.ecoser.2017.09.004.
Riechers, M., Barkmann, J., Tscharntke, T., 2016. Perceptions of cultural ecosystem services from urban green. Ecosyst. Serv. 17 (February), 33–39. https://doi.org/10.1016/j.ecoser.2015.11.007.
Rotondi, Maintainer Michael A. 2018. 'Package "KappaSize"'.
Schulz, Christopher, and Julia Martin-Ortega. 2018. 'Quantifying Relational Values — Why Not?' Current Opinion in Environmental Sustainability 35 (December 2017): 15–21. 10.1016/j.cosust.2018.10.015.
Small, N., Munday, M., Durance, I., 2017. The challenge of valuing ecosystem services that have no material benefits. Global Environ. Change 44, 57–67. https://doi.org/10.1016/j.gloenvcha.2017.03.005.
Stålhammar, S., Thorén, H., 2019. Three perspectives on relational values of nature. Sustainability Science.
Stephenson, J., 2008. The cultural values model: an integrated approach to values in landscapes. Landscape Urban Plann. 84 (2), 127–139. https://doi.org/10.1016/j.landurbplan.2007.07.003.
TEEB. 2010. The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB. Environment. Project Code C08-0170-0062, 69 pp.
Tenerelli, P., Demšar, U., Luque, S., 2016. Crowdsourcing indicators for cultural ecosystem services: a geographically weighted approach for mountain landscapes. Ecol. Ind. 64, 237–248. https://doi.org/10.1016/j.ecolind.2015.12.042.
Thiagarajah, J., Wong, S.K.M., Richards, D.R., Friess, D.A., 2015. Historical and contemporary cultural ecosystem service values in the rapidly urbanizing city state of Singapore. Ambio 44 (7), 666–677. https://doi.org/10.1007/s13280-015-0647-7.
Tieskens, K.F., Van Zanten, B.T., Schulp, C.J.E., Verburg, P.H., 2018. Aesthetic appreciation of the cultural landscape through social media: an analysis of revealed preference in the Dutch river landscape. Landscape Urban Plann. 177 (May), 128–137. https://doi.org/10.1016/j.landurbplan.2018.05.002.
Turkelboom, Francis, Michael Leone, Sander Jacobs, Eszter Kelemen, Marina García-Llorente, Francesc Baró, Mette Termansen, et al. 2018. 'When We Cannot Have It All:

Ecosystem Services Trade-Offs in the Context of Spatial Planning'. Ecosystem Services 29 (November 2017): 566–78. 10.1016/j.ecoser.2017.10.011.
United Nations, 2018. World urbanization prospects. Demographic Res. 12 https://doi.org/10.4054/demres.2005.12.9.
Upton, V., Ryan, M., O'Donoghue, C., Dhubhain, A.N., 2015. Combining conventional and volunteered geographic information to identify and model forest recreational resources. Appl. Geogr. 60, 69–76. https://doi.org/10.1016/j.apgeog.2015.03.007.
Vaz, Ana Sofia, Ricardo A. Moreno-Llorca, João F. Gonçalves, Joana R. Vicente, Pablo F. Méndez, Eloy Revilla, Luis Santamaria, Francisco J. Bonet-García, João P. Honrado, and Domingo Alcaraz-Segura. 2020. 'Digital Conservation in Biosphere Reserves: Earth Observations, Social Media, and Nature's Cultural Contributions to People'. Conservation Letters, no. December 2019: 1–9. 10.1111/conl.12704.
Winder, Samantha G., Heera Lee, Bumsuk Seo, Emilia H. Lia, Spencer A., Wood. 2022. 'An Open-source Image Classifier for Characterizing Recreational Activities across Landscapes'. People and Nature, July, pan3.10382. 10.1002/pan3.10382.
Wood, S.A., Guerry, A.D., Silver, J.M., Lacayo, M., 2013. Using social media to quantify nature-based tourism and recreation. Sci. Rep. 3 https://doi.org/10.1038/srep02976.
Zanten, Boris T. van, Derek B. Van Berkel, Ross K. Meentemeyer, Jordan W. Smith, Koen F. Tieskens, Peter H. Verburg. 2016. Continental-scale quantification of landscape values using social media data. Proc. Natl. Acad. Sci. 113 (46): 12974–79. 10.1073/pnas.1614158113.
Zapata-Caldas, E., Calcagni, F., Baró, F., Langemeyer, J., 2022. Using crowdsourced imagery to assess cultural ecosystem services in data-scarce urban contexts: the case of the Metropolitan Area of Cali, Colombia. Ecosyst. Serv. 56 (August), 101445 https://doi.org/10.1016/j.ecoser.2022.101445.