This is a post-peer-review, pre-copyedit version of an article published in Sustainability Science. The final authenticated version is available online at: https://doi.org/10.1007/s11625-019-00672-1

Digital co-construction of relational values: understanding the role of social media for sustainability

Article type: Review article

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Abstract

There is a deeply relational aspect to the systems people employ for sorting through and prioritizing plural values assigned to social-ecological interactions. Spurred by interpersonal relationships and adhesion to societal core values, such as justice and reciprocity, relational values go beyond instrumental and intrinsic approaches to understanding human behaviour vis-à-vis the environment. Currently, this relational dimension of values is entering the spotlight of the Cultural Ecosystem Services (CES) literature focusing on non-material benefits and values people derive from ecosystems, such as aesthetics and sense of place. Relational values foster reflections on appropriateness and morality of preferences and respective behaviours in contributing to collective flourishment across space and time, holding implications for social-ecological justice and sustainability. Recently, several studies explored the potential of using social media data for assessing values ascribed to CES, but did not look at how this emerging approach could contribute to an enhanced understanding of relational values. In order to take up this goal, we conducted a systematic review, screening 140 publications and selecting 29 as relevant for exploring the extent to which relational CES values are inferable through social media. Our results show that social media data can reveal CES values' plural and relational dimension. Social media platforms, thus, can be understood as new arenas for the co-construction of values, where relational values stemming from social-ecological interactions are negotiated and defined. Yet, work on their implications for social-ecological justice and sustainability needs to be extended.

Keywords

Cultural Ecosystem Services, Social Media analysis, Relational values, Sustainability

Introduction

Social values, as a system of preferences, principles, and virtues co-constructed and held in common by the members of a social group, are critical to the endeavour of sustainability in that they are closely linked to people's behaviour (Chan et al. 2012b; Manfredo et al. 2016). A subgroup of social values influences which non-material benefit humans prioritize as a result of interactions with and within their natural environment. Since the Millennium Ecosystem Assessment (2005), these non-material benefits are often referred to as cultural ecosystem services (CES) (Chan et al. 2012a; Milcu et al. 2013). Values related to CES are increasingly assessed to highlight the importance of natural assets for sustaining human wellbeing through land-use planning, environmental decision making, and ecosystem-based management (MEA 2005; Chan et al. 2012a; Dickinson and Hobbs 2017). This focus on CES represents an important cornerstone of the wider ecosystem services (ES) framework, allowing ES research to move beyond the stalemate between the "new conservationists" advocacy for the instrumental value of nature and the traditional conservationist claim for protecting nature based on its intrinsic value (Klain et al. 2017).

Mediated through human senses and perceptions (MEA, 2005), the intangible benefits of CES are shaped by social values and direct human behaviour in ways that defy the intrinsic-instrumental dichotomy. The systems people employ for sorting through social values make certain provisioning and regulating ES more cognitively accessible (Chan et al. 2012a; Milcu et al. 2013; Dickinson and Hobbs 2017) and, thus, motivate nature conservation and stewardship (Andersson et al. 2014). Yet, the intangibility and incommensurability of values ascribed to CES make them ill-suited to be measured in

monetary terms and difficult to be appropriately assessed and incorporated into processes of structured decision-making (Chan et al. 2012a; Milcu et al. 2013; Dickinson and Hobbs 2017). Monetary approaches for CES valuation - e.g. the travel cost method, hedonic pricing, and willingness to pay - primarily aim to protect nature by internalizing environmental values into markets. However, such approaches compartmentalize ES into discrete units for marginal valuation (Chan et al. 2012b; Milcu et al. 2013) and assume objectivity in measurement (Raymond et al. 2014). This, critics argue, potentially results in a destructive commodification of nature (Kallis et al. 2013; Milcu et al. 2013) and risks obscuring context-dependent, inter-connected, reciprocal, and plural values that actually shape how humans relate to nature (Chan et al. 2012b; Hernández-Morcillo et al. 2013; Raymond et al. 2014).

In this context, Chan et al. (2016) describe values assigned to CES as non-consumptive, non-replaceable, socially-constructed and inherently relational.

The relational dimension of CES values manifests when people relate with and within nature, and emerges from a set of preferences, principles and virtues that are fundamentally social and ethical (Kenter et al. 2015). Relational CES values may generate a desire to preserve a landscape due to its close connection with a certain cultural identity, or to engage in green stewardship due to a communally-expressed appreciation for such activities. The relational dimension of values ascribed to CES, thus, associates societal choices, principles and corresponding behaviours to people's shared sense of justice, care, reciprocity and responsibility towards one another, including humans, non-humans, and ecosystems (Díaz et al. 2015; Chan et al. 2016; Klain et al. 2017; Pascual et al. 2017). Relational values ascribed to CES are, thus, the central conceptual pathway through

which ES connects with efforts to build just and sustainable social-ecological systems. Yet, the implications of relational CES values for social-ecological justice – an emerging notion wherein distributional-, procedural-, and recognition-based claims for justice emanate from neither strictly social nor strictly environmental implications, but always from the interplay between the two - and sustainability are still to be conceptualized in order to provide a well-grounded research framework for empirical studies in this area.

Often, non-monetary, participatory and deliberative valuation approaches are proposed to account for the multidimensionality of relational values ascribed to CES, building on the longstanding theories of communicative rationality (Raymond et al. 2014). Such methods consist of individuals taking part in collective and elicited processes of CES valuation and co-construction of meanings (Fischer and Eastwood 2016). From these collective co-constructions the researcher can either assemble stated values (e.g. through survey or focus groups) or deduce revealed values (e.g. by analysing behaviours) (Raymond et al. 2014; Kenter et al. 2015). These collective processes of valuation, mostly aiming to assess CES distribution and distributional justice across society and space, can also respond to claims of recognition and procedural justice in that they embrace diverse stakeholders and their preferences in a participatory way (Schlosberg 2007). Nevertheless, participatory and deliberative approaches to CES valuation are highly sensitive to the proper representation and empowerment of different social groups and have limited spatial and temporal scope, which may result in imperfect simulations of the process through which values are negotiated within communities (Schafer and Gallemore 2015; Maraja et al. 2016).

In an attempt to overcome these limitations, revealed values are increasingly derived from more widely representative social media (Hamstead et al. 2018; Ilieva and McPhearson 2018; Langemeyer et al. 2018; Lenormand et al. 2018). Already leveraged to empirically test social science theories (De Nadai et al. 2016), social media represents a digital arena where members of virtual communities share and exchange multimedia content. Social media content can include any information shared on a digital platform, including pictures, tags (text descriptions and geolocalization), or running or biking tracks, for instance. At its root, this content reflects individual user values regarding tangible and intangible aspects of the environment, such as landscape aesthetics, outdoor recreation, cultural identity, and sense of place (Guerrero et al. 2016).

When aggregated, social media content related to CES becomes doubly relational. First, the content reflects the inherently relational aspect of values ascribed to CES within wider society. People are reflecting their prior communally shaped notions of what should be valued as they post to social media. Also, because digital communication platforms are co-constructed and shared among the members of a community, the process of producing the content is embedded in a given set of norms that adds a second layer of relationality onto social media data. As individuals share their personal experiences, they expose their social-ecological perceptions and activities to public appraisal and comment within the digital community. In doing so, according to findings from social psychology research, they are motivated and affected by the perceived presence of others (Ames and Naaman 2007) and, in seeking alignment with social values of the group, implicitly express relationality based on sentiments of care and reciprocity for the preferences of others. For some, deepening this type of communal relationality relative to the environment is

essential for efforts to build just and sustainable social-ecological systems (Chan et al. 2016).

Apart from revealing the relational dimension of values ascribed to CES, this process of co-construction of meaning (Fischer and Eastwood 2016) holds further implications for assessing social-ecological justice and sustainability. Drawing on Kenter et al. (2015), exchanging multimedia data related to CES on social media platforms can be viewed as a "digital", non-deliberative and collective valuation approach. This approach ideally overcomes the above-mentioned limitations (e.g. representativeness, power relations, etc.) of other participatory and deliberative valuation approaches and allows for a more inclusive elicitation of values (procedural and recognition justice). Also, since each user produces social media data individually, it might provide a finer picture of values held by diverse people or, when aggregated, by different social groups, offer a useful basis for assessing distributional justice. Moreover, the high spatial and temporal frequency and scale at which social media data can reveal relational values attributed to CES allow researchers to account for users' behavioural response to ecosystem changes and to the cultural *stimuli* expressed through social media. Thus, the increased resolution of social media data will likely provide a wide set of complementary information to plan for sustainable social-ecological systems (Ilieva and McPhearson 2018).

In essence, social media data assessments are based on capturing components of social processes through various functions, such as sharing, liking, and commenting, and through multiple types of content including, e.g. photos, tags, and posts that represent the ongoing co-construction of relational values ascribed to CES. Thus, based on a review of

existing work on CES and social media, we propose this developing approach as an important new empirical basis on which to conceptualize relational values. In particular, drawing on Kenter et al. (2015), we highlight how multimedia content co-constructed by the users of a social media platform through a non-deliberated process exposes the relational nature of social values assigned to CES, whether those values are classified as transcendental (e.g. symbolic, spiritual), contextual (e.g. aesthetics, recreation), non-monetary, other-regarding and/or communal. In sum, because of being co-constructed through a collective valuation process that aligns individual with communal values ascribed to CES (e.g. landscape aesthetic values negotiated among members of a digital community), social media data is especially suited to exposing relational values (see Fig. 1).

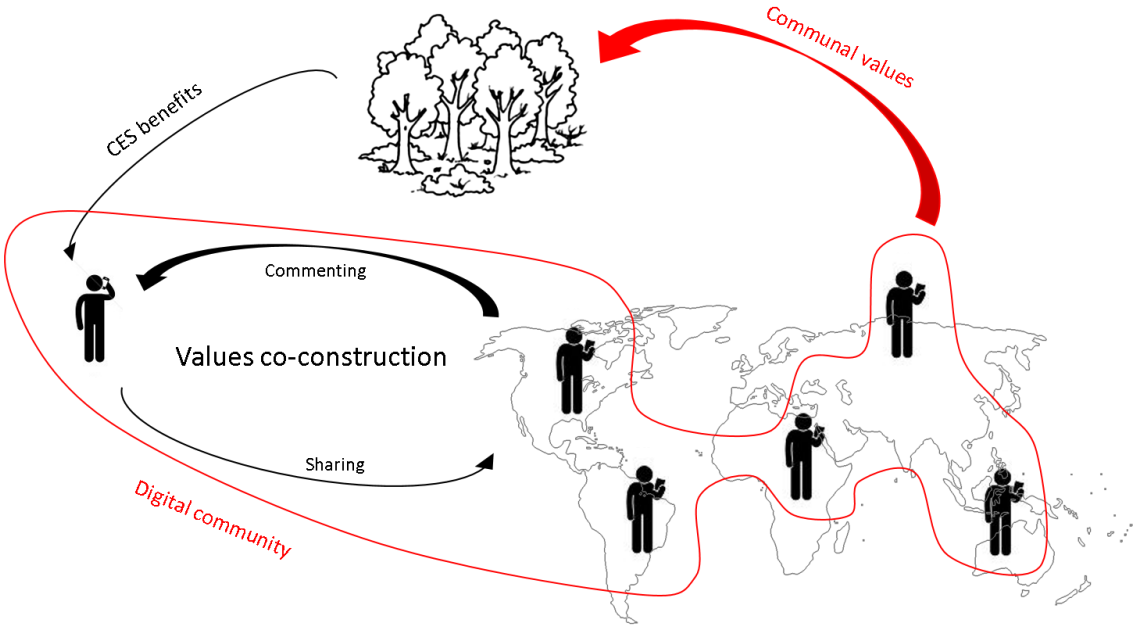

Figure 1. Relational values co-construction through interactions on social media.

We view relational values expressed through social media data through a bounded relativist ontological lens. As content is shared within social groups whose definition is bounded in space and time, values arise from people's interaction with nature and among

127 themselves (Moon and Blackman 2014). These values are constructed from a
128 combination of the subjects' experiences and the wider societal constructs that shape
129 these experiences – in essence, reflecting a process at the interface between constructivist
130 and subjectivist epistemologies. Given this approach, we are motivated by the hypothesis
131 that social media is a fertile ground for observing relational values ascribed to CES and
132 arising from their collective negotiation. To demonstrate this, we first examine the
133 relevance of social media data in assessing plural/multiple values related to CES and in
134 unveiling their relational dimension. In addition, we specifically focus on how social
135 media can sharpen our understanding of social-ecological justice and sustainability
136 related to relational CES values. Finally, we highlight opportunities and limitations in
137 using social media data for assessing relational values.

Materials and methods

138 We performed a literature review of studies using social media data for CES assessment
139 with a focus on the potential for examining relational values. Particularly, we analysed
140 each study's respective achieved goals, the challenges encountered, and further research
141 suggested in order to assess the potential for addressing relational issues. We performed
142 a systematic, structured quantitative literature review of peer-reviewed articles[1],
143 following a replicable procedure. The following criteria guided the search and selection
144 of relevant papers:
145 (i) clear mention of CES;

[1] Including one master thesis (Catana 2016) and one peer-reviewed conference proceeding (Goldberg 2015).

(ii) use of data retrieved from social media platforms, such as Flickr, Wikipedia or OpenStreetMap, representing the user's revealed values;
(iii) assessment (e.g. quantification, valuation, mapping) of at least one CES, as well as development or discussion of a framework or application.

Accordingly, we searched for studies that included in their title, abstract or keywords terms pertaining to two main categories (see Appendix A for details on search terms). The first category restricted the focus of our study to CES. As there are several CES classifications (see Haines-Young & Potschin, 2018; MEA, 2005; TEEB, 2010), we deliberately chose the most general and less detailed search terms. The second category included all the terms that were found to be synonymously used with social media data in scientific publications, e.g. crowdsourced data.

We excluded studies not directly relating to the CES framework because we wanted to address the framework's inherent dimension of relationality stemming from nature-society interactions and its specific aim to shape environmental policy-making for sustainability. Other papers referring to, for instance, scenic route or landscape perceptions rather than CES, either focus strictly on the methodological innovation of the assessment (Levin et al. 2015; Hao et al. 2016), on the potential computing advances (Stefanidis et al. 2013; Chen et al. 2017) or do not address nature-society interactions (Girardin et al. 2008; García-Palomares et al. 2015). We also deliberately excluded studies employing active research approaches to collect primary data, including (active) citizen science approaches, participatory GIS, interviews, focus group discussions and

questionnaires. In addition, we discarded publications in languages other than English, those whose full-text could not be found and conference abstracts.

We ran an advanced search on Web of Science and retrieved 58 publications meeting our criteria in November 2017. We supplemented these articles with an additional 23 articles that were either still in press or were found to have performed CES assessment through social media but not as their main analysis, so the chosen search terms were not in their abstract or keywords and were not extracted by Web of Science. Among those 81 articles, we selected 22 as directly relevant for our study according to criteria i, ii, and iii (above). We then performed a second round of searches based on those 22 articles. We screened the title of the articles cited by and citing the 22 selected articles and identified 48 new potentially relevant manuscripts. Seven of those 48 met our three criteria. Repeating the same procedure of screening the citations of those 7, we found 11 new potentially relevant articles but none met criteria i, ii, and iii and thus were outside of our study focus (see Appendix B for a detailed diagram of the search). Through this iterative three-stage procedure we reviewed a total of 140 potentially relevant articles and reached saturation of those that met our specific criteria.

Only the 29 articles that met all three criteria were included in detailed analyses. Among those excluded, 56 were addressing relevant topics (such as tourism and recreation, scenic and cultural value), but not clearly referring to the CES framework (e.g. see Barry, 2014; Dunkel, 2015; Levin et al., 2015; Seresinhe et al., 2017). The remaining 55 articles were related to other topics, mostly because the acronym “CES” used for the search is valid also in disciplines such as medicine or statistics (e.g. Syahid et al. 2016).

For conducting the analysis of the relevant articles we used a standardized assessment protocol (see Appendix C) that allowed us to use the most significant and frequent codes to synthesize and explain large segments of data. The assessment protocol was based on predefined questions regarding general information (publication data, case study location, spatial and temporal scales, data sample) and detailed questions concerning the number and type of CES assessed, the method of assessment, the aim and the further gaps identified by the study. In particular, with these questions, we wanted to understand what motivated the study and whether our hypothesis about the suitability of social media in inferring plural and relational CES values was in some way acknowledged or proven by the selected studies. In addition, we coded the publications based on keywords (e.g. "cultural footprint", "plurality", "context-specificity", etc.) and concepts retrievable from the text (e.g. shared conceptualization, co-construction of values, justice, strategy for conservation, etc.) that aligned with our research objectives. The set of keywords and concepts was continuously updated during the course of the analysis by identifying the synonymous terms used by the different authors.

We acknowledge that the screened publications do not include every paper that mentioned CES in relation to social media, and therefore may miss some insights. However, the final sample does allow us to gain a broad and, we believe, representative overview of the most significant literature for drawing reliable conclusions on recent social media-based approaches to CES research. In the sections below we highlight the strongest of these conclusions.

Results and discussion

Overview and general patterns

Overall, the number of publications addressing CES through social media has grown conspicuously since 2012 (see Fig. 2). By nationality, the plurality of the 32 case studies addressed in the 29 papers selected for careful study were located in the USA (n=5), followed by the UK and Singapore (n=3), Africa, Argentina, Denmark, Switzerland, France and Finland (n=2) and then Australia, Japan, Estonia, Germany, Greece, Hungary, Ireland, Spain, and Sweden (n=1) (see Fig. 3). The spatial scale of the studies ranged from global (n=2) to regional (n=15) to urban (n=6) and to local (n=6) (see Appendix C), and data were generally analysed across several years (see Appendix C), with the starting year depending on when the different platforms for social media were launched (see Appendix D). Most of the studies used the pictures shared either on Flickr or on Panoramio, with a small number of them combining the two (n=6). Some studies compared Flickr with original (e.g. survey, interviews, participatory GIS) or official data from statistical or cartographic entities (e.g. land cover map) (n=4). A few studies also used Instagram as a data source, some in combination with other platforms (n=3), some others with original or official data (n=2) (see Fig. 4).

Regarding the methods of assessment, many studies performed a visual content analysis of geolocated pictures (n=8), several processed the data using statistical (n=11) and geo-statistical tools (n=7), and some used the available data to model the distribution of where data was missing, both across space and time (n=5). The goal of most studies was to perform correlation analyses between CES and either landscape features (n=13), social groups (n=3) or ecosystem stress (n=1). Other studies aimed to compare the differences between social media and traditional data sources in performing CES assessment (n=5) and to evaluate the different advantages in using each social media platform (n=2). In a

233 few other studies, an analysis of trade-offs and co-benefits was performed (n=2) and some
234 evaluated the spatial distribution of CES (n=6) for either informing decision-makers or
235 prioritizing areas for scenic conservation (see Appendix C).

Table 1 Summary of the 29 reviewed articles on CES and social media

CES assessed	Study reference	Study description
Landscape plurality of value (recreation, aesthetics, sense of place, social and spiritual values)	Oteros-rozas et al. (2017)	CES assessment, trade-offs and synergies among them and identification of the landscape features underpinning their provision
	Tenerelli et al. (2016)	Assessment of CES distribution and correlation with landscape composition
	Martínez Pastur et al. (2015)	CES hot-spots assessment and trade-offs, synergies and correlation with social and biophysical variables
	Catana (2016)	CES assessment in protected landscapes
	Levin et al. (2017)	Examining the potential of crowdsourced data for assessing protected area importance. Compares and evaluates multiple crowdsourced data with protected area visitor counts
	Richards and Friess (2015)	Assessment of CES distribution and correlation with landscape composition at fine spatial scale
	Thiagarajah et al. (2015)	Assessment of CES change over time
	Guerrero et al. (2016)	Assessment of CES spatial distribution for informing urban green space governance
Landscape aesthetics	Richards and Tunçer (2017)	Development of a novel method for spatial CES assessment

and recreation	Kothencz et al. (2017)	Comparison with surveyed data for assessing CES predictor value for visitors' level of satisfaction and the self-reported quality of life
	Derungs and Purves (2016)	Development of bottom-up approaches to describing landscapes, land cover and land use by building spatial folksonomies
	van Zanten et al. (2016)	Continental comparative assessment of the different social media platforms ability in predicting CES appreciation
Landscape aesthetics	Tammi et al. (2017)	Supplementary, non-monetary mapping of aesthetic ES index
	Tenerelli et al. (2017)	Assessment of the distribution of CES among users with different provenance and correlation with landscape composition
	Yoshimura and Hiura (2017)	Comparison between CES supply and demand
	Figueroa-Alfaro and Tang (2017)	Assessment of CES spatial distribution
	Casalegno et al. (2013)	Assessment of spatial covariation between supporting, provisioning, regulating and cultural ES
	Goldberg, (2015)	Point of Interest identification and prioritization for scenic conservation
Cultural Identity	Gliozzo et al. (2016)	Assessment of CES spatial distribution, hot/cold spots identification and comparison between the spatial behaviour of different platform users
	Sherren et al. (2017)	Description of the interdisciplinary state-of-the-art that is converging to enable new tools for Social Impact Assessment (SIA), using hydroelectricity as a case study
Recreation	Cord et al. (2015)	Assessment of CES distribution and correlation with landscape composition

	Allan et al. (2015)	Quantification of spatial distribution of recreational facilities and correlation with ecosystem stress assessment
	Upton et al. (2015)	Assessment of accessibility to recreational forests and recreation demand modelling
Recreation and ecotourism	Heikinheimo et al. (2017)	Comparison with surveyed data to assess the added value of social media analysis in reveal correlation with social group characteristics
	Hausmann et al. (2017)	Exploration of which socio-economic, geographical and biological factors explain social media use
	Sonter et al. (2016)	Assessment of nature-based recreation within conserved lands using social media, analysing its predictor value for visitation rate and its correlation with landscape composition
	Wood et al. (2013)	Use of data from social media to predict visitation rates at sites around the world comparing it to empirical data, such as type of attraction, income-level, temporal changes, etc.
	Willemen et al. (2015)	combining photo counts with species range data to determine the protected areas with the highest potential to attract wildlife tourists
Recreation and education	Ghermandi (2016)	Investigate patterns of public use in natural treatment systems

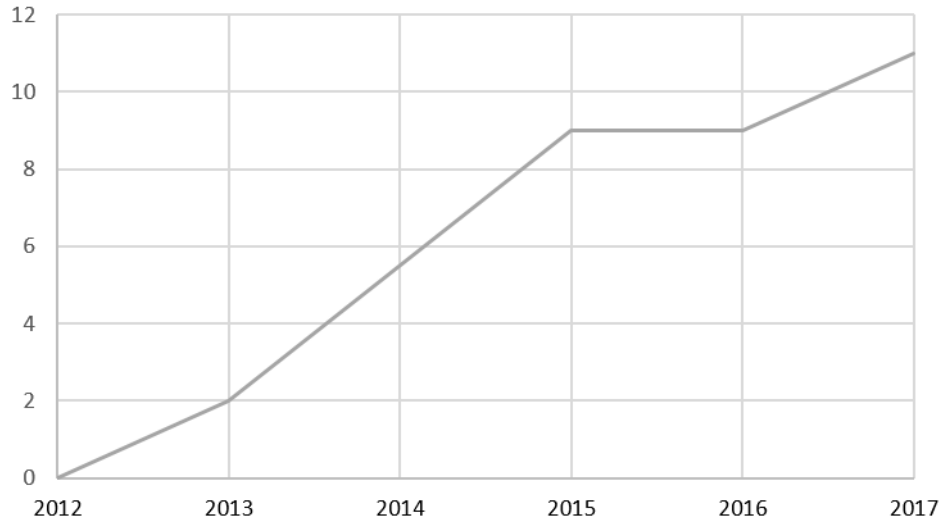

Figure 2. Number of publications per year

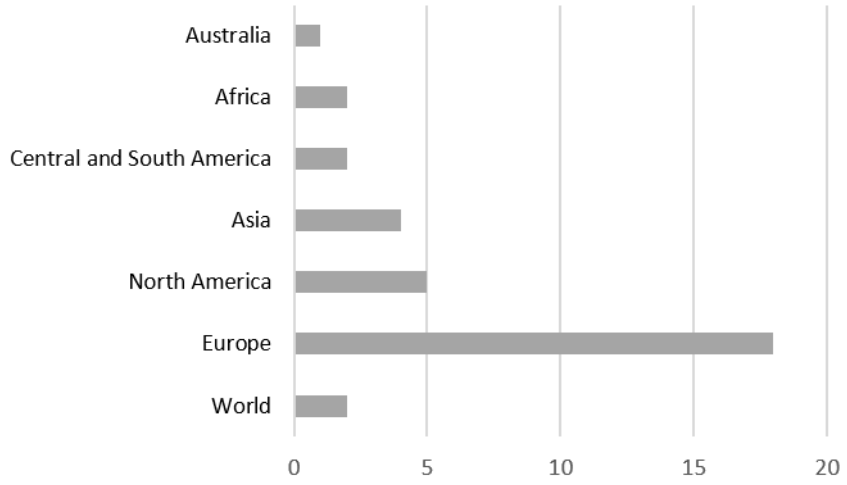

Figure 3. Geographical distribution of the case studies

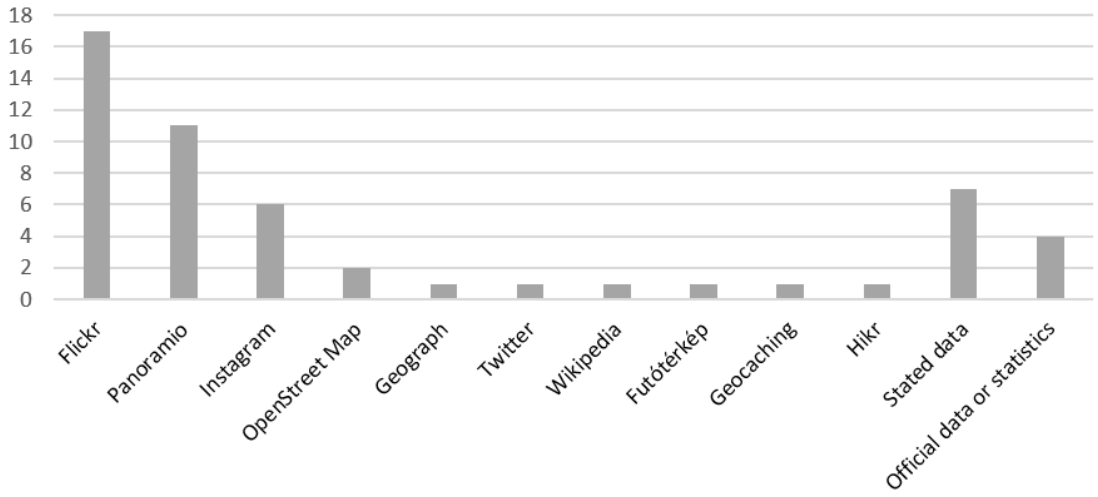

Figure 4. Number of studies adopting the different social media platforms

Social media assessment of plural CES values

Quantitatively assessing the plurality of CES values has always challenged researchers, both timewise and in terms of costs. Here we unveil the advantages in using social media data for addressing this challenge. Among the selected papers, the majority (more than 60%) include an assessment of multiple CES values and, in some cases, of their spatial co-presence, ranging from a minimum of two to a maximum of eight values (see Fig. 5). These studies confirm social media as a suitable data source for understanding the context-dependency and holistic nature of CES values. Despite the fact that studies adopted different systems of classification (e.g. Haines-Young and Potschin, 2018; MEA, 2005; TEEB, 2010), it is possible to highlight connections between the CES values assessed and the methods implemented. Among studies that restricted their analysis to one or two main CES, there was a general agreement on the need to recognize that there are many ways in which the environment is perceived (Tenerelli et al. 2017). These articles express an interest in exploring the multiple means of perception for better

integrating non-expert conceptualizations of landscape into policy (e.g. Derungs and Purves, 2016).

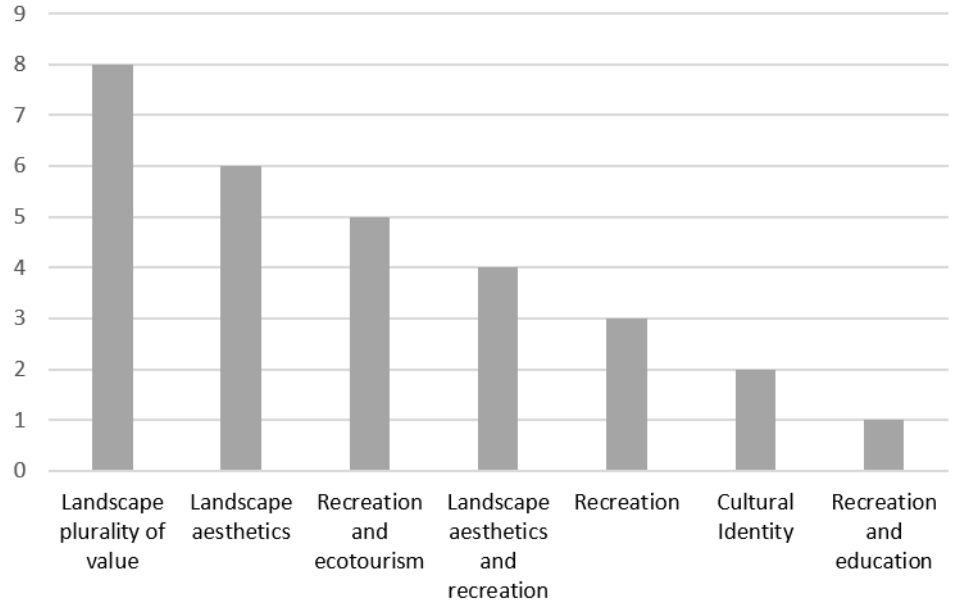

Figure 5. Number of studies assessing the different CES

Among the studies assessing more than two CES, visual content analysis of geolocated crowdsourced pictures is the most applied methodology. Visual content analysis allows the researcher to assess a wide spectrum of CES, including landscape aesthetics (Martínez Pastur et al. 2015; Thiagarajah et al. 2015; Catana 2016; Guerrero et al. 2016; Tenerelli et al. 2016); recreation and ecotourism (Catana 2016; Tenerelli et al. 2016; Oteros-Rozas et al. 2017); cultural heritage and social and spiritual values (Oteros-Rozas et al. 2017); social relation and species existence value (Richards and Friess 2015; Catana 2016), local identity (Martínez Pastur et al. 2015); and sense of place (Guerrero et al. 2016). In addition, studies complementing social media data with primary crowdsourced data, such as those obtained from a public participation GIS (PPGIS) workshop (Levin et al. 2017) or surveyed and mined from archives (Thiagarajah et al. 2015), reveal the potential to

provide a wider spectrum of CES values, adding conservation, therapeutic, wilderness and inspirational values to the list.

Yet, confirming previous findings (Hernández-Morcillo et al. 2013; Milcu et al. 2013), among CES studies aesthetic and recreational values are, in general, the most frequently quantified, either in single or multiple value assessments. Many of the studies assessed either only aesthetics (more than 30%) (Casalegno et al. 2013; Goldberg 2015; Figueroa-Alfaro and Tang 2017; Tammi et al. 2017; Tenerelli et al. 2017; Yoshimura and Hiura 2017), only recreational values (more than 30%) (Allan et al. 2015; Cord et al. 2015; Upton et al. 2015), or both (more than 20%) (van Zanten et al. 2016; Kothencz et al. 2017; Richards and Tunçer 2018).

Apart from the multiple CES values that social media have thus far proven suitable to assess, many studies showed also the potential of these methods to account for the different predictors or explanatory variables that help to understand how CES values are constructed. Some studies explore the environmental variables that enable specific CES values, such as how complexity and "naturalness" determine attractiveness in landscape aesthetics (Tenerelli et al. 2017), while others focus on the extent to which species richness (Willemen et al. 2015; Hausmann et al. 2017) or landscape features (Tenerelli et al. 2016) influence recreation, tourism, or aesthetic potential. In addition, social media data allow researchers to correlate plural CES presence to predictor variables, such as accessibility (Thiagarajah et al. 2015; Upton et al. 2015; Willemen et al. 2015; Ghermandi 2016; Guerrero et al. 2016), population density (Hausmann et al. 2017), type of habitat and the presence of human artefacts (Gliozzo et al. 2016; Guerrero et al. 2016), scenic

284 spots (Tenerelli et al. 2016), and natural protection areas (Levin et al. 2015; Catana 2016).
285 Similarly, Oteros-Rozas et al. (2017) recognize the context-specificity of CES and their
286 results show a positive relationship between landscape diversity and CES diversity,
287 thereby, verifying previous findings (Casalegno et al. 2013; Gliozzo et al. 2016; Tammi
288 et al. 2017). Moreover, Yoshimura and Hiura (2017) and Tenerelli et al. (2017) found
289 further evidence of the different preferences expressed by foreign and local users,
290 although this finding is not confirmed by other works (Richards and Friess 2015).

Social media assessments revealing relational values

291 A person's perspective on place or landscape has recently been argued to result from
292 interactions that bridge transcendental (or held) and contextual (or assigned) values
293 (Levin et al. 2017). The argument builds on the concept of relational value, which,
294 although already present in the environmental psychology and sociology literature
295 (Stephenson 2008; Graham et al. 2013), was first explicitly attributed to CES in Chan et
296 al. (2016) and is, thus, relatively new and clearly not present in the relevant articles
297 published before that date, nor explicitly assessed by those analysed in this study. Only
298 Catana (2016) refers to the dimension of relationality in order to show how human values
299 are connected to perceptions, preferences, and ultimately to well-being. However, in
300 order to verify our hypothesis on the specific potential of social media data to infer this
301 so far neglected value dimension, we looked for similar concepts or for promising
302 assessment methods in the reviewed articles, despite the fact that they were primarily
303 addressing other objectives.

304 Many studies expressed the need to capture the meanings that people collectively assign
305 to landscapes and that regulate inter-societal relationships involving nature. In this regard,

306 social media data is seen as a valuable source of information about shared
307 conceptualizations and about the process of culture creation relative to the natural
308 environment, as in the case of frequently used tags and hashtags (Derungs and Purves
309 2016; Guerrero et al. 2016). More specifically, some studies suggest that sharing a
310 landscape picture on a social media platform is a form of "digital interaction" that adds
311 another collective dimension to social values, contributing to peoples' shared image of
312 landscapes and, consequently, attachment to nature and to one another (Oteros-Rozas et
313 al. 2017). These attachments may also be based on their historical and cultural
314 background (Guerrero et al. 2016). People sharing content on social media are, indeed,
315 responsible for influencing their "digital receptors" with what is referred to as their
316 cultural ecosystem footprint (Gliozzo et al. 2016). In addition, social media not only
317 serves as a platform to dispute and share relational CES values, but also stores the process
318 of value creation that generates heritage, allowing the persistence of CES values and
319 counteracting the "extinction of experiences" of nature in modern societies(Miller 2005).

320 In addition, the different forms of interaction allowed on social media, motivate people
321 to co-construct values in diverse manners (Cord et al. 2015). In this regard, we also found
322 some evidence of a correlation between the relational and plural attributes of values. In
323 platforms allowing voluntary and non-restricted participation, such as *Flickr*, *Instagram*
324 and *Panoramio*, people are motivated to share data because of the global visibility they
325 obtain and, thus, tend to express plural and context-specific values (Gliozzo et al. 2016;
326 Guerrero et al. 2016). On the contrary, when a platform has a compiling purpose intended
327 to provide a specific output to decision-makers, such as *Geograph*, data are more
328 homogeneously distributed and less informative of people's multiple held values (Gliozzo

et al. 2016). Therefore, across the reviewed literature, the majority of the authors recognize the correlation between the collective process of co-construction of meaning associated with social-ecological interactions and the expression of relational principles of care, reciprocity and responsibility towards nature and others. This strain of findings in the literature affirms that social media platforms are suitable arenas for negotiating and capturing relational values assigned to CES.

Furthering social-ecological justice and sustainability by inferring relational values from social media platforms

The production of values is part of a socialization process that occurs through repeatedly engaging in countless experiences and phases of learning, either formal or informal. This process "embrains" the spontaneous responses and cultural practices that allow individuals and groups to adapt to their social-ecological surroundings without much effort or deliberation (Gliozzo et al. 2016; Manfredo et al. 2016). Therefore, since we assume that value attachment to places motivates people's actions and the consequent effects on their surroundings (Yoshimura and Hiura 2017), we look at this process with particular attention.

In social media, apart from their values and emotions, people share digital and geolocated traces of actions driven by underlying values and, further eased by Internet functionalities, influence each other (Gliozzo et al. 2016). The process of mutual influence in ascribing values to CES provided by places or activities can lead others to personally experience them (Cord et al. 2015) or not (Goldberg 2015; Gliozzo et al. 2016), such as for CES that do not require a physical interaction to be experienced (e.g. cultural heritage, existence value, and spiritual values) (Richards and Friess, 2015). Hence, some studies show

empirical evidence of these processes of co-construction of values, mutually influenced behaviour in interacting with nature, and consequent co-production of ES (Fischer and Eastwood 2016), demonstrating that CES values expressed on social media cluster around popular scenic (Goldberg 2015) or recreational spots (Cord et al. 2015) and widely known species (Willemen et al. 2015).

In this regard, some studies suggest using "likes" and ratings associated with social media data (Gliozzo et al. 2016; Hausmann et al. 2017) or simply the number of times each picture posted on a social media platform has been visualized (Goldberg 2015), or its location has been reached (Cord et al. 2015), by another user as a proxy for CES hot-spot identification. Mapping CES hot-spots helps identify areas where the services are most highly valued (Goldberg 2015; Guerrero et al. 2016) and whether this results in ecosystem stress (Allan et al. 2015), providing useful information to prioritize areas for conservation (Hausmann et al. 2017) and cultural services management (Guerrero et al. 2016).

In addition, several of the reviewed studies have highlighted the lack of methodological approaches for addressing social-ecological justice and sustainability. Some argue for performing a demographic profile of social media users in order to account for procedural and recognition justice in the assessment, as well as assessing distributional justice by accounting for variables such as gender, social class, age or area of residence (Gliozzo et al. 2016) and specifically seeking to reach less represented user groups (Guerrero et al. 2016). Others propose to perform an assessment of cross-cultural differences (Cord et al. 2015). Some studies recommend monitoring the trends of social preferences towards CES exploring their evolution across geographic and temporal scales (Wood et al. 2013; Martínez Pastur et al. 2015; Derungs and Purves 2016; Guerrero et al. 2016), or to

perform scenario-based simulations (Wood et al. 2013) and develop means for quantifying ecosystem resilience over time (Allan et al. 2015). This would help correlate changes in visitation rates with changes in ecosystem health, site access, infrastructure development and alternative management regimes. Finally, some studies recognize the potential of social media data for revealing city dwellers' preferences and values in order to respond to important challenges for place-based culture and well-being (Guerrero et al. 2016; Tenerelli et al. 2017), and plan for healthy green spaces (Kothencz et al. 2017). All of these are promising directions for translating CES knowledge derived from social media data into a more coherent and systematic understanding of relational CES values and of their role for social-ecological justice and sustainability.

Opportunities and limitations in the use of social media data

Because social media data can be collected passively, its greatest benefit for questions of internal validity is that it provides a research route that compensates for shortcomings affecting data obtained through more active collection approaches, such as surveys, interviews or photo elicitation (Guerrero et al. 2016). Geolocated social media data, indeed, reveals perspectives that arise from directly experiencing the environment at the same time as it is being evaluated (Tenerelli et al. 2017) and is less costly and time-consuming (Yoshimura and Hiura 2017). In addition, because it is collected across a wide variety of the population and can have high spatial resolution thanks to the embedded geotag (van Zanten et al. 2016; Oteros-Rozas et al. 2017) and be reported in real-time (Gliozzo et al. 2016; Oteros-Rozas et al. 2017), it has higher representativeness over space and time than many alternatives.

Moreover, geolocated social media data are especially useful because the digital interactions that they allow are believed to spur participants to mutually influence gradual changes in their values, associated behaviour and, eventually, produced environment. Such changes, to the extent that they are transferred to the policy level, have been often indicated as necessary to achieve global environmental sustainability (Stern et al. 1999; Manfredo et al. 2016). In addition, given that most of the people using social media are urban dwellers (Guerrero et al. 2016; International Telecommunication Union 2016), this data source is valuable in that it allows researchers to assess CES values held by people with gradually declining opportunities of interaction with nature (Dickinson and Hobbs 2017).

Of course, there are limitations to the use of geolocated social media data as well. For example, some studies recognize the limitations that arise when the researcher interprets data in a one-directional way (Derungs and Purves 2016; Oteros-Rozas et al. 2017) and because of the temptation to see patterns in the available data where none actually exist (what is known as *apophenia*) (Wood et al. 2013). This limitation could be partly addressed through the establishment of unified coding protocols for social media data. Others highlight the spatial bias as a result of data gaps in places characterized by poor data (Catana 2016; Levin et al. 2017) or poor reliability of the geotag (Oteros-Rozas et al. 2017). Questions emerge also due to data representativeness. Several existing digital divides and fashions in the use of certain social media platforms, such as those related to age, gender and income level, might mislead the analyst because the data accounts only for behaviours and perceptions of certain profiles and social groups (Wood et al. 2013; Allan et al. 2015; Martínez Pastur et al. 2015; Willemen et al. 2015; Oteros-Rozas et al.

418 2017; Tenerelli et al. 2017). For example, recent studies found a strong gender imbalance
419 (64% male; 36% female) in the users of the photo-sharing platform *Flickr* who responded
420 to a user questionnaire (Lenormand et al. 2018). Such perceptions might further be
421 influenced by specific individuals, groups or private corporations that, by implementing
422 communication or market strategies on social networks, reach their target audience and
423 influence values creation and data availability (Oteros-Rozas et al. 2017).

424 All of these limitations direct us to consider how social media deals with issues of uneven
425 power relations, which is perhaps the central issue impacting recognition, procedural,
426 distributional justice outcomes (Schlosberg 2007). Especially with regard to procedural
427 justice, a poor accounting of the effect of uneven social power relations has long been
428 central to the urban scholarship critique of communicative rationality (Huxley and
429 Yiftachel 2000). These limitations are believed to decrease with the continuing increase
430 in number and awareness of social media users and in data accuracy allowed by newer
431 technologies (Guerrero et al. 2016; Tenerelli et al. 2017) and the combination of different
432 data sources. However, private monopolies on social media data bare the risk of
433 restricting the scientific analysis of data, for instance by platforms like *Facebook* and
434 *Instagram*, and, thus, limit a less biased societal representation of relational values
435 through social media-based research. This relates to questions of ethics, privacy and
436 copyright, which have been raised in relation to accessing social media data (Guerrero et
437 al. 2016), concerns also addressed by the latest European General Data Protection
438 Regulation (COM/2018/043), and which so far lack a more specific discussion from the
439 angle of sustainability science.

Conclusions and further recommendations

With this study, we aimed to contribute to the emerging questions of relationality within sustainability research. We found evidence of social media platforms serving as valuable data sources for revealing the multiple values that people assign to the environment. In addition, we showed the dimension of relationality within plural CES values. We propose a novel conceptualization that relates relationality to the collective processes of co-construction of values ascribed to CES and, which is visible within social media data. We found that the reviewed literature frequently points at the ability of social media data to reveal people's willingness to share their experiences online. This is believed to be significant in influencing the co-construction process of plural CES values, people's interactions with and within the environment and, consequently, the co-production of ES, proving useful information on value and behaviour for landscape and urban planning.

However, social disparities are reproduced in this process and, once translated into action, can have implications for social-ecological systems justice and sustainability (e.g. increased visitation rate in touristic spots and consequent gentrification and ecosystem stress). Hence, this study calls for further exploring the different social and environmental factors at play, and specific biases characterizing data sources, in order to enable the potential of social media data to inform just and sustainable landscape planning and management. Future research should also focus on the potential of social media-based approaches to explore the path from value to action, assessing the influence of values created on social media in enhancing people's agency toward the collective improvement of their well-being (see Hicks et al. (2016)) and, eventually, to activate citizens in a process of co-production of nature (Linders 2012; Guerrero et al. 2016).

Acknowledgements

We acknowledge financial support from the 2015-2016 BiodivERsA COFUND call for research proposals through the Spanish Ministry of Science, Innovation and Universities (PCIN-2016-002) and from the European Research Council (Greenlulus 678034). F.C. thanks the AGAUR Catalan governmental agency (Grant number 2018FI_B00635) and the Institute for the right to university studies in Lazio, Laziodisu (Grant "Torno Subito 2017" number 7425-18092017) for the funding received to support this study. A.T.A.M. acknowledges support by the European Commission through an Erasmus Mundus scholarship (JEMES CiSu UAB2016/No. 1). J.J.T.C. thanks the Spanish Ministry of Sciences, Innovation, and University's Subprogram of Juan de la Cierva Incoporacion (IJCI-2016-31100). We also thank the reviewers for their valuable remarks.

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