



Sociocultural valuation of ecosystem services for operational ecosystem management: mapping applications by decision contexts in Europe

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Abstract

Sociocultural valuation (SCV) of ecosystem services (ES) discloses the principles, importance or preferences expressed by people towards nature. Although ES research has increasingly addressed sociocultural values in past years, little effort has been made to systematically review the components of sociocultural valuation applications for different decision contexts (i.e. awareness raising, accounting, priority setting, litigation and instrument design). In this analysis, we investigate the characteristics of 48 different sociocultural valuation applications—characterised by unique combinations of decision context, methods, data collection formats and participants—across ten European case studies. Our findings show that raising awareness for the sociocultural value of ES by capturing people's perspective and establishing the status quo, was found the most frequent decision context in case studies, followed by priority setting and instrument development. Accounting and litigation issues were not addressed in any of the applications. We reveal that applications for particular decision contexts are methodologically similar, and that decision contexts determine the choice of methods, data collection formats and participants involved. Therefore, we conclude that understanding the decision context is a critical first step to designing and carrying out fit-for-purpose sociocultural valuation of ES in operational ecosystem management.

Keywords Sociocultural valuation · Ecosystem services · Local-to-regional scale · Operational use

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Introduction

Over the past 20 years, nature conservation and natural resource management have increasingly adopted an anthropocentric perspective to explain and highlight the need for conservation measures to support essential goods and services that nature supplies to societies all around the world (Costanza et al. 2017; Mace 2014). The concept of ecosystem services (ES) provides a theoretical framework of this policy perspective and emphasises the need to communicate, assess and quantify the value of ecosystems (Gómez-Baggethun and Barton 2013). Along with ecological and economic values, sociocultural values have been emphasised in determining the value of goods and services that ecosystems provide to the well-being of society (e.g. de Groot et al. 2002).

Sociocultural values describe the principles, importance or preferences expressed by people towards nature (Pascual et al. 2017). They are associated with either “held values, principles or moral duties” or “assigned values” that describe the importance, worth or usefulness expressed by people towards nature (Díaz et al. 2015; Scholte et al. 2015; Iniesta-Arandia et al. 2014), and can be instrumentally, intrinsically and relationally motivated (Chan et al. 2016). Although the idea of sociocultural value of ES was conceptualised and emphasised early (de Groot et al. 2002), ES assessments mostly focused on ecological and economic valuations until recently (Nieto-Romero et al. 2014; Liqueste et al. 2013). Sociocultural value has strongly gained in importance over the past 5 years, since value pluralism was again emphasised as an important goal in ecosystem service assessments (Pascual et al. 2017). One prominent example for that are the most recent advances of the Intergovernmental Panel of Biodiversity and Ecosystem Services, which endorse nature’s contributions to people and so highlight the cultural context of nature’s benefits (Díaz et al. 2018).

Sociocultural valuation (SCV) is the process of identifying these values to particular benefits that humans obtain and enjoy from nature (Scholte et al. 2015). It is particularly suitable for capturing values and perceptions that people assign to ES. Thus, it increases our understanding of how important ES are to people (e.g. Iniesta-Arandia et al. 2014), which ES are more important to people than others (e.g. Martín-López et al. 2014), how perception differs between groups of people (e.g. Hummel et al. 2017) and between positive and negative aspects associated to ecosystems (e.g. Ruiz-Frau et al. 2018). SCV further allows to map ES geographical distribution (Ruiz-Frau et al. 2011; García-Nieto et al. 2015), to identify benefits that people wish for in the future (Schmidt et al. 2017), to reveal conflicts between groups (Iniesta-Arandia et al. 2014), and to identify the reasoning behind the allocation of values to improve our understanding of held values (Gould et al. 2014).

Sociocultural values can be captured both in qualitative and quantitative ways. Among the qualitative information, we find narratives (e.g. Ramirez-Gómez et al. 2015) or free listing (e.g.

de Souza Queiroz et al. 2017). Many of the quantitative measures use non-monetary ranking or scaling (e.g. Schmidt et al. 2017). Monetary methods that expose people’s preferences and perceptions based on stated and revealed preferences are also used to reveal anthropocentric values (Jacobs et al. 2018; Martín-López et al. 2014) despite their widely discussed caveats (Gómez-Baggethun and Ruiz-Pérez 2011). However, market-based economic approaches are found less capable to represent sociocultural values due to their limitation to markets and exchange values (Koetse et al. 2015; Schmidt et al. 2016).

Capturing ES and their value for society is expected to support decision-making in global conservation and natural resource management (UNEP 2000, 2010) and led to several global initiatives, e.g. the Millennium Ecosystem Assessment (MA 2005), The Economics of Ecosystems and Biodiversity (TEEB 2010), and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES 2015). At European level, the Mapping and Assessment of Ecosystems and their Services (MAES) is a prominent process to capture the value of ecosystems (Maes et al. 2016). At local-to-regional level, numerous advances to operationalise ES into everyday decision-making, e.g., in forestry (Locatelli et al. 2015), agriculture (Loucougaray et al. 2015), management of recreational parks (Schmidt et al. 2018), wetland restoration (Liski et al. *In press*), management of mountain landscapes (Walz et al. 2016) and concepts for the integration of ES into formal planning processes (Haaren et al. 2016) were discussed.

The wide range of decision contexts in conservation and natural resource management requires tailor-made ES assessments. Earlier studies present first approaches to distinguish decision contexts for methodologically adapted setups of ES assessments (e.g. Tallis and Polasky 2009). More recently, Jacobs et al. (2018) suggest the following five decision contexts: awareness raising, accounting, priority setting, instrument design and litigation issues (based on Barton et al. 2012; Gómez-Baggethun and Barton 2013), and show how specific decision contexts are usually related to particular spatial coverage, resolution and accuracy in economic valuation (Gómez-Baggethun and Barton 2013). We postulate here that a similar adaptation is true also for SCV. We focus explicitly on local-to-regional scale empirical studies and investigate the choice of methods, data collection formats and participants addressed for different decision contexts to identify typical combinations in the setup of SCV studies for different decision contexts.

We identify what methods, data collection formats and types of participants are commonly used and combined to inform ecosystem management in different decision contexts. The specific goals of our study are (1) to provide an overview of diverse decision contexts, methods, data collection formats and participants included in local-to-regional SCV applications, (2) to show whether methods and formats vary according to the decision context of their application, and (3) to show methodological

choices within SCV assessments for different decision purposes. To do so, we systematically analyse local-to-regional, multi-step SCV studies which all aimed at operationalising the ES concept in practical ecosystem management.

Methods

Overview of case studies

For the analysis of methods, data collection formats and participants approached for different decision contexts, we sampled ten local-to-regional scale case studies that used SCV (see also Table 2). All case studies ultimately aimed at demonstrating the operationalisation of the ES concept into practical decision-making in natural resource management, planning or restoration, as part of the European research project OPERAs (www.operas-project.eu). SCV was used in most of these case studies in combination with other approaches to capture the biophysical functioning of ecosystems and economic value. No common protocol was applied to align the procedures between case studies, and the individual steps taken in each case study vary considerably in type and number between case studies.

Data collection and coding

We distributed a template among the case studies to identify individual SCV applications within the overall case study, and hence, to capture samples of independent SCV applications from each case study including their decision contexts, specific methods, formats and participants involved (Table 1).

According to the typology of decision contexts by Jacobs et al. (2018), we distinguish between the five decision contexts (Tables 1 and 2, for examples on decision contexts):

- Awareness raising where knowledge of sociocultural values can inform and raise awareness of decision makers and the public for varying perceptions of ES;
- Accounting where knowledge of the change of ES values over time is used to monitor the effect of a change in the management regime;
- Priority setting where knowledge of a preferred scenario or a vision for management informs priority setting of the future management;
- Instrument development where knowledge on management priorities, willingness to pay, or willingness to accept limitations give indication for the feasibility of a new management regime (e.g. management actions, user fees, zoning);
- Litigation issues where knowledge on the willingness to pay for alternative ecosystem management can be used to determine damage and compensation costs.

Our typology of SCV methods builds on the four methods described by Santos-Martín et al. (2016) (1–4 in Table 1), complemented by another two to fully describe our sample (5–6 in Table 1):

- Scenario assessment combines various techniques (e.g. interviews, visioning exercises, ranking exercises) to assess or develop plausible descriptions of alternative futures;
- Preference assessment directly assesses the individual and social importance of ES regarding motivations, perceptions, knowledge and associated values of ES using different techniques (e.g. ranking, rating, free listing);
- Participatory mapping (often also referred to PPGIS in the literature) assesses the spatial distribution of ES according to the perceptions and knowledge of stakeholders during workshops, interviews or surveys;
- Narrative/deliberative methods collect qualitative data about the plural and heterogeneous values of ES through stories (told verbally or visually);
- Multi-criteria analysis (MCA) combines different assessments of ES (e.g. biophysical ecosystem assessment, economic assessment, sociocultural assessment) and evaluates the performance of management alternatives to support transparent decision-making (Saarikoski et al. 2016);
- Content analysis summarises and quantitatively analyses content from different sources (e.g. social media, management plans; Neuendorf 2016).

The typology of the main formats used in our study is adapted from Scholte et al. (2015):

- Workshops bring together groups of people, show a high level of interaction between participants, and use—at least in parts—deliberative methods;
- Interviews interrogate individual people at a high level of detail, are usually analysed qualitatively, are structured in varying degrees and can be conducted either face-to-face or via telephone;
- Questionnaire-based surveys interrogate a large number of individual people, are usually analysed quantitatively, are more or less structured and can be conducted either face-to-face or via telephone;
- Observations describe and/or count people's behaviour and do not directly intervene with people.

Finally, we distinguish between three, mutually not exclusive groups of participants:

- The public includes people with no specific relation to the issue at stake, often randomly included in participatory formats;
- Stakeholders include people who are affected, or responsible for the issues at stake including decision-makers,

Table 1 Classes used in the analysis for each of the four characteristics to describe sociocultural applications

Characteristic	Classes used for analysis	Examples
Decision context	Awareness raising	Which ES is important to stakeholders? How do values differ between user groups? What are services and disservices? What are synergies and trade-offs between services?
	Accounting	How does the social value vary with changing ES over time?
	Priority setting	What are priorities for ecosystem management? What are potential management options? What are hotspots for management? What are trade-offs/synergies of management options?
	Instrument development	How can the social value of ES be incorporated into existing or new instruments?
	Litigation	How can social value of ES be accounted for in damage and compensation claims?
Methods	Scenario assessment/visioning	visual, narrative
	Preference assessment	rating, weighting, ranking, choice experiments, q-methodology
	Participatory mapping	
	Narrative/deliberative methods	listing, reasoning
	Multi-criteria analysis	
Data collection formats	Content analysis	social media, document analysis
	Workshop	expert, stakeholder, participatory, focus group workshop
	Interview	structured, semi-structured, unstructured, face-to-face/online, telephone
	Survey	structured, semi-structured, unstructured, face-to-face, online, telephone
	Observation	in person, social media, documents
Participants	Public	general public, affected public
	Stakeholders	people affected, people responsible, decision makers
	Experts	professionals, researchers

often included in participatory processes through representatives;

- Experts include people who are knowledgeable but not directly affected by the issue at stake.

Based on these classifications, we distinguished discrete individual SCV applications within the set of case studies based on unique combinations of decision context, method, format and participants. For instance, in the study for the Pentland Hills Regional Park, we differentiated the following six applications: (1) awareness raising: quantify the value of ES for park users by rating, (2) awareness raising: quantify the value of ES for park users by weighting, (3) priority setting: elicit preferences for land use vision of visitors, (4) awareness raising: participatory mapping of ES hotspots through stakeholders and experts, (5) awareness raising: analyse current management plan through content analysis, and (6) instrument development: identify gaps of ES implementation for management plan with stakeholders and experts.

Statistical analysis

First, we conducted a multi-dimensional scale analysis (Mair et al. 2015) to discover structures in our dataset how applications of different decision contexts vary in methods, formats

and participants involved and visualise them in ordination plots. Due to the nominal quality of the variables characterising the SCV applications, we use non-metric multi-dimensional scaling (NMDS), which has proven useful for similar samples also in ecosystem service research (e.g. Cárcamo et al. 2014). NMDS builds on computed rank distances between observations, and adjusts a selected number of orthogonal axes in an iterative procedure to map the observed distances (Oksanen 2015). Specifically, we used Gower's distance as implemented in the "daisy" function in the R package "cluster" to compute all distances (Gower 1971; Struyf et al. 1997). For this, all observations in our dataset were pairwise compared, the number of unmatching characteristics for each of the variables were counted and then sorted. We chose a reduction to two dimensions for optimal visualisation, started the procedure with a random initialisation and iterated it 100 times to ensure a robust result. We drew a hull around all observations belonging to a particular decision context to emphasise membership. We used an analysis of similarities (ANOSIM) to test statistically significant differences between the three decision contexts within the ordination (function "anosim", package "vegan"), and subsequently used vector fitting to test the significance of decision context for the ordination (function "envfit", package "vegan").

Table 2 Overview of the ten case studies with numbers of sociocultural valuation (SCV) applications, and the decision contexts, formats, methods, and participants involved

Short name	Pentland Hills	Irish Coast	Inner Forth Wetlands	Montado	Grenoble Region	Lower Danube	Grenoble Region	Barcelona	Balearic Islands	Wine production
Case study	Pentland Hills Regional Park: Value and future management	Cultural seascapes: Sociocultural benefits of the Irish coastline	Inner Forth: Cultural value mapping along the Inner Forth	More than Cork: Cultural Landscapes in the Montado	Residential development in peri-urban Edinburgh	Traversing waters: waterway management in the lower Danube	Land use legacies: looking at territorial development in the central Alps	Desert in the city: Urban dunes in Barcelona	Blue Carbon in the Balearic Islands: The future of seagrass	Values and Vines: Reaching out to consumers on responsible wines
No. of SCV applications of individual case study	6	3	9	6	1	6	7	2	4	4
Decision contexts	X	X	X	X	X	X	X	X	X	X
Awareness	-	-	-	-	-	-	-	-	-	-
Raising	X	X	X	-	-	X	X	-	-	X
Accounting	X	-	-	-	-	-	-	-	-	-
Priority Setting	X	X	X	-	-	X	X	-	-	X
Instrument	X	-	-	-	-	X	-	X	X	-
Development	-	-	-	-	-	-	-	-	-	-
Liability	-	-	-	-	-	-	-	-	-	-
Methods	X	-	X	-	-	-	-	X	-	-
Content	-	-	-	-	-	X	X	-	-	-
Multi-criteria analysis	-	-	-	-	-	X	X	-	-	-
Narratives	-	X	X	-	-	-	X	-	-	X
Participatory mapping	X	X	X	-	-	-	X	-	-	-
Preference assessment	X	X	X	X	X	X	X	-	X	X
Scenario assessment	X	X	X	-	-	X	X	-	-	-
Formats	X	X	X	X	-	X	X	-	-	-
Workshop	-	-	X	-	-	X	-	-	X	X
Interview	X	-	X	-	X	X	-	-	X	X
Survey	X	-	-	-	-	-	X	X	-	-
Observation	X	-	-	-	-	-	-	-	-	-
Participants	X	-	X	-	X	X	-	X	X	X
Public	X	X	-	X	-	X	X	X	X	X
Stakeholders	X	-	-	X	-	X	-	-	-	-
Experts	X	-	-	X	-	X	-	-	-	-

The second statistical analysis aimed at discovering how specific methods, formats and participants were combined in our dataset and which were most frequently combined to what purpose. To do so, we used classification tree analysis, as the special case of the classification and regression tree (CART) analysis dealing with variables of nominal character. CART determines the most important variables and their value to split up dataset for a target variable (Breiman et al. 1984). To compute a CART, the dataset is split into subsets based on the variable and its specific value with the highest discriminative power for the dataset. In recursive partitioning, this process is repeated on each derived subset. The recursion is completed when the derived subset has the same value of the target variable, or when splitting no longer adds value to the predictions, e.g. because the generated groups become too small. Based on the discriminating power of decision context identified in the NMDS, we chose decision context as the target variable, and quantified the probability that a certain decision context is addressed depending on the combinations of methods, formats and participants providing in the 48 applications. We used the splitting index “information” for the partitioning and allowed a minimum of five observations for a split to be attempted. We used the R package “rpart” with recursive partitioning to conduct this analysis (Therneau et al. 2016).

All calculations were performed with the statistical software R version 3.3.3 (2017-03-06; R Core Team 2017).

Results

Overview of sociocultural applications

Unique combinations of decision contexts, methods, formats and participants presented in the ten case studies resulted in 48 distinct SCV applications (Table 2). In 9 out of 10 case studies, several individual applications were carried out within a single case study. All case studies covered awareness raising within the range of their decision contexts, i.e. to capture the sociocultural value of ES, possible differences between groups of people and make decision-makers aware of these values. Many multi-application studies followed one or two additional decision contexts, in either priority setting or development of instruments.

Awareness raising was the dominant decision context among the 48 applications (53%), followed by applications for priority setting (32%) and instrument development (15%) (Fig. 1a). Accounting and litigation issues were not addressed in these local-to-regional scale studies. The case studies cover the entire range of key methods. The dominant method within the 48 applications includes preference assessment with 53% ($n = 25$). Scenario analysis was used by 15% of the applications ($n = 7$), participatory mapping by 11% ($n = 5$), MCA by 9% ($n = 4$) and deliberative/narrative methods by another 9% ($n = 4$) and the remaining 6% used content analysis either investigating social networks or existing management plans ($n = 3$) (Fig. 1b). Over

50% of the 48 applications used workshop formats to elicit sociocultural values ($n = 25$), followed by structured surveys with 26% ($n = 12$) including face-to-face, online and telephone surveys, in-depth interviews with 15% ($n = 7$) and observational studies with 6% ($n = 3$), such as counting visitors to different stretches of urban beaches (Fig. 1c). In terms of people involved, out of the 48 applications, the public was addressed by 32% ($n = 15$), stakeholders by 30% ($n = 14$), combined groups of stakeholders and experts by 28% ($n = 13$) and combined groups of stakeholders and the public by 11% ($n = 5$) (Fig. 1d). Most case studies address several groups of people, i.e. a combination of the public, stakeholders and experts, in subsequent SCV applications.

Variation in methods, formats and stakeholders for diverse decision contexts

The choice of SCV methods, data collection formats and participants involved was not equally distributed between applications of different decision contexts (Fig. 2). The majority of the applications for awareness raising chose preference assessments as their main methods (> 60%), applications for priority setting used predominantly either preference or scenarios assessments (in sum > 80%) and applications for instrument development made use of a wider range of methods, including also content analysis, MCA and again preference assessment (in sum > 60%). Some methods occurred predominantly in particular decision contexts, e.g. narrative methods for awareness raising, scenario assessments for priority setting or more structured methods like MCA or content analysis for instrument development. In contrast, preference assessments were used widely in all decision contexts. We find a similar dominance within the data collection formats used in our sample where workshop formats dominate across all decision contexts, whereas surveys show a peak for awareness raising. Looking at the participants addressed, the applications for awareness raising and priority setting show very similar distributions with a slight focus on the general public and stakeholders (in sum > 60%). Applications for instrument development show, by contrast, a shift towards a more knowledgeable group of participants, and involve most often combined groups of stakeholders and experts (> 60%).

SCV applications following the same decision context are grouped when we plot the results of the NMDS (Fig. 3). In particular, studies that aim for priority setting show a clear distinction to studies for awareness raising or instrument development. Applications for awareness raising and instrument development show some overlap, with heterogeneity between applications for instrument development being larger than between applications for awareness raising. Testing the similarity between SCV applications in ANOSIM reveals that the groups of applications for specific decision context differ from each other with a significance level of 0.001.

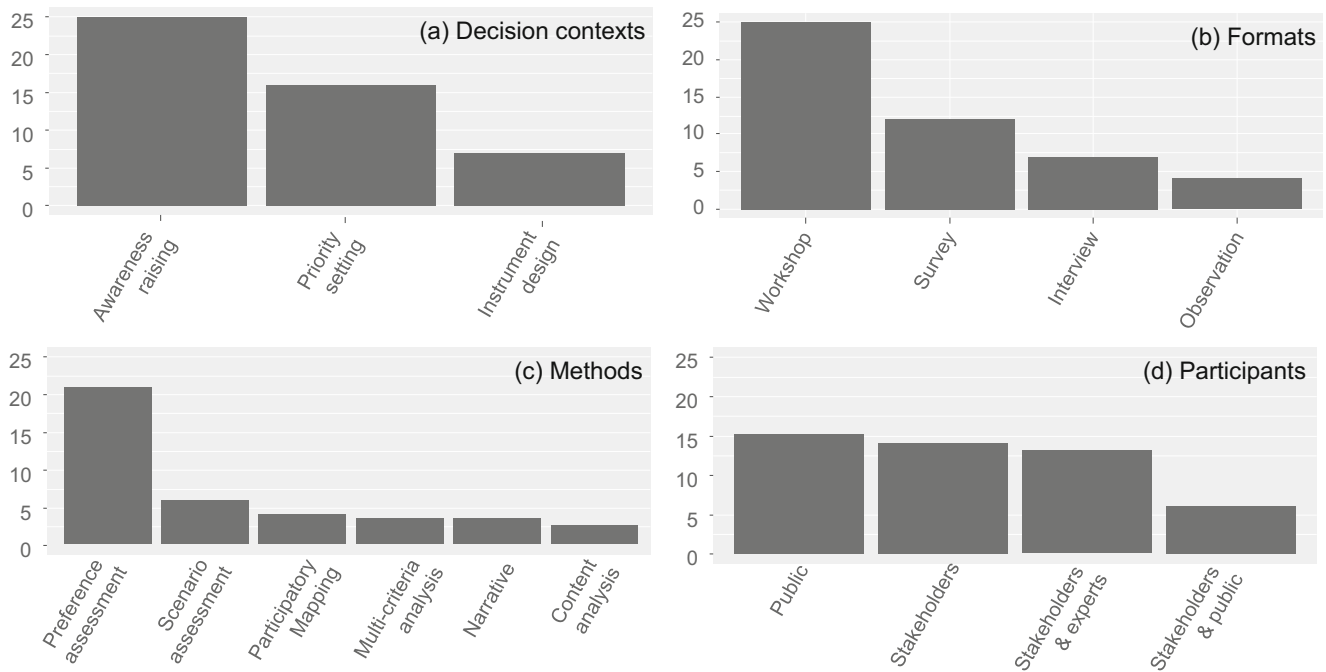


Fig. 1 Number of applications addressing different **a** decision contexts, **b** formats of data collection, **c** methods and **d** participants

Along the orthogonal axes, combining methods, formats and participants, applications of the same case studies are not particularly clumped, as the distribution of case studies specific colours indicate (Fig. 3). One exception is the Balearic Island case study where awareness raising was dominant among the social valuation applications, including mainly interviews and surveys among different groups of participants. Figure 3 also indicates, that the distribution of applications within the orthogonal space of the NMDS cannot be explained by a single factor, but only the combination of application characteristics. For instance, the methods used are not clumped (highlighted in Fig. 3 through symbols).

Choices of methods, formats and participants for decision contexts

The CART reveals that particular combinations of methods, formats and participants were more common for certain decision contexts (Fig. 4). The choice of method is identified as the dominant criteria to classify the applications. Preference assessments and narrative methods versus all remaining methods are the first discrimination criteria to group the dataset, and the remaining methods are further split between MCA and content analysis versus a node that groups all applications using scenario analysis and participatory mapping. Also, the choice of formats and participants are decisive at

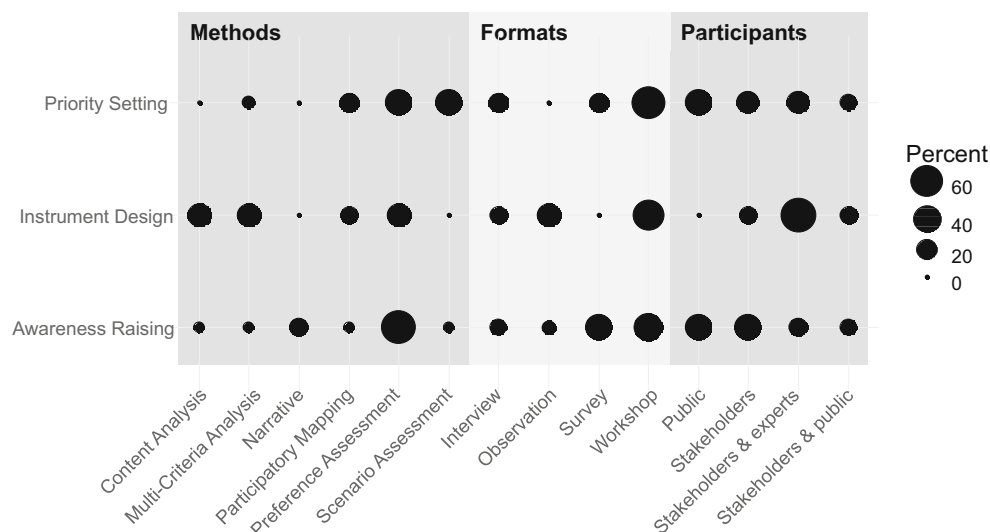
lower levels indicating that the combination of the three is essential to identify typical methodological setups for different decision contexts.

Preference assessments and narrative were the dominant methods within the investigated SCV applications with 51% of all methods used in the overall sample. In the format of workshop and surveys, they were mainly used for awareness raising (79%), and only to a lesser extent for priority setting (17%) and development of instruments (4%). Similarly, typical is the use of scenario assessments and participatory mapping for priority setting, which is the decision context of 75% of applications using these methods. Not surprisingly, highly formalised and information intense MCA and content analysis turn out to be the most common methods for the development of instruments.

Discussion

The increasing policy relevance of the sociocultural value of ES for integrated valuation (e.g. Jacobs et al. 2018) calls for methodological advice and practical examples from the ES community. In this study, we investigate a total of 48 independent SCV applications from ten case studies to uncover methodological choices in SCV within specific local-to-regional decision contexts. Based on this limited sample size, our

Fig. 2 Percentage of applications of sociocultural valuation ($N=48$) employing particular methods, formats of data collection and groups of participants for different decision contexts



findings provide first evidence about typical methodological choices in SCV for different decision contexts.

Multi-application approaches

We found that almost all case studies encompassed several applications of SCV. This demonstrates that SCV on a local-to-regional scale very often is part of an elaborate process to discuss and incorporate the role of ES in local-to-regional natural resource management. Such a process might have been designed as a step-by-step processes right from the beginning, such as in the Grenoble case study, where the procedure had been elaborated in an early stage between stakeholders and researchers (Bierry et al. 2015); or it develops over the course of action towards a vivid dialogue, such as in the Pentland Hill case study, where collaboration evolved dynamically including initiatives of additional high-level actors (Schmidt 2018).

Decision context

Awareness raising, i.e. establishing and communicating knowledge of values and preferences that people hold and assign to ES, was the prominent decision context in our data set (53%). The case study of the Balearic Islands reflects this particular decision context, for instance, through the capture of perceptions and level of knowledge on the Mediterranean seagrass *Posidonia oceanica* among both the public and stakeholders (Ruiz-Frau et al. 2018), or for wetland along the Danube in Bulgaria (Scholte et al. 2016). Awareness raising built the first step towards applications with more concrete decision contexts, such as priority setting (32%) and instrument development (15%). This reflects the need to first raise and build awareness on the sociocultural value before incorporating them in more concrete decision contexts. For instance, capturing the sociocultural value of the Pentland Hills Regional Park through

user surveys helped to raise sufficient awareness across stakeholder groups to open issues such as priority setting in the future management of the park and the potential alignment of the Regional Park Management Plan to the ES concept (Schmidt et al. 2018). Priority setting is also targeted in the WeLCA tool developed in the wine case study, which helps winegrowers to prioritise conservation actions in the vineyard based on their preferences and feasibilities (<https://oppla.eu/product/17473>). We acknowledge awareness raise as the first necessary step towards integrating the sociocultural value of ES in decision-making. However, this should not obscure the high potential of SCV also for more concrete decision contexts, such as priority setting and instrument development, as demonstrated in many of the case studies.

However, two of the five decision contexts suggested by Jacobs et al. (2018) were not covered by any of the included studies, namely litigation and accounting. The lack of applications on litigation reflects the general scarcity of ES approaches in legal issues (Phelps et al. 2015; Jacobs et al. 2016), and a particular under-representation of sociocultural values (Kroeger and Casey 2007). How sociocultural value can be recognised in litigation, is currently still a prevailing issue, some advances include first concepts (e.g. for remediation of rivers in Ireland, Bullock and O'Shea 2016) and implementations (e.g. accounting for pollution damages in the Ecuadorian Amazon forest as reported by Kallis et al. 2013). The lack of applications for accounting in our sample needs to be explained by our explicit focus on highly contextualised regional-to-local studies. As ES accounting is strongly motivated by national obligations to monitor ES for the convention on biodiversity, and therefore targets mostly national level (e.g. Weber 2014; Maes et al. 2016; Schröter et al. 2016). Within the European MAES project, SCV is explicitly suggested as an important asset in ES accounting (Maes et al. 2016), and has been investigated intensively either based on proxies (e.g. Paracchini et al. 2014), social

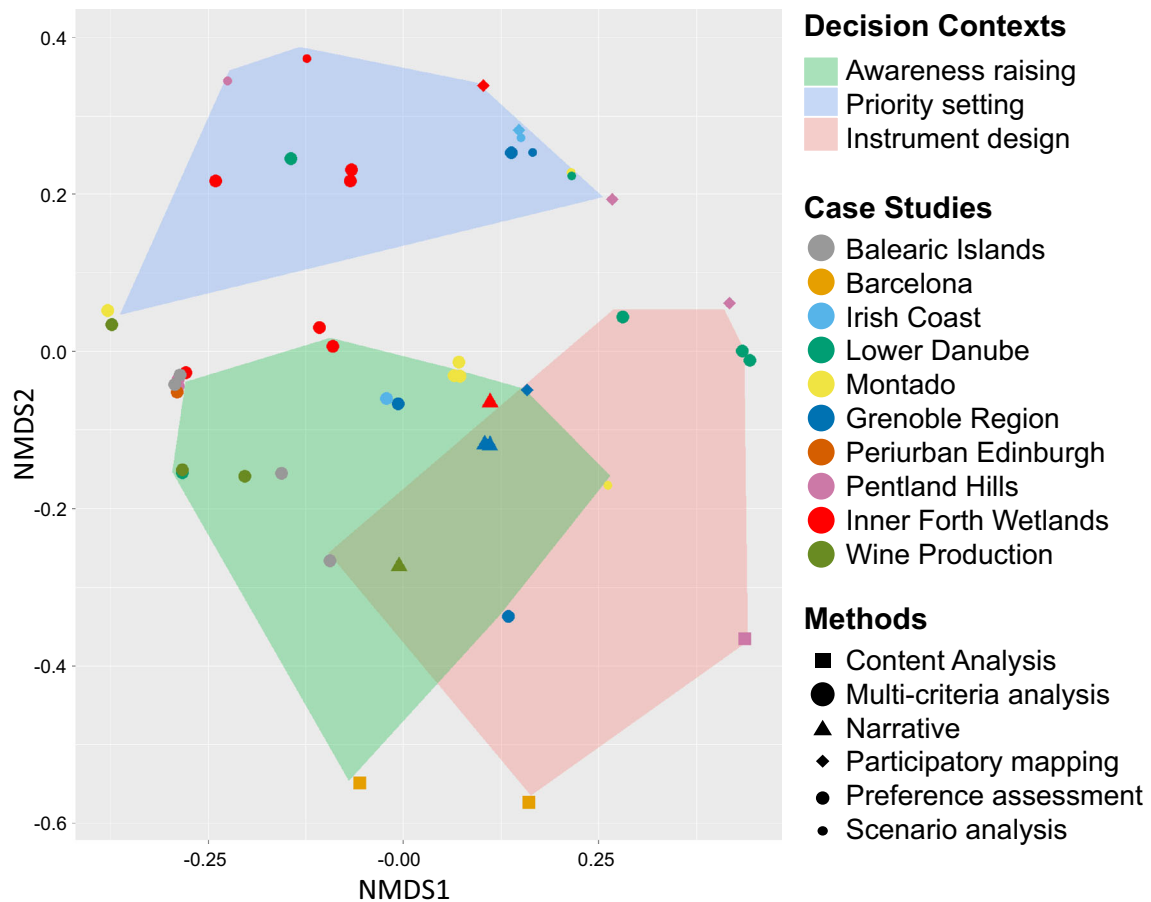


Fig. 3 Distribution of the 48 applications within a two-dimensional, orthogonal space based on non-metric multidimensional scaling (NMDS), points are jittered to make them all visible. The two synthetic axes are the product of optimised dissimilarity measures based on the choice of methods, formats, participants and decision contexts of each

application. The three convex hulls comprise all studies of a specific decision context. The colour of the symbol refers to the case study the applications belong to. The shapes indicate exemplarily one of the variables describing the application and used for the NMDS, here the method used in an application is displayed

media (e.g. Figueroa-Alfaro and Tang 2017) or combined approaches (Komossa et al. 2018).

Methods

The dominance of preferences assessment is generally widespread in SCV of ES, not only in this sample (e.g. Lamarque et al. 2011; Martín-López et al. 2012; Zoderer et al. 2016). Preference assessments are the most common method to capture the value of ES and raise awareness among decision-makers, and thus are the entry point to most SCV approaches of ES. They are also common for priority setting and instrument development, where usually preferences for distinct future options or policy instruments are then asked for. The great advantage of preference assessments includes a relatively simple setup with a list of distinct options (e.g. ES or management options) which are then rated. Despite all methodological uncertainties (Hou et al. 2013), preference assessments can be easily understood by the participants, and allow approaching a large number of people for their opinion, and thus can quickly give an impression of the sociocultural values of ES.

For priority setting, scenario analysis is a second dominant method, which by contrast does not play an important role in any other decision context. Participatory scenarios analysis is an established, adaptable tool for natural resource management (e.g. Walz et al. 2007; Walz et al. 2014; Reinhardt et al. 2018). Most scenario assessments are conducted in workshop formats, where plausibility, including trade-offs between ES, can be regularly checked in group discussions. But we also find scenarios developed by individuals within our sample, here an interactive app was used that incorporated already major trade-offs (LANDPREF, <https://www.oppla.eu/product/2099>).

Methods used for the development of instruments to manage ES show a tendency towards more structured methods, including formal MCA and content analysis, but generally do not show clear tendencies in the methods used. This could be the result of the limited and highly diverse sample of 15 applications, addressing a wide range of instruments from formal management planning in a regional park to practical measures, such as removal of reed in a wetland.

Both quantitative methods, such as survey-based preference assessments or MCA, as well as deliberative methods,

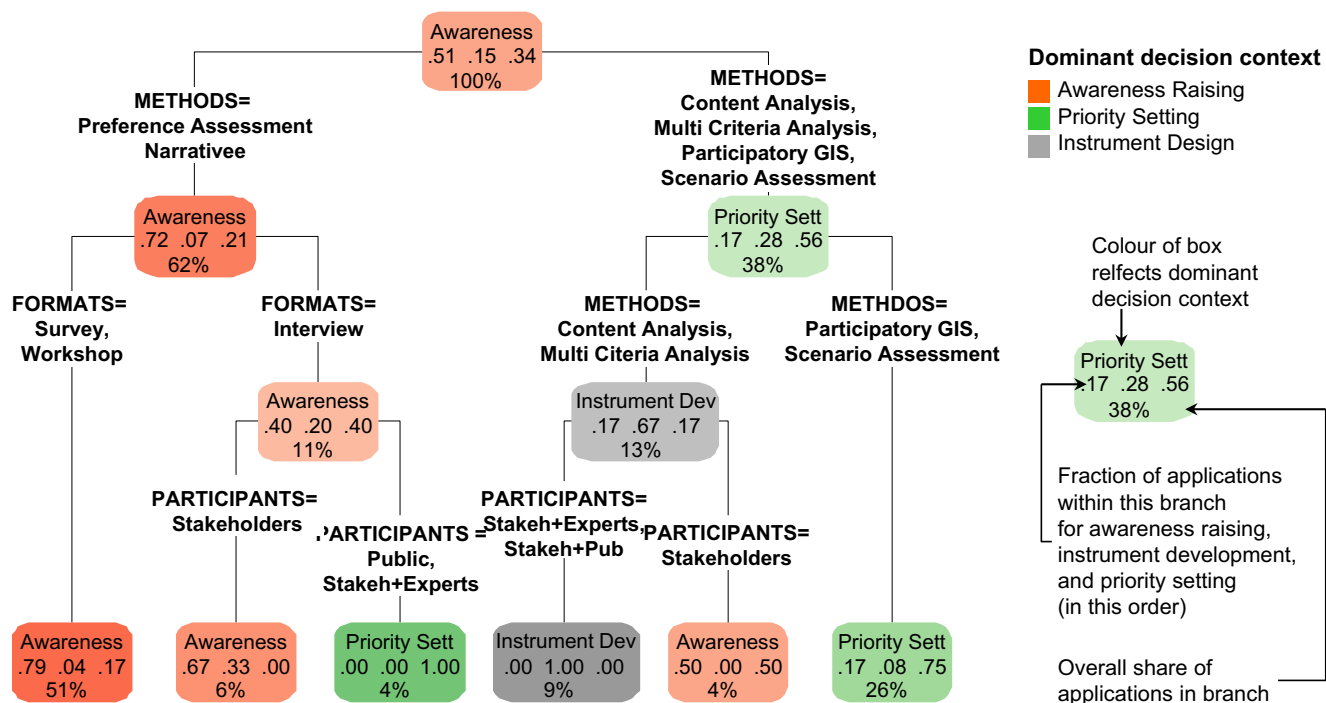


Fig. 4 Classification tree indicating the principal combinations of methods, formats and participants for specific decision contexts and classification criteria among all 48 applications studied here. The colour of the boxes indicate the decision context of the majority of applications grouped in this node. The three fractions within the boxes relate to the

three possible decision contexts (first: awareness raising, second: instrument development, 3rd: priority setting). Percentages within the boxes indicate the proportion of all applications grouped in this node. The conditional statements at the branchings indicate the criteria for the left branches, with the remaining values going to the right branch

such as in-depth interviews or workshops, have been used within the 48 SCV applications. However, there is still a tendency towards quantitative and more structured methods. This reflects to some extent that much ES research is still predominantly conducted by quantitatively oriented researchers, and suggests that much of the potential of qualitative methods is not fully exploited. Making better use of qualitative and quantitative social science techniques by combining them, has lately been promoted in the environmental social science (Vaccaro et al. 2010), and could also be a strong step forward towards improving our fundamental understanding the role of ecosystems and ES for the well-being of people.

Formats

The vast majority of the applications (93%) within our dataset directly approached people. This is typical for many regional-to-local studies. Knowledge was drawn through workshop (51%), surveys (26%) or interviews (15%). All three formats have proven highly valuable to capture sociocultural value, preferences, conflicting interests between groups of people and spatial hotspots of human benefits from ES. Mainly semi-structured to open interviews have been used to improve our knowledge on held values and the reasoning behind the assigned values, mostly in combination with narrative methods.

At the same time, however, all these direct formats strongly intervene with the people involved and by themselves can influence the perception, knowledge and preference of ES. Such effects have been revealed for workshop formats as the most interactive format (Murphy et al. 2017; Kenter et al. 2016), and are likely to be triggered also by formats that approach individuals, such as interviews and surveys. This interaction can increase the awareness of the addressed and improve the understanding of underlying ecosystem functions, trade-off between ES or synergies. In the Balearic Islands case study, for instance, raising the issue of the role of the seagrass *Posidonia oceanica* for society and providing some information during interviews lead to an increased willingness to make trade-offs between positive (services) and negative (disservices) aspects associated with *Posidonia* (Ruiz-Frau et al. 2018). In most cases, such side-effects of the valuation procedure are not problematic, but if such effects are to be avoided, observational studies and the use of proxies are more appropriate.

Participants

Our results show that the public and stakeholders are mainly involved in awareness raising and priority setting, whereas experts and stakeholders dominate the development of instruments. This is not surprising, as the degree of details and the

technical and administrative knowledge required for the development of instruments is a lot higher. None of the applications involved experts only, which underlines that all our studies seek to capture the genuine sociocultural value and not expert opinions on this value.

Many SCV applications in our sample approached stakeholder representatives, e.g. selected individuals of the tourism association, instead of a representative sample of tourists or hotel owners. To target stakeholder representatives in SCV has great advantages, as they are usually outspoken and knowledgeable. But limiting SCV to stakeholder representatives also has disadvantages, since it makes it difficult to discern whether the views collected are a true representation of the group. Furthermore, the selection of these stakeholder representatives is critical to ensure a complete picture and legitimacy of the results. Systematic stakeholder analysis, accounting also for opposing views within the same stakeholder group as well as stakeholders which might not be organised, is essential for a representative selection of the individuals.

Typical combinations

Investigating our sample of empirical SCV applications, methods were revealed as the most decisive factor to discriminate between decision contexts. But also formats and participants were important at lower levels of the classification. This indicates that the combination of the three factors is essential to identify typical methodological setups for different decision contexts.

Given the ex-post-analysis of the SCV application, this classification hierarchy in the CART differs from the sequence of steps in designing a SCV study where the people to be approached, and the data collection formats are usually decided before the methods. The CART fails, for instance, in indicating the tendency in approaching stakeholder representatives and experts for instrument development. This can be attributed to (1) the dominance of applications for awareness raising and the lower representation of instruments development in the overall sample, and (2) the compensation by the choice of the method due to its correlation to decision context, format and participant.

Methodological limitations

We described the SCV application based on classifications building on the current literature. These classifications can, of course, be debated. For instance, overlaps between the decision context “awareness raising” and “priority setting” might exist, when a survey asks to list preferences in future ES supply. If the question would ask preferences for current ES supply, the application would clearly be assigned to awareness raising, and if the question would have explicitly accounted for trade-offs, the applications would have been assigned to priority setting. But in the given case, the final assignment remains ambiguous, even after deeper

consideration of the application’s context. To reduce ambiguity in the involved groups of participants, we collapse the group of decision-makers with stakeholders. This simplification seemed appropriate, as most decision makers also follow personal or political interests, and many stakeholder representatives can, to some extent, take decisions.

We present here a descriptive analysis of the characteristics of SCV applications, without measuring suitability and impact. We refrain from doing so, as we are convinced that impact should rather be defined at the level of entire case studies ideally capturing also ecological and economic value, instead of single SCV applications (see also Patenaude et al. 2018, this issue).

Our sample size limits to some extent the ability to generalise our results. The selected sample of 48 SCV applications within ten case studies made it feasible for us to communicate individually with the researchers conducting these SCV applications. In doing so, coherent descriptions of the applications, in particular with respect to the decision contexts sensu Gómez-Baggethun and Barton (2013), could be ensured—at the cost of a more extended pool. A systematic search of empirical case studies on SCV or opening up the database to applications of similar projects with a strong focus on operational use of the ecosystem service concept would have led to a larger sample size. From our perspective, a larger sample size would have mainly two valuable effects:

- (1) It would complement mainly the range of methods covered in our study. The set of SCV methods presented in Jacobs et al. (2018), for instance, includes additional techniques based on visual media, games and time use. However, we assume, the number of decision contexts, formats and stakeholders involved would have not considerably changed with more local-to-regional SCV applications. The identified gap of SCV studies in the context of litigation, for instance, is not a result of our limited sample. Even a targeted search could not identify SCV applications in that decision context; it thus reveals an existing knowledge gap when it comes to the operational use of integrated, multi-dimensional valuation of ES.
- (2) It could enhance the relevance of the classification tree analysis. The presented classification tree structures our dataset for decision contexts. Three hierarchical levels seem a minimum to understand the role of different criteria in this structure. But for three levels, our limited sample size and the uneven distribution of samples between decision contexts result in several very small nodes. This leads to a purely descriptive value of the presented classification tree. We assume a larger sample size with similar proportional coverage of all three decision contexts would result in a more robust pattern of the decisive criteria. With a large enough sample, bootstrapping techniques could further enhance the robustness of the classification tree and avoid overfitting (used for instance in Fan et al. 2013).

Practical implications

This research demonstrates how methods, formats and stakeholders involved in SCV change according to decision context. The identified methodological patterns represent an overview over important factors of SCV. In combination with information on resource intensity and options to combine them with economic and ecologic valuation (Jacobs et al. 2018), these factors can support future research and assessments in the context of practical decision-making. Integrating not only economic values (e.g. via resource use) and ecologic value (e.g. via protection status), but also the sociocultural value that people assign to ecosystems is a big step forward towards a more democratic way to manage ecosystem and the services they provide (Dick et al. 2018; Jacobs et al. 2018). This is true for all decision contexts, although we only show applications for awareness raising, priority setting and instrument design. As explained earlier, our focus on regional-to-local scale explains the lack of studies that relate to accounting in our study. However, the lack of SCV in the context of litigation is indeed problematic, in particular, because the commonly used monetary valuation and subsequent financial compensation reveal its limitations too. as shown in the case of pollution of the Amazon rain forest caused by oil operations in Ecuador (Kallis et al. 2013). Establishing SCV for ecosystems and the services they provide, can help to recognise loss beyond the realm of financial damage and compensation also in court. In the case of the lawsuit against oil operations in Ecuador, a clear distinction was, for instance, made between claims for damage and restoration costs and social losses. These social losses were related to values of recognition, responsibility and honour that went beyond money and led to the claim for a public apology (Kallis et al. 2013).

Conclusion and outlook

Our ex-post-analysis of 48 SCV applications from ten regional case studies demonstrates that SCV is most often embedded in a number of additional activities, and is thus part of a wider dialogue. It captures people's perception and preferences and creates exchange between different parts of society, from the general public to organised stakeholder groups and experts.

Raising awareness for the sociocultural value of ES by capturing people's perspective and establishing the status quo was found the first decision context in all case studies, and sets the scene for further SCV in more concrete decision contexts. The applications for priority setting and instrument development demonstrate the potential to include SCV also in these decision contexts. However, the number of SCV applications decline with more concrete decision contexts. None of our SCV application addressed litigation issues; given the increasing importance of perception in legal cases to prevent or

compensate for decline of ES, we see considerable demand for research in this area.

Decision contexts control typical combinations of methods, data collection formats and participants in SCV studies. The hierarchy of factors indicates that decision context strongly determines the choice of methods. In particular, preference assessments and scenario assessments show a strong link to specific decision context, namely awareness raising and priority setting. The classification hierarchy of this ex-post-analysis differs from the sequence of steps in designing a SCV study, where people to be approached and the data collection formats are usually decided before the methods, but clearly underlines the importance of the decision context in the overall study design.

The common methodological choices for different decision contexts represent an overview over important factors of SCV and support future assessments for practical decision-making. Integrating the ecologic, economic and sociocultural value of ES is a big step forward towards a more democratic way to manage ecosystem and the services they provide.

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