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Comparing landscape value patterns between participatory mapping and geolocated social media content across Europe

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HIGHLIGHTS

- We compare the use of PPGIS and Flickr in landscape value assessments.
- Landscape values and their spatial patterns are compared across sites.
- We find more cross-site differences than similarities both in spatial patterns and value types.
- PPGIS elicits a wider spectrum of values, while Flickr mainly elicits relationships to and with landscapes.
- We recommend a complementary use in future landscape value studies.

ABSTRACT

In this study, we bring together participatory mapping and analysis of geolocated social media content from the Flickr platform in an assessment of similarities and differences in their utility for landscape value elicitation. We do so in a Pan-European context comparing types of landscape values and their spatial patterns across 19 case sites in 11 European countries. Across these sites, we find great variety in volume, types and spatial patterns of landscape values elicited from participatory mapping by local people and opportunistic use of tags and image locations crowdsourced from Flickr. Most agreement in spatial patterns across the two data sets are found in densely populated landscapes; however, comparison of types of perceived landscape values is challenged by the differing assumptions of each value elicitation technique. We argue for the complementary potential of both approaches and highlight the strengths and weaknesses of using the two together in landscape research, planning and management. An integrated approach is likely to increase the inclusiveness of landscape value assessments.

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1. Introduction

The geographic information universe is experiencing inflationary growth, fuelled by open georeferenced data, sensors, environmental imagery, and social media, allowing capture, monitoring and tracking of citizens' values, preferences and behavioural patterns (Helbing, Caron & Helbing, 2019; Miller, 2020). At the same time, landscape sustainability science is undergoing growth in participatory planning ideals with focus on deliberative processes, co-creation and inclusion of diverse values for integrated landscape planning and management (Albert, 2019). Environmental policy and decision-makers are increasingly seeking out new approaches to integrate different value concepts and valuation methods, promoted under the concept of 'plural valuation' (Pascual, 2017; Zafra-Calvo, 2020). Plural valuation seeks to inform not only the efficient allocation of resources, but also support a range of environmental justice, equity and well-being goals.

Here we focus on plural valuation from the perspective of comparing two different approaches for value elicitation, namely: a) actively contributed data from participatory mapping and b) passively contributed geolocated data from social media. Participatory mapping techniques aim to support the inclusion of diverse values held by residents, visitors, and various stakeholders into integrated landscape management. In public participation geographic information systems (PPGIS), participants are actively recruited to purposely map socio-cultural values or place values about specific landscapes (e.g., Brown, Reed, & Raymond, 2020; Fagerholm, 2019). PPGIS participants typically use a predefined, top-down typology designed to capture notions related to place-based perceptions and experiences. Landscape value elicitation by PPGIS approaches have been applied in different planning contexts. Examples include participant mapping of landscape values to support protected area planning (Engen, 2018; Strickland-Munro, 2016), landscape planning (Fagerholm, 2019; Plieninger, 2018), and green space planning (Ives, 2017; Rall, Hansen, & Pauleit, 2019).

In contrast, social media data is contributed by online communities for other purposes, and thus can be differentiated from active data elicitation as *passive crowdsourcing*. Such data are opportunistically extracted by researchers and planners to conceptually and spatially elicit landscape values such as cultural ecosystem services (e.g. Richards & Tunçer, 2018) and relational values (e.g. Calcagni, 2019). In this study, we focus on social media data crowdsourced from Flickr. Flickr is a photo-sharing social media platform that is especially popular for sharing nature-related content (Di Minin, Tenkanen, & Toivonen, 2015). Globally, more than four billion photos are shared at Flickr (Flickr 2021) with estimates of the proportion of geolocated images of around 4% in 2016 (Dunkel, 2016). Compared to the top-down categorisation of landscape values used by PPGIS participants, Flickr users tag images to make them distinctive yet findable in an indexing system, thus building a bottom-up folksonomy (Beaudoin, 2007) dominated by basic level and superordinate terms well suited to this task (Rorissa & Iyer, 2008). Flickr has been used as an indicator of nature-based tourism (Donaire, Camprubí, & Galí, 2014; Wood, 2013) and in many studies to assess landscape values such as cultural ecosystem services in multiple types of landscape, e.g. rural landscapes (Oteros-Rozas, 2018), river landscapes (Hale, Cook, & Beltrán, 2019) and urban green spaces (Depietri, 2021). Similar to the use of PPGIS approaches, landscape elicitation using content from the Flickr platform has been used to support protected area planning (Tenkanen, 2017; Walden-Schreiner, 2018), landscape planning (Wartmann & Mackaness, 2020), and green space planning (Donahue, 2018; Hamstead, 2018).

The values data collated using active participatory mapping techniques and passively crowdsourced data are rarely compared. A few case studies have previously contrasted and discussed PPGIS and Flickr approaches in protected area contexts (Levin, Lechner, & Brown, 2017; Muñoz, 2020) and within urban green spaces (Depietri, 2021; Heikinheimo, 2020). However, we are not aware of studies that have systematically and empirically compared PPGIS and social media data in terms of type, intensity, distribution and overlap of values across multiple study areas in different countries. Such cross-site investigations are important because the geographies of social media do not reflect underlying national borders and populations (Graham, Stephens, & Hale, 2013). Further, different value elicitation methods have different levels of spatial data quality and accuracy (Brown, 2012; Jacobs, 2018), which require further examination to better understand their relative and combined usefulness in integrated landscape planning and management.

In this study, we bring PPGIS and Flickr approaches together in an exploration and discussion of their similarities and differences in eliciting landscape values. In contrast to previous comparative studies focused on single study sites in a protected area context, we focus on rural to *peri*-urban landscapes and expand the analyses from a single case area to cross-site analyses of 19 landscapes across Europe. We argue that in order for planners to harness the qualities of both landscape value elicitation approaches, we need to place a spotlight on strengths and shortcomings of each approach and identify core opportunities for complementary use. We do this by examining two research questions:

1. What are the cross-site similarities and differences in the spatial distribution, intensity and type of landscape values elicited using PPGIS and Flickr approaches (hereafter referred to PPGIS and Flickr data)?
2. To what extent are cross-site similarities and differences in the spatial distribution of landscape values related to different social-ecological characteristics of the study sites (site characteristics)?

2. Material and methods

Before describing our method in detail, we first elaborate on how data created through PPGIS and Flickr approaches have been used for similar landscape value purposes, and how we conceive the two as methodological approaches as worth a detailed comparison despite their different points of departure.

2.1. Conceptual basis for eliciting landscape values using PPGIS and Flickr

Common to PPGIS elicitation of landscape values is participant mapping of contextualised values that have been formulated according to project and planning specific needs (e.g. protected area management). Further, smaller focused study sites are common across PPGIS applications, and recruitment of participants are usually based on representative and stratified approaches although crowdsourced sampling of participants also takes place (Brown & Fagerholm, 2015; Brown & Kyttä, 2014).

Landscape values elicited by use of data from the Flickr platform is often based on content coding of images and/or accompanying text, adapted to the project and planning focus. In contrast to PPGIS studies, sampling is opportunistic, and examples of application use vary across scales from the local (Levin et al., 2017) to assessing values for entire continents (Figueroa-Alfaro & Tang, 2017; Havinga, 2021).

PPGIS and Flickr both generate data that express landscape values and which are used for very similar purposes in planning, management and research. However, they come with very different limitations and strengths. First of all, Flickr data through volume covers 'breadth' across landscapes, while PPGIS provides an opportunity for context rich data – 'depth' – of a single landscape (Verplanke, 2016). Moreover, in terms of engagement, PPGIS builds on active engagement around participatory mapping activity, whereas Flickr makes use of data created for other purposes (Bubalo, van Zanten, & Verburg, 2019). Further, PPGIS generates stated value preferences (according to planning/project aims), whereas Flickr reflects revealed preferences (Ghermandi, 2018; Tieskens, 2018).

Despite these fundamental differences, we argue that the similar use of both approaches to elicit landscape values justifies a careful comparative analysis. We know from the few previous comparative analyses carried out so far that there are indeed differences between the two. Studies focused on single sites reported large spatial differences in comparative distributions; Flickr data was mostly concentrated in popular and accessible areas, whereas PPGIS data also covered less popular and less accessible areas (Depietri, 2021; Heikinheimo, 2020; Levin et al., 2017; Muñoz, 2020). Further, it was noted that PPGIS data was better than Flickr data to assess full range of protected area values (Levin et al., 2017), e.g. 'existence value' (Muñoz, 2020) and 'recreational services' (Depietri, 2021), whereas Flickr was successful in assessment of 'aesthetic values' (Depietri, 2021) and 'scenic landscape' values (Muñoz, 2020).

The comparative findings from these four studies are though highly contextualised. Indeed, because landscape values are shaped in specific sociocultural and biophysical contexts, they also are termed contextualised or assigned types of values (Kendal & Raymond, 2019; Rawluk, 2019). However, we do not know if contextualised findings of differences for individual study sites are replicated across study sites with different social and ecological properties. Hence, in our study we explore similarities and differences at sites spanning different social and ecological properties across Europe.

2.2. Study areas

This study was performed at 19 study sites in 11 European countries (Fig. 1) identified in two separate European Union Framework Program 7 funded research projects, Agforward and Hercules. The sites were predominantly agricultural landscapes and form consistent social-ecological units (i.e. local areas sharing similar biophysical and socio-economic properties, Martín-López, 2017). All study sites included towns and urban areas, and were examples of multifunctional landscapes hosting mosaics of different land covers allowing for multiple uses and functions. They spaned a gradient of land-uses and biogeographic settings, differing in area between 24 km^2 and 1640 km^2 with population densities ranging from 3 to 185 inhabitants per km^2 and showed large differences in wealth (gross domestic product/capita/year: 8500–43,100 €, unemployment rate: 2.7–27.5%).The proportion of each site belonging to protected area networks varies from 0% to 84%.

2.3. Overview of methodological steps in relation to analyses

A study flowchart was developed in order to provide an overview of methods, including handling procedures and the data involved (Fig. 2). The flowchart illustrates the main methodological steps and how these were interrelated with the main comparative analyses and results.

2.4. Site characteristics across study sites

We calculated site characteristics to allow us to explore potential drivers of variation in landscape values in PPGIS and Flickr data across the study sites. These variables reflect different dimensions of human interactions with landscape and allow us to assess relationships between groups of study sites (landscapes) with high/low spatial overlap in spatial value distribution (see section 2.8).

First, social media data shows centrality (Dunkel, 2015; Sun, Fan, Li, & Zipf, 2016), and spatial values elicited by PPGIS most often reflect spatial discounting, meaning that participants mainly value landscapes close to home (Brown et al., 2020). Hence, population density seemed a relevant variable in our multifunctional landscapes. Secondly, we included GDP as a measure of economic wealth, as GDP per capita is known to correlate with urbanization levels (Chen, 2014; Fagerholm, 2019). Thirdly, accessibility relates to volume of Flickr data (Solecka, 2022) and spatial patterns of PPGIS data (Cusens, Barraclough, & Måren, 2021; Fagerholm, 2019; Garcia-Martin, 2017; Solecka, 2022). Hence, as a proxy for accessibility, the density of trails and roads was included.

In addition, certain types of land use, like forest and water surfaces/coastlines positively relate to landscape value preferences (Garcia-Martin, 2017; Plieninger, 2013; van Berkel & Verburg, 2014), and hence, share of land cover classes such as forest and water surfaces were included.

All variables required harmonised European data. Population density and mean GDP per capita was calculated for each study site using population data at NUTS 3 level from Eurostat and the Swiss Federal Statistics Office, reference year of 2014. Accessibility, in terms of trail and road density was calculated using open topographic data available from OpenStreetMap. Shares of main types of land cover were calculated using Corine Land Cover (CLC) 2018, version 2020_20u1 made available

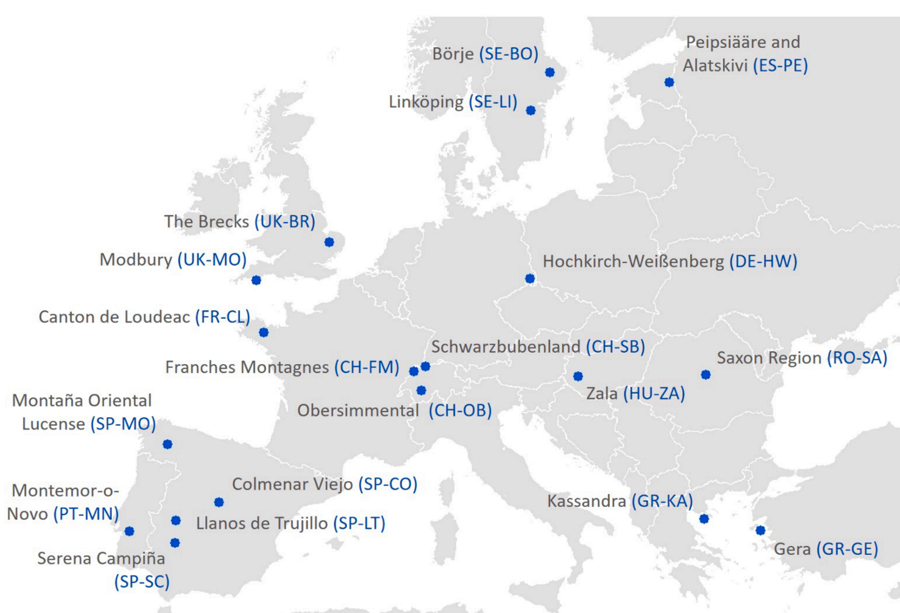

Fig. 1. Map of Europe with locations of the 19 study sites including full names and abbreviations used in the paper. The first two letters in the abbreviations indicate a country.

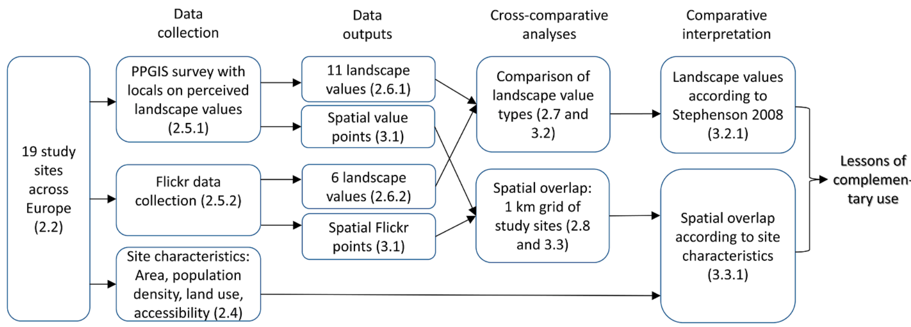

Fig. 2. Study flowchart. The number in parenthesis is a reference to the relevant section number.

by the European Environment Agency (EEA) at: https://land.copernicus.eu/pan-european/corine-land-cover/clc2018, reclassified into four main land use classes: settlement and artificial surfaces (CLC classes 111–142), agricultural areas (CLC classes 211–244), forest and semi-natural areas (CLC classes 311–335), and wetlands and water-bodies (CLC classes 411–523).

We refer to Appendix A for a description of each study site including site characteristics per study site.

2.5. PPGIS and Flickr data

2.5.1. PPGIS data collection

At each study site, we surveyed full or part time local residents through purposive stratified sampling based on the criteria of gender and age (15–29 years, 30–59 years, ≥60 years) reflecting local census data. Informants were chosen by convenience sampling on site and approached at key public locations, such as market places, cafés, schools, and health care centres. The aim and purpose of the survey was explained and we highlighted that the use of results and individual responses would remain anonymous and confidential. Participation was on a voluntary basis. The final sample was representative in respect to age and gender compared to local census data (Fagerholm, 2019; Garcia-Martin, 2017).

We carried out data collection between May 2015 and August 2016 through a web-based public participation GIS (PPGIS) survey operated on tablets and laptops. The method was pilot tested in the study area of SP-LT (Fagerholm, 2016). The survey was filled in on-site, in local languages, with the help of local facilitators provided with a manual and trained over 2–3 days to ensure data collection consistency across all study sites. Due to poor internet coverage, we performed the surveys using paper questionnaires and maps in RO-SA and manually inserted the data to the survey platform. A total of 3,027 respondents responded to the survey.

2.5.2. Flickr data collection

Our analysis focused on three dimensions of Flickr metadata: unique user ids, locations and image tags. Tags are a rich and reliable source of semantics that both reflect image content and provide insights with respect to perceived elements of the landscape (Dunkel, 2015). We collected data using Flickr's application programming interface (API), retrieving metadata for all georeferenced images within bounding boxes surrounding the sites in November 2019. We retained metadata for all unique images found within 500 m of the polygon bounding each site, irrespective of the date they were uploaded to Flickr.

To compare the Flickr data to PPGIS data we extracted two distinct dimensions. The first dimension focused on the semantics captured through user-assigned tags. To reduce any bias caused by bulk uploads and participation inequality, we identified unique tags used by unique users, and ranked these according to the total number of users using this tag for a given site. We retained all shared tags used by at least two users. The second dimension explored unique locations visited by users. Here, we were interested in exploring the extent to which users had visited (as captured by the coordinates assigned to images) specific locations within sites. Thus, we extracted all unique point locations visited by unique users for each site. Both measures reduce bias, since prolific users can only contribute a unique tag or unique location once, irrespective of how much content is associated with a tag or location.

2.6. Semantic analysis

2.6.1. Landscape value typology in PPGIS data

In the PPGIS survey facilitators stressed the focus on an informant's personal relationship with nature and landscapes in the area. The survey started by asking respondents to map their home location and their perceived landscape values as point locations (related survey question: "Do you find some particular place or area special in this landscape?"). Respondents could map an unlimited number of places or choose not to map a specific landscape value. The background map was a Bing satellite image overlaid with Open Street Map objects. A minimum zoom level of 1:25 000 was enforced to ensure spatial scale coherence in mapping. Mapped points denoted a single place or area but did not account for the size of the area mapped.

We developed a locally relevant landscape value typology (Table 1) that addressed both subjective perceptions and uses of the landscape that emerge from the direct interaction with the landscape (Setten, Stenseke, & Moen, 2012) and from the relationships among the people and between people and the landscape (Pascual, 2017). It captures a subset of individual anthropocentric self-regarding values, particularly values assigned by a person to the landscape (assigned values) (Chan, Satterfield, & Goldstein, 2012; Kenter, 2015) (for a detailed elaboration

Table 1
Landscape value typology used in the participatory mapping. The column "Descriptions" specified spatially explicit answers to the question: "Do you find some particular place or area special in this landscape?".

Landscape value	Description in the survey
Farm products	I appreciate, produce or can buy farm products here.
Harvested products	I harvest fruits, berries, flowers, mushrooms, asparagus, fish, game etc.
Outdoor activities	I practice outdoor sports, walking, hiking, biking, dog walking etc.
Social interactions	I spend time together with other people.
Aesthetic values	I enjoy seeing this beautiful landscape or landmark.
Culture and heritage values	I appreciate the local culture, cultural heritage or history.
Inspirational values	I am inspired by feelings, new thoughts, religious or spiritual meanings etc.
Existence values	I appreciate this place just for its existence regardless of benefits for me or others.
Habitats and biodiversity	I appreciate the plants, animals, ecosystems etc.
Environmental capacities	I appreciate the environmental capacity to produce, preserve, clean, and renew air, soil, and/or water.
Special place	Other special place or area to me

on the typology see Fagerholm (2019)).

2.6.2. Flickr tag analysis

User-generated content in the form of georeferenced images with keywords (tags) attached offers an opportunity to studying relational and cultural values, which are difficult to automatically extract using image recognition (Richards & Friess, 2015). Tags capture what people who visited a landscape and shared pictures consider salient, thus offering direct and nuanced information on people-landscape relations.

Based on the cultural values model (Stephenson, 2008) we developed tag annotation guidelines distinguishing forms, practices and processes, and relationships. Forms refer to physical, tangible and measurable aspects including vegetation, historic features, natural landforms, and human-made structures. The category forms was further subdivided based on a previously developed coding scheme for Flickr tags (Wartmann, Acheson, & Purves, 2018) into i) biophysical landscape elements and ii) cultural landscape elements. The category practices and processes includes human activities and natural processes, acknowledging "that human practices and the processes of nature are a continuum of dynamic action rather than conceptually separate" (Stephenson, 2008, p. 134). The category relationships includes values based on people–-people interactions in the landscape or on people–landscape interactions. Furthermore, we included place names as a common form of tag content in Flickr images (Sigurbjörnsson & van Zwol, 2008), including names for countries, regions, mountains and so on. Finally, we also annotated other/unknown as a category for content deemed irrelevant or photography related (Table 2).

The tag analysis focused on the most popular shared tags across unique users. Hence, popularity is not a function of frequency, but reflects the most common shared tags used by multiple contributors. For each site we coded a representative subsample of shared tags (95%, 10CI).

Since annotation is subjective, we developed guidelines and assigned two annotators to code all the Flickr tags for each site. Each annotator independently annotated tags using the guidelines. We then ran a Fleiss Kappa test to determine agreement between annotators using the nine categories we used in our initial coding guidelines (Table 2). Using this formalized coding scheme, we achieved an overall inter-annotator agreement of Fleiss Kappa = 0.828 (CI 0.803–0.854), an almost perfect fit (Landis & Koch, 1977), and significantly higher than the agreement expected by chance ($p < 0.001$).

Next, we compared cases where annotators did not agree and recoded those cases where possible. For instance, where place names or terms in local languages were not recognized by one annotator and marked as "unknown" but an annotator with local knowledge could code the tags, we assigned the tag to a class based on local knowledge. Cases of disagreement among categories other than "unknown" and cases marked for discussion were few and resolved by consistently applying the coding guidelines. We also merged the categories "unknown and not relevant" into a single category "other" for our final coding. To determine the differences between study sites in how users described their photographs, we calculated the percentage of photos with tags for each category.

Table 2
Coding scheme developed for the thematic coding of Flickr tags.

Landscape value	Tag examples	Elaboration
Biophysical landscape elements:	mountain, river, hill, flower, rocks, forest, ibex, marmot, glacier	Biophysical landscape elements contain terms relating to geology, landforms, soil, land cover, flora, fauna, and celestial bodies (stars, sun, moon)
Cultural landscape elements	village, street, car, cow, dog, child, hikers, cornfield, garden, people	Cultural landscape elements contain terms referring to land use, settlements, infrastructure, domesticated animals, and anthropogenic objects.
Human activities	hiking, biking, walking, mountaineering, climbing	Recreational activities
Ecological processes	summer, winter, raining, snowing, sunset, sunrise	Changing seasons and weather
Relationships	blue, green, quiet, tranquil, beautiful, beauty, nature, wilderness, tradition, joy, happy, home, panoramic	Values based on people–people interactions in the landscape or on people–landscape interactions; including also valued relationships within a landscape where there is little or no direct human involvement (e.g., sense of place, aesthetics, sensory responses, memories, meanings, ecological relationships). Include perceptual elements include terms referring to color, touch/feel, sounds, smells, as well as sense of place, mentions of meanings, feelings, memories, as well as terms relating to a sense of attachment, identity, or history of a place or landscape.
Place names	switzerland, makedonia, roumanie, plattensee, aegean	All named places, including names for countries, regions, villages, mountains, rivers or specific buildings
Other (not relevant)	nikon, squareformat, iphoneography, flickriosapp: filter = nofilter, uploaded:by = flickrmobile	Content that we do not code for this exercise, may include photography-related vocabulary, tags for photographer names, unrelated content
Other (unknown)	μακεδονια, tsvetok	Content in languages that the coder does not understand/is unfamiliar with

2.7. Comparison of landscape value types

The PPGIS data and Flickr tags were annotated using different taxonomies. We were interested in whether or not these taxonomies were related to one another, despite their quite different origins and semantics. To compare categorizations, we firstly prepared spider plots for each site, allowing a qualitative overview of the variation in

Table 3
Elicited categories of landscape values from the two approaches grouped according to three fundamental components of landscape values: Practices and processes, relationships and forms.

	Stephenson (2008) original definition	PPGIS elicited values	Flickr elicited values
Practices and processes	Past and present actions, traditions and events; ecological and natural processes; and those practices/ processes that incorporate both human and natural elements	Harvested products Outdoor activities Environmental capacities	Ecological processes Human activities
Relationships	People–people interactions in the landscape, people–landscape interactions, and valued relationships within the landscape.	Aesthetic values Existence values Inspirational values Social interaction Special place	Relationships Place names
Forms	The physical, tangible and measurable aspects of landscape	Farm products Habitat and biodiversity	Biophysical elements Cultural elements

categorization both within and between data sets and sites. To quantitatively compare the two categorizations, we compared matrices of site similarity using the Mantel test, a non-parametric test of the correlation between distance matrices. Similarity was calculated between sites defined as the Euclidean distance between vectors representing the proportion of each category found at a site. Finally, we used principle components analysis to explore how different categories contributed to site similarity within datasets.

The landscape values elicited by the two approaches results in categories of values that are hard to compare directly. Consequently, Stephenson's three-component framework was used as an overarching comparative framework for the summary of similarities and differences between the content parts of the two analysis results. The 10 values from PPGIS and the six values from Flickr were organized within each overarching component as summarized in Table 3. We categorized 'place names' as relationships since place names are often associated with identity and cultural heritage (Hakala et al. 2015). Further, meanings of place names were also originally considered as relationship by Stephenson (2008). This simplification made it possible to compare the volume and variance of each value type from PPGIS and Flickr according to the Stephenson's three component framework.

2.8. Spatial analysis

To compare spatial distribution of valued sites in PPGIS and Flickr, we overlaid a 1 km resolution grid on each study site. This resolution was chosen as a pragmatic compromise allowing us to capture variabilities in PPGIS and Flickr contributions even within relatively small study sites while still being tractable across larger sites (study site area range from a minimum of 37 km^2 to a maximum of 1725 km^2, with a mean of 521 km^2).

To explore variation in spatial patterns of contribution, we calculated counts of unique respondents (in PPGIS) and users (in Flickr) for each grid cell. This measure means that a Flickr user visiting a location many times over the years would have the same count as a PPGIS informant (who was interviewed once on a specific date). Having calculated counts for each site, we then used the 5th quintile of counts to identify the most popular locations.

To compare spatial patterns in PPGIS and Flickr data we calculated Jaccard scores (Heikinheimo, 2020) for all cells with non-zero counts and the 5th quintiles. The Jaccard index measures the similarity between two sets as the intersection of two sets divided by their union. A value of 1 indicates complete overlap between the two datasets, and value 0 means the two sets do not overlap at all (Korpilo, 2018). We then grouped our study sites according to the resulting Jaccard scores of all grid cells and for the 5th quintiles.

Finally, we explored the resulting grouping of study sites by relationship to the site characteristics (Appendix A). For this purpose we used a Kruskal-Wallis test of group difference.

3. Results

3.1. Comparison of PPGIS and Flickr data volume

The total number of individuals and locations reported in the PPGIS and Flickr data are similar in magnitude, with 5707 unique Flickr contributors sharing 47,600 unique locations, compared to 3027 PPGIS respondents who mapped 32,029 landscape value locations (Appendix B). Between site variation was less for the purposively sampled PPGIS data than Flickr, as reflected by the values of coefficients of variation.

We found a significant correlation in the number of PPGIS respondents per inhabitant per km2 with the number of Flickr contributors per inhabitant per km2 (Spearman's $\rho = 0.613$, $p = .005^{**}$), see Appendix C. However, the number of PPGIS locations per km^2 was not significantly correlated with Flickr locations per km^2 (Spearman's $\rho = 0.151$, $p = .538$). These results suggest that availability of individuals is likely to contribute to the overall response rate, while the area of a site itself does not necessarily drive the number of locations valued in PPGIS or photographed in Flickr.

3.2. Types of landscape values elicited in the two datasets

Out of the 11 perceived landscape values included in the PPGIS surveys, the most frequently mapped by local respondents across the 19 sites were outdoor activities, aesthetic values, and sites for social interactions (Appendix D). These three values contributed about 50% of all 11 values across most study sites, except for the Spanish site (SP-MO) and the Romanian site (RO-SA) where they contributed around 30% of all values.

The comparison between the seven different tag categories of the Flickr images showed that place names were by far the most common tags, with around 50% (±20%) of all coded tags across all study sites (see Appendix F). Biophysical elements and cultural elements were widely used across study sites (Appendix E) and negatively correlated (Spearman's $\rho = -0.631$, $p = .002^{**}$). This result suggests that cultural and natural attractions or heritage seem to dominate different study sites. People's affective relationships with landscapes, captured in the 'relationship' category, included aesthetic values, perceived sensory dimensions, and social interactions (see Table 2). This category was also evident across all 19 sites, but varied greatly between 2% and 31% of the tag codes (Appendix E). In stark contrast to the PPGIS data, human activities in terms of outdoor activities were the least common tag category. They were not used for nine study sites at all, and for the other 10 study sites limited to a maximum of 4% of all tag categories (SP-MO). There were no significant correlations between the categories of landscape values used across sites in PPGIS data and Flickr according to the Mantel test ($r = 0.08$, $p = 0.225$).

To explore how sites are differentiated by categories of landscape value in the two approaches, we carried out a principal component analysis to identify which categories best captured variation between sites. In Fig. 3, we plot similarity of individual sites according to the first two principal components, and the eigenvectors of each categories. The first two principal components capture 61% and 81% of the variance respectively, and are thus an effective way of summarizing the differences in landscape value between two sites. By plotting positions of individual sites and the eigenvectors, we can better interpret how categories influence individual sites.

In the PPGIS data (Fig. 3, to the left) we note the importance of outdoor activities, with a high magnitude eigenvector parallel to the first principal component. Most other eigenvectors are orthogonal, with the most important being aesthetic value and culture and heritage. Many other values are clustered (e.g. special place, existence values, inspirational values) and have smaller magnitudes, suggesting that these categories have similar influences in the variance in landscape value distributions.

The dominant eigenvector parallel to the first principal component in Flickr data relates to place names (Fig. 3, to the right). As suggested by the descriptive statistics, biophysical elements and cultural elements contribute in opposing directions to value distribution. Interestingly, the eigenvector for ecological processes is parallel to biophysical elements, suggesting these contribute in similar ways to variation in landscape value.

3.2.1. Conceptual similarities and differences

Although we found no significant correlations between the specific landscape values types across PPGIS and Flickr, conceptual similarities between types of values were present according to the overarching framework proposed by Stephenson (2008), Table 3. To explore this further, we organized the resulting 10 PPGIS values and the 6 Flickr values according to Stephenson's framework with visual representation of proportion of content (size of circles) and variation between the study sites (size of grey borders) (Fig. 4). From this conceptual organization of

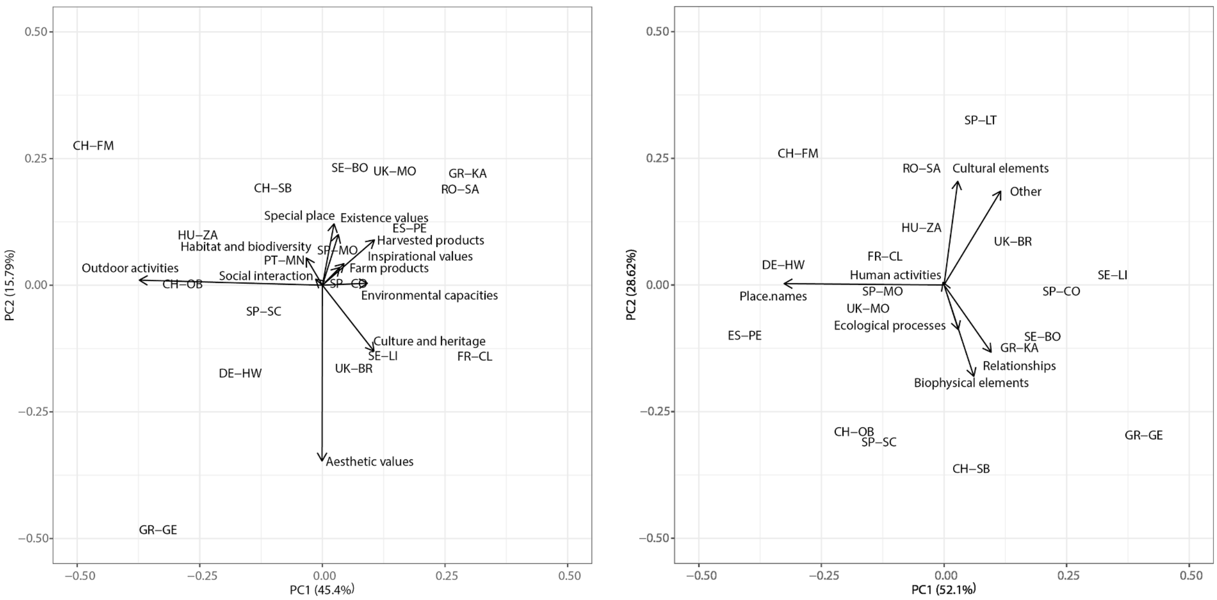

Fig. 3. Result plots of principal component analyses of landscape value distributions. The plot shows the two first principle components (PC1 and PC2) in each analysis together explaining 61% of variance for PPGIS (to the left) and 81% of variance for Flickr values (to the right). The line arrows represent eigenvectors for each value type. Study sites are plotted using their names.

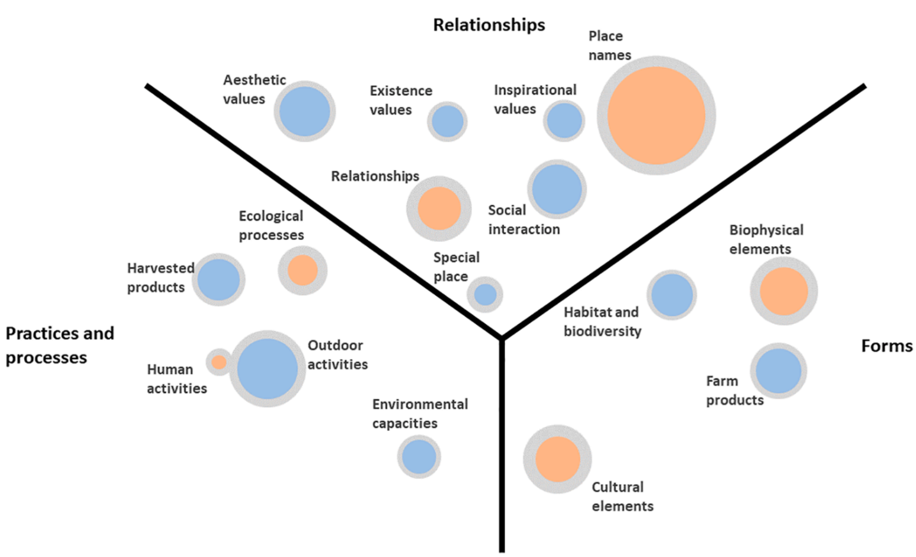

Fig. 4. Visual summary of the elicited landscape values according to three fundamental components of landscape: forms, practices and processes, and relationships (Stephenson, 2008). Values types are represented as circles, orange are Flickr and blue circles are PPGIS. Circle size indicates percentage of content, and the grey borders the coefficient of variation over the sites. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.).

landscape values, it was clear that overlaps were present within the results from the two approaches, i.e. both were capable of capturing values relating to 'landscape practices and processes', 'landscape forms', and 'relationship' with and within landscapes.

3.3. Patterns of spatial overlap

The comparison of numbers of PPGIS respondents and unique Flickr users per grid cell captured the spatial overlap between the two systems in terms of Jaccard index scores (Fig. 5). Jaccard scores ranged from very low (SP-SC: 0.06) to high, i.e. more than 0.6 (UK-MO). With two exceptions (HU-ZA and CH_OB) 5th quintile values (i.e. the most visited locations in both datasets) were lower, with an average Jaccard score of 0.17. Only 22% of the variance in these Jaccard scores is explained by the overall Jaccard scores.

By ordering sites according to their overall Jaccard scores (Fig. 6) we visually identified three groups of sites. Four study sites had a high overlap (group 1), seven study sites had medium overlaps (group 2), and eight study sites had very low overlap between grids across all quintiles (group 3).

Further, there did not appear to be a relation between countries and Jaccard index (i.e. high and low values were found in the same countries across clusters), though, there was a tendency for smaller study sites to be clustered in group 1 (mean of 77 km^2, SD of 72 km^2), compared to group 2 (mean of 685 km^2; SD of 527 km^2) and group 3 (mean of 684 km^2, SD of 575 km^2). However, this difference was not significant according to a Kruskal-Wallis test of group differences ($p = .079$).

3.3.1. Spatial overlap patterns according to site characteristics

A visual map-based interpretation of the Jaccard index pointed to some possible links to specific landscapes contexts within study sites (Fig. 6). Examples from group 1 included landscapes from Switzerland (CH-FM) and Spain (SP-CO), and the cells with overlap relate to urban areas in both communities. The group 2 overlap in 5th quintile (both)

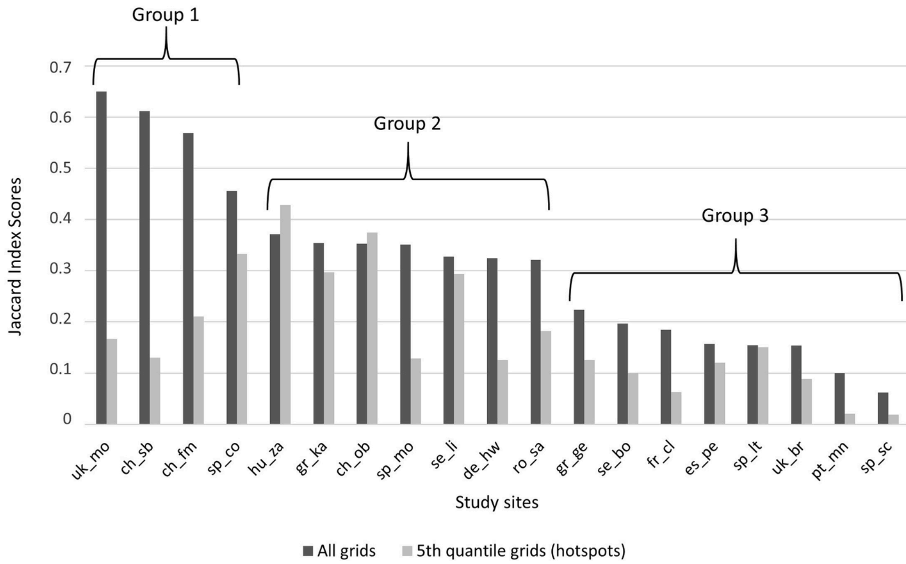

Fig. 5. Jaccard index scores of grids comparing number of PPGIS respondents and number of unique Flickr contributors. Jaccard values from all grids and 5th quantile grids are included. Three groups of study sites were interpreted from the 'All grids' function, interpreted as study sites of relatively similar Jaccard index scores (see text for elaboration).

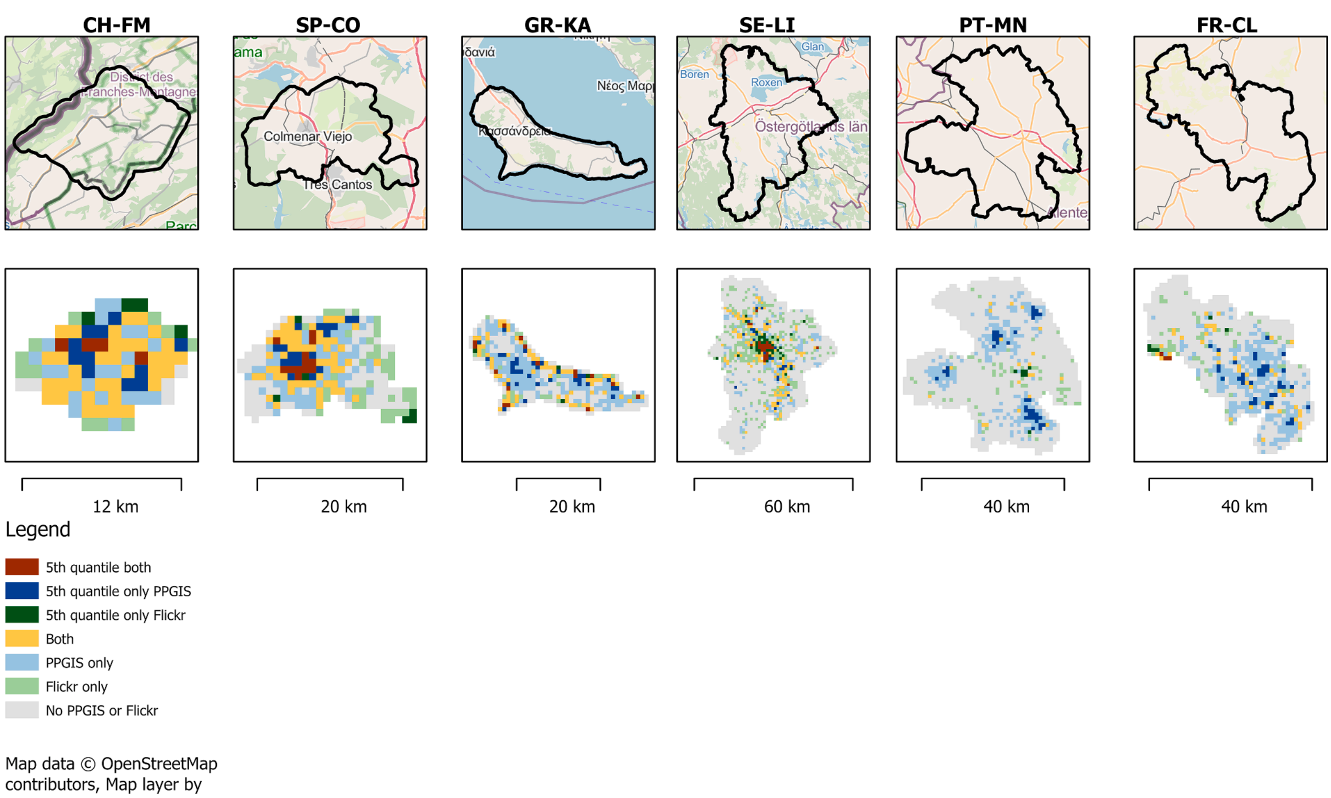

Fig. 6. Examples of comparative overlay map results from six different case sites. Group 1 with highest overlap: CH-FM and SP-CO, group 2 with medium overlap: GR-KA and SE-LI, and group 3 with limited overlap: PT-MN and FR-CL. Cell size 1 km. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

cells was evident along the coastline of the Kassandra Peninsula in Greece (GR-KA), and the south-north road corridor in Linköping, Sweden (SE-LI) suggesting the importance of coastal environments and accessibility as being strongly related to shared landscape value. Finally, the lack of overlap is clear from the group 3 cases in Portugal (PT-MN) and France (FR-CL), i.e. the domination of light blue cells (only PPGIS) and light green cells (only Flickr).

The visual map-based interpretation was explored further by comparing groups of study sites in relation to selected site characteristics (Table 4). The study sites with the greatest overlap overall were also those with the highest population density, GDP, road densities and proportions of artificial surfaces, suggesting that in areas with higher urban populations, more disposable income and access to recreational areas more similar locations are shared in PPGIS and Flickr. In contrast,

Table 4
Mean landscape characteristics in relation to the three groups of study sites with different Jaccard index scores.

Groups of study sites with similar Jaccard indexes	Pop. Density (inh/km2)		Accessibility, network density (km/km2)		GDP per capita in 2014 (€)		Artificial Surfaces (% of area)		Agricultural areas, (% of area)		Forest and seminatural areas (% of area)		Water bodies (% of area)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Group 1 (n = 4)	386.8	(346.1)	5.88	(2.77)	45,286.5	(18,554.8)	5.0%	(2.4)	49.4%	(32.6)	45.0%	(31.1)	0.6%	(0.8)
Group 2 (n = 7)	84.3	(53.3)	3.45	(1.34)	26,644.7	(22,780.9)	3.4%	(2.8)	42.6%	(25.7)	48.4%	(26.2)	5.5%	(7.1)
Group 3 (n = 8)	51.7	(34.0)	2.52	(1.27)	20,437.5	(10,778.7)	2.1%	(1.9)	64.0%	(18.9)	30.7%	(19.2)	3.2%	(5.4)
Kruskal-Wallis test of group difference	*P =.040** *(x2 (2) = 6.455)*		*P =.040** *(x2 (2) = 6.455)*		*P =.089* *(x2 (2) = 4.849)*		*P =.114* *(x2 (2) = 4.339)*		*P =.307* *(x2 (2) = 2.365)*		*P =.509* *(x2 (2) = 1.351)*		*P =.776* *(x2 (2) = 0.507)*	

the least shared locations were found in group 3 and these study sites had the lowest population densities, GDP and road density and the greatest proportion of agricultural land use. However, only the difference in population and road density was statistically significant between the three groups, and hence, these results should be treated with caution.

4. Discussion

Our study was motivated by a desire to compare landscape value in actively contributed PPGIS data covering 19 European sites with passively contributed social media data at each of these sites. We were particularly interested in exploring patterns in the spatial distribution, intensity and types of landscape value within and between the two data sources.

In the majority of sites the spatial distribution and intensity of landscape value across PPGIS and Flickr approaches were different. For the vast majority of our study sites (15/19) spatial overlaps were only moderate to very low (sites in group 2 and 3). Flickr images are taken somewhere in the landscape, often reflecting accessibility, and most strikingly for group 3, our data reveal that some locations are quite simply not on the map in terms of social media. In contrast, PPGIS data appear more likely to include less accessible interiors, perhaps because landscape value is assigned to areas known and valued by, but not necessarily visited by, locals (Muñoz, 2020).

We also found differences in value types across approaches. Flickr provided detailed and rich data on place names and associated attributes, whereas PPGIS provided finer grained data concerning specific attributes of interest to a given survey, including relationship and practice values not captured by Flickr. The PPGIS approach included more types of values relating to practices and relationships compared to values induced from Flickr. Hence, PPGIS seems to be better suited to capture a larger range of different intrinsic and social affective landscape values compared to Flickr. This result seems to be in accordance with findings from the few other comparative studies carried out so far (Depietri, 2021; Heikinheimo, 2020; Levin et al., 2017; Muñoz, 2020). Future research would benefit from comparing Flickr data to other types of attributes mapped in PPGIS; for example, development preferences or preferences for integrated landscape management. This is needed since type of values and valued parts of the landscape not captured through one or the other assessment system fail to be legitimised, and thus risk being ignored. Planning and management need to acknowledge and draw upon place-specific knowledge weaving together multiple knowledge systems (Díaz, 2015; Tengö, 2017), as represented here through PPGIS and Flickr. One potential approach, given the very common use of place names in Flickr, would be to explore the types of places named since, as argued by critical toponymists, this is one way of exploring relations to place (Tucker & Rose-Redwood, 2015).

Nonetheless, there are also points of convergence between approaches. Spatial overlaps in landscape values were found between PPGIS and Flickr approaches for four sites with high accessibility and population density (group 1), suggesting that both PPGIS and Flickr data can be reliably used in highly populated and accessible landscapes. Indeed, in these areas both approaches capture value types related to practices, relationships, and forms. This also relates to the fact that population density was one of the few statistically significant site characteristics identified, correlating with the number of participants and users in both PPGIS and Flickr, and explaining variation between the different groups as characterized by Jaccard scores. Generally though it is important to acknowledge that site characteristics did not explain similarities and differences in landscape values in terms of either location or types.

4.1. Conceptual and methodological comparison of Flickr and PPGIS techniques

Together, Flickr and PPGIS provide a more holistic picture of a landscape than each method can uncover alone. The approaches are suited to different research questions depending on the value attributes of interest, types of respondents, and assumptions about previous place-based knowledge of participant or their landscape usage behaviour. Fig. 7 highlights points of differences to consider when deciding on use of the two methods in landscape value assessments. Passive elicitation by use of social media like Flickr has the advantage of data being readily available allowing for opportunistic sampling of visitors' bottom-up expressed landscape values. However, when analysing and categorising data such as tags the elicited value typology spectrum is narrow due to the use of basic levels and superordinate terms (Rorissa & Iyer, 2008). In contrast, PPGIS allows for inclusion of as many value types as defined in top-down pre-categorisation of values. We do not recommend social media analyses as a fast and quick fix to replace PPGIS studies in uncovering the diverse and multifaceted ways we value landscapes, but to make complementary use of both passive and active approaches in future landscape value assessments. This recommendation is in line with other recent work exploring the use of PPGIS and image content analysis from Flickr across urban green areas in Israel (Depietri, 2021). It is though a cautionary note given the burgeoning research using social media to explore landscape value and particularly cultural ecosystem services – our results suggest these approaches generate useful, but different patterns. In highly populated, accessible regions the overall signal with respect to visitation may be similar, but even here the pattern with respect to the most popular locations may be quite different.

Finally, and while we did not address it explicitly, our study provides insights into differences regarding temporality. Social media data accumulates continuously allowing for temporal and spatio-temporal analyses of values over different timespans, e.g. months or seasons (Walden-Schreiner, 2018). Clearly, this contrasts with PPGIS, which typically is a one-off survey; although follow-up surveys may be allow for longitudinal studies of landscape values (Brown & Donovan, 2014). Future studies should combine and compare active and passive collected data on landscape value change over time.

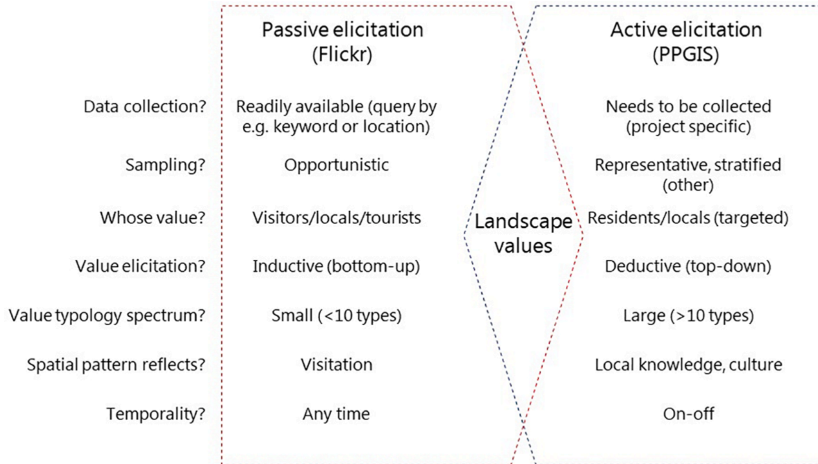

Fig. 7. Complementary use: Summary of main points of differences between the two systems.

4.2. Study limitations

Comparing data collected in very different ways and with different purposes raises a number of conceptual and practical issues. The PPGIS data used in this research were collected in-situ by trained facilitators who purposively sampled local inhabitants according to gender and age. This contrasts starkly with Flickr data, where we have no direct knowledge of the contributors. Previous studies have though suggested that males are more likely to geotag images than females (O'Hare and Murdock (2012) reported than from a sample of 320 thousand geotagged users around 15% were contributed by females and 47% by males). Furthermore, Flickr users are commonly acknowledged to not only incorporate locals, but also tourists (Preis, Botta, & Moat, 2020) visiting a region. Thus, it is clear that those contributing to the two datasets not only differ demographically, but likely have different cultural backgrounds. These potential differences between users may also explain some of the differences in the intensity of landscape value mapped.

Spatial distributions and variation in intensities of landscape values were mapped using point locations within a given region. Regions defined in the original PPGIS work were used to query the Flickr API for geotagged images. However, the point locations from each method have different underlying areas of interest. In the PPGIS data, participants were provided instructions about how to identify a location associated with a landscape value on a map and a technical spatial limitation, allowing mapping only at a specific scale relevant for local landscapes. In Flickr, images are often assigned coordinates recording the photographer's position (Zielstra & Hochmair, 2013) rather than that of the scene photographed. Furthermore, both approaches assumed that landscape value can be assigned to points rather than regions. Although our use of a 1 km grid reduces these issues, it is important to note that spatial distributions are likely influenced as a function of landscape type, with more open landscapes and vistas likely having larger discrepancies between PPGIS data and Flickr as the discrepancy between photographer and photographed region increases.

A further limitation concerns the assignment of landscape values to types. The typology of landscape values in the PPGIS data was deductively developed around cultural ecosystem services, i.e. assigned top-down by the research team, and further explained by facilitators to participants if needed. Initial attempts quickly showed that this typology was ill-suited to annotating Flickr tags. We therefore used a simpler classification scheme, developed in earlier work (Wartmann et al., 2018) for which inter-annotator agreement was high. However, the two typologies demonstrate important differences in the semantics of the two data sources. Perhaps the most prominent of these are the complete absence of named places in the PPGIS data, which make up on average 47% of the annotated Flickr tags. We did not include an analysis of place name meanings in this study, but the difference remains striking and it demonstrates an important contrast between passively collected social media data and actively elicited PPGIS data.

4.3. Implications for planning and management.

In regional and rural settings, planners can draw upon aesthetic values from Flickr approaches given their relatively even coverage (Figueroa-Alfaro & Tang, 2017; Havinga, 2021). Flickr also provides data on values associated with named places, especially from the perspective of visitors. However, we recommend that planners draw upon PPGIS approaches if the goal is to obtain more detailed information about other landscape values types, such as different relationships to and within the landscape, and practices such as outdoor activities across the region.

The question about whose values are integrated and not, and how, relates to procedural justice in ecosystem service assessments (Calderón-Argelich, 2021; Langemeyer & Connolly, 2020). Clearly, Flickr data seems to more accurately represent the values of visitors who seek out land marks and named places, whereas PPGIS seems to be more inclusive of different people and different types of values in landscape assessments. Data from both PPGIS and Flickr are important when seeking to draw upon the values of both residents and visitors. Flickr also has an important role in rapid appraisals of landscape values and could serve as a foundation for a wider assessment using PPGIS to fill gaps in landscape valuation.

5. Conclusions

The 19 case sites across Europe provided a unique opportunity to compare perceived landscape values from passive and active forms of collecting data and reasoning across multiple case sites. The study shows how, despite the temptation (as they both provide spatial results), the two approaches to landscape value elicitation are not very comparable. First, the types of landscape values elicited were different and even contrasted for some sites, and we interpret this result as a difference in value mapping behaviour. Secondly, we found high to moderate spatial agreement between the two mapping outputs for only a few densely populated landscapes. For most of our study sites, very low overlap was evident when comparing the spatial patterns of values elicited. Our results suggest a need for more thought in studies using a single approach, and show the complementary benefits of combining passive and active approaches in order to accommodate plural valuation through the participation of people, and going beyond e.g. spatial data proxies applied for representing landscape values. This allows inclusion of more voices in landscape planning and management. We presented a conceptual framework for harnessing the benefits of both approaches in future integrated landscape management studies and landscape planning application.

Declaration of Competing Interest

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

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Appendix A. Description and social-ecological properties (site characteristics) for each study site.

Study site	Landscape description (a)	Area (km2)	Pop. Density (inh/km2) (2014) (b)	GDP per capita in € (2014) (b)	Accessibility, road density (c)	Land cover (d)			
						Artificial Surfaces (%)	Agricultural areas (%)	Forest and seminatural areas (%)	Water bodies and wetlands (%)
Franches Montagnes (CH-FM)	"Mountain plateau with small villages; forest and grasslands with trees; outdoor recreation tourism; wood pastures with free ranging horses and cattle"	52	86	27,900	3.72	3%	89%	7%	2%
Obersimmental (CH-OB)	"Alpine pasture landscape; several land-use related traditions (cheese-making, typical local architecture), high touristic value"	123	173	43,100	2.66	2%	45%	53%	0%
Schwarzbubenland (CH-SB)	"Gently rolling hills with small villages; farmland; grasslands; traditional orchards (esp. cherry); mosaic of forest patches; recreation area for nearby city"	50	543	61,833	9.91	6%	40%	54%	0%
Hochkirch-Weißenberg (DE-HW)	"Gently undulating fertile loess land with small villages and intensive agriculture; forests; heterogeneous agricultural land with arable crops mixed with semi-natural features (hedgerows, farm trees, woodlots, riparian woodlands)"	93	128	60,813	5.42	3%	58%	38%	1%
Peipsiääre and Alatskivi (ES-PE)	"Drumlin field and plain area adjacent to large lake; shaped by traditional land-use practices (partly specific for an ethnic minority)"	160	44	13,100	3.23	2%	70%	14%	0%
Canton de Loudéac (FR-CL)	"Flat terrain with villages; arable land with mixed diary, fodder and grain production dominating; some grasslands; traditional hedgerow networks on arable land (bocage)"	737	86	23,100	4.85	2%	85%	13%	0%
Gera (GR-GE)	"Small-scale traditional agricultural landscape (olive plantations, pastures) with rich history"	87	47	72,113	3.04	1%	12%	87%	0%
Kassandra (GR-KA)	"Gently undulating peninsula with 14 villages; arable land (cereals) of small farms, half of it covered by scattered olive trees; pine forests; olive groves with understory cultivation or grazing or both; tourism as main economic activity"	336	34	8500	4.92	9%	24%	53%	4%
Zala (HU-ZA)	"Hilly area, belongs partly to national park; mainly small scale farming: arable lands; traditional agroforestry, vineyards, forest, woodland and small patches of ancient	133	75	10,300	1.57	2%	36%	54%	2%

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(*continued*)

Study site	Landscape description (a)	Area (km2)	Pop. Density (inh/km2) (2014) (b)	GDP per capita in € (2014) (b)	Accessibility, road density (c)	Land cover (d)			
						Artificial Surfaces (%)	Agricultural areas (%)	Forest and seminatural areas (%)	Water bodies and wetlands (%)
	oak wood pastures; Balaton lake a crucial part of the landscape and the economy (tourism)"								
Montemor-O-Novo (PT-MN)	"Flat area with slight undulation; oak pastures (montado) combined with dry lands agriculture (cereals)"	1229	22	30,600	4.48	8%	11%	81%	0%
Saxon Region (RO-SA)	"Traditional land use practices and low levels of infrastructure development; small villages; pastures with scattered trees, typically oak forests; arable fields"	238	104	9000	1.01	2%	63%	35%	0%
Börje (SE-BO)	"Mix of rural farmland and urban areas on a tableland with inland and coastal plains, visible historical features dating back to the Neolithic"	47	42	13,100	4.01	5%	51%	29%	0%
Linköping (SE-LI)	"Flat peri-urban area with 10 municipalities; in North arable and urban land, Southern part mostly coniferous forest; largest remnant area of cultural landscapes in Sweden with open and patchy oak pastures"	1578	42	20,800	2.83	1%	23%	77%	0%
Colmenar Viejo (SP-CO)	"Rural landscape based on livestock farming at the outskirts of a megacity, commuter area, rich natural and cultural heritage"	183	801	15,300	1.33	0%	76%	24%	0%
Llanos de Trujillo (SP-LT)	"Flat land with small villages around larger town; dry grasslands; shrublands; extensive cereal crops; extensive grazed holm oak; pastures (Iberian dehesa); livestock breeding (sheep, cattle, Iberian black pigs); increasing nature tourism"	940	21	24,300	4.30	3%	87%	9%	0%
Montaña Oriental Lucense (SP-MO)	"Mountainous area with river basin; small villages, suffering from migration to cities; forests; pastures; arable land; traditional chestnut groves"	527	35	16,000	1.17	1%	46%	53%	0%
Serena Campiña (SP-SC)	"Flat and hilly lands with small villages; arable lands; arable lands with scattered oaks (dehesa); forest and shurblands; increasing nature tourism"	638	32	14,300	1.67	1%	78%	20%	0%
The Brecks (UK-BR)	"Lowland open rural landscape, with small towns and villages; free draining sandy soils that (with irrigation) can be used for intensive agriculture; outdoor pig production; crop and vegetable production; plantation conifer forestry"	1640	119	39,900	3.51	5%	41%	46%	0%
Modbury (UK-MO)	"Diverse landscape with peri-urban areas, undulating farmland with hedgerows (bocage-style), coastal areas and moorland"	24	117	27,100	4.16	6%	75%	19%	0%

a) Sites descriptions from electronic supplementary material from Fagerholm, N. et al. (2019) and Garcia-Martin et al. (2017).

b) Population density and mean GDP per capita calculated using of population data at NUTS 3 level from Eurostat and the Swiss Federal Statistics Office, reference year of 2014.

c) Accessibility calculated as road density (km/km^2) using OpenStreetMap data that includes both major roads but also smaller roads and paths.

d) Land cover calculated using Corine Land Cover (CLC) 2018, version 2020_20u1 made available by the European Environment Agency (EEA) at: https://land.copernicus.eu/pan-european/corine-land-cover/clc2018, reclassified into four main land use classes: settlement and artificial surfaces (CLC classes 111–142), agricultural areas (CLC classes 211–244), forest and semi-natural areas (CLC classes 311–335), and wetlands and waterbodies (CLC classes 411–523).

Appendix B. Comparison between PPGIS and Flickr data for the 19 study sites.

Community			PPGIS		FLICKR		
study site	study area (km^2)	pop density (inhab./km^2	respondents	value locations	unique contributors	images	locations[a]
CH-FM	52	86	167	1770	62	780	300
CH-OB	123	173	65	408	173	3195	1701
CH-SB	50	543	219	2740	78	1114	419
DE-HW	93	128	146	978	25	412	194
ES-PE	160	44	144	1569	50	284	244
FR-CL	737	86	146	1753	172	1513	633
GR-GE	87	47	150	1259	23	186	104
GR-KA	336	34	173	2235	356	3506	1753
HU-ZA	133	75	139	1392	305	2923	1518
PT-MN	1229	22	171	2445	134	835	450
RO-SA	238	104	182	1937	139	1174	503
SE-BO	47	42	40	240	38	129	75
SE-LI	1578	42	170	1993	697	21,551	10,442
SP-CO	183	801	316	2410	248	3303	1642
SP-LT	940	21	207	2002	595	5810	2549
SP-MO	527	35	171	2493	331	4188	2713
SP-SC	638	32	181	2317	21	149	123
UK-BR	1640	119	172	1677	2205	92,259	21,933
UK-MO	24	117	68	411	55	498	304
Mean	463.95	134.26	159.32	1685.74	300.37	7568.89	2505.26
Standard deviation	526.92	193.49	59.96	744.02	499.65	21065.68	5254.67
Coefficient of variation	1.14	1.44	0.38	0.44	1.66	2.78	2.10

[a]The number of locations is lower than number of geocoded images, since locations are filtered by unique contributors (see methods).

Appendix C. Ratios comparing PPGIS data and Flickr data with study area size and population density.

Study site	Pop density (inhab/km^2)	PPGIS value locations per km^2	PPGIS respondents per inhab./km^2	Flickr locations per km^2	Flickr contributors per inhab/km^2
CH-FM	86	34,0	1.9	5,8	0.7
CH-OB	173	3,3	0.4	13,8	1.0
CH-SB	543	54,8	0.4	8,4	0.1
DE-HW	128	10,5	1.1	2,1	0.2
ES-PE	44	9,8	3.3	1,5	1.1
FR-CL	86	2,4	1.7	0,9	2.0
GR-GE	47	14,5	3.2	1,2	0.5
GR-KA	34	6,7	5.1	5,2	10.5
HU-ZA	75	10,5	1.9	11,4	4.1
PT-MN	22	2,0	7.8	0,4	6.1
RO-SA	104	8,1	1.8	2,1	1.3
SE-BO	42	5,1	0.9	1,6	0.9
SE-LI	42	1,3	4.1	6,6	16.7
SP-CO	801	13,2	0.4	9,0	0.3
SP-LT	21	2,1	10	2,7	28.6
SP-MO	35	4,7	4.9	5,1	9.5
SP-SC	32	3,6	5.6	0,2	0.7
UK-BR	119	1,0	1.4	13,4	18.5
UK-MO	117	17,1	0.6	12,7	0.5

Appendix D. Spider plots (radar charts) of the distribution of landscape value types by PPGIS mapping per study site.

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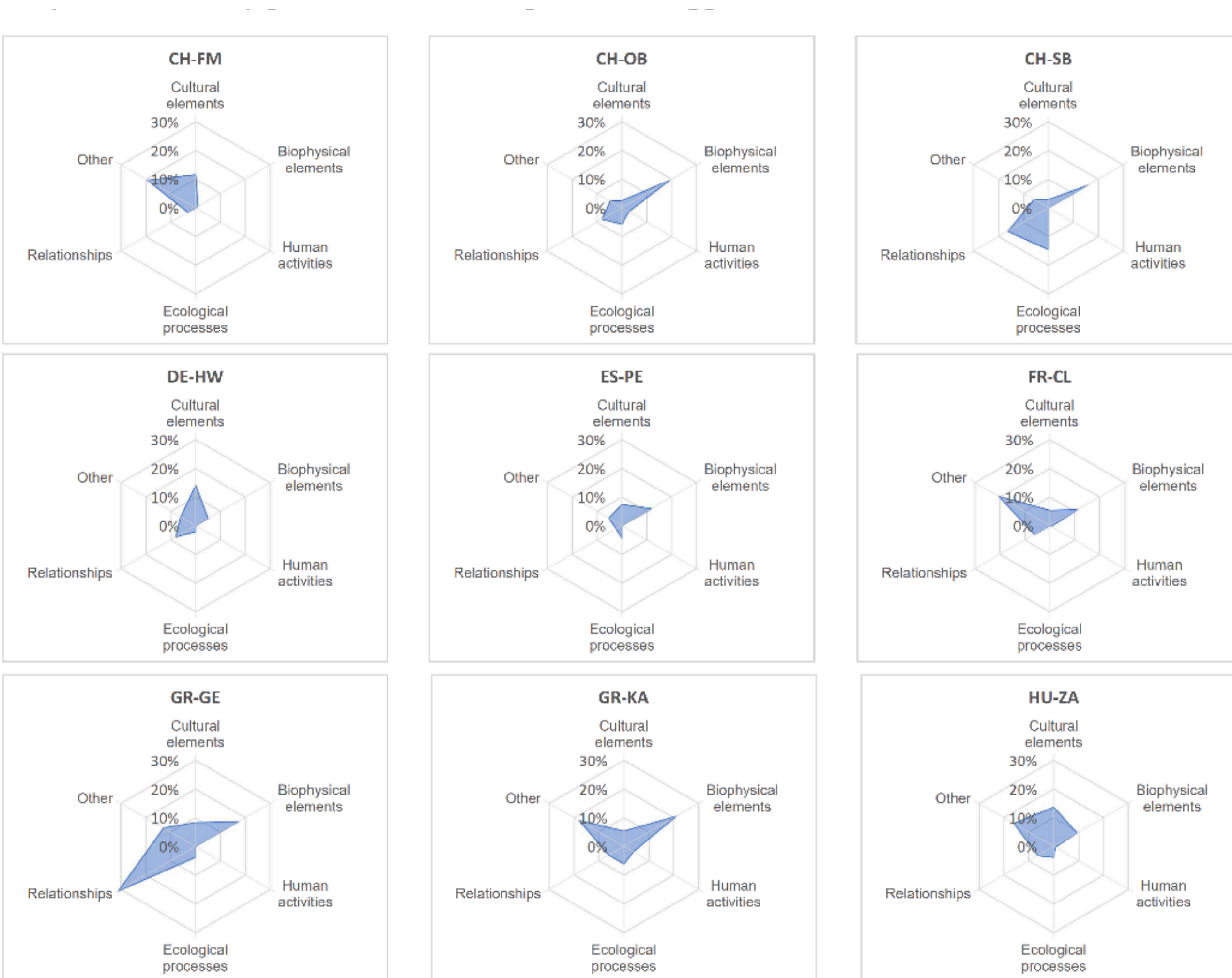
SE-LI
Outdoor activities
Social interaction
Aesthetic values
Habitat and biodiversity
Culture and heritage
Environmental capacities
Existence values
Farm products
Harvested products
Inspirational values
Special place
30%
20%
10%
0%
SP-CO
Outdoor activities
Social interaction
Aesthetic values
Habitat and biodiversity
Culture and heritage
Environmental capacities
Existence values
Farm products
Harvested products
Inspirational values
Special place
30%
20%
10%
0%
SP-LT
Outdoor activities
Social interaction
Aesthetic values
Habitat and biodiversity
Culture and heritage
Environmental capacities
Existence values
Farm products
Harvested products
Inspirational values
Special place
30%
20%
10%
0%
SP-MO
Outdoor activities
Social interaction
Aesthetic values
Habitat and biodiversity
Culture and heritage
Environmental capacities
Existence values
Farm products
Harvested products
Inspirational values
Special place
30%
20%
10%
0%
SP-SC
Outdoor activities
Social interaction
Aesthetic values
Habitat and biodiversity
Culture and heritage
Environmental capacities
Existence values
Farm products
Harvested products
Inspirational values
Special place
30%
20%
10%
0%
UK-MO
Outdoor activities
Social interaction
Aesthetic values
Habitat and biodiversity
Culture and heritage
Environmental capacities
Existence values
Farm products
Harvested products
Inspirational values
Special place
30%
20%
10%
0%
UK-BR
Outdoor activities
Social interaction
Aesthetic values
Habitat and biodiversity
Culture and heritage
Environmental capacities
Existence values
Farm products
Harvested products
Inspirational values
Special place
30%
20%
10%
0%

Appendix E. Spider plots of the distribution of landscape value types elicited by Flickr tags per study site (for clarity place names are not plotted, see appendix F).



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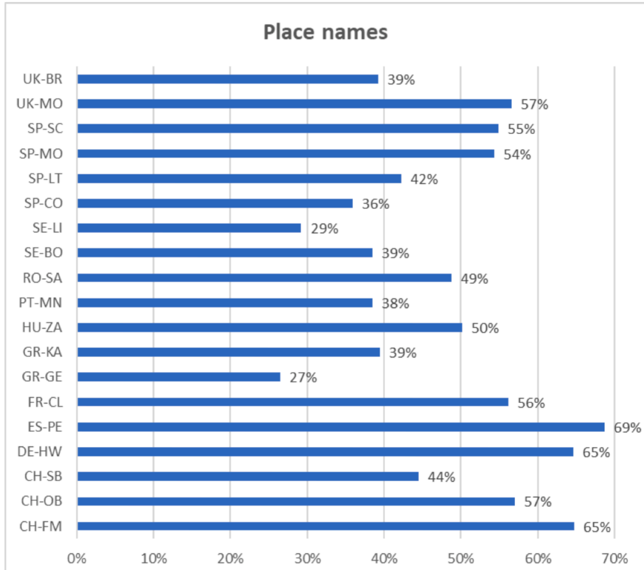
PT-MN
RO-SA
SE-BO
SE-LI
SP-CO
SP-LT
SP-MO
SP-SC
UK-MO
UK-BR
Cultural elements
Biophysical elements
Human activities
Ecological processes
Relationships
Other
30%
20%
10%
0%

Appendix F. Cross study sites distribution of place names as tag in the coded Flickr data (share of all coded tags).



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